Sciences

Middle Years Programme

Teacher support material

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For use from September 2005 or January 2006, depending on the start of the school year.

International Baccalaureate Organization

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Middle Years Programme
Sciences—teacher support material

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Contents

Introduction

Teacher support material accompanies the guide for each subject group and the personal project within the Middle Years Programme (MYP).

This teacher support material is designed to accompany the MYP *Sciences guide* (published January 2005). It contains examples of assessed student work, and is intended to give practical help to support teachers' understanding and implementation of the theory presented in the guide. It is printed in loose-leaf format for ease of use.

Content

The sciences teacher support material contains examples of assessed student work for year 5. Please note that these are **examples** only. They have been included to demonstrate what tasks and student work may look like and do not form a part of a mandatory curriculum for schools.

The examples of student work presented here are all from year 5 and are divided between three types of assessment, as follows.

- Tests
- Scientific investigations
- Pieces of writing

Teachers may wish to use these examples as a guide to creating appropriate sciences tasks, or as an indication of the standard expected of students by the end of the final year of the programme.

The **appendix** contains examples of completed forms F3.1 and F4.4 to assist teachers in preparing for moderation and monitoring of assessment.

Please note that the MYP sciences teacher support material exists in four languages (English, French, Spanish and Chinese). If teachers are familiar with more than one of these languages, it may be worthwhile for them to look at the other language versions, as some examples of assessed student work are different for each language.

Acknowledgments

Thanks are due to the schools and students who allowed the use of their work in this document, and to the experienced MYP practitioners who worked so carefully on all of the content.

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Assessed student work

Example 1: Genetics test

Test—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	5	-	-	-

Background

Students had covered the main topics of genetics and evolution. They were familiar with classic Mendelian monohybrid crosses problems. Students had also studied some of the possible uses of genetics such as fingerprinting and genetic engineering techniques.

The test consisted of multiple-choice questions and short-answer questions that were designed to examine students' information-recall and problem-solving abilities. Data-based questions were included to test students' ability to interpret and analyse scientific information. Unfamiliar situations were also included to encourage students to apply their understanding of scientific ideas and concepts.

Students were given two hours to complete both sections of the test.

The test was assessed using criterion C.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text. For multiple choice questions, the student´s answer is represented by a circle.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
5–6	The student explains scientific ideas and concepts and applies scientific understanding to solve **problems in familiar and unfamiliar situations**. The student **analyses** and **evaluates** scientific information by making **scientifically supported judgments** about the information, the validity of the ideas or the quality of the work.

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This work achieved level 5 because the student:

- demonstrates an understanding of genetics and applies this to solve problems in familiar situations (section A: questions 6, 7 and 8; section B: question 3)
- analyses information by identifying relationships and causes, and provides an explanation of his/her understanding
- solves a problem in an unfamiliar situation (section B: question 4).

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Student work

End-of-term test—genetics

A. Each of the questions or incomplete statements in this section is followed by four suggested answers or completions. Select the one that is best in each case.

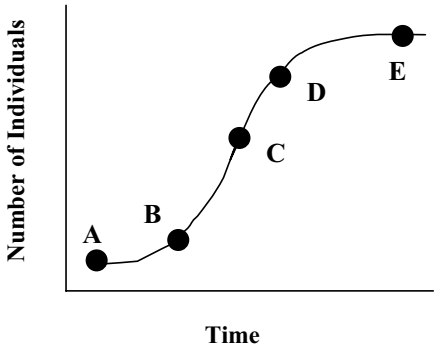
1. An explanation that is supported by the results of scientific experiments and observations is called a:

(a.) theory
b. hypothesis
c. controlled experiment
d. law

2. Ecology is the:

a. study of life and life forms, their anatomy and function
(b.) study of the interactions between organisms and their environment
c. Earth, air and water
d. biotic and abiotic components in an ecosystem

3. Which point on the curve in the diagram below best represents the carrying capacity of the environment for the population shown?



a. A
b. B
c. C
d. D
(e.) E

4. The rapid increase in human population at the beginning of the 20th century was due to:

a. religious beliefs
b. land availability
(c.) the Industrial Revolution
d. a later age of marriage

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Reminder: the Punnet squares shown here have been drawn by the student.

5. A couple has five children, all sons. If the woman gives birth to a sixth child, what is the probability that the sixth child will be a son?

a. 5/6
b. 1/2
c. 1/4
d. 1/6

Questions 6 and 7 refer to the birth of a child with blood type A to a mother with blood type B

6. Which of the following blood types must the father have?

a. AB only
b. Either AB or B
c. Either AB or O
d. Either AB or A
e. AB or A or O

Mother: $I^B I^B$
Child: $I^A I^A$

	I^B	i
I^A	$I^A I^B$	$I^A i$
I^B	$I^B I^B$	$I^B i$

	I^A	I^B
I^B	$I^A I^B$	$I^B I^B$
I^B	$I^A I^B$	$I^B I^B$

7. If the father has blood type AB, which of the following statements is correct about the mother?

a. She contributes an I^B allele, which is recessive to the father's I^A allele.
b. She contributes an i allele, which is recessive to the father's I^A allele.
c. She contributes an I^B allele, which is co-dominant to the father's I^A allele.
d. She contributes an i allele, which is co-dominant to the father's I^B allele.
e. She is homozygous for the I^B allele.

8. Red–green colour-blindness is sex-linked and caused by a recessive allele. One in 80 males is colour-blind but only 1 in 6,400 females. Which of the following statements is true?

a. All the chromosomes contain the allele.
b. Only the X chromosome contains the recessive allele.
c. Only the Y chromosome contains the recessive allele.
d. Both the X and Y chromosome contain the recessive allele.

	X^R	X^r
X^R	$X^R X^R$	$X^R X^r$
Y	$X^R Y$	$X^r Y$

	X^r	X^r
X^r	$X^r X^r$	$X^r X^r$
Y	$X^r Y$	$X^r Y$

	X	X^r
X	XX	$X X^r$
Y^r	$X Y^r$	$X^r Y^r$

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9. What is the diploid chromosome number for humans?

a. 2

b. 23

c. 46

d. 92

10. Which of the following is the best description of deoxyribonucleic acid (DNA)?

a. A single-stranded molecule made up of sugar, phosphate and nitrogen

b. A single-stranded molecule made up of acid, base and water

c. A double helix made up of an acid, base and water

d. A double helix made up of sugar, phosphate and nitrogenous bases

B. Answer the following questions in the spaces provided.

1. Explain why the results of an experiment cannot prove a hypothesis to be true.

The results of an experiment cannot prove a hypothesis to be true because the results must show conclusive every time. One experiment can be the same as your hypothesis, but someone else might get different results which contradict that same hypothesis. One simple contradictory results/experiment can however, prove a hypothesis wrong because in order for the hypothesis to be correct it must be true every time. That's why scientists have developed theories and laws as ways of saying that the hypothesis has been supported by the results from many experiments.

2. State two modern examples of observed evolution.

Humans – Became bipedal after living in the trees with ancestors. Allowed them to walk around now as modern day man.
Convergent – Similar structure in terms of appearance and similar function but different bone structure. E.g. a frog's jumping legs compared to a kangaroo's similar function but did not evolve from same ancestors; completely different structure inside.
Divergent – Alligator's forelimbs and human's forelimbs. Same structure, but used for different purposes suggests a common ancestor. Alligator uses for main movement where humans use it for dexterity and lifting items.

3. Hair colour in mice is controlled by a gene with two alleles. A homozygous black-haired mouse was bred with a homozygous brown-haired mouse. All of the offspring were black-haired.

a. Which is the dominant hair colour in mice?

Black

	B	B
b	B b	B b
b	B b	B b

B=Black

b=Brown

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b. One of the heterozygous black-haired offspring was bred with a homozygous brown-haired mouse. Draw a Punnet square to show the outcome of this cross.

Genotypic ratio: 2 : 2 = 1 : 1 ⟶ B b : b b
Phenotypic ratio: 2 black haired : 2 brown haired = 1 black : 1 brown

	B	b
b	B b	bb
b	B b	bb

c. State the phenotypic ratio of the above offspring.

1 : 1 = 1 black : 1 brown

4. A tomato grower has heard that global warming is good for his tomatoes.

a. Include a clear hypothesis.

If the CO_2 production increases and global warming increases, then my tomatoes will grow larger and more plentiful (larger yield).

b. Identify the following.

i. Independent variable

The independent variable is the amount of CO_2 increase/ amount of global warming increase (temperature).

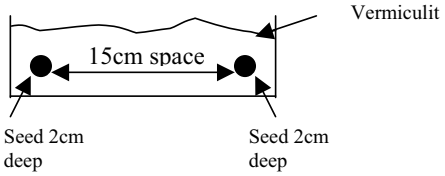
ii. Dependent variable

The status of his tomatoes; the growth, (how large?) and how many there are (yield).

c. Develop an experiment to test this idea.

Materials:
1. 2 fish aquariums container (no water)
2. Cling film
3. (10m, 5 each) Calcium Hydroxide (Hydrochloric Acid that increases amount of CO_2 produced)
4. 2 air tubes (for air into aquarium)
5. (4) Tomato seeds
6. (50g, each) Marble chips and Vermiculite
7. 200ml water each
8. 2 conical flasks

Procedure:
1. Set up the two aquariums side by side in direct sunlight.
2. Spread 50g Vermiculite over the bottom of each aquarium and plant the tomato seeds (2 each) 2cm deep and 15cm apart. Add 200ml of water to each container.



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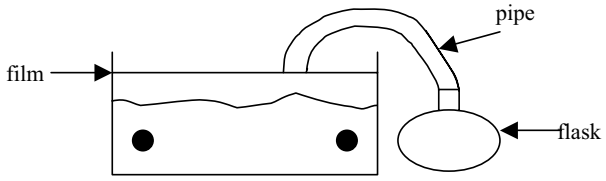
3. Tightly wrap cling film over the top of both aquariums and then cut a hole large enough in the top of each to fit the air pipe. Insert the one end of the pipe to each aquarium.



4. Mix 5ml of hydrochloric acid and 20 grams of marble chips in one flask. Attach to other end of air pipe. Allow CO_2 gas to enter container.
5. Attach the empty flask to the second aquarium—this is the control.
6. Watch and record regularly for 2-3 weeks.

More decisions for the tomato grower.

"The first genetically engineered tomato went on the market last May when the Food and Drug Administration approved a tomato that can be shipped vine-ripened without rotting rapidly. The Flavr-Savr tomato is the first ready-to-eat food product available to the public that uses recombinant DNA processes."

5. What would you advise the tomato grower to do? Identify the advantages and disadvantages of the genetically engineered tomato that should be considered by the tomato grower.

I would advise the tomato grower to 'go for it', but I would also first warn him of the risks. This seems like a miracle to the grower because companies that sell produce will buy his tomatoes in bulk since they last longer and consumers will buy those types of products. This obviously brings in a profit for the company and the grower retains a steady salary that will allow him to live and send children to school. However, these tomatoes may also destroy his land faster or require more resources to grow e.g. H_2O. this could be a problem as water is at a worldwide shortage. Plus, if the farmer is local, the companies from which he'd obtain the seed would not let him keep it for the next year. Companies such as Monsonto actually track this and check up on farmers with DNA fingerprinting. Therefore, the farmer would have to re-but seed from the company each year which might cost more than his income. Plus, with genetically engineered foods, the flavour is not retained as well because the energy is spent on preservation. Overall, money is a motivator and I'd tell the farmer to try it because it could establish good crops that last and give him a steady wage and reputation throughout the year. People will buy the food if it looks good and lasts long because society is fast moving these days, and sometimes you just can't eat everything you buy at once.

6. Describe the evidence that fossils provide.

Fossils provide evidence for evolution. In hard part fossils, where the bones leave impressions, we can see the changes in structure of animals back then to present day animals. From this, people can conclude what type of speciation occurred and what the

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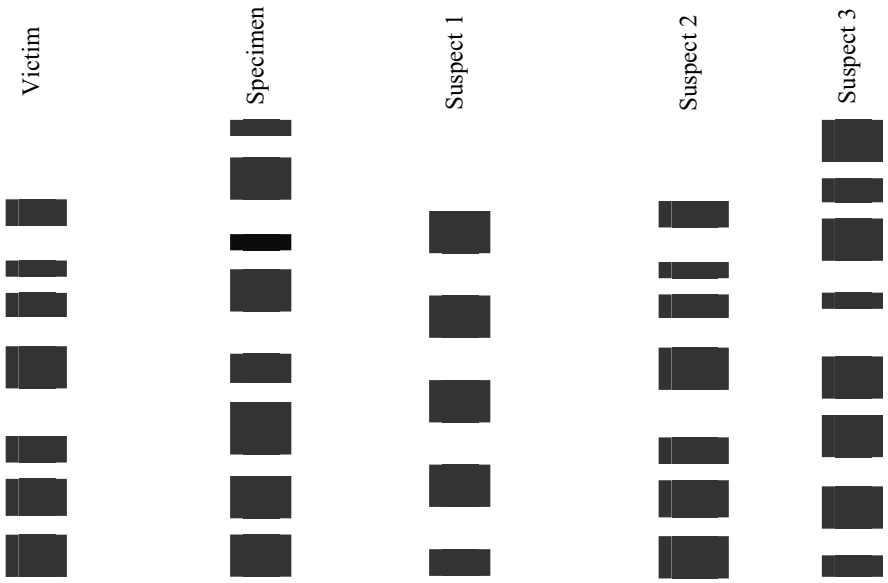
land may have been like back then. Plus, fossils can also provide an idea of what the landscape/climate was like because of the carbon dating – how old and thus how long ago it was underground (layers of earth built up; bogs and glaciers) and various other fossils of trees e.g. petrified forest in Egypt that may suggest a forest or jungle. Historians and scientists can also conclude from fossils, about how long ago the species was living through carbon/uranium dating, this provides an idea of our own history.

7. There has been a murder in your town. You are the detective and you have asked for a DNA fingerprint analysis of the scene of the murder (represented below).



a. According to you, who is the murderer?

Suspect 2.

b. Explain why using the evidence of the DNA fingerprint analysis.

The evidence is based on genetic technology, DNA fingerprinting to be exact. The investigators take the DNA samples and put them through a process where the various proteins/bases are highlighted and can be seen. Then, they compare the bands of the fingerprints and see how many bands match between the strip the restriction enzymes cut. To match these must be the same length bands, and in the above fingerprint suspect 2 matches perfectly.

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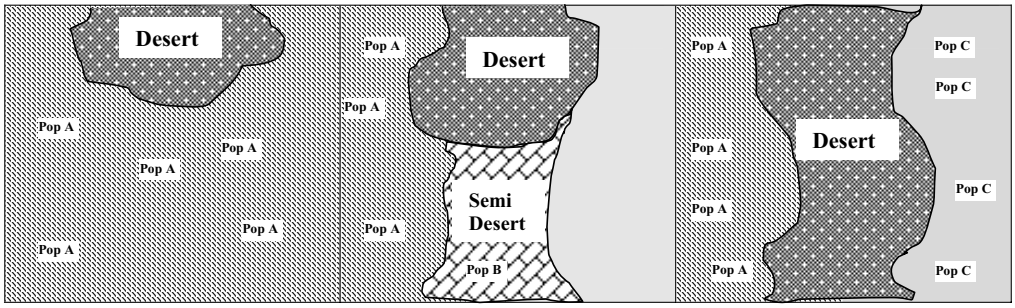
8. One important factor in speciation is geographic isolation. Use the drawing below to explain how new species arise.



Drawing 1 **Drawing 2** **Drawing 3**

a. In drawing 1, only one species of prairie dog inhabits the land around the desert. Explain the reason for this in terms of natural selection.

Only one species of prairie dog needs to inhabit the land around the desert, because there have been no geographical barriers that have forced the prairie dogs to adapt. Without this, the population can grow and only leaving those with favourable characteristics to pass on genes, they all get to pass on genes.

b. In drawing 2, the climate has changed. There are now three kinds of environments. How does this affect the population of prairie dogs in these areas?

The prairie dog population has many variations as it is. With this new environment, the individuals with traits favourable to semi desert survive and non-desert (grassland) environment. The structures of each population change so they become better suited to the environment they are forced to live in.

c. In drawing 3, the desert has spread. Now the desert has separated the population A from the population C. What happens to populations A and C?

PopA and PopB can no longer interbreed, they are geographically isolated. Thus, these populations reproduce within themselves and form a new species that is better adapted to their environment. Each population continues to grow in divergent evolution with each species in a different environment.

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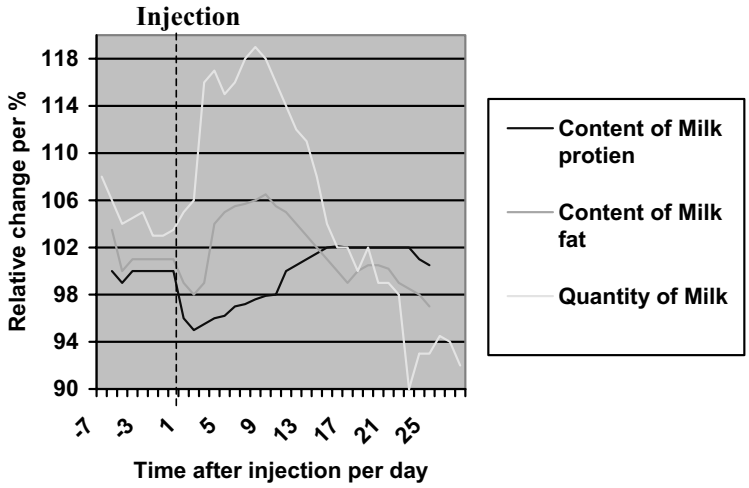
9. Growth hormones are used in livestock production. Cows received an injection of growth hormone. Scientists measured the relative change in milk quantity, milk fat content and milk protein content. The results are shown in the graph below.



a. From the information given in the graph, identify three effects of growth hormone injections on milk production in this experiment.

- For a period of around 6 days the milk quantity was increased, but then began to decrease as the hormone stopped being effective. More or less constant except for a drop at day 5. Up by approx. 15%
- The milk fat content in the production also increases by approx. 9% at first rapidly but then a slower, more stable increase. Finally the hormone wore off and the content reduced.
- The milk protein content decreased throughout the effect of the hormone, then increased to normal levels. Decrease of approx. 5%.

b. Calculate the percentage change in milk fat content from day 2 to day 9.

Day 2: 98% Day 9 ≈ 107% ∴ ≈ 1.2857 per day↑.

Percentage change ≈ 9%.

c. Deduce how long the effect of the growth hormone injection lasts in cattle.

The effect probably is only good for 9 days, because then the effects begin to wear off and levels return to somewhat normal.

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Example 2: Ecology test

Test—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	6	-	-	-

Background

Students were assessed on their understanding of the main ideas of ecology and how populations, communities and ecosystems interact with each other and the environment. Students were familiar with basic ecological terminology and were able to solve simple problems about ecosystems and populations.

The test included a range of questions of different levels of complexity, from simple recall and application questions to more complex questions that required students to interpret and analyse information from graphs and diagrams (see questions 6, 7 and 8). Question 4 was labelled as unfamiliar because no discussion about succession or drainage had taken place in the class and students were expected to apply their understanding to evaluate a new situation. Question 5 required students to analyse and evaluate a situation by making scientifically supported arguments. The topic of vegetarianism had not been discussed in class; therefore, this question was presented as an unfamiliar situation.

The test was assessed using criterion C.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
5–6	The student explains scientific ideas and concepts and applies scientific understanding to solve **problems in familiar and unfamiliar situations**. The student **analyses** and **evaluates** scientific information by making **scientifically supported judgments** about the information, the validity of the ideas or the quality of the work.

This work achieved level 6 because the student:

- demonstrates an understanding of ecology and ecosystems and applies this to solve problems in familiar situations (questions 1, 2 and 3)
- solves problems in unfamiliar situations (questions 4 and 5)
- analyses information by identifying relationships and causes, and provides an explanation of his/her understanding (questions 6, 7 and 8)
- evaluates information and presents opinions by making scientifically supported arguments (question 4).

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Student work

Ecology test

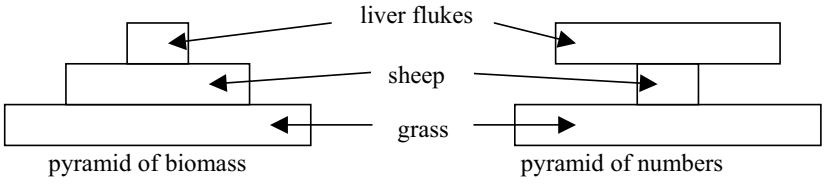
1. Use the following terms in a paragraph set in a prairie or jungle ecosystem (you may choose but state your choice.) Use each term in a way that makes its meaning clear and that ties to the ecosystem you have chosen.
Terms: ecology, trophic level, producer, consumer, top carnivore, decomposer, community, population, habitat.

When studying ecology, you might learn about a prairie ecosystem. The community include many different populations, such as the lion population, gesell population and so on. The biggest producer is the grass, which feeds the next trophic level of the gesells. The gesell is the primary consumer and the top carnivore, the lion, which eats the gesell is the secondary consumer. All the animals, after they have eaten have to get rid of what the body doesn't want and this is decomposed and used as energy for the grass again. And so the food chain continues.

2. For each pair of terms: define, compare (say what they have in common) and contrast (say how they are different).

a) Pyramid of numbers/pyramid of biomass

- A pyramid of numbers is a food pyramid where the blocks are drawn in proportion to represent the number of each specie.
- A pyramid of biomass is a food chain pyramid where the different blocks are drawn in proportion to represent the biomass (mass x number of individuals) of each specie.
- What they have in common is that they both represent a food chain and can be used to show the relationship in the food chain.
- They are different because the pyramid of numbers shows the number of individuals and the pyramid of biomass shows the mass of all the individuals together.



b) Density-dependent and density-independent limiting factors (give two examples of each)

- Density dependent limiting factors are factors limiting a populations growth because of the density. The density dependent limiting factors are caused by the density, e.g. food shortage or disease.
- Density independent limiting factors are limiting factors not affected by the density of the population, e.g. disaster or climate/seasonality or human intervention
- They are alike because they both limit the growth of a population, but they are different because one is caused by density in population and the other is not.

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c) Limiting factor/environmental resistance

- Limiting factor is a certain thing limiting the growth of a population.
- Environmental resistance is the resistance the population faces when it reproduces and wants to grow.
- Environmental resistance is a broader term than limiting factor, limiting factor is included in environmental resistance.

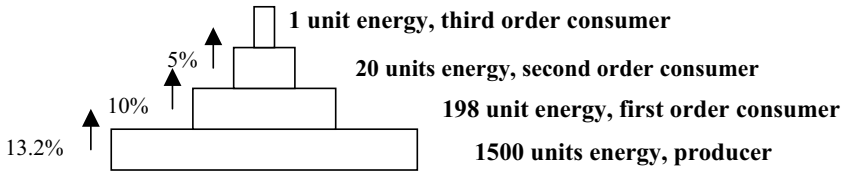
d) Biotic potential/carrying capacity

- Biotic potential is the highest possible potential a population has to grow and develop. The biotic potential is the highest possible number of individuals the population can handle to get.
- The carrying capacity is the limit the environment puts on the population growth. The carrying capacity is much like the biotic potential, when they both are reached then the population doesn't grow anymore.

e) Abiotic factor/biotic factor (give three examples of each)

- Abiotic factor is a factor having to do with the non-living environment, e.g. the sun, the water and rocks.
- The biotic factor is all living organisms, such as trees, birds and fish.
- They are alike in the way that they both have to do with the environment and they describe it. They are different in the way that they are total opposites.

3. a) Define energy conversion efficiency and calculate it for the pyramid shown.



Energy conversion efficiency is how efficient the energy is being used, how much of the energy is used.

b) Briefly describe the efficiency as one moves up the food chain.

The efficiency decreases as one moves up the food chain.

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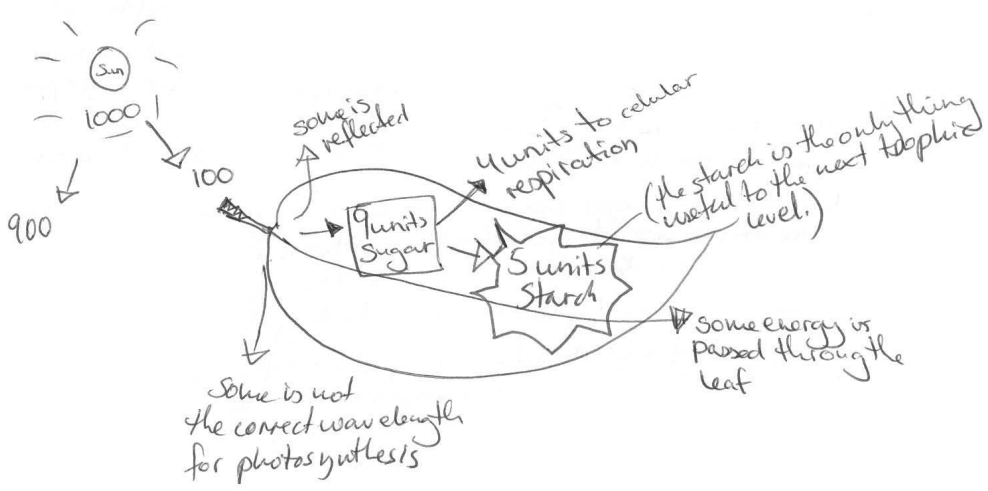
c) Show (using a labelled diagram) what happens to the energy in sunlight that strikes a plant leaf. Assume 100 units of energy strikes the leaf. Give several reasons to account for the energy that is "lost" during this event.



d) Suppose the leaf you have just discussed is eaten by a cow. What proportion of the sun's energy striking the leaf is getting into the cow's tissues? Show your reasoning.

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4. At the peat bog in Kemeri National Park in Latvia, park workers are blocking the natural drainage channels of the bog.

a) Give a reason for this practice.

This is so the bog doesn't dry out and the wetland is therefore preserved.

b) What changes to the biotic and abiotic environment would occur in the area over the next 100 years if this practice were not done?

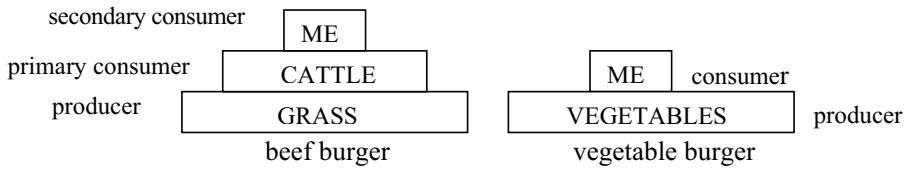
If this practice were not done, the bog would after 100 years probably have turned into a forest. The abiotic environment would have changed completely, as the water disappears and the bog would dry out. This would have great effects on the biotic life of the bog, as all the living conditions would change. For example, the small pine trees would get ideal conditions (regarding acidity etc) and would be as high as the pines of the forest. Then the small plants wouldn't get enough sunlight and they would eventually disappear. Also, migrating birds would not land there any more and the wolf family wouldn't go there to rest. Basically, everything would change totally.

c) Which AOI best applies to this practice? Explain your choice.

The AOI community and service would apply best to the drainage practice, because the park workers are saving the environment of the peat bog from dying out and turning into a forest. They serve the community of the bog.

5. You are faced with having to choose between a beefburger and a vegetable burger.

a) Sketch the probable pyramid of energy for each with you at the top. Label the trophic levels.



b) Which is more likely to be more expensive? Why? Justify your reasoning by using scientifically supported arguments.

The beef burger is likely to be more expensive, because the cattle needs to be fed with large amounts of grass and other vegetable produce. The feeding process of the cattle is more expensive and takes more time and it costs a lot for the farmer. The vegetables only need water and sunlight and that doesn't require as much work as with cattle. The vegetables don't need to be looked after as much as the cattle needs, and therefore the beef burger is likely to be more expensive.

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c) Which is likely to be more energy efficient?

The vegetable burger is likely to be more energy efficient. As energy is lost at each level of the pyramid only a 10% of the energy received by the plants will be available for the cattle to grow. For example a 100 kg of grass will be needed to grow 1 kg of cattle. So in terms of energy the vegetable burger is more efficient than the cattle.

d) Which is likely to be more environmentally friendly?

I think that the vegetable burger is more environmentally friendly. It takes a larger amount of land to provide the energy for cattle or sheep to grow. If the same amount of land is used then more plants (wheat, soy, grains, etc.) can be grown and therefore a more people can be fed with vegetable burgers or other vegetable and grain products. Growing plants, cereals and grains is a friendly way of looking after the environment than using the same land for grassing cattle as I explained in b. Looking after cattle is more expensive as well!

6. The following figures show the concentration of mercury in seawater and in various organisms in a particular area. The measurements are in parts per million (ppm).

Seawater	**0.00003**
Algae	**0.003**
Fish	**0.3**
Water birds	**2.0**

a) How many more times concentrated is the mercury in the fish than in seawater?

10,000 more times concentrated

b) What is this problem called?

Biomagnification

c) Describe the key ideas behind this problem using another example.

DDT is a pesticide which doesn't break down inside a body. The plants sprayed with DDT are eaten by a herbivore and now the herbivore has a higher concentration of DDT in its body than the plant, because the herbivore doesn't only eat one plant. The herbivore is eaten by a carnivore and the carnivore doesn't only eat one individual, it needs many more, so the concentration of DDT in the body of the carnivore is high. And when another type of carnivore eats some of the carnivore from the lower trophic level, it gets an even higher concentration of DDT. The concentration of an element that doesn't break down (like DDT) increases exponentially through the trophic levels. The Peregrine falcon was affected by this since they are on top of a long food chain and their egg shells didn't get hard enough, so birth rate decreased.

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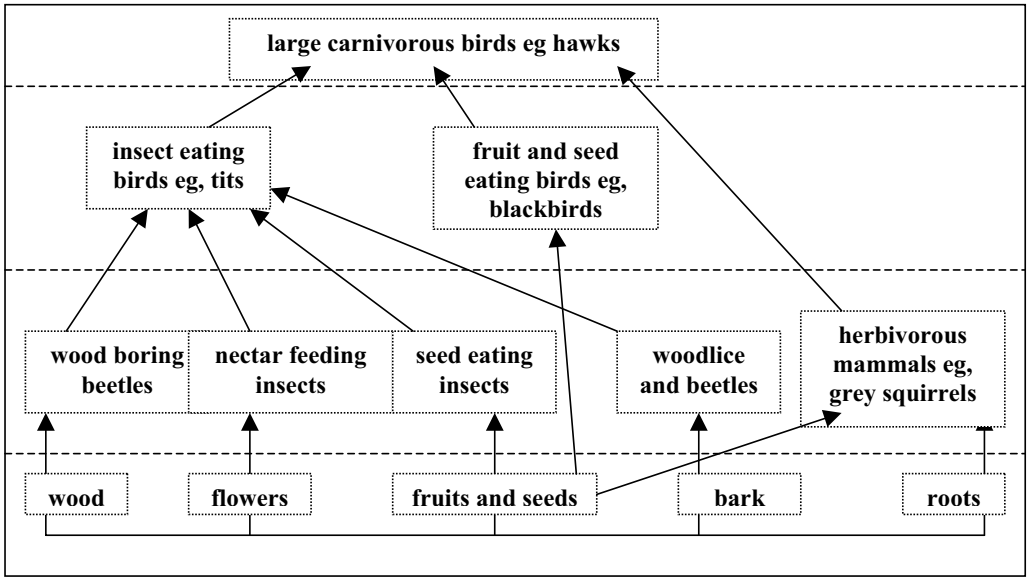
d) Plant plankton in the sea make vitamin D and store it in their tissues. Fish store vitamin D in their livers, which is why cod liver oil is such a good source of vitamin D. What characteristics of vitamin D can you deduce from this information?

Characteristics of vitamin D that can be deduced from this information is that its not broken down by the body, it is stored. Vitamin D doesn't break down that is why one shouldn't eat too much of it. It's not water soluble like vitamin C.

7. Study the food web shown and then answer the questions.

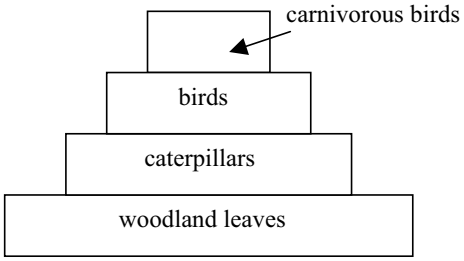


(dotted lines ------ indicate trophic levels)

a) Give one example of a predator in the food web, and write down the name of the animal upon which it preys.

Hawks eat tits.

b) The food web does not include the leaves of woodland plants. Write down a food chain that might lead from the leaves.



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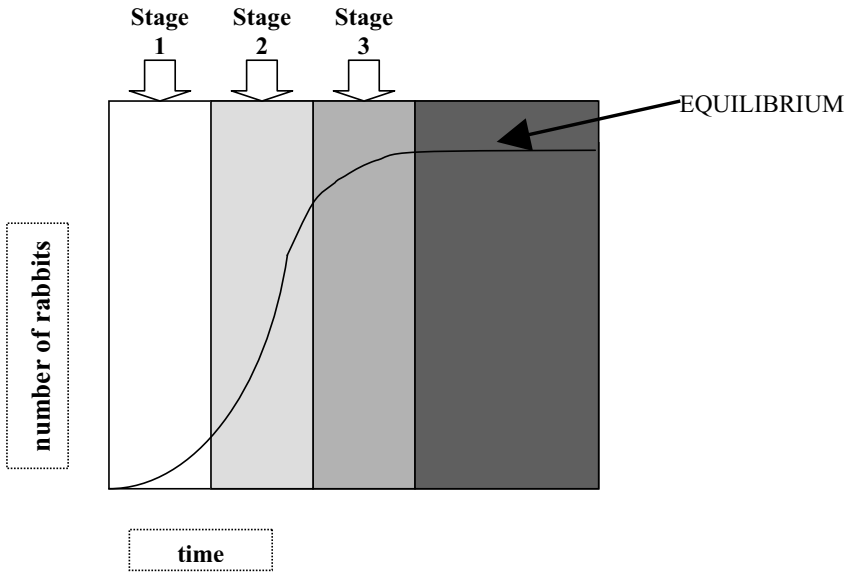
c) A chemical substance, poisonous to animals but not to plants leaks onto the ground in the wood. Explain how this might affect the food web.

First, the insects would decline greatly in number and also all the other animals because of the chemical substance. The insect eating birds wouldn't get enough to eat and none of the other animals would either, as many would die from poisoning and those that didn't would die from lack of food. Second, when all the animals eating the plants dies, then the plants would rapidly increase in number and there would be flowers and plants everywhere, because they would be left alone.

d) What might happen to the wood eventually if all the foxes were destroyed? Explain your answer.

If the foxes were destroyed, then at first the number of herbivorous mammals would increase, because now only the large carnivorous birds would feed on them and because of the increase in the numbers of herbivorous mammals, they would eat more of fruits, seeds and roots and affect the amount of that. If they ate a lot of the fruits and seeds, then the seed eating insects and the seed eating birds would probably get less food, because of increased competition and the populations might decline in numbers.

8. The graph shows how the population of rabbits may grow.



a) Explain the changes in the population growth in stages 1, 2 and 3. Give specific reasons for the changing shape of the graph in each section.

Stage 1 is the beginning of the growth of the population and the rabbits seek mates etc.
Stage 2 is the exponential growth where the rabbits all reproduce and eat and thrive.
Stage 3 is when the rabbit population has reached the carrying capacity and has almost reached equilibrium and no longer grows.

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b) Define equilibrium and label it on the graph.

Equilibrium is when death rate = birth rate.

c) Describe two possible situations that would allow the carrying capacity of the environment to rise.

A possible situation might be that an animal above them on the food chain has declined in numbers due to a problem they face and then less rabbits would become preys.
Another possible situation is that the climate has changed to the better and there is more grass to eat and than they thrive and reproduce more.

9. a) What is the chemical equation for photosynthesis and state its ultimate purpose.

$6H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$
It produces starch.

b) What is the chemical equation for cellular respiration and state its ultimate purpose.

$6O_2 + C_6H_{12}O_6 \longrightarrow 6H_2O + 6CO_2$
It takes starch and produces carbon and water for the animals to use in its own body.

c) Using carbon as an example, show how it cycles in nature (in words or with labelled diagrams).

Carbon cycles around through the photosynthesis and the cellular respiration. Photosynthesis and cellular respiration are opposites, they continue to cycle the carbon around in nature.

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Example 3: Carbon chemistry test

Test—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	4	-	-	-

Background

Students were assessed on their knowledge and understanding of carbon chemistry. The test consisted of seven questions that presented students with simple and familiar problems as well as complex and unfamiliar problems. Question 6 introduced a new concept of bond breaking and making, and was included to test students' ability to deal with an unfamiliar situation. In the teaching of this topic, the terms "exothermic" and "endothermic" had only been used to describe energy changes in reactions, but no explanation on the particle level had been given. In question 7 students were asked to evaluate different hypotheses by making scientifically supported judgments when selecting the evidence provided.

The test was assessed using criterion C and was designed to allow students to reach the highest level of this criterion.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
3–4	The student **explains** scientific ideas and concepts and applies scientific understanding to solve **problems in familiar situations**. The student **analyses** scientific information by identifying parts, relationships or causes. The student provides an **explanation** that shows understanding.

This work achieved level 4 because the student:

- applies and uses scientific ideas and concepts to solve problems in familiar situations
- analyses information and provides explanations that show understanding; however, he/she struggles to solve problems in unfamiliar situations (like that in question 6c) and when evaluating scientific evidence in question 7.

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Student work

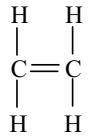
Reminder: The elements appearing in bold were given by the teacher; the non bold are the student's answer

Carbon chemistry test

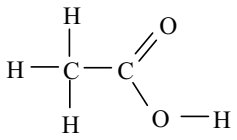
Answer all questions by writing in the spaces provided.

1. Draw the structure of the following compounds: ethene, propanol and methanoic acid.

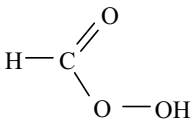
Ethene: C_nH_{2n}



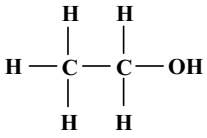
Propanol: $C_nH_{2n+1}OH$



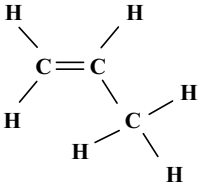
Methanoic acid: $C_nH_{2n+1}COOH$



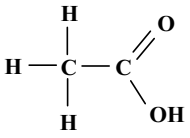
2. Look at the structures below and answer the questions that follow.



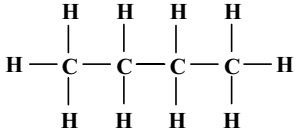
A



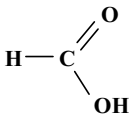
B



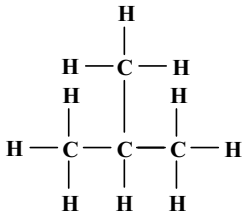
C



D



E



F

a. Give one example of an alkane. D

b. Which substance is ethanoic acid? E

c. Which two substances are in the same homologous series? D and F

d. Which two substances react together to make an ester? E and C

e. Which substance can be polymerised? B

3. This question is about propane and propene.

a. In what way are propane and propene similar? They both have 3 carbons.

b. In what way are the structures of propane and propene different? Propene is composed of a double bond and propane single bonds.

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c. Which of the two substances will decolourise bromine water? Explain your answer.
Propene because it has a double bond.

d. Propane can be liquefied to make LPG, which is used as a fuel. The table below compares LPG with other fuels.

Name of fuel	Heat produced		Relative cost per KJ
	KJ/g	KJ/cm^3	
Natural gas (CH_4)	56	0.001	1.4
LPG	50	30	2.0
Oil	48	35	1.8
Coal	34	76	1.6

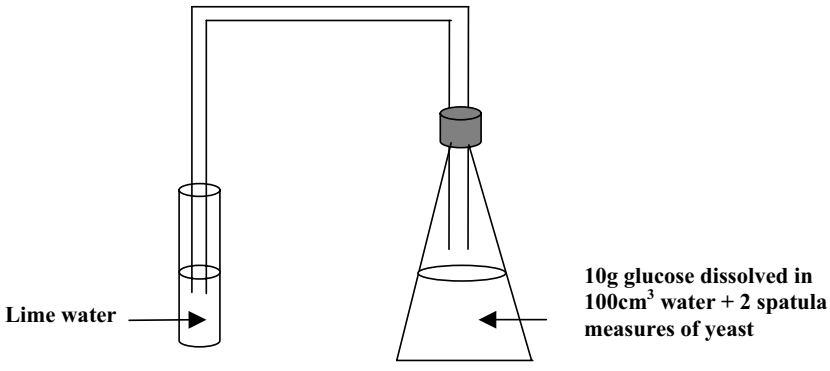
i. Make a bar chart to show the heat produced per gram of each fuel. (See chart)

ii. Suggest a reason why CH_4 has a much lower value for the heat produced in KJ/cm^3.
Because it is a very light fuel. But it needs a lot of it to produce heat.

iii. Which fuel is the best value for money? Explain your answer.
Coal is the 2nd cheapest on the table however it produces much more kj with less of it.

iv. Write a balanced equation for the complete combustion of propane.
$2C_3H_8 + O_2 \rightarrow C_5H_{16} + CO_2$

4. The diagram below shows the apparatus needed for the fermentation of glucose.



a. Write the equation for the fermentation process.
$C_6H_{12}O_6 \rightarrow 2C_2 + H_5 + OH + CO_2$

b. What will the limewater look like? Explain your answer.
It will turn foggy white and milky. This tests the presence of CO_2.

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c. Let's imagine we are doing the same experiment but that we are changing the temperatures: one experiment will be carried out at 10°C and the other one at 60°C. What difference(s) will you notice? Explain your answer.

With 60°C, the difference noticed is less reaction. Because enzymes start to die at this temperature.

5. Cars run by burning petrol. Petrol is mainly octane—an alkane with eight carbon atoms per molecule.

a. Write the formula of octane. C_8H_{18}

b. What might happen if a car engine is run in an enclosed space? Suggest why this might be dangerous.

Car engine gives out carbon monoxide. This gas is very dangerous if you inhail it and if this gas gets very concentrated you can die.

c. Some car engines are fitted with a "choke". When the choke is pulled out, the air supply to the engine is reduced. This makes the engine easier to start, but it often makes the exhaust gases black or smoky.

i. What do you think that the black smoke is?

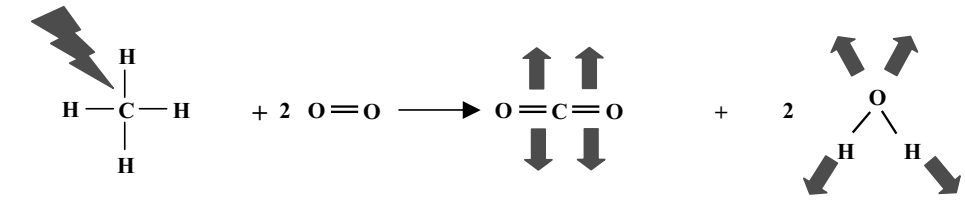
It is more carbon and less oxygen.

ii. Explain why the black smoke forms when the choke is pulled out.

Because there is les oxygen going in then the reaction made has more carbon this then comes out as burnt carbon which is the black smoke. Instead of being a complete combustion it becomes an incomplete combustion.

6. We use methane as a domestic fuel. The complete combustion of methane is, overall, an exothermic reaction. During the reaction, bonds in the reactants are broken and new bonds in the products are made.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$



Breaking bonds needs energy and is endothermic.

Making new bonds gives out energy and is exothermic.

In the reaction, the energy change for bond breaking and making is not in balance.

a. What does "exothermic" mean?

Exothermic is a reaction which produces heat.

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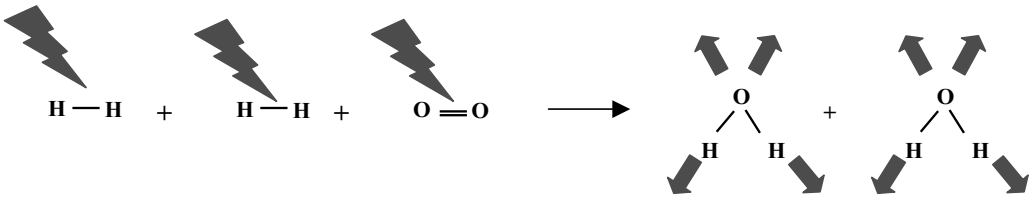
b. Complete the following sentence: "In an overall exothermic reaction,…energy is released in making bonds than is needed for…bonds."

In an overall exothermic reaction, more energy is released in making bonds than is needed for separating bonds.

c. Look at the diagram above and complete the table below. The first box has been done for you.

Bonds broken	Bonds made
Between C and H in methane	$CH_4 + H_2O$

d. Hydrogen can also be used as a fuel because it reacts exothermically with oxygen, for example:



Breaking bonds uses energy.

Making bonds gives out energy.

i. Draw a similar table to that in question c above to show the bonds broken and made during the reaction.

$2H_2O$

ii. Use the table to explain why the reaction is overall exothermic.

The reaction is exothermic because it needs energy to separate and join the bonds, this reaction gives out heat meaning that it is an exothermic reaction.

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7. This question is about different hypotheses that have been proposed to explain where oil, coal and gas come from.

The following facts about oil and coal are known to be true.

1. **Coal is impure carbon. It contains some hydrocarbon compounds. Fossils in coal indicate it came from trees and that it is millions of years old.**
2. **Hydrocarbons have been found in some meteorites that come from outer space.**
3. **Oil reserves under the Earth's crust are running out rapidly.**
4. **Most oil is found near the boundaries between the plates of the Earth's crust.**
5. **Helium and mercury are quite rare in the Earth's crust, but they are found in quite large amounts along with oil and gas. It is believed that they travelled through the Earth's crust along with methane.**
6. **Oil has been found up to 6km below the Earth's crust in granite rock.**
7. **Sometimes, we find one oil reservoir directly beneath another one.**
8. **The Middle East contains by far the largest proportion of the world's oil reserves. This does not seem to match the amount of plant and animal life that could have lived there.**
9. **When volcanoes erupt, large amounts of carbon dioxide are released. This could come from combustion of fossil fuels.**

Scientists have looked at these facts and have come up with three different hypotheses to explain them.

A: Oilius Productus Hypothesis

Doctor Trebor Eel believes that a plant once thrived both in desert regions and at great depths in the oceans. These plants, called Oilius productus had roots that buried deep into the ground, often through gaps in the Earth's crust. The roots released oil, which was absorbed by some rocks. None of these plants are known to exist today, although they could exist in unexplored parts of the rainforests.

B: Creation Hypothesis

Dr Thomas Gold believes that hydrocarbons were trapped deep within the Earth when the planet was first formed. He believes that they have been there for billions of years (before plants or animals existed) and are preserved by the high pressures close to the centre of the Earth. If the hydrocarbons escape, he says, they start to break down to make methane.

C: Kerogen Hypothesis

Plants and animals die and their remains collect at the bottom of seas, rivers and lakes. They are buried by sediment and compressed over millions of years, converting the remains into a hydrocarbon sludge called kerogen. This is particularly likely where a river empties into a sea basin. High temperatures and pressures gradually change the kerogen into different hydrocarbon molecules and force it into areas where the rock can trap it and prevent it moving further.

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a. Write one piece of factual evidence from the list to support each hypothesis. Write each one in the table below.

Hypothesis	Supporting evidence
A: Oilius productus	3
B: Creation	6
C: Kerogen	1

b. Which hypothesis do you think is least likely to be true? Explain your answer by stating the facts which are evidence against the hypothesis. Suggest your own reasons for disbelieving the hypothesis.

I think that oilius hypothesis is the most unbelievable because mainly oil is found in the plate boundaries then this doesn't make sense because then the plants would only live on the plate boundaries.

c. Which hypothesis do you think is best? Give your reasons in about four sentences.

I think that kerogen is the best because it all makes sense. The plants and animals turned to fossils and with time it created layers. This pressure made the oil. It is possible to find deep down in the earth's crust because of lots of layers.

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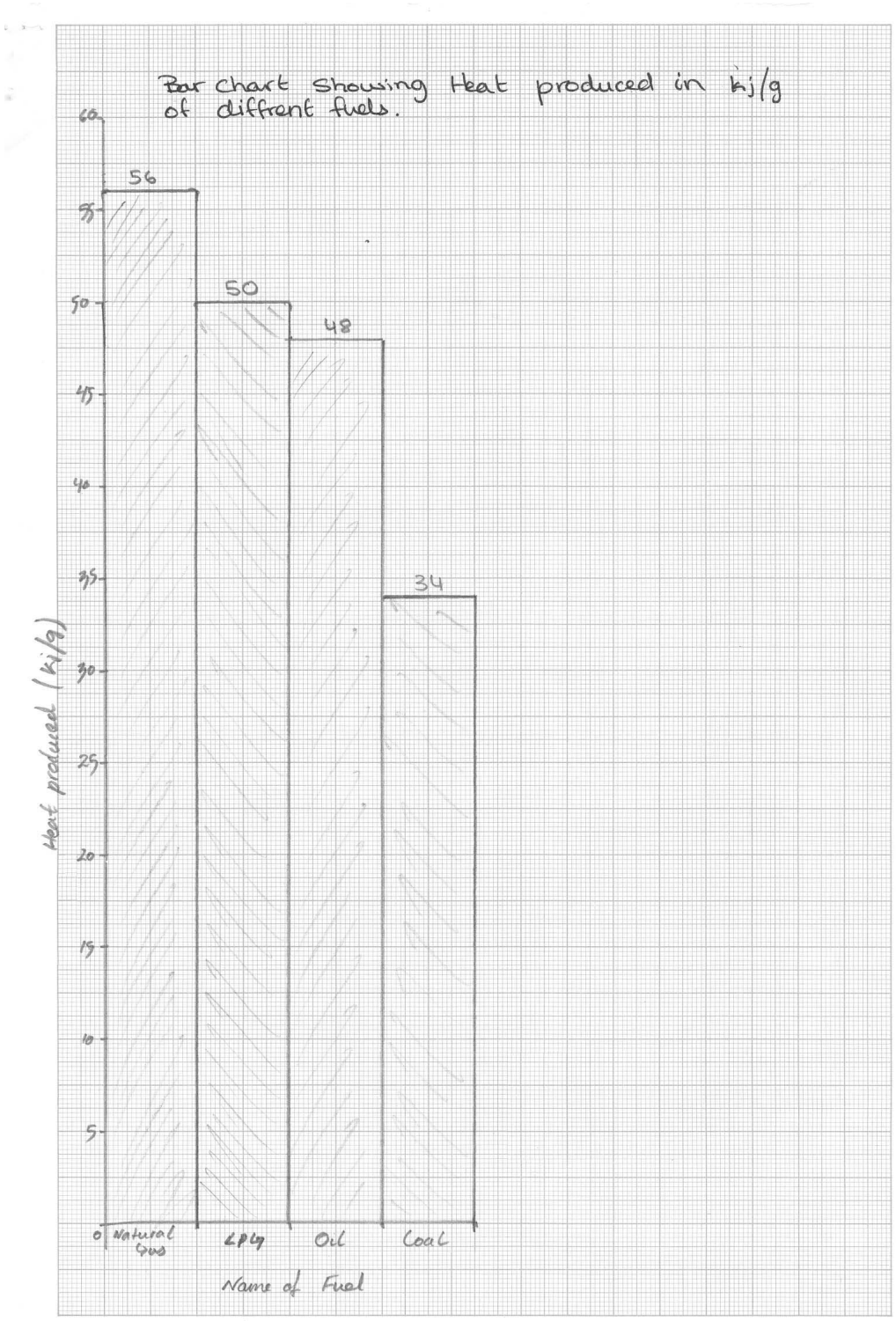

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Example 4: Organic chemistry examination

Test—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	6	6	-	-	-

Background

Students had covered the main topics of organic chemistry and hydrocarbons, including the study of chemical properties of alkanes, alkenes and alkynes. Students were also familiar with the properties of aromatic hydrocarbons and had begun to study spirits. At the end of each topic the teacher used a range of different assessment tasks, including quizzes, interviews and short tests to formatively assess students.

The test represented a summative assessment, which was performed at the end of the semester. It was assessed using criteria B and C.

The test included a range of questions of different levels of complexity, which allowed students to apply their understanding of scientific concepts to more open-ended or unfamiliar situations (see questions 13, 14 and 15). Question 14 asked students to evaluate and justify their answers using scientific knowledge.

The test provided students with familiar and unfamiliar situations, as well as problems where they were asked to evaluate information using scientifically supported arguments.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text. For multiple choice questions, the student´s answer is represented by a circle.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
5–6	The student communicates scientific information **effectively** using **scientific language correctly**. The student presents all the information appropriately using symbolic and/or visual representation accurately according to the task. The student acknowledges sources of information **appropriately**.

This work achieved level 6 because the student:

- uses scientific language correctly when communicating scientific knowledge and understanding
- uses appropriate symbolic representation and chemical notation when writing empirical formulae and molecular structures
- uses correct units of measurements and scales for measuring magnitudes.

For this test the student was not required to acknowledge sources, therefore, this line of the descriptor has been ignored as it is not appropriate here.

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Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
5–6	The student explains scientific ideas and concepts and applies scientific understanding to solve **problems in familiar and unfamiliar situations**. The student **analyses** and **evaluates** scientific information by making **scientifically supported judgments** about the information, the validity of the ideas or the quality of the work.

This work achieved level 6 because the student:

- demonstrates an understanding of the topic and applies it to solve problems in familiar situations
- analyses information, identifying relationships and causes like those in question 13
- uses scientifically supported arguments to justify his/her reasoning and arrive at solutions for problems in unfamiliar situations—examples of this are illustrated in questions 14 and 15.

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Student work

Organic chemistry test

1. The gas that is used for gas fires and Bunsen burners consists mainly of methane. When it is burnt in a Bunsen burner (which gives its supply of air) carbon dioxide and water vapour are formed.

a. Methane is a hydrocarbon. What is a hydrocarbon?

Hydrocarbon is a simple organic chemical compound which consists from carbon (C) and hydrogen (H) only.

b. What is the shape of methane?

The shape is tetrahedral.

c. Why are alkanes like methane and butane used as fuels? Give three reasons.

Alkanes like methane and butane burn well in good supply of Oxygen excriting large amounts of energy. There are gases. Methane is North Sea gas, butane is calor gas. Propane and butane are camping gases.

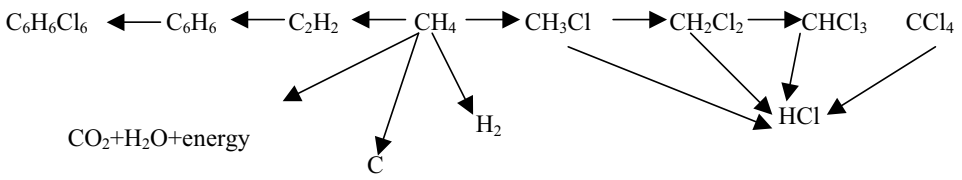
d. Write a balanced equation for the burning of butane in oxygen.

$2C_4H_{10}\,(g) + 13O_2\,(g) \longrightarrow 8CO_2\,(g) + 10H_2O\,(l) + Q$

butane oxygen carbon dioxide water energy

2. It is a well-known fact that one of the most important parts of natural gas is methane. What substances that are used in national economy can be produced from methane, without using any other organic substances?

Present your answer in the form of reactions of methane changing into other substances, describe the use of these substances and write the equations of these reactions.



$CH_4 + 2O_2 \longrightarrow CO_2 + H_2O + \text{energy (fuel)}$

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl \text{ (solvent)}$

$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl \text{ (solvent)}$

$CH_2Cl + Cl_2 \longrightarrow CH_3Cl + HCl \text{ (solvent)}$

$CH_3Cl + Cl_2 \longrightarrow CCl_4 + HCl \text{ (solvent)}$

$CH_4 \xrightarrow{\text{Heat}} C + H_2\uparrow$ (H for hydrogenation)

$CH_4 \xrightarrow[\text{Catal}]{\text{Heat}} C_2H_2 + H_2\uparrow$

$3C_2H_2 \xrightarrow[\text{Catal}]{\text{Heat}} C_6H_6 \text{ (solvent)}$

$C_6H_6 + 3Cl_2 \longrightarrow C_6H_6Cl_6$

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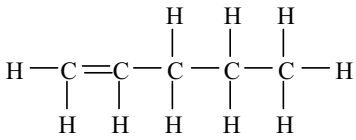
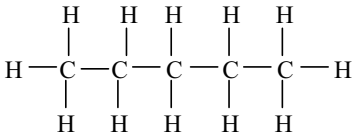
3. Hexadecane is a long chain of hydrocarbon that can be broken down by cracking.

$$C_{16}H_{34} \longrightarrow H_2 + C_5H_{12} + C_5H_{10} + C_6H_{10}$$

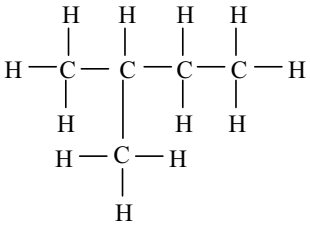
a. i) Draw a structural formula for C_5H_{10}.



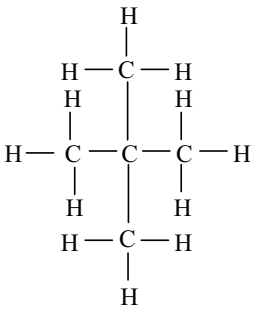
ii) Draw molecular structures for all the isomers of C_5H_{12}.



Pentane



2-methylbutane



2,2-dimethylpropane

b. i) Explain, with the aid of structural formulae, how propene (C_3H_6) reacts with bromine to form 1,2-dibromopropane. What change in colour would you see?

Propene is alkene. It has a double bond and is unsaturated hydrocarbon. As π-bond breaks down, propen undergoes addition reactions. The orange color of bromine becomes colourless. This property is used as test for unsaturation.

$$C_3H_6 + Br_2 \longrightarrow C_3H_6Br_2$$

ii) Explain, with the aid of structural formulae, how propane (C_3H_8) reacts with blank bromine in the presence of UV light to form 1-bromopropane.

Propane is alkene. Saturated hydrocarbon. It undergoes reactions of substitution in the presence of UV light.

$$\underset{\text{propane}}{C_3H_8} + \underset{\text{bromine}}{Br_2} \xrightarrow{UV} \underset{\text{1-brompropane}}{C_3H_7Br} + \underset{\text{hydrobromic acid}}{HBr}$$

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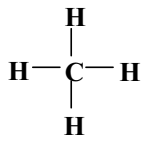
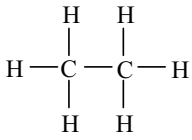
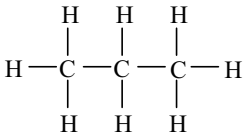
Reminder: the elements appearing in bold in the table below were given by the teacher; the non bold are the student's answer.

4. This question is about a group of compounds called alkanes.

a. Complete Table 1.

Table 1		
Name of alkane	**Formula of alkane**	**Structure**
Methane	**CH_4**	
Ethane	C_2H_6	
Propane	**C_3H_8**	

b. Use the information in Table 2 to complete Graphs 1 and 2.

Table 2		
Number of carbon atoms in alkane molecule	**Relative molecular mass of alkane (Mr)**	**Boiling point of alkane (°C)**
1	**16**	**-160**
2	**30**	**-90**
3	**44**	**?**
4	**58**	**0**
5	**?**	**?**

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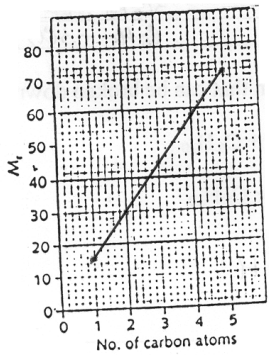
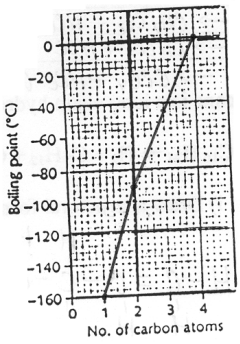
Graph 1



Graph 2



i. **From Graph 1, estimate the relative molecular mass (Mr) of the alkane containing five carbon atoms.**
72

ii. **In the absence of the graph, what information is needed to calculate the relative molecular mass?**
The general formula for alkanes is C_nH_{2n+2} where n is number of carbon atoms. The relative atom mass of carbon and hydrogen is needed.
Mr (C_5H_{12}) = 5Ar(C) + 12Ar(H) = 5X12 + 12X1 = 72

iii. **From Graph 2, estimate the boiling point of an alkane containing three carbon atoms per molecule.**
The boiling point of the alkane with 3 carbon atoms per molecule (propane) is nearly -46°C

iv. **Explain why the boiling point of alkanes increases as the chain gets longer.**
The longer the chain of alkane is, the more molecules are attracted to each other, the more energy is needed to separate them.

5. Determining chemical formulae.

Octane is a member of the alkane family. Its composition is 84.2% carbon and 15.8% hydrogen. Its formula mass is 114. What is its molecular formula?

Given:
W(C)=84.2%
W(H)=15.8%
Ur (octane)=114
Molecular formula?

Solution:
C and H per 100g.
C: 100g X 84.2% = 84.2g of carbon
C: 100g X 15.8% = 15.8g of hydrogen

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$\delta=\frac{m}{n}$; n=nr; nr=Ar; $nr(C)=Ar(C)=12$

$n(C)=12g/mole$; $\delta=\frac{84.2g}{12g/mole}=7.02moles$

$nr(H)=Ar(H)=1$; $n(H)=1g/mole$; $\delta(H)=\frac{15.8g}{1g/mole}=15.8moles$

$$\frac{\frac{7.02moles(C)}{7.02moles}}{\frac{15.8moles(H)}{7.02moles}} = \frac{1}{2.25} = \frac{4}{9}$$

C_4H_9 – empirical formula. $nr(C_4H_9)=4Ar(C) + 9Ar(H)=57$

$\frac{114}{57}=2$, therefore actual formula is 2 X $C_4H_9= C_8H_{18}$

Answer: C_8H_{18}

6. **Polypropene is a polymer.**
   a. **Name the monomer used to make it.** Propene
   b. **Name the type of reaction where many monomer molecules join together to form a polymer.** Polymerization

7. **Some plastics are thermosoftening or thermoplastics. Some are thermosetting plastics or thermosets.**
   a. **What is the difference?**
   Thermosets have cross-linking bounds what makes them dense. They don't melt and don't change their form. At high temperatures they decompose. Thermoplastics have not cross-linking; they are light. They are runny when heated and can easily change their shape.
   b. **Which type of polymer mentioned above would be used for making saucepan handles? Give two reasons for your answer.**
   Thermosets would be used as it can endure high temperatures and don't change their shapes.
   c. **Give one advantage and one disadvantage of using plastics to make bicycle parts.**
   Plastics are light and cheap in comparison with other substances. But if plastics get in nature they can remain for hundreds of years polluting the environment.

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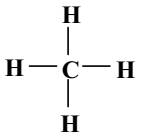
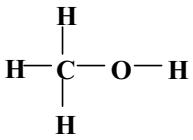
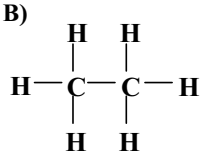
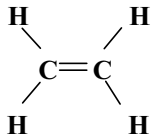
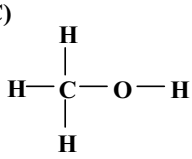
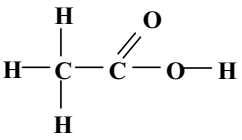
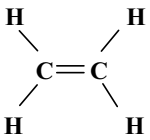
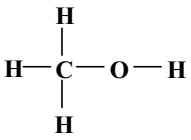
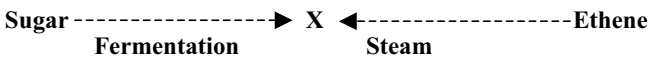
8. Which pair of compounds contains an alkene and alkane? Explain your answer.

A) 		**B)** 	
C) 		**D)** 	

B contains alkane and alkene. Those are ethane (C_2H_6) and ethane (C_2H_4). I made the conclusion basing on their general formulas and on the bonds; alkane's general formula is C_nH_{2n+2}, single δ bonds; alkene's general formula C_nH_{2n}, one double bond.

9. The diagram below shows two ways of obtaining a substance X.



What is X?

a) carbon
b) carbon dioxide
c) ethane
d) ethanol

$C_2H_{12}O_6 \xrightarrow[\text{yeast}]{\text{Enzyme}} 2C_2H_5OH + 2\ CO_2$

Ethanol; $C_2H_4 \xrightarrow[t,p]{\text{Steam}} C_2H_5OH$

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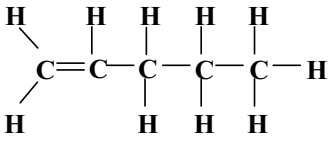
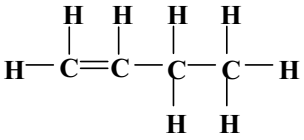
10. For each of the following questions, choose an answer (A–F) from the grid. There may be more than one answer to each question.

A) CH_2CHCH_3	**B)** 	**C)** C_7H_{16}
D) Hexene	**E)** C_5H_{10}	**F)** 

Which box represents:

a. Pentene? B, E

b. Propene? A

c. A molecule that is not unsaturated? C

d. After the fourth alkene? B, E

e. After the fifth alkene? D

11. Which one of the following molecules is produced when ethanol (C_2H_5OH) is dehydrated?

A) CH_4 B) C_2H_6 C) C_2H_4 D) CO_2

Write down the chemical equation.

$$\underset{\text{ethanol}}{C_2H_5OH} \longrightarrow \underset{\text{ethene}}{C_2H_4} + \underset{\text{water}}{H_2O}$$

12. Methylated spirits is a mixture of ethanol (about 90%) and methanol (about 10%), together with a small quantity of purple dye.

Explain why the ethanol is treated in this way before being sold as "meths".

Methanol is very poisonous compound. A very little dose of it can cause blindness if it is drunk. That's why substances that contain methanol are coloured with purple dye to attract people's attention not to drink it. "Meth" means poisonous.

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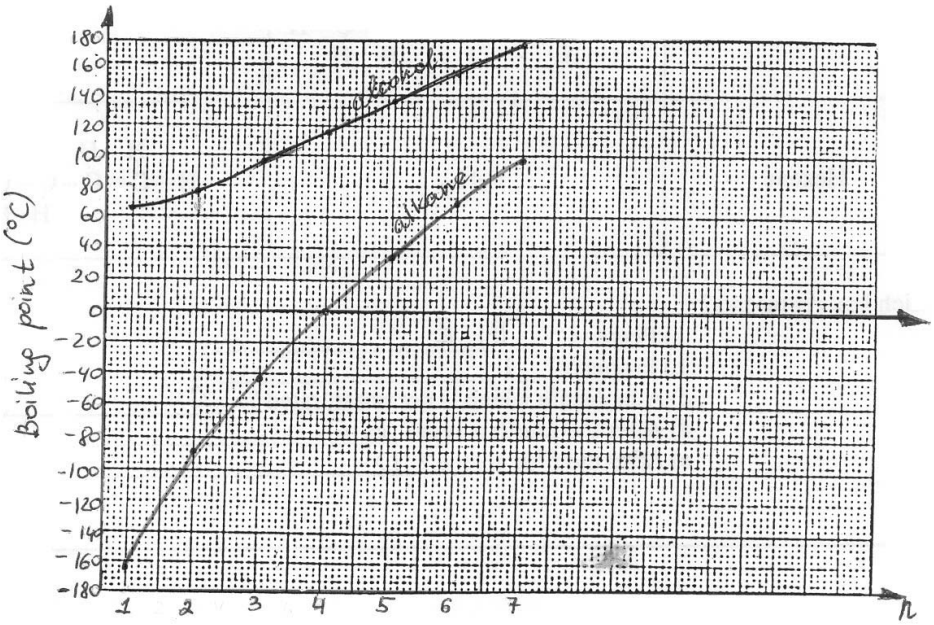
13. Plot a graph of dependence of alkanes and alcohol boiling point on number of carbon atoms (n) in the substance molecule.

Name of alkane C_nH_{2n+2}	Boiling point of alkane (°C)	Name of alcohol $C_nH_{2n+1}OH$	Boiling point of alcohol (°C)
Methane	**-162**	**Methanol**	**65**
Ethane	**-89**	**Ethanol**	**78**
Propane	**-42**	**Propanol**	**97**
Butane	**0**	**Butanol**	**117**
Pentane	**36**	**Pentanol**	**137**
Hexane	**69**	**Hexanol**	**?**
Heptane	**98**	**Heptanol**	**177**



a. Why is the boiling point of alcohol higher than the alkane's one?

The alcohols contain OH group. Oxygen is negatively charged and it has hydrogen bonds with hydrogen atoms of other molecules. Additional energy is needed to break down the bonds, that's why boiling point at alcohol is more, than at alkanes.

b. What is the relationship between the number of carbon atoms in straight-chain alcohols and the boiling point?

The boiling point increase with growth of number of carbon atoms.

c. Use your graph to estimate the boiling point of the alcohol with six carbon atoms.

≈ 156°C

d. Use the information contained in the table above and the in the graph to name alcohols that are gases at a temperature of 100°C.

Methanol (65°C), ethanol (78°C), propanol (97°C)

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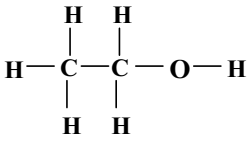
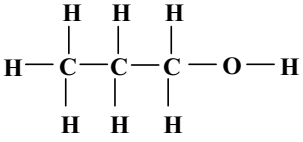
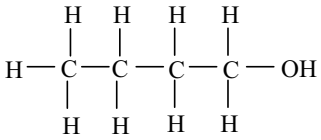
e. The displayed (graphical) formulae of ethanol and propanol are shown below.



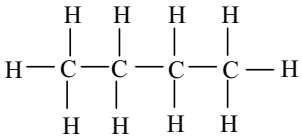


Draw the displayed formulae of three isomers, which have the molecular formula C_4H_9OH.

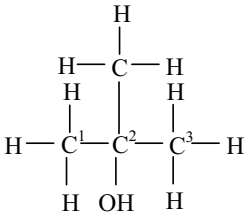
Butanol-1



Butanol-2



2-methylpropanol-2



14. Read the following newspaper article about biofuels and answer the questions that follow.

> ***Hot rod car enthusiasts may soon be screeching into garages and filling up with the latest super petrol– made form the humble potato. Biofuels – produced from potatoes, sugar beet and oil seeds – are to be given a big tax boost by European Community leaders. EC experts say biofuels could mean less pollution from carbon dioxide emissions and a new outlet for the community's agriculture. Bioethanol is produced by fermenting sugar from sugar beet or starch from potatoes and is already propelling a quarter of Brazil's cars. About one million vehicles are running successfully on petrol containing up to 20 per cent bioethanol. If the new fuels take off experts predict a five per cent drop in the use of conventional fossils fuels in ten years, with a consequent reduction in carbon dioxide emissions – the major cause of the greenhouse effect.***
>
> **Express & Star, Saturday 14 March 1992.**

a. i) Explain what is meant by "fossil fuels".

Fossil fuels are organic compounds that are remains of plants and animals who lived millions of years ago. They are coal, oil and gas.

ii) Explain what is meant by the "greenhouse effect".

We call carbon dioxide the greenhouse gas as it composes a blanket around the Earth which allows the heat from the sun get into Earth's atmosphere, but then the heat is unable to leave. This causes worldwide warming.

b. What is released into the atmosphere, other than carbon dioxide, when coal, oil and gas are burnt?

Sulphides, which cause acid rain; nitrogen oxide, which attacks lungs and cause acid rain; ozone, which at ground level cause sore eyes, nose, throat, etc; tiny solid particles, mainly from coal.

c. Ethanol and bioethanol are the same substance. Suggest why the newspaper article uses the term bioethanol.

Bioethanol is ethanol obtained from plants by fermentation.

d. i) Briefly describe how a solution of ethanol can be made in the laboratory from sugar by fermentation.

Glucose can be converted into ethanol with the help of enzyme in yeast a temperature equal to 35°C—40°C. The conversion is called fermentation.

$$\underset{\text{glucose}}{C_6H_{12}0_6} \xrightarrow{\text{enzyme}} \underset{\text{ethanol}}{2C_2H_5OH} + \underset{\text{carbon dioxide}}{2CO_2}$$

ii) Name the method used to obtain almost pure ethanol from this fermented solution.

Fractional distillation.

e. Write the equation for the complete combustion of ethanol when used as a fuel in car engines.

$$\underset{\text{ethanol}}{C_2H_5OH} + \underset{\text{oxygen}}{3O_2} \longrightarrow \underset{\text{carbon dioxide}}{2CO_2} + \underset{\text{water}}{3H_2O}$$

f. Ethanol is widely used as a car fuel in Brazil, but used very little in Britain. Suggest a reason for the difference.

Large plantations of sugar beet are cultivated in Brazil because of the suitable hot climate and necessary amount of water. There is little oil. In comparison with it, the conditions in Britain are the other way round. That's why Britains extract oil and produce petrol, and it's beneficial to produce ethanol by fermentation for Brazilians.

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g. Suggest why using plants to produce biofuels helps to maintain the carbon dioxide/oxygen balance in the atmosphere.

When biofuels burn they excrete carbon dioxide and water. Trees use CO_2 to produce oxygen during photosynthesis in supply of UV.

15. Limiting reagent problems.

Acetylene (C_2H_2) can be generated form calcium carbide by the addition of water.

$$\mathbf{CaC_2(s) + 2H_2O\ (l) \longrightarrow Ca(OH)_2(aq) + C_2H_2\ (g)}$$

If 165g of CaC_2 are mixed with 95.0g of water, which reagent is limiting?

What mass of C_2H_2 is formed?

Given:

$M(CaC_2) = 165g$

$m(H_2O) = 95g$

$m(C_2H_2) = ?$

Solution:

$\delta = \frac{m}{n}$; $n = nr$

$nr(CaC_2) = Ar(Ca) + 2Ar(C) = 40 + (2 \times 12) = 64$

$n(CaC_2) = 64g/mole$

$$\delta(CaC_2) = \frac{165g}{64g/mole} = 2.6mole$$

$nr(H_2O) = 2Ar(H) + Ar(0) = (2 \times 1) + 16 = 18$

$n(H_2O) = 18g/mole$

$$\delta(H_2O) = \frac{95g}{18g/mole} = 5.3\ mole$$

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

$$\frac{2.6\ mole\ (CaC_2)}{1\ mole} < \frac{5.3\ mole\ (H_2O)}{2\ mole}$$

CaC_2 is limiting reagent.

$$\frac{2.6\ mole\ (CaC_2)}{1\ mole} = \frac{x\ mole\ (C_2H_2)}{2\ mole}$$

$x\ mole\ (C_2H_2) = 2.6\ mole$

$m = n\delta$; $nr(C_2H_2) = 2Ar(C) + 2Ar(H) = 2 \times 12 + 2 \times 1 = 26$

$n(C_2H_2) = 26g/mole$

$m(C_2H_2) = 26g/mole \times 2.6\ mole = 67.6g$

Answer: 67.6g of C_2H_2 is formed.

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Example 5: Newton's laws of motion test

Test—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	6	-	-	-

Background

As part of a unit in mechanics, students had studied Newton's laws of motion. The teacher also introduced the concepts of terminal velocity, friction and inertia. Students had covered the mathematical expressions of Newton's laws, as well as the vector representation of forces. Their understanding of trigonometry and Pythagoras' theorem was evident in their demonstrations and explanations.

This was a conceptually challenging end-of-unit test, which included complex and unfamiliar problems. It was assessed using criterion C.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
5–6	The student explains scientific ideas and concepts and applies scientific understanding to solve **problems in familiar and unfamiliar situations**. The student **analyses** and **evaluates** scientific information by making **scientifically supported judgments** about the information, the validity of the ideas or the quality of the work.

This work achieved level 6 because the student:

- explains physics concepts such as inertia, tension and free fall, and applies this understanding to solve problems in both familiar and unfamiliar situations
- applies his/her understanding of vectors and trigonometry to support his/her answers, especially in questions 8, 9 and 10.

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Student work

Newton's laws of motion—test

This test will be assessed using criterion C (knowledge and understanding of science).

PART I: Explanation—justify each answer with an explanation and a reference to one of Newton's laws of motion when appropriate.

1. **Your empty hand is not harmed if it bangs lightly against a wall but is harmed if you are carrying a heavy load in your hand. Why is this so?**

   Once your hand is in motion, at a collision course for the wall, the harder it is, the more inertia it has. More inertia equals less will to be stopped, so with the weight in your hand, the smack would be much more significant.

2. **If you jump up in a bus that is moving at a constant velocity, will you land farther back? Explain.**

   Although it may look like you're standing still on a bus, you're not; you're moving at the same pace as the bus, relative to the ground. When you jump, you maintain the horizontal component, the speed, and simply land back where you jumped from.

3. **Suppose in a high-flying airplane the captain announces that the plane is flying at a constant velocity of 900 km/h and the thrust of the engines is a constant 80,000N. What is the acceleration of the plane? Explain.**

   Obviously, there is going to be 0 acceleration if the plane is going at a constant velocity.

4. **You exert 200N on your refrigerator and push it across the kitchen floor at a constant velocity. What friction force acts between the refrigerator and the floor? Explain.**

   The friction inflicted upon the fridge is literally pushing against the pushing man; it's a conflict of strength and work. If there is no friction, objects would slide around all the time. The friction is meant to balance out unbalanced objects (forces). Hence the friction being 200N.

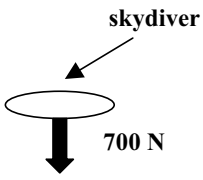
5. **You pull on one end of a rope with 100N of force and your friend pulls on the other end with 100N of force. What is the total tension in the rope? Explain.**

   Both the persons will pull with a force of 100N at a single rope stretched between them. So twice the 100N is applied to the same string, thus 200N are acted upon the string in total.

6. **A skydiver jumps from an airplane. (The skydiver is represented by the oval form in the diagrams; the forces are represented by the thick black arrows).**

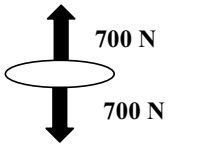
   a. **When he first jumps out of the airplane, what is his speed and acceleration? Explain.**

      His speed is 5m/s and his acceleration is 10m/s^2. These are basic figures which are common to free falling objects.

   b. **At the point when the force of air resistance equals his weight, what can be said about his acceleration and speed?**

      At this point, his acceleration must be zero, and travelling at a constant speed towards the earth.

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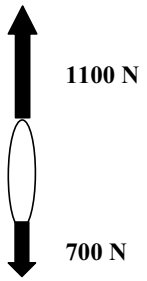
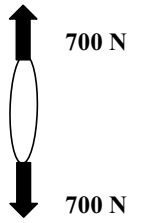
c. When his parachute opens, the air resistance increases. What can be said about his speed and acceleration at this point?

Once the air resistance is greater than the parachutist's weight by gravity, his acceleration will drop (decelerate) and his velocity will be decreased. The air resistance caught in the parachute provides a good breaking.



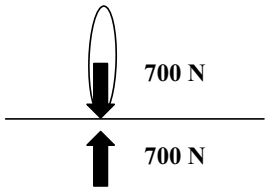
d. Eventually the two forces are equal again. Why does this happen?

When the air resistance was greater, the forces were unbalanced, something which nature doesn't tolerate. The forces will become balanced again, but the speed remains constant.



e. When he hits the ground, what can be said about his speed and acceleration at this point?

On the ground, he has come to a full stop. There is no more acceleration, and no more speed.



PART II: Calculations—calculate the following. Be sure to answer using correct units and show all working. (Assume g = 10m/s^2)

7. What is the acceleration of a 747 jumbo jet, mass 30,000kg, in take-off when the thrust for each of its four engines is 30,000N?

$$a = \frac{F}{m}$$

$$a = \frac{120{,}000}{30{,}000} \qquad (30{,}000 \times 4)$$

$$a = 4 \text{ m/s}^2$$

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8. If the mass of an object hanging from a rope is 2,000kg, and its angle with the horizontal is 30°, what is the tension in the rope?

$\sin 30 = \frac{o}{h}$

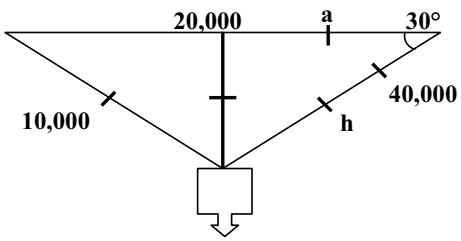
$\sin 30 = \frac{(F=2000\times10)}{h}$

$\sin 30 = \frac{20,000}{h}$

$h = \frac{20,000}{\sin 30}$

$h = 40,000$ N

total tension=80,000N

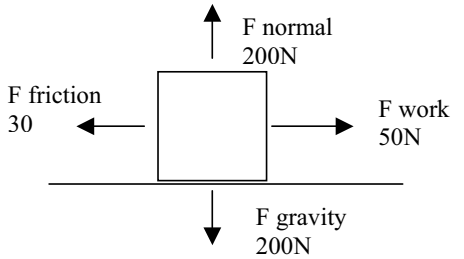


9. A 20kg object slides across a horizontal surface. If the percent friction (coefficient of friction) is 15%, and the object is being pushed with 50N, find:

a. the net force on the object

b. the acceleration of the object.

Draw a free-body diagram and label the forces involved.



20 X 10 = 20 N

Friction = M • F_N

Friction = 0,15 • 200

Friction = 30 N

$\text{Acceleration} = \frac{F_{net}}{M}$

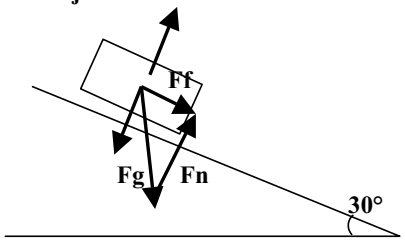
$A = \frac{20}{20}$

$A = 1$ m/s^2

Answers:

Acceleration = 1 m/s^2
Net Force = 20 N

(Challenge) If the object above is on the same table but is not being pushed, what force (if any) would be necessary to hold the object motionless if the table is held at a 30° angle above the horizontal?



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Example 6: Electricity test

Test—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	5	-	-	-

Background

Students had covered a range of theoretical and practical learning exercises designed to teach them the fundamental principles regarding force and motion, energy and electricity. After each unit, students were assessed summatively with a written test.

The test presented here consisted of a series of multiple-choice questions as well as problem-solving situations of differing levels of complexity (questions 23 and 24), which posed a greater challenge for students. Question 29, in particular, provided students with an opportunity to analyse and evaluate the scientific validity of ideas. The test was assessed using criterion C.

Students were given one hour to complete the test. Calculators were allowed.

Note 1: As the work was done under examination conditions, the student's responses were handwritten; they have been retyped here to facilitate reading. The teacher's writing is presented here in **bold** text; the student's work appears in normal text. For multiple choice questions, the student´s answer is represented by a circle.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion C: knowledge and understanding of science

Maximum level: 6

Achievement level	Descriptor
5–6	The student explains scientific ideas and concepts and applies scientific understanding to solve **problems in familiar and unfamiliar situations**. The student **analyses** and **evaluates** scientific information by making **scientifically supported judgments** about the information, the validity of the ideas or the quality of the work.

This work achieved level 5 because the student:

- demonstrates an understanding of the main ideas of electricity and applies this to solve problems in both familiar and unfamiliar situations, despite making some mistakes on straightforward questions.

This work did not achieve level 6 because the student made some mistakes in the interpretation and analysis of the information (as shown in question 28), and his/her scientific arguments against the Greek belief about falling objects are only partially developed (as shown in question 29).

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Student work

Electricity test—physics

Part A

1. Electrical resistance is measured in:

A. ohms

B. volts

C. watts

D. amperes

2. What is the resistance of a toaster that uses 2A of current when connected to a 240V power source?

A. 240 Ω

B. 120 Ω

C. 60 Ω

D. 2 Ω

$V = 1R$

$\frac{240}{2} = \frac{2 \times R}{2}$

$R = 120\ \Omega$

3. A globe glows brightly when connected in series with an ammeter and a cell, but the ammeter reads zero. The most likely reason for this is that:

A. the cell is not working correctly

B. the globe is not working correctly

C. the ammeter is not working correctly

D. the connecting wires are not working correctly.

4. When two globes are connected in series and one of the globes breaks the other will:

A. glow twice as brightly

B. dim and glow faintly

C. glow exactly as it did before

D. not glow at all.

5. The current passing through connecting wires in a circuit can be measured by:

A. an ammeter in series with the connecting wire

B. an ammeter in parallel with the connecting wire

C. a voltmeter in series with the connecting wire

D. a voltmeter in parallel with the connecting wire.

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6. In a simple parallel circuit:

A. the current through each branch is always the same
B. the voltage across each branch is always the same
C. the resistance of each resistor is always the same
D. the current is the same as the voltage in each branch.

7. To increase the brightness of a desk lamp a student replaces a 60W light bulb with a 100W light bulb. The lamp is plugged into a constant 240V household power supply. Compared to the 60W light bulb the 100W bulb:

A. has less resistance and draws more current
B. has less resistance and draws less current
C. has more resistance and draws more current
D. has more resistance and draws less current.

8. When standing in a bus that stops suddenly you lurch forwards because:

A. the bus throws you forward
B. your inertia keeps you moving
C. the gravity force stops acting
D. air resistance keeps you moving.

9. What is 72km/h in m/s?

A. 20
B. 7.2
C. 12
D. 3.6

72km/h
72 000m/h ÷ 60 ÷ 60

10. A cyclist travels 25km in two hours. Her average speed is:

A. 0.08km/h
B. 8km/h
C. 12.5km/h
D. 50km/h

$$V = \frac{S}{T} = \frac{25}{2}$$

11. The acceleration due to gravity on Earth is taken as 9.8m/s^2 while on the moon it is 1.6m/s^2. This means that:

A. you would have less mass on the moon
B. you would have more mass on the moon
C. your mass and weight would be the same on the Earth and on the moon
D. you would have less weight on the moon.

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12. How much inertia would a 4kg mass of feathers have compared to a 2kg mass of iron?

A. four times as much
B. twice as much
C. the same
D. one half as much.

13. An unbalanced force of 50N acts on a mass of 5kg. The acceleration of the mass in m/s^2 will be:

A. 5
B. 10
C. 50
D. 250

$F = m \times a$

$\frac{50}{5} = \frac{5 \times a}{5}$

$a = 10$

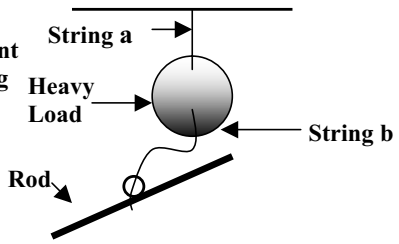
14. If a train travelling at 10m/s starts to accelerate at $1m/s^2$ for 15s on a straight track its final velocity in m/s is:

A. 10
B. 15
C. 20
D. 25

$1 = \frac{x - 10}{15}$

$15 = x - 10 \qquad x = 25$

15. Examine the apparatus to the right. A teacher asked a student to choose which string she wanted to break without breaking the other string. The student chose string b. Which of the following alternatives explains how to break string b *and* gives the correct explanation?



	Action taken	Explanation
A.	Jerk rod down quickly	The load remains at rest.
B.	Pull rod down slowly	The total downwards force is the sum of the applied force and the weight of the load.
C.	Jerk rod down quickly	The total downwards force is the sum of the applied force and the weight of the load.
D.	Pull rod down slowly	The load remains at rest.

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16. If the acceleration due to gravity is 10m/s^2, an object falling from rest will:

I. fall with a constant speed of 10m/s^2

II. fall 10m every second

(III.) have a speed of 20m/s after two seconds.

Which statement is correct?

A. I, II and III

B. II and III

C. I and II

(D.) III

17. When a bicycle rolls from rest down a hill with a brake on, what forms of energy are transformed?

A. Stored chemical into kinetic energy only

B. Potential energy into heat energy only

(C.) Potential energy into kinetic energy and heat energy

D. Stored mechanical energy into heat energy

18. A ball is thrown into the air with 120J of kinetic energy, which is transformed to gravitational potential energy at the top of its trajectory. When it returns to its original level, after encountering air resistance, its kinetic energy will be:

(A.) less than 120J

B. more than 120J

C. 120J

D. not enough information given.

19. Potential energy is the energy of an object because of its:

A. temperature

(B.) location

C. weight

D. speed.

20. The unit of work is the:

A. Newton

(B.) Joule

C. Watt

D. none of the above.

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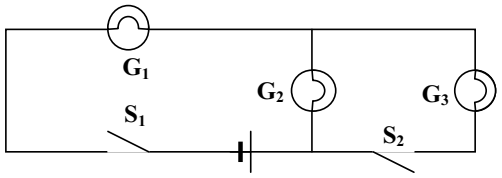
Part B

21. A light bulb allows 0.5A to flow through it when it is connected to a 12V battery. What is the resistance of the light bulb?

$R = \frac{V}{I}$ $R = \frac{12}{0.5}$

R = the light bulb has a resistance of 24Ω.

22. The diagram to the right represents an electric circuit containing three light globes (G_1 G_2 and G_3), two switches (S_1 and S_2) and a cell.



(a) Which light globes will be lit when switch S_1 is shut and switch S_2 is open?

$G_1 + G_2$

(b) Which light globes will be lit when switch S_1 is open and switch S_2 is shut?

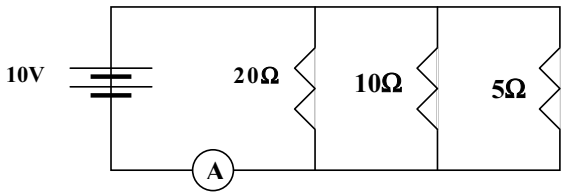
None

(c) If each globe has the same resistance, describe the brightness of each globe relative to each other globe when switches S_1 and S_2 are closed.

G_1 will glow 2x as brightly as G_2 and G_3 because the current through G_2 +G_3 will have to split between the two. If we do not count the resistance of the wire, G_2 +G_3 will glow the same.

23. (a) For the illustrated circuit determine the total current that would be measured by the ammeter.

(b) On the diagram label with the letter S a location for a switch such that when the switch is open the current will be 0.5A



Total R

$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{10} + \frac{1}{5}$

$\frac{1}{R_T} = \frac{1}{20} + \frac{2}{20} + \frac{4}{20}$

$\frac{1}{R_T} = \frac{7}{20}$

$\frac{7}{20} = \frac{R_T \times 7}{7}$ $R_T = 2.857$

$V = 1R$ $10 = 1 \times 2.857$

$\text{Current} = \frac{10}{2.857}$

Current = 3.5 Amperes

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24. An electric toaster has the markings "240V" and "1200W".

(a) Calculate the electric current flowing through the toaster when it is turned on.

$P = IV$

$1200 = 240 \times I$

$I = \frac{1200}{240}$

Electric current = 5 Ampers

(b) Determine the amount of energy used and its cost over a week (seven days) if the toaster is used for 30 minutes each day and electricity costs 12.4 cents per kilowatt-hour.

$E = t \times p$

$E = 3.5\ h \times 1.200\ kW$

$E = 4.2\ kWh$

$4.2 \times 12.4 = 52.08\ c$

Answer: E = 4.2 kWh and cost = 52.08 c.

25. Give an everyday example to demonstrate:

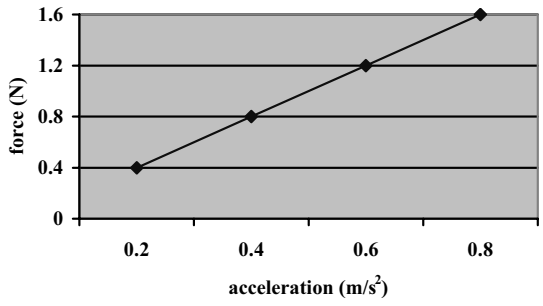
(a) Newton's First Law

An ice skater will continue to move in the same direction for a long distance because there is very little friction: if there was no friction they would keep going at the same speed in the same direction unless another force acted upon it. Friction is the force causing it to slow down.

(b) Newton's Second Law

You must apply a force to push a trolley/change its speed.

26. The graph below shows the results of an experiment to find out how the motion of a trolley was related to the force acting on it.



What was the mass of the trolley?

$F = m \times a \qquad m = \frac{F}{a} \qquad$ and slope $m = \frac{0 - 0.8}{0 - 1.6} = 5$

mass = 0.5 kg or 500 g

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27. Calculate the acceleration of a car that changes its speed from 24m/s to 52m/s in eight seconds.

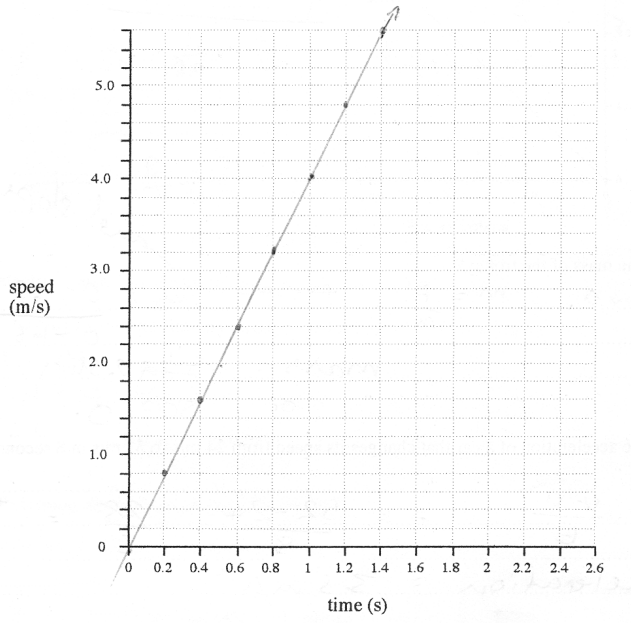
$a = \frac{V - U}{t}$ $\quad a = \frac{52 - 24}{8} = \frac{28}{8} = 3.5\ m/s^2$

acceleration = $3.5\ m/s^2$

28. The table below gives the speed of a vehicle at time intervals of 0.2 seconds.

Time (s)	**0.0**	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**
Speed (m/s)	**0.0**	**0.8**	**1.6**	**2.4**	**3.2**	**4.0**	**4.7**	**5.2**	**5.4**	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**

(a) Draw a graph of speed (y-axis) against time (x-axis).



(b) At what time did it have a speed of 2.0m/s?

0.5 seconds

(c) When did it travel with constant speed?

At 0

(d) What was its average acceleration over the first 0.8 seconds?

$a = \frac{3.2}{0.8}$

acceleration = $4\ m/s^2$

(e) How was its motion changing from 1.0 to 1.8 seconds?

4m/s ⟶ 5.5 m/s

Difference = + 1.5 m/s
or 1.5 m/s faster

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29. Ancient Greek philosophers (ca 300 BC) believed that heavier objects would fall faster than lighter ones. They believed this to be so obvious that they did not bother to test the idea. It is said that the Italian, Galileo was the first to disprove this "self evident fact" by dropping cannon balls of different masses from the Tower of Pisa in the 16th century.

(a) Suggest, with an everyday example, why the ancient Greeks jumped to the conclusion that they did.

Because the heavier object would have more force when it hit the ground than a lighter one. For example, an apple hitting your head from a certain hight would hurt a lot less than a shot put.

(b) Use Newton's equation *F = ma* and the concept of *weight* to explain why different spherical masses accelerate towards the earth at the same rate.

This is because when you change the "m" on the equation it does not alter the "a". Also weight is the mass of an object x the gravitational pull/force (9.8 m/s^2 on earth). The more mass an object has the more force the object will have as it accelerates. The accelerating towards the earth in constant, but the force of an object is the mass x acceleration.

In the equation F = ma w=F
so weight = m x a.

The only thing which would alter the acceleration towards the earth is the air resistance which is why a balloon takes longer to float down than a metal ball of the same size.

30. In the world today we are looking for alternative energy sources that are renewable instead of relying on non-renewable sources.

(a) Explain the difference between renewable and non-renewable sources. Give two examples of each.

A renewable source is one which will reproduce itself or cannot be used up. For example wood (that reproduces) or wind (kinetic energy)

A non-renewable source is a limited one which can be used up. For example uranium or coal.

(b) Briefly describe how you could extract useful energy from one renewable source.

You can use the kinetic energy from the wind to sail a boat or a kite, by trapping it in a material and the wind forces the object along.

You can use the wind for energy on a windmill (the kinetic energy of the wind turning the blades) this can be used to pump water or grind grain. We are now able to use turbines to generate electricity.

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Example 7: Investigating fuels laboratory report

Scientific investigation—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	5	4	*

Background

As part of a unit on hydrocarbons, students investigated the characteristics of a good fuel. Students were asked to plan, design and carry out an experiment to compare two fuels for their energy output and produce a scientific laboratory report of their findings. They were expected to follow the method chosen and obtain results that would allow them to calculate the quantity of energy released.

The task was assessed using criteria D, E and F.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method, commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 5 because the student:

- defines the purpose of the investigation briefly without elaborating on the characteristics of a good fuel; however, he/she manages to formulate a testable hypothesis and uses scientific reasoning to explain it
- identifies the relevant variables but does not clearly explain how to manipulate them
- designs a suitable method, including appropriate materials and equipment, and accounts for the safety measures taken when performing the experiment
- evaluates the method, accounting for possible sources of error and comments on both the reliability of the measurements and the validity of the method used and the conditions of the experiment
- suggests ways to correct and improve the experimental protocol.

The idea of precision and accuracy can be developed in this practical by discussing the measurement of temperatures with the thermometer.

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Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
3–4	The student organizes and **transforms** data into **numerical and diagrammatic forms** and presents it using **appropriate communication modes**. The student draws a **conclusion consistent with the data**.

This work achieved level 4 because the student:

- organizes and presents the data using tables with appropriate headings and units, and converts the data of the table into a bar chart
- provides a conclusion that is consistent with the interpretation of the data and uses his/her understanding of scientific ideas to explain the findings.

Criterion F: attitudes in science

*(Please note: criterion F is assessed but not moderated.)

This practical requires risk assessment. Students should discuss safety issues and evaluate the risk of potential accidents and health hazards when manipulating and burning fuels.

The method devised by the student makes some references to safety measures, as indicated by the use of eye protection when handling and burning fuels. However, assessment of personal and practical skills (such as group work and performance in experiments) should be a part of the assessment for every scientific inquiry.

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Student work

Chemistry
Lab Report

Investigating Fuels

Problem: We are trying to figure out which is the best fuel, Ispirto (CH3OH) or Turpentine (C10H16)

Hypothesis: I think that Ispirto will be the best fuel because it is an alcohol. I know it is an alcohol because carbon and OH is present in the molecular formula. As we have learned from our class notes alcohols combust easily and produce a lot of energy. Most importantly, I think that Ispirto with combust more completely than Turpentine therefore producing less amounts of pollutant agents since Ispirto contains less carbon atoms.

Variables:

Independent:
The type of fuel used for each test: Ispirto and Turpentine.

Dependent:
Which fuel gives off the most energy (measure the temperature change of the water, using a thermometer).

Controlled:
Volume of fuel in each test (2cm cubed)
Type of glass dishes
Volume of water used (30ml)
Type of Beaker used (100ml size beaker)
Thermometers used
Height of beaker from the fuel (6cm away from the fuel)
Type of matches used

Equipment:
Safety glasses
Matches
1 Beaker
2 glass dishes
30ml of water in each beaker
1 Thermometer
1 stand
1 clamp
2cm cubed of each fuel for each test
Measuring cylinder

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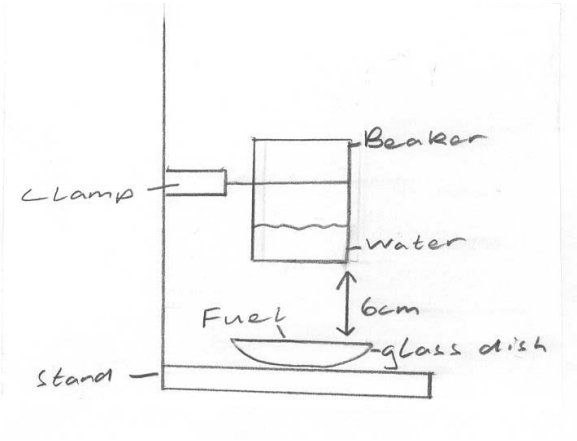
Method:

1. Set up all the equipment on the desk and put on your safety glasses.
2. Put 2cm cubed of Ispirto into one glass dish. Adjust the clamp to the stand. Pour 30ml of water into one beaker and tighten the beaker into the clamp. Adjust the height of the beaker until it is 6cm away from the fuel.
3. Measure and record the starting temperature of the water using the thermometer. Place the glass dish under the beaker. Ignite the fuel using a match.
4. When the fuel has finished combusting (when no more flame is present) record the ending temperature of the water using the thermometer. Empty the beaker of water and clean the bottom of it.
5. Repeat steps 2, 3 and 4 five times for the fuel Ispirto
6. Repeat steps 2, 3 and 4 six times using the second fuel Turpentine. Use the second glass dish for turpentine.
7. Record all your results in an appropriate table.

Diagram:



Data:

Temperature Change of water After Heating

Fuel: Ispirto CH3OH	Temp. of water before heating (c)	Temp. of water after heating (c)	Temp. change of water after heating (c)	Observations
Trial 1	20	75.5	55.5	During the trials there were no obvious observations with the combustion of Ispirto
Trial 2	20	78	58	
Trial 3	20	81	61	
Trial 4	20	73.5	53.5	
Trial 5	20	79	59	
Trial 6	20	92.5	72.5	

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Temperature Change of water After Heating

Fuel: Turpentine C10H16	Temp. of water before heating (c)	Temp. of water after heating (c)	Temp. change of water after heating (c)	Observations
Trial 1	20	71.5	51.5	During the trials I noticed that a black substance formed on the beaker, probably carbon.
Trial 2	20	90	70	
Trial 3	20	88.5	68.5	
Trial 4	20	79	59	
Trial 5	20	82	62	
Trial 6	20	95	75	

Data Processing:

To calculate the mean for the temperature change of the water, from the start of the experiment until the end:

Add all the temperatures changes of water after heating together, and then divide the sum by the number of trials.

Ispirto:

55.5+58+61+53.5+59+72.5 / 6= 59.9

The mean of the temperature change in the water after heating is 59.9

Turpentine:

51.5+70+68.5+59+62+75 / 6= 64.3

The mean of the temperature change in the water after heating is 64.3

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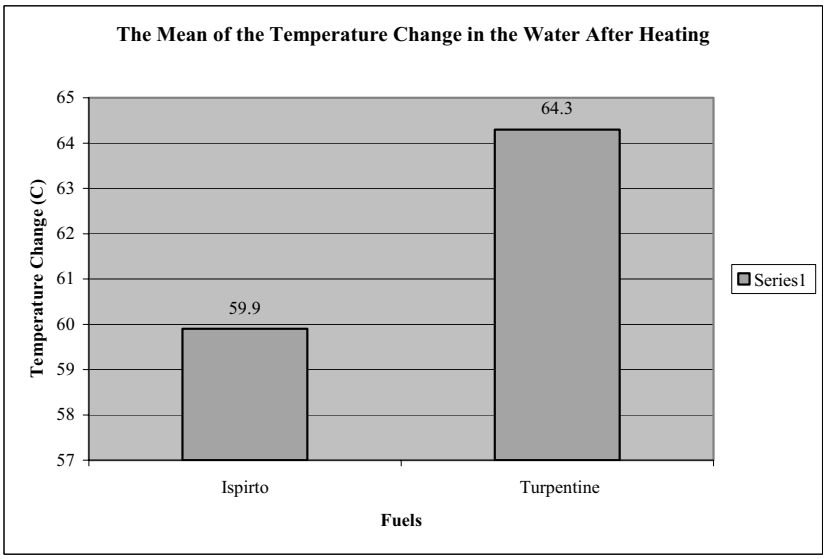
Results:



Looking at the data the experiment I can see that Turpentine produces more energy when combusted compared to Ispitro. However while observing the combustion of the each fuel, I noticed that turpentine produces a black substance that makes the beaker turn black. This substance is known as carbon. Therefore I realized that Turpentine combusts incompletely. The molecular formula for the incomplete combustion of Turpentine:

$$C_{10}H_{16} + 6O_2 \longrightarrow 4CO + 8H_2O + C$$

While observing the combustion of Ispirto, I didn't notice any black substance around the beaker, therefore Ispirto combusts completely. The molecular formula for the complete combustion of Ispirto:

$$CH_3OH + \frac{3}{2}\ O2 \longrightarrow CO_2 + H_2O$$

Evaluation:

The results from my expirement are relatively reliable with the exception of a couple temperatures. With both fuels the temperatures of the water after heating were pretty consistent except for the 6th trial with both fuels. The temperatures jump up to 92 degrees Celsius for Ispirto and 95 degrees Celsius for Turpentine. I think the reason for this is because for both fuels, by the 6th trial we used a new beaker. Even though we did not write this step in our method we chose to change the beaker because it was too hot to use for the last trials. We did not wait for it to cool down because it would have taken to long. When selecting we found an identical sized beaker, but maybe the thickness of the glass was thinner, therefore when we ignited the fuel the water heated quicker.

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When igniting the fuels we used matches. This could have affected the fuels because the matchstick contains carbon, which might have entered the glass dish. With more carbon added to the fuel the type of combustion could have slightly changed as well. To improve the method of igniting the fuel a lighter could have been used.

Throughout the expirement there was a draft in the classroom, from people entering and exiting the lab, which affected the direction of the flame. Therefore during some trials the water did not receive all the heat that was being produced. Also the rubber and metal clamp that was adjusted onto the beaker was absorbing a portion of the heat.

It was difficult to tell when the fuel stopped burning. This could have affected the results because when the fuel stops burning you have to measure the temperature of the water. Even by eye you can never tell when the fuel stops burning. As a solution to this problem a certain type of microscope could have been used to see the flame at a higher magnification.

After each trial we added 2cm cubed of fuel into the glass dish. But an important step was forgot after each trial. We did not rinse the glass dish and this might have affected some tests. For example on the second trial the amount of the fuel might have increased because a couple drops might have not ignited from the previous trial.

I think the number of tests that we carried out was sufficient enough to determine which fuel produced the most energy, and which fuel produced pollutant gases. Although it is always better to make more trials for a more accurate mean of results.

Conclusion:

From the expirement I realize that my hypothesis is partially correct. I have learned that even though Ispirto is an alcohol is does not produce more energy than Turpentine. However this doesn't necessarily mean that turpentine it is a superior fuel over Ispirto. Turpentine produces pollutant gases, carbon monoxide (CO) and carbon (C), because of incomplete combustion.

$$C_{10}H_{16} + 60_2 \longrightarrow 4CO + 8H_20 + C$$

These are very bad gases for the environment and humans. Carbon monoxide is a poison and if the percentage of carbon monoxide increases in the air, we could suffer from breathing this poison. Even though Ispirto produces slightly less energy than Turpentine, is the best fuel because it combusts more completely and it doesn't produce harmful pollutant gases.

$$CH_3OH + \frac{3}{2}0_2 \longrightarrow C0_2 + 2H_20$$

The reason for Ispirto to combust more completely is because the fuel contains less carbon atoms, as I stated in my hypothesis. The only carbon that is produced is the carbon in carbon dioxide which is not a major pollutant compared to carbon monoxide.

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Example 8: Rate of reaction—double displacement investigation

Scientific investigation—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	6	-	6	6	*

Background

This experiment formed part of a unit on chemical reactions. Students were already familiar with the different types of chemical reactions: synthesis, decomposition and single and double displacement. Students had also discussed the way antacid tablets work as an example of the reaction between carbonates and acids in the stomach.

Students were asked to design an experiment using the double displacement equation below to investigate how the rate of the reaction between calcium carbonate and hydrochloric acid could be affected by a selected factor.

$CaCO_3$ (s) + 2HC1 (aq) ⟶ $CaC1_2$ (aq) + H_2O (1) + CO_2 (g)

Students were allowed to choose how to measure the rate of reaction. The teacher also gave them the following hints.

- Consider the collision theory and how it applies to the reaction.
- Consider how sources of error will affect your results.
- The rate of any reaction will change as the reaction proceeds.

Students set up the experiment to measure the rate of reaction of calcium carbonate and hydrochloric acid under what they considered to be optimum conditions. They then studied how changing different factors affected the rate of the chemical reaction.

The experiment was assessed using criteria D, E and F and the laboratory report was assessed using criterion B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
5–6	The student communicates scientific information **effectively** using **scientific language correctly**. The student presents all the information appropriately using symbolic and/or visual representation accurately according to the task. The student acknowledges sources of information **appropriately**.

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This work achieved level 6 because the student:

- communicates scientific information effectively and uses scientific language correctly
- presents the information appropriately using appropriately labelled tables and clear line graphs with correct titles and labelled axes
- acknowledges sources of information according to a recognized referencing convention, uses text marks when paraphrasing and includes a bibliography.

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 6 because the student:

- defines the purpose of the investigation in the aim, formulates suitable hypotheses for the various experiments and uses scientific information to explain his/her reasoning and predictions
- clearly identifies all the relevant variables in each experiment and explains how to manipulate them
- provides a comprehensive evaluation of the method, making reference to the reliability of the results and the precision and accuracy of the measurements and measuring instruments, and accounts for the conditions of the experiment to ensure fair testing and validity.

Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
5–6	The student organizes and transforms data into numerical and diagrammatic forms and presents it logically and clearly, using appropriate communication modes. The student **explains trends, patterns or relationships** in the data, comments on the reliability of the data, draws **a clear conclusion** based on the correct interpretation of the data, and explains it using **scientific reasoning**.

This work achieved level 6 because the student:

- organizes and transforms data into numerical and diagrammatic forms, and presents it logically and clearly, using appropriately labelled tables and line graphs
- interprets the data from tables and graphs to deduce trends, patterns and relationships
- draws conclusions based on a clear interpretation of the results
- uses scientific reasoning to support his/her explanation.

Criterion F: attitudes in science

*(Please note: criterion F is assessed but not moderated.)

This experiment was used to assess students' attitudes in science. Students had to pay attention to safety when dealing with chemicals and chemical reactions. Safety goggles were used throughout the experiment. Students worked in small groups and attended to health and safety issues at all times.

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Assessment task

Rates of reaction (Chemistry)

Investigation

Reaction of Calcium Carbonate with Hydrochloric acid

Introduction

This lab is concerned with investigating how the rate of the reaction between calcium carbonate changes when you alter various factors. You need to carry out a multi-part investigation showing how at least three different independent variables affect the rate of this chemical reaction.

$CaCO_3 + 2HCL \longrightarrow CaCl_2 + H_2O + CO_2$

Hints

- You can measure the rate of the reactions in any way you like.
- The rate of any reaction will change as the reaction proceeds.
- Think about collision theory and how it applies to this reaction.
- Keep your eyes open for sources of error here and how they will affect your results.

Assessment

- Your work will be assessed against criteria D, E and F.

Aims

The aims of this task are:

- to plan an experiment for an open-ended task
- to write a full scientific report
- to investigate the factors affecting rates of reactions.

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Student work

The Rate of Reaction

To begin with:

Every chemical reaction has a rate to which it reacts. In some cases reactions happen in a matter of split seconds, in other cases reactions happen over hours. This has got to do with the reactants that are involved in the reaction mainly, however there are factors that can speed it up or slow it down. Humans can cause most of these factors.

Our aim:

Our aim for this investigation is to find out the factors that contribute to the rate of a reaction and to what extent they affect it. We will use the reaction between calcium carbonate and hydrochloric acid as an example. We will perform a number of experiments that will all have one variable that will be changed (a factor) and we will witness the effects that has, compared to the original reaction of calcium carbonate.

The equation (it's always good to know what reaction you are working with):

$CaCO_3 + 2HCL$ --------► $CaCl_2 + H_2O + CO_2$

Identifying the factors:

First we need to identify the factors that will alter the rate of reaction; in other words, we have to define our independent variables. What conditions can be changed to possibly speed up or slow down the reaction time?

- Temperature of the reactants
- Surface area of the calcium carbonate
- Number of moles of calcium carbonate (in other words the mass)
- Number of moles of hydrochloric acid (in other words the volume)
- Concentration of hydrochloric acid

Order of experimentation:

The first experiment that we will conduct is the basic experiment of reacting calcium carbonate and hydrochloric acid, as that is the experiment we will be basing all the experiments on - we will compare everything to these sets of results. After that, it is completely up to us which factors we choose to investigate and in what order we conduct those experiments.

Things to keep in mind beforehand:

The first experiment is most likely to give us a reliable set of results, as it is the easiest one. However, for the rest of the experiments it has to be considered that the factors might have such an effect that they don't give the wished results or even enough results. Since we have no real idea of what effect the factors will add to the experiment, we have to be extra observant, patient and accepting of mistakes.

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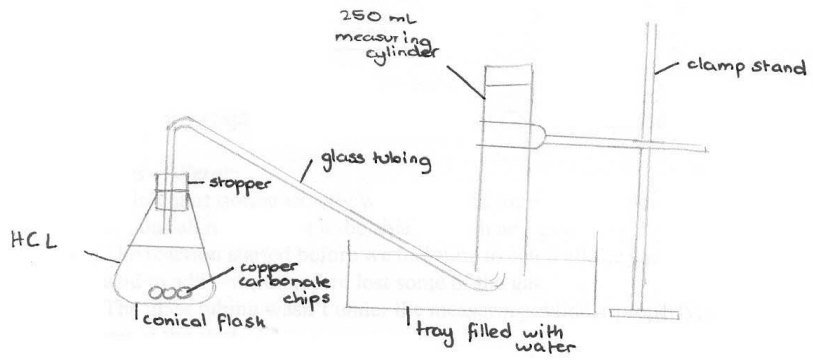
Rate of Reaction of Calcium Carbonate

Aim: To find the rate of reaction of calcium carbonate.

Apparatus: conical flask, stopper, a large measuring cylinder, a small measuring cylinder, glass tubing, a tray full of water, a clamp stand, 100 ml of hydrochloric acid (HCl – 1.0 mol^{-1}), 8 grams of marble chips (calcium carbonate – $CaCO_3$), balance, stopwatch

Diagram:



Method:

- Set up apparatus as seen in the diagram above.
- Using a balance measure a known mass (roughly 8 grams) of calcium carbonate chips, which will be the constant variable.
- Using the smaller measuring cylinder, measure 100 ml of hydrochloric acid (concentration 1.0 mol^{-1}), which will be a constant variable as well.
- Pour the hydrochloric acid in the conical flask.
- Put the calcium carbonate chips in the conical flask and put the stopper on as fast as you can.
- Start the stopwatch as soon as the stopper is on the conical flask.
- Observe the gas being collected in the larger measuring cylinder placed upside down.
- For every 30-second interval, read the amount of gas collected and note it down.
- Continue this until you have a collection of about 8 results, or until the reaction ends.
- After the experiment is completed, the rate of reaction needs to be worked out.
- This is done by plotting a graph with the results collected — time (seconds) vs. amount of gas collected (volume).
- Draw a line of best fit.
- Find the gradient of the graph (rise over run) and that is the answer to the rate of reaction of calcium carbonate.

$$\text{Rate of reaction} = \frac{\text{volume}}{\text{Time}}$$

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Results:

Time (seconds)	Volume (ml)
30	35
60	65
90	102
120	140
150	183
180	222
210	250

Rate of Reaction:
(From looking at the graph)

$\frac{74}{60} = 1.23$ r

Graph:
(See attached graph 'The Rate of Reaction of Calcium Carbonate and Hydrochloric Acid')

Sources of Error:
- Didn't start timing exactly when the acid touched the calcium carbonate because we had to pour all of it in first to be able to catch any gas.
- The reaction started before we had time to catch all the gas because we had the remaining acid to add — we therefore lost some of the gas.
- The glass tubing wasn't under the measuring cylinder properly, so we lost some of the gas at the start.
- The measuring cylinder in which we caught the gas wasn't straight up, so reading the numbers was hard and inaccurate.
- We didn't dry out the conical flask and the measuring cylinder after we first messed up. This could have given the chance for the acid to become more diluted (although this is very unlikely to have contributed).

Conclusion:
This is the rate of reaction we are going to base all our other experiments on, so there isn't anything to conclude. This experiment was simply to identify our starting point. We have found out that the rate of reaction is roughly 1.23. We can now begin to compare the other rates of reaction to this figure.

The Experiments Following This:
The experiments that will follow now, will have the same method as this one, yet the change of only one variable. This variable will be stated at the beginning, without a complete repeat of the method. To see the method again when conducting the following experiments, one should refer to the method used at the start.

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The Effect of Temperature on the Rate of Reaction of Calcium Carbonate and Hydrochloric Acid

Aim: To find out what effect the change in temperature will have on the rate of reaction of $CaCo_3$ and HCl.

Hypothesis: I think that the warmer the temperature of the reaction is made, the faster the rate of reaction will be. Likewise, I think that the colder the temperature of the reaction is made, the slower the rate of reaction. I think this because particules in a reaction get more energy when they are heated, meaning they hit the particules of the other substance faster and with more force. The particules get less 'energetic' when less heat is applied. (*The Material World*).

Changing Variable:
Instead of using HCl at room temperature like done before, this time the acid should be heated and then cooled down.
First experiment: Heat the acid to 40 C by placing it on a heat machine and keeping track of the temperature with a thermometer. Once it has hit 40 C add the acid to the already waiting calcium chips in the conical flask. Proceed as told in first method.
Second experiment: Cool the acid down to a temperature of 11 C, by putting it in the fridge and keeping track of the temperature with a thermometer. Then proceed as indicated above.

Results:
(Experiment One)

Time (seconds)	Volume (ml)
30	145
60	250
90	350

(Experiment Two)

Time (seconds)	Volume (ml)
30	(no recording)
60	20
90	40
120	65
150	100
180	135
210	174
240	208
270	243

Graph:
(See attached graph 'The Effect of Temperature on the Rate of Reaction of Calcium Carbonate and Hydrochloric Acid')

Rate of Reaction:

Experiment One: $\frac{62}{18} = 3.44$

Experiment Two: There are two gradients because the reaction starts off as a curve and then evens out into a straight line. We took the gradient of both parts of the line, so the results to conclude are more accurate.

Curve: $\frac{30}{57} = \frac{10}{19} = 0.53$ Straight line: $\frac{37}{30} = 1.23$

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Sources of Error:

Experiment One:

- We lost gas at the beginning because the glass tubing got stuck next to the measuring cylinder.
- Some air was already in the measuring cylinder when we started - this means it wasn't wholly accurate.
- We didn't put the stopper on immediately because of the process of pouring the HCL into the conical flask, so we lost some gas.

Experiment Two:

- We didn't record at the first 30-second interval because the measuring cylinder was inaccurate - it was hard to read the numbers because they go up in big numbers.
- There was a bubble at the top of the measuring cylinder.
- The cooled hydrochloric acid wasn't exactly 11 degrees by the time we started the experiment, because we left the acid out of the fridge for a while, so the outside temperature heated it up slightly.

Conclusion:

This is a very tricky experiment to conclude, because of various reasons. Firstly, the heated experiment went very well, as we got a result that matched out hypothesis. The rate of reaction was indeed much faster than the original rate of reaction. This can also be seen by the steepness of the line on the graph. Using the collision theory, I can confirm my results (Holman 1996: 184 - 188). The collision theory states that chemical reactions occur when particles of the reactants collide. A minimum energy is needed to make these particles collide, called the activation energy. In the case of calcium carbonate and hydrochloric acid, the activation energy is very low, so a reaction happens at a low temperature (as seen by our second experiment). Using the collision theory it can be concluded that if the activation energy is increased, the particles of the reactants will collide faster (in this case the particles of the acid were given more energy through the heat), therefore producing a faster reaction, in other words an increased rate of reaction.

The second experiment with cooled hydrochloric acid at first shows that the decreased temperature has decreased the rate of reaction as well, as we got a result of 0.53. Again, using the collision theory it can be stated that the less activation energy, the slower the reaction will happen. However, our experiment encountered a problem as when the curve straightened out, it gave us a rate of reaction that is the same as the one for our basis experiment (on the graph the two lines can be seen as parallel). There is no valid explanation for this that I can make. We recorded the temperature of this particular experiment after we had finished it and we got a temperature of 17 degrees. It had only increased 5 degrees (this due to the heat of the reaction but also the climatic heat). If it would have been a temperature close to 26 degrees (which is what the temperature was with the basis experiment), it could have been concluded that the acid had heated up so much that it was now under the same condition. A far-fetched explanation could be that the temperature of the acid might have been 17 degrees, but maybe the temperature of the acid just around the marble chips was close to 26 degrees. I can't make a valid conclusion for the results for the second conclusion. Maybe this is due to the sources of error we had during the process of the experiment, which could have affected the results significantly.

From my results I can make the overall conclusion and additional predictions that the higher the temperature, the faster the rate of reaction; the lower the temperature, the slower the rate of reaction. However, I do think that there is a point at either end where the rate of reaction won't be able to increase or decrease, as there is only so much energy that the particles can take and there is a particular amount of energy the particles need to react.

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The Effect of Surface Area on the Rate of Reaction of Calcium Carbonate and Hydrochloric Acid

Aim: To find out what effect the surface area has on the rate of reaction of the two reactants we're working with.

Hypothesis: I think that with the increase of surface area (which is the only factor we will be able to test), the rate of reaction will speed up because there are more calcium carbonate particles coming in contact with the hydrochloric acid at once (from the collision theory – *The Material World*). This means more particles will react at once. I therefore also believe that this reaction will probably go very fast and might be a hard one to record. Because of my predicted effects of the increase of surface area, this should be an interesting experiment to do.

Changing Variable:
Instead of using marble chips, we will use calcium carbonate in powder form. The powder has a r\5 much larger surface area because there are smaller bits open to react. Using the same method as described at the start, the experiment will be performed with only one difference – instead of 8 grams of marble chips, 8 grams of calcium carbonate powder will be used. The rest of the experiment should be kept as it is.

Results:
(Because the experiment was too fast, the results were taken in a different way)

Time (seconds)	Volume (ml)
4	50
8	110
17	170
38	250

Rate of Reaction:
(from graph)

$$\text{Rate of reaction} = \frac{116}{12} = 9\ 2/3 = 9.66$$

Graph:
(See attached graph 'The Effect of Surface Area on the Rate of Reaction of Calcium Carbonate')

Sources of Error:
- Most of the reaction had already taken place before we could actually put the stopper on the conical flask. It was surprisingly fast, and it gave us no results what so ever.
- The powder settled down on the bottom of the flask and then refused to react more unless it was stirred. We tried this after we had finally gotten the stopper on and found that when we shook the conical flask, all the apparatus moved and the glass tubing ended up beside the measuring cylinder.
- The experiment failed twice, so we altered it. Instead of calling out the volumes at time intervals (this went too fast to keep track of), we recorded how long it took for the gas to fill up to a certain volume (see results table). This worked a lot better — we actually got some decent results.

Conclusion:
The rate of reaction for this experiment is definitely higher than that of the base experiment (1.23) – actually, nearly 9 times higher. This is quite a difference, but a difference that can be accounted for. The results support my hypothesis and can be explained using the collision theory. When the surface area of the calcium carbonate is increased, more particles are exposed and there is therefore a higher chance that they will come in collision with the particles from the acid within a shorter time span. With the calcium carbonate chips used to start of with, there were more particles packed inside the chip and so it took longer for the acid to get through to them. In simple words, there

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is more surface area that the hydrochloric acid particles can hit, which then increases the rate of reaction.

If the surface area were to be continuously increased, there would be a point where the particles would be separate from each other and there is no more surface area to be exposed. There is where the rate of reaction would not increase anymore. If the surface area were to be decreased even more, there would be a point where there are too little hydrochloric acid particles to react with the amount of calcium carbonate particles. This would result in no reaction happening, as there wouldn't be enough acid particles to ignite the reaction. Not to mention that there wouldn't be sufficient acid to cover the surface of calcium carbonate, as with the decrease of surface area, the size of the calcium carbonate 'lump' is increased.

The Effect of the Change of Mass of Calcium Carbonate on the Reaction of Calcium Carbonate and Hydrochloric Acid

Aim: To find out what effect changing the mass of calcium carbonate has on the rate of reaction.

Hypothesis: I think that if the ratio of calcium carbonate to hydrochloric acid is made less, the rate of reaction will slow down. On the other hand, I think that if the ratio of calcium carbonate to hydrochloric acid is increased, the rate of reaction will increase (if the amount of calcium carbonate isn't too much). If the amount of calcium carbonate is decreased, there will be less calcium carbonate to react with the acid, so the rate of reaction will be slower. If the amount of calcium carbonate is increased, there will be more or even enough to react with the acid, so the rate or reaction will be faster. However, there is an optimum for the amount of calcium carbonate that can be added to the hydrochloric acid, as at one point it will be the case that there won't be enough acid to react with the calcium carbonate. Hopefully the amounts we use won't be as big to cause that to happen. (scientific source)

Changing Variable:
In this pair of experiments, only one variable has to be altered, and that is the amount of calcium carbonate that will be added. It will be in the normal chips form.
Experiment one – take half of the original mass of calcium carbonate (4 grams)
Experiment two – double the amount of calcium carbonate (16 grams)
Keep the rest of the experiment procedure the same as in the first experiment (the base experiment).

Results:
Experiment one –

Time (seconds)	Volume (ml)
30	5
60	15
90	17
120	25
150	30
180	35
210	50
240	55
270	71
300	77

Experiment two –

Time (seconds)	Volume (ml)
15	28
30	66
45	120
60	182
75	240

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Graph:
(See attached graph 'The Effect of the Mass of Calcium Carbonate on the Reaction of Calcium Carbonate and Hydrochloric Acid')

Rate of Reaction:

Experiment one (*less* $CaCO_3$)

$$\frac{28}{120} = 0.23$$

Experiment two (*more* $CaCO_3$)

$$\frac{102}{27} = 3.77 \text{ r}$$

Sources of Error:

- The measuring cylinder was very hard to read, because of the big numbers
- The reaction went quite fast, so the measuring cylinder filled up relatively fast. This prevented us from recording many results.
- There was a small bubble present at the top of turned the measuring cylinder.

Conclusion:

The results we recorded have produced the outcome that was predicted. From looking at the graph it can be told that with the decrease of the mass of calcium carbonate, the slope of the line became less steep, meaning the rate of reaction dropped significantly. This was also evident through how slow the bubbles were exerted during the experiment. From the graph it can also be said that the plotted points aren't all nicely lined up, suggesting that there were definitely sources of error present. However, because we managed to get so many recordings, I feel the line of best fit is quite accurate.

The second line on the graph indicates the rate of reaction to be somewhat faster than the other two graphed lines. Again, according to my hypothesis this makes sense. Because the reaction happened quite fast during the experiment, we weren't able to record many results. This makes them less accurate. However, they do give a good line of best fit. What is noticeable is that at the start the line curves and then straightens out. This curve is most likely due to the fact that it takes a while for a reaction to get started (it needs the activation energy and then needs to reach the potential of that energy). Also, we shook the conical flask at the start, to give all the pieces of chips a chance to react with the acid. This curve might be the depiction of where we exposed a larger surface area to the acid and it therefore sped up.

From both experiments it can be concluded that I was right in my hypothesis by saying that the larger the mass of calcium carbonate added to a constant amount of hydrochloric acid, the greater the rate of reaction. At the start of experimenting with this factor I thought it would be an independent one, just like the previous two I have tried out. However, I came to realize that the change in mass of calcium carbonate chips simply effects two factors of which I have already identified one. Not only does the increase of mass provide more calcium carbonate particles for the hydrochloric acid to react with, it also increases the surface area of the calcium carbonate because there is more of it. The effect of the shaking and the produced curve in the second experiment showed this link very well – as we exposed more surface area of the chips, the rate of reaction increased.

Regarding the optimum amount of calcium carbonate that I had predicted as a possible problem, we had no worries. We stayed under that level with the increase of calcium carbonate chips. However, as the mass of calcium carbonate is increased, there will be the point where there are too few acid particles to react with. It would be interesting to find out what the optimum amount of calcium carbonate would be for 100 ml of hydrochloric acid. To the other extent, if the mass of added calcium carbonate is too small, there aren't enough particles there to react with the ones in the acid.

We found no results in the fact that we had used twice and half of the original amount for the two experiments that we could conclude. This is a pity, but I'm already happy I was able to achieve such agreeable results.

Final Conclusion:

Unfortunately there wasn't enough time to conduct the factor of concentration. However, from the results that other groups obtained and scientific evidence, I know that the higher the concentration

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of the acid, the faster the rate of reaction (there are more acid particles to react with). All the experiments gave me the results that I had hypothesized (disregarding the sources of error) and I am now able to understand what effect each factor has on the rate of reaction and why.

Final Evaluation:

Overall, the results we have obtained throughout with experiment aren't been very reliable as we observed many sources of error and had some problems. This caused inaccuracy. This is shown through nearly all the plotted graphs - we were forced to draw a line of best fit because the results weren't in a perfect line. Some graphs don't seem to indicate such inaccuracy, but that is because they are graphs that only show three or four points. That is hardly enough to determine the real slope of the graph. The rates of reaction of those graphs are therefore not accurate. Despite the evidence, I believe that our results are reliable enough as they gave substantial information to prove our hypothesis and can be scientifically supported.

I can't account for any anomalous results, as there didn't appear to be any. All results aren't very accurate, but there are no results that are outrageously inaccurate. The slight inaccuracies are all due to the sources of error that were present. This is a review of some of the sources of error that had most effect:

- We couldn't start timing exactly at the start of the reaction, as it happened before we were able to get all the calcium carbonate in the conical flask. This delayed the placing of the stopper as well, meaning we lost the first few seconds of gas emission.
- We were too concentrated on getting the calcium carbonate in the conical flask, that we forgot to check whether the glass tubing was in the right place. After moving the measuring cylinder around, the glass tubing would often slip out of its place. We lost quite some bubbles of gas at the start of the experiment before we had the problem fixed.
- It was nearly impossible to prevent a bubble from forming at the top of the filled measuring cylinder. This bubble caused the recording of the amount of gas to be slightly more than it actually was.
- We didn't dry out the conical flask after rinsing it for the next experiment. This means that the acid was diluted slightly. I doubt this source of error contributed that much to the course of the experiment.

We had a number of problems (which contributed as source of error) during the experiments. Our first problem was trying to observe and control all the aspects of the set up experiment at the same time. As time progressed we became more skilled, but at the start this caused for a number of experiments to be done again. When we got to the experiment with powdered calcium carbonate (surface area), the reaction went too fast for us to record. We had to adjust our method, which I presume brought about a number of the sources of error because we didn't apply exactly the same conditions. Due to the fact that the experiments we conducted happened over a period of a couple of lessons, we had different equipment. We thought we were still working with the measuring cylinder that went up in 5 ml intervals, but it turned out to be 10 ml intervals. We had to redo the experiment again (less mass of calcium carbonate), which lost us time. We found out it was very hard to read the 10 ml measuring cylinder, especially with fast rates of reaction because you had to roughly guess what the recordings would be.

If we had time to restart this entire investigation, I think I could perform it much better and get much better results with the help of some improvements. Firstly, I would plan out all my experiments beforehand and identify why I am choosing such factors. I would also identify all my hypotheses. Next, I would make sure to understand the set up of the experiment and keep track of the reaction and the recording. I would also make sure that I use the same equipment all the way through and pay attention to the small sources of error that would still make a difference (i.e. drying out the conical flask). One thing I wouldn't be able to prevent is the gas lost before putting the stopper on the flask – there is simply no other way to do it.

An experiment I would like to do as a follow up from this one, is see whether there is a difference in the rate of reaction of different elements. It would be interesting to see if all elements simply depend on the factors that we have investigated or that the difference in material also makes a

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difference. This would give a more in-depth understanding of rates of reaction – what some larger factors may be.

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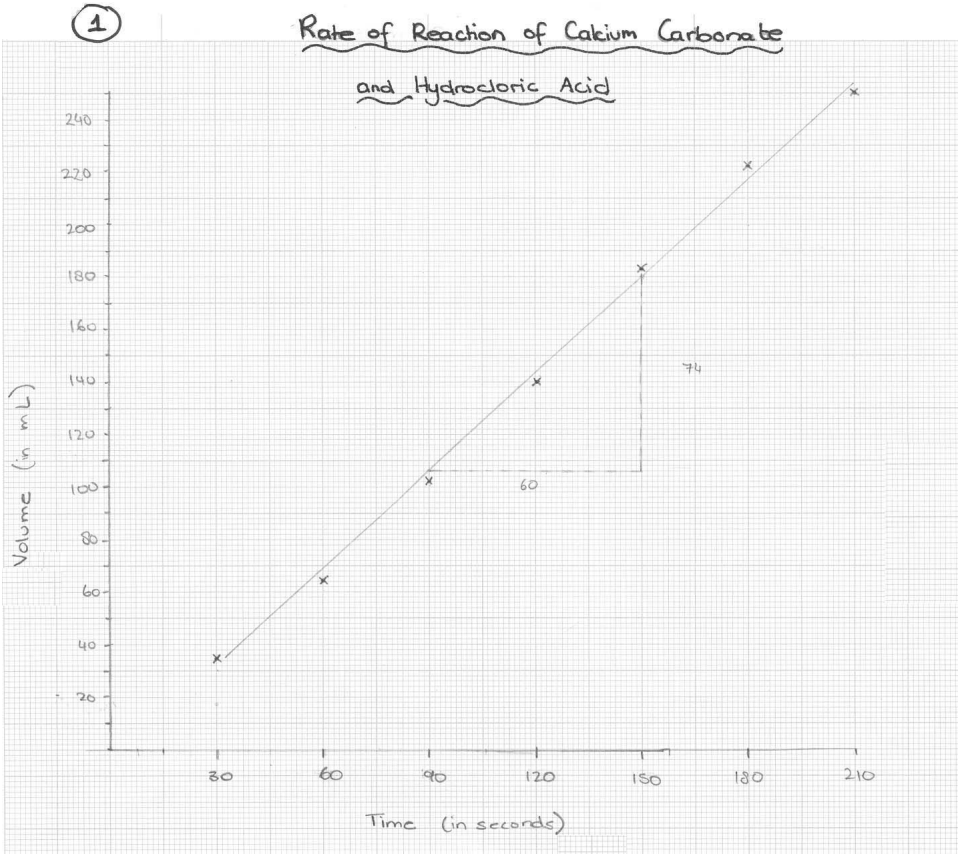

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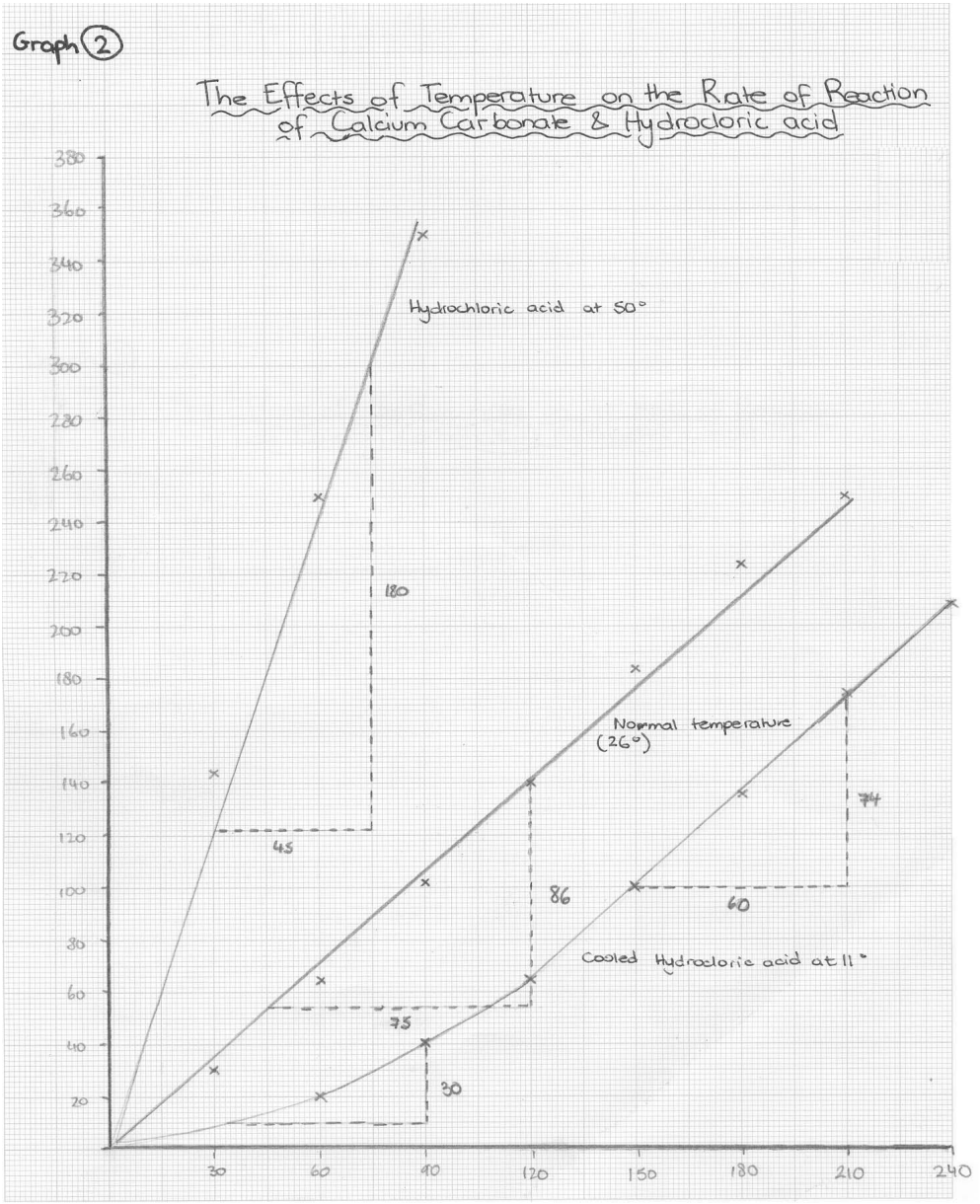
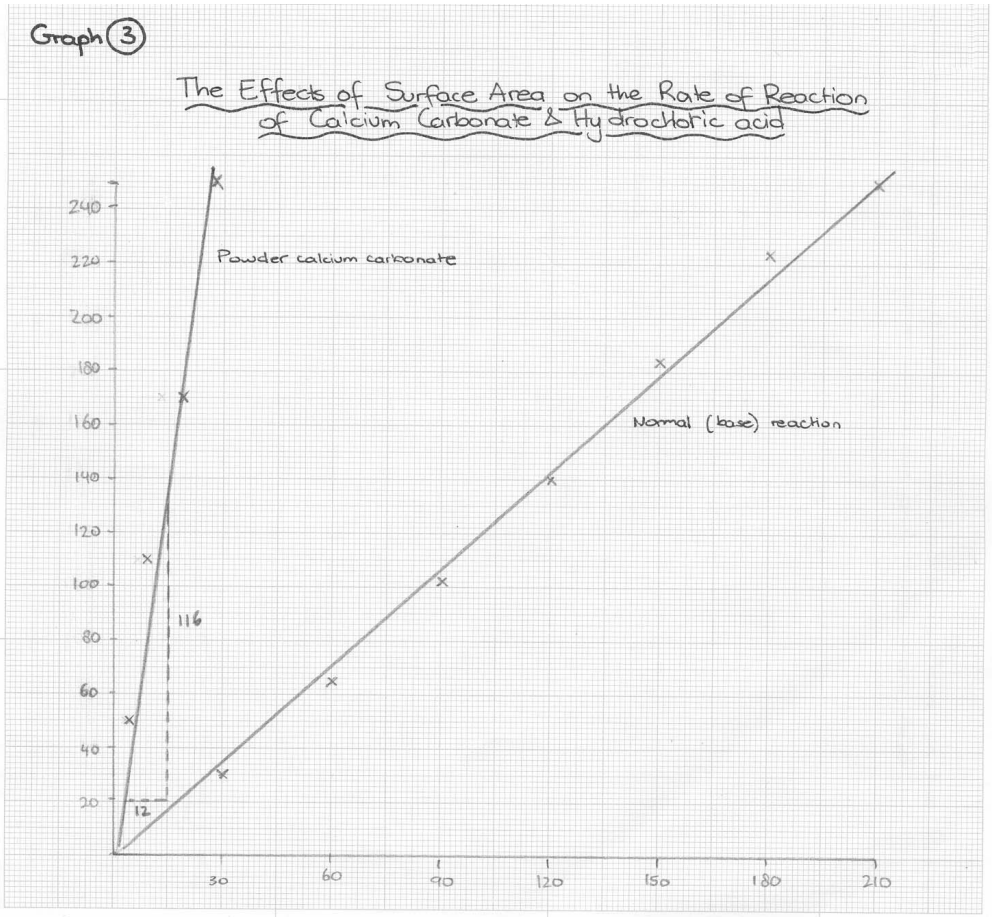

Graph (2)
The Effects of Temperature on the Rate of Reaction of Calcium Carbonate & Hydrocloric acid
Hydrochloric acid at 50°
Normal temperature (26°)
Cooled Hydrocloric acid at 11°
180
45
86
75
74
60
30
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
30
60
90
120
150
180
210
240



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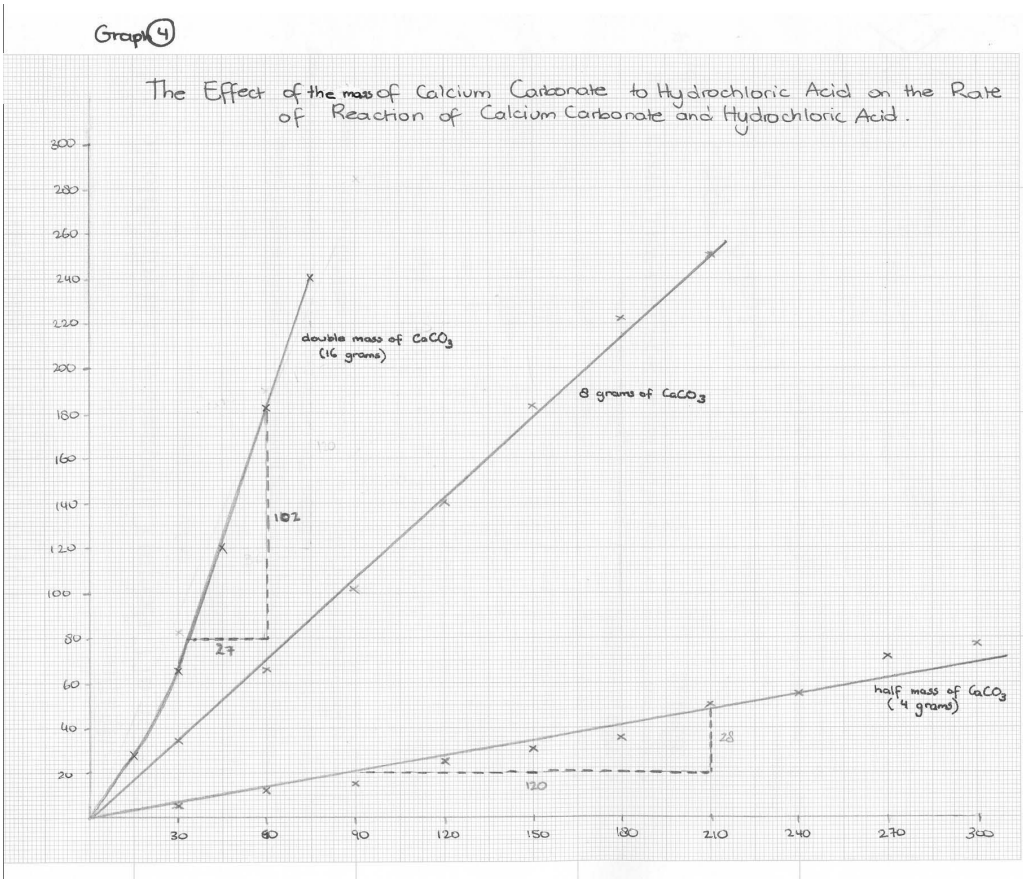
Graph 4
The Effect of the mass of Calcium Carbonate to Hydrochloric Acid on the Rate of Reaction of Calcium Carbonate and Hydrochloric Acid.
double mass of $CaCO_3$ (16 grams)
8 grams of $CaCO_3$
half mass of $CaCO_3$ (4 grams)
102
27
28
120
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
30
60
90
120
150
180
210
240
270
300

Example 9: Rate of marble destruction investigation

Scientific investigation—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	5	6	*

Background

Students had studied chemical reactions in their chemistry classes. The issue of acid rain was used as an example of a chemical reaction occurring in nature, which causes damage to limestone buildings. Students had to design an experiment to investigate which factors were involved in the chemical weathering of limestone. They were given time to research and plan their investigations before conducting the experiments.

Even though the student whose work is reproduced here chose to produce computer-generated graphs, this was not required in the task. Many other students produced graphs by hand with equivalent results.

Students' experimental reports were assessed using criteria D, E and F.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 5 because the student:

- defines the purpose of the investigation and predicts possible factors (such as acid concentration, temperature and the surface area of the particles) that will affect the rate of reaction
- formulates a testable hypothesis and explains it using scientific reasoning
- designs, plans and carries out three independent experiments to investigate the effect of acid, temperature and surface area, and proposes a suitable hypothesis for the other two experiments
- identifies the relevant variables involved in the experiment and clearly shows how to manipulate and control them effectively through the experimental designs
- suggests a method that is complete, including numbered instructions of steps to be followed, appropriate lists of materials and equipment and useful diagrams to illustrate the apparatus used.

This work did not achieve level 6 because the student does not fully discuss sources of possible errors in the evaluation of the method and misses opportunities to account for the reliability of the data.

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Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
5–6	The student organizes and transforms data into numerical and diagrammatic forms and presents it logically and clearly, using appropriate communication modes. The student **explains trends, patterns or relationships** in the data, comments on the reliability of the data, draws **a clear conclusion** based on the correct interpretation of the data, and explains it using **scientific reasoning**.

This work achieved level 6 because the student:

- clearly organizes and transforms data into numerical, tabular and graphical form: the tables presented are clearly labelled with titles and appropriate units; the graphs have suitable scales, clearly labelled axes and the curves are easily identified by the use of appropriate keys
- provides a thorough analysis of the results, indicating the presence of trends and relationships in the data, and draws clear conclusions supported by empirical evidence and scientific reasoning.

Criterion F: attitudes in science

(Please note: criterion F is assessed but not moderated). Students were expected to observe safety measures and take precautions when dealing with acids and manipulating laboratory equipment.

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Student work

Chemical factors influencing on the rate of marble destruction

Basic information:

Chemical reactions run with different speed. Some chemical reactions can be very quick; others can run for months or even years. It is known that the same reaction can run quickly or slowly depending on conditions. A large amount of architectural constructions consisting of marble and limestone are exposed to environment. What does influence on the rate of reaction? I easily answered this question thanks to study of theme "Rate of chemical reaction and factors influencing on the rate"

Factors that can change rate of reaction are

- Size of solid reagent chips
- Concentration of reagent in solution
- Temperature
- Presence of light
- Adding of catalyst
- Degree of mixture (for solid chips)

Problem:

Thus, I define the problem of my investigation: what factors from the environment promote destruction of marble.

Hypothesis:

I know that acid rains lead to destruction of facades of buildings, sculptures and other constructions, if they contain limestone or marble, calcium carbonate in other words. Acid can dissolve it. I think that a reaction of calcium carbonate with solution of hydrochloric acid can be held. The following chemical reaction will take place with that going on:

$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

I predict that the concentration of the acid will influence on the rate of destruction of marble. The more is concentration of acid, the more is the probability of collision of molecules and the rate of the reaction increases. I want to run experiment using hydrochloric acid of different concentration.

I will collect carbon dioxide into measuring cylinder filled with water. Water will be displaced by CO_2 as carbon dioxide doesn't dissolve in water.

I think that temperature influence on the rate of destruction of marble as well. I predict that this factor will influence on the rate of destruction of architecture monuments made from marble in the places where the temperature changes rather frequently and the sun warms greatly. This will happen as the number of active molecules moving fast grows with increase of the temperature and collision of molecules of acid and $CaCO_3$ become more energetic. That means that the rate of reaction grows.

I suppose that the effect of surface area also influences on the rate of destruction of marble. To prove my point I will make experiments using rather large chips of marble and very small (powder). I think the reaction with the powder will take place faster because the surface area is larger and collisions happen more frequently.

Other factors will affect less on the rate of destruction of marble.

Variables:

My method will include following main alterations

- The volume of carbon dioxide will change
- Concentration of acid will change in first experiment
- The second experiment will be run at different temperature
- I'll run the third experiment with large and small chips of marble.
- The mass of calcium carbonate is 2g in the 1^{st} experiment and 1g in 2^{nd} and 3^{rd}

The volume of acid taken in excess will remain the same in each experiment.

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Apparatus and equipment:

- Stop-watch
- Conical flask (100 cm^3)
- Heater
- Thermometer
- Measuring cylinder (250 cm^3 and 25 cm^3)
- Solution of hydrochloric acid (0.5M, 1M, 2M)
- Marble (small (powder) and large chips)
- Trough
- Scales
- Device for obtaining gas
- Coaster
- Clamp and stand

Instructions:

My plan lies in investigating of influence of concentration of acid, temperature and size of chips on the rate of reaction of dissolving of marble.

➢ *Experiment #1: Influence of concentration on the rate of chemical reaction*

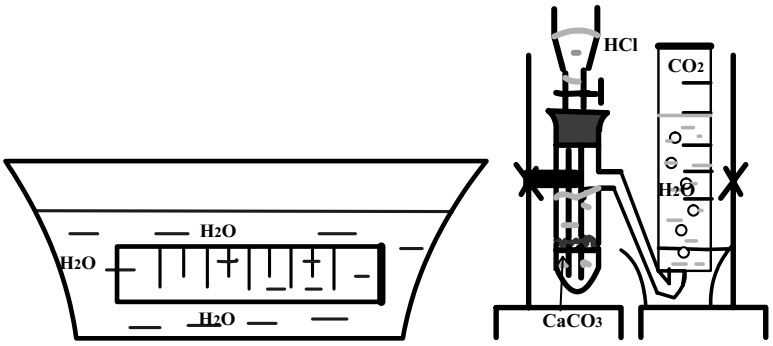
I will investigate the influence of concentration of acid on the rate of reaction. Therefore, I'll run experiment with 0.5M, 1M and 2M solution of hydrochloric acid. I'm going to put the volume of emitted gas down every 20 seconds.

1. Construct the device needed to get CO_2 in accordance with diagram 1.
2. Fill the trough with water, so that the larger measuring cylinder end was immersed into it.
3. Fill the measuring cylinder with water, so that there was no air in it.
4. Carefully turn the larger cylinder upside-down under water, in order not to let the air get into the cylinder, and fix it in clamp and stand vertically
5. Put chips of marble into device of obtaining gas
6. Place the bended rubber tube of the device under the measuring cylinder
7. Pour 40 cm^3 of 0,5M hydrochloric acid into boiling tube of the device
8. Measure the volume of emitted gas every 20 seconds and write the measurements down in a table
9. Repeat the experiment using 1M and 2M hydrochloric acid

Factors:

- Sizes of chips of marble – determined
- The mass of the taken marble – weighed
- The volume and concentration of acid – determined
- Time of collecting gas – determined every 20 seconds
- The volume of obtained gas – measured

Diagram 1



➢ *Experiment #2: Influence of temperature on the rate of chemical reaction*

I will investigate the influence of temperature on the rate of reaction. Therefore, I'll run experiment with 2M solution of hydrochloric acid at temperature of 20ºC, 30ºC and 40ºC. I'm going to write the passed time every 10 cm^3.

1. Follow steps 1-6 of experiment #1
2. Pour 40 cm^3 of 2M hydrochloric acid into boiling tube of the device
3. Watch the passed time every 10 cm^3 and write the measurements down in a table
4. Repeat the experiment at 30ºC and 40ºC

Factors:

- Sizes of chips of marble – determined
- The mass of the taken marble – weighed
- The volume and concentration of acid – determined
- Time of collecting gas – determined every 10 cm^3
- The volume of obtained gas – measured

➢ *Experiment #3: Influence of surface area on the rate of chemical reaction*

I want to find out the influence of the effect of surface area on the rate of reaction. I'll make the investigation with small and large chips and 2M solution of hydrochloric acid at temperature of 20ºC. I'm going to write the passed time every 10 cm^3.

1. Follow steps 1-5 of experiment #1
2. Put large chips of marble into device of obtaining gas
3. Pour 40 cm^3 of 2M hydrochloric acid into boiling tube of the device
4. Watch the passed time every 10 cm^3 and write the measurements down in a table
5. Repeat the experiment with small particles (powder)

Factors:

- Sizes of chips of marble – determined
- The mass of the taken marble – weighed
- The volume and concentration of acid – determined
- Time of collecting gas – determined every 10 cm^3
- The volume of obtained gas – measured

Results:

➢ *Experiment #1: Influence of concentration on the rate of chemical reaction*

I know the chemical equation of getting carbon dioxide. With the help of it I calculated what volume of 2M hydrochloric acid is necessary to have 2g of marble reacted.

$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

ν = 1mol ν = 2mol

M = 100g/mol M = 36.5g/mol

m = 100g m = 73g

$$1)\ \frac{100g}{73g} = \frac{2g}{xg}$$

$x = 1.46g$

$$2)\ \frac{1000\ cm^3}{73g} = \frac{y\ cm^3}{1.46g}$$

$y = 20\ cm^3$

- The mass of marble = 2g
- The volume of acid = 40 cm3
- The concentration of acid = 0.5M, 1M, 2M
- Temperature = room, 20ºC

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Table #1: Data of the experiment run with acid of different concentration

	0.5M acid	1M acid	2M acid
Time/seconds	Volume of CO_2/cm^3	Volume of CO_2/cm^3	Volume of CO_2/cm^3
0	0	0	0
20	8	20	37
40	16	35	54
60	23	45	63
80	30	53	69
100	35	58	74
120	42	63	76
140	48	70	78
160	54	74	80
180	60	76	
200	65	80	
220	70		
240	75		
260	80		

Graph #1: Data from the table #1 is shown in graph as dependence of emitted CO_2 on time

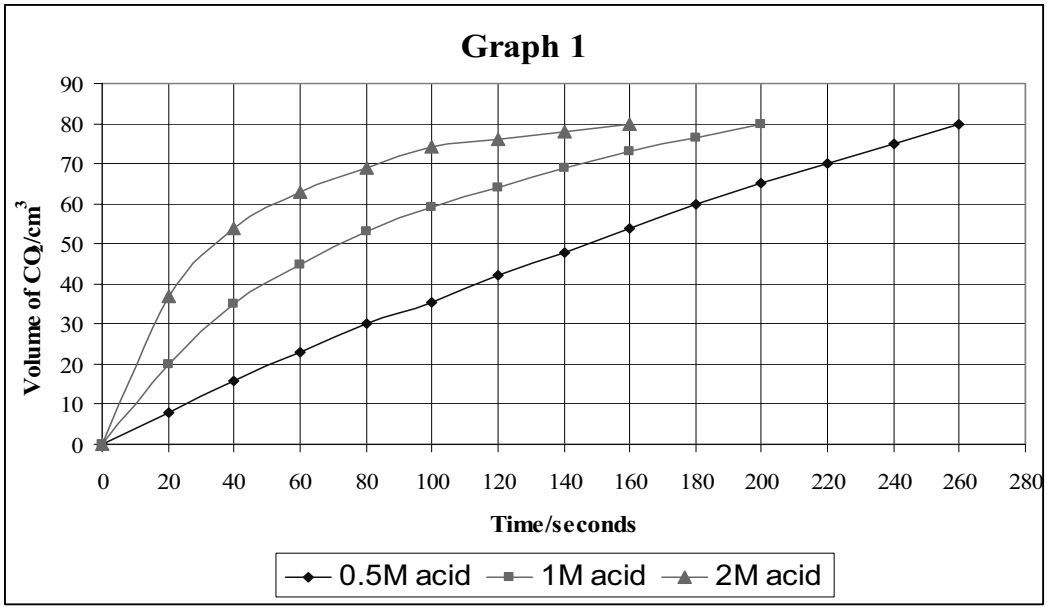

Table #2: Data from Graph 1 showing the passed time according to every 10 cm^3 of CO_2

	2M acid	1M acid	0.5M acid
Volume of CO_2/cm^3	Time/seconds	Time/seconds	Time/seconds
0	0	0	0
10	5	10	25
20	10	20	51
30	16	32	80
40	23	49	113
50	33	72	146
60	52	104	180
70	83	144	220
80	160	200	260

Analysis of experiment #1: the data of the tables proves the rate of reaction increases with increase of concentration of acid and graph 1 clearly shows that. It takes reaction 260 seconds to stop at the point of 80 cm^3 of CO_2 when 0,5M acid is used while it takes only 200 seconds when 1M acid is used and 160 seconds in reaction with 2M acid is used.

- *Experiment #2: Influence of temperature on the rate of chemical reaction*

  I run the experiment with 2M hydrochloric acid, but the reaction went too fast. While the first 250 cm^3 the rate was about 2 seconds per 10 cm^3. That's why I chose 0.5M acid for the investigation. I calculated what volume of 0.5M hydrochloric acid is necessary to have 1g of marble reacted.

  $CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)
  ν = 1mol ν = 2mol
  M = 100g/mol M = 36.5g/mol
  m = 100g m = 73g

  1) $\frac{100g}{73g} = \frac{1g}{X}$

  x = 0.73g

  2) $\frac{1000\ cm^3}{73g} = \frac{y\ cm^3}{0.73g}$

  y = 10 cm^3

  - The mass of marble = 1g
  - The volume of acid = 10 cm3
  - The concentration of acid = 0.5M
  - Temperature = 20ºC (room), 30ºC, 40ºC

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Table #3: Data of the experiment run at different temperatures

	Temperature of 20ºC	Temperature of 30ºC	Temperature of 40ºC
Volume of CO_2/cm^3	Time/seconds	Time/seconds	Time/seconds
0	0	0	0
10	36	7	0.5
20	69	17	1
30	105	31	2
40	150	56	9
50	190	82	20
60	240	117	39
70	304	166	62
80	390	240	103
90	498	350	145
100	670	508	220

Graph #2: Data from the table #3 is shown in graph as dependence of emitted CO_2 on time

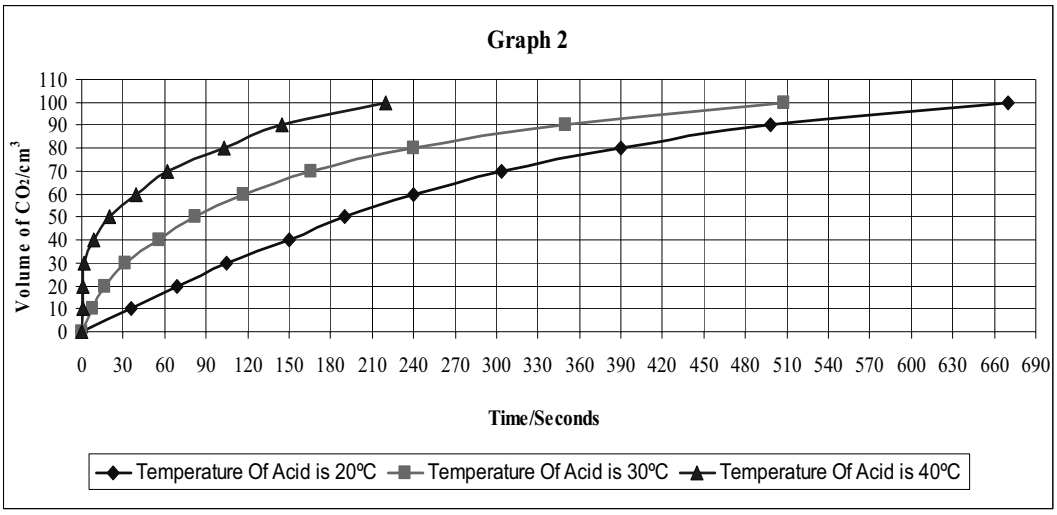

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Table #4: Data from Graph 2 showing the volume of CO_2 collected every 30 sec

	Temperature of 20ºC	Temperature of 30ºC	Temperature of 40ºC
Time/minutes	Volume of CO_2/cm^3	Volume of CO_2/cm^3	Volume of CO_2/cm^3
½	8,3	31	56
1	17	41	69
1,5	26,7	53	77,5
2	33,4	60,8	85
2,5	40	67,5	92,5
3	48,2	72,5	95
3,5	55	76,6	98
4	60	80	
4,5	65	83	
5	70	86	
5,5	73,8	88,5	
6	76,8	91	
6,5	80	93,5	
7	83,5	95	
7,5	87	97	
8	88,4	98,5	
8,5	91,7	100	
9	92,5		
9,5	94		
10	96		
10,5	97,5		
11	99,5		

Analysis of experiment #2: the data of the tables proves the rate of reaction increases with increase of temperature of acid and it can be neatly understood from graph 2. It takes 670 seconds to emit 100 cm^3 of CO_2 at the temperature of 20ºC while it takes only 508 seconds to produce the same amount of CO_2 at the temperature of 30ºC and 220 seconds in reaction when the acid is heated to 40ºC.

- *Experiment #3: Influence of surface area on the rate of chemical reaction*
  Again, when I run the experiment with 2M hydrochloric acid, the reaction went too fast and I chose 0.5M acid for the investigation. The volume of acid remains the same as in experiment #2

  - The mass of marble = 1g
  - The volume of acid = 10 cm3
  - The concentration of acid = 0.5M
  - Temperature = 20ºC (room)

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Table #5: Data of the experiment run with chips of different size

	Large chips	Small chips (powder)
Volume of CO_2/cm^3	Time/seconds	Time/seconds
0	0	0
10	0,5	0,5
20	1	1
30	3	1.5
40	9	4
50	16	5
60	25	7
70	33	9
80	42	11
90	51	13
100	62	16
110	75	20
120	90	26
130	109	35
140	130	53
150	154	78
160	180	105

Graph #3: Data from the table #5 is shown in graph as dependence of emitted CO_2 on time

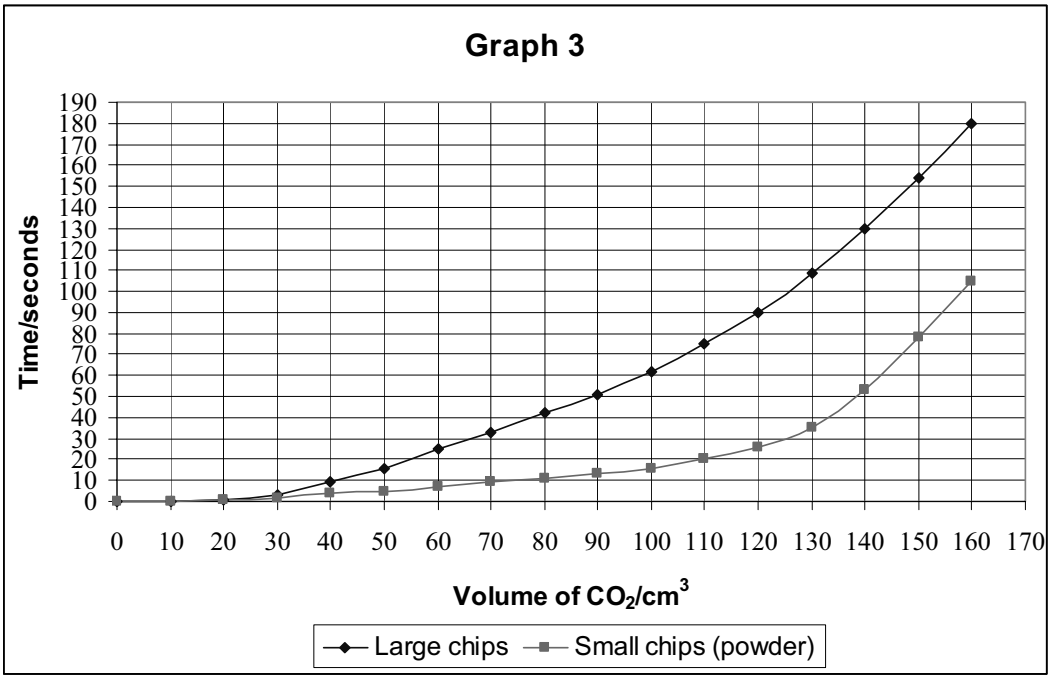

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Table #6: Data from Graph 3 showing the volume of CO_2 collected every 30 sec

	Large chips	Small chips
Time/minutes	Volume of CO_2/cm^3	Volume of CO_2/cm^3
0	0	0
½	65	125
1	98	142.5
1.5	120	155
2	134	
2.5	148	
3	160	

Analysis of experiment #3: The graph of large chips ends at the point equal to 180 seconds while the other one ends in the point of 105 seconds. The reaction is faster for the small chips. This means that the rate of reaction increases with increase of surface area of marble.

Conclusion:

The reaction of dissolving of marble took place with gassing and formation of water and calcium chloride

$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

My predictions concerning influence of concentration of acid on the rate of reaction are confirmed. The rate of reaction increases with growth of concentration of reagents. My results proved that my predictions are right. For example, the volume of emitted carbon dioxide after 1 minute is

	0.5M acid	1M acid	2M acid
Time/minutes	Volume of CO_2/cm^3	Volume of CO_2/cm^3	Volume of CO_2/cm^3
1	23	45	63

Why does the rate of reaction increase with the growth of concentration of solution?

The necessary condition for two particles (molecules, atoms) to react is collision. More precisely, the particles should draw together so close, that the atoms of one among them experienced action of electrostatic field made by atoms of another particle. Regrouping of atoms is possible only in that case. As a result, molecules of new substances occur – products of reaction. That's why the rate of reaction is proportional to number of impacts.

The higher is the concentration of reagents, the more the number of collisions is as there are more molecules of acid available. My results show that the fastest reaction is the reaction with 2M acid, the slowest is the reaction with use of 0.5M acid.

According to the experiment I can say with confidence that acid rains lead to destruction of facades of buildings, sculptures and other constructions made from marble. And the destruction will be heavier where the acid rains happen more frequently and their concentration is higher, i.e. near large industrial plants and factories, major highways.

My thoughts about influence of temperature on the rate of reaction are right too. The results after one minute are

	Temperature of 20ºC	Temperature of 30ºC	Temperature of 40ºC
Time/minutes	Volume of CO_2/cm^3	Volume of CO_2/cm^3	Volume of CO_2/cm^3
1	17	41	69

The rate of reaction increases when the reagents are heated. This happens because particles (molecules, atoms, etc.) receive some amount of energy needed to split or loose bonds. This is necessary to form new compounds. If collisions of molecules do not have the amount of energy, the collision won't be effective and won't lead to forming of new molecules. That's why such energy is called activation energy. In addition, the heat turns into kinetic energy and makes molecules move faster. It leads to more frequent collisions and the rate of reaction increases. I can conclude if the temperature is lower than some minimum then the reaction won't take place.

The results show that more collisions took place after one minute at temperature of 40ºC and the lowest rate was recorded at the temperature of 20ºC. The ratio of results made at the temperature of 30ºC to 20ºC is equal to 2.4; ratio of 30ºC to 40ºC is 1.7 Therefore, I can make conclusion that the

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rate increases almost twice with every 10ºC. Then the destruction of constructions made of marble is heavier in the places where there's much sunlight, climate is hot and buildings and sculptures become heated.

I predicted that the size of chips influences the rate and my suggestion was proved.

	Large chips	Small chips
Time/minutes	Volume of CO_2/cm^3	Volume of CO_2/cm^3
1	98	142.5

The smaller chips are the less time is needed to dissolve them. This happens because the surface of collision is larger. The molecules of acid can interact with greater number of molecules of marble and the rate increases proportionally. The result proves the statement. The rate of destruction of powder is 1.5 times more than the rate of destruction of large chips of the same mass. That's why blasted or corrupted monuments destruct faster in acid rains.

Evaluation of my investigation:

All in all my investigation went well. All my predictions were confirmed by the run experiments. I suggested three factors that were based on my knowledge. My conclusion is connected with hypothesis. I'm sure that if I consult the chemistry manual I'll find the same factors I suggested.

As my hypothesis was right then the procedure and equipment are right too. The main benefit of my method is in possibility of running the experiment in rather informal places. But it's crucial to follow the rules of safety as something may go the way a person doesn't expect.

I was very accurate when I was running the experiment; used chips of approximately equal size. However, I believe that the result may vary a bit as I was not able to use identical chips and the surface of interaction is a factor influencing the rate of reaction. To be surer in the results it is necessary to run experiments several time, what will allow finding average I couldn't do that due to limit in time.

If I had more time, I could investigate more factors. I know that amount of reagents influence on the rate of reaction. In addition, different catalysts also affect the reaction. I'm living in mountain area where the pressure is lower and the level of humidity is low. I want to investigate how the experiment would go in other conditions.

I believe the investigation I made has some significance. I found out a lot of important data that can be used by other students.

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Example 10: Rate of enzyme reaction investigation

Scientific investigation—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	4	2	-

Background

As part of a unit on enzymes, students were asked to design a scientific investigation to investigate the effect of a given factor on the rate of an enzymatic-controlled reaction. Students had to research the factors affecting the rate of chemical reactions in general, and enzymatic reactions in particular. Factors such as temperature, pH, enzyme and substrate concentration and the presence of inhibitors and activators were suggested. Students discussed these factors with the teacher and individually decided to study one factor each.

The system of liver catalase was used as an enzymatic model and fresh pig liver tissue was used as the source of enzyme. The teacher demonstrated the action of the liver catalase on the decomposition of hydrogen peroxide into oxygen and water and the effervescence produced as a result, as in the equation below.

$2\ H_20_2$ catalase $\longrightarrow$ $H_20 + O_2$ effervescence

Students designed practical investigations independently to determine the effect of one selected factor on the rate of the enzymatic activity of catalase.

The student whose work is reproduced here chose the effect of temperature on the rate of catalase enzymatic reaction and the decomposition of hydrogen peroxide into water and oxygen. The rate of the enzymatic reaction was measured by the volume of oxygen gas liberated, as shown by effervescence.

Students were assessed in their ability to design and carry out a scientific investigation by being able to formulate a suitable hypothesis, identify and manipulate variables and design a suitable method. After conducting the experiment, they produced an evaluation of the suitability of their methods in rendering reliable results.

The task was assessed using criteria D and E.

Note: All orthographical or content errors remain as per the original work.

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Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
3–4	The student **defines** the purpose of the investigation and provides an **explanation/prediction** but this is not fully developed. The student acknowledges **some of the variables** involved and describes how to manipulate them. The method suggested is **complete** and includes appropriate materials/equipment. The **evaluation** of the method **is partially developed**.

This work achieved level 4 because the student:

- clearly defines the purpose of the investigation
- acknowledges some of the variables involved and describes how to manipulate them, but makes some errors and omissions (for example, in the references to pig liver size, enzyme concentration and the effect of pH)
- suggests a method that is complete and includes appropriate material and equipment, but does not communicate effectively the way in which the experiment was actually designed and the degree of assistance received from peers and the teacher
- evaluates the method, including an acknowledgment of critical errors made during experimentation, and suggests some ways to improve the investigation.

This work did not achieve level 5–6 because the student:

- articulates information leading up to the formulation of a hypothesis, but this is not fully developed and supported by sufficient scientific reasoning (for example, he/she does not support his/her reasoning with scientific knowledge about enzymes and their properties as biological catalysts)
- makes some mistakes in identifying the relevant variables involved and the concept of fair testing is not fully developed in the explanation of variable manipulation and control
- misses many opportunities to discuss the reliability and validity of the method used (for example, he/she does not suggest doing more trials or increasing the precision and accuracy of the measurements).

Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
1–2	The student **organizes** and presents data using **simple numerical or diagrammatic forms** and draws an **obvious conclusion**.

This work achieved level 2 because the student:

- organizes and presents the results in a simple table and a graph and draws an obvious conclusion
- observes general trends in enzyme reaction rates and discusses these in the analysis of the data.

This work did not achieve a higher level because the amount of data generated is insufficient to assess fully the student's ability in data processing and analysis. Multiple trials and several readings should have been built into the experimental design to allow the manipulation of larger amounts of data. The results could also have been extrapolated to those of other students or textbooks for further analysis.

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Student work

Rate of Enzyme Reaction

Problem:

It is known that enzymes are proteins, they are specific in their action, and they can be used over again and their sensitive to pH. Enzymes speed up a chemical reaction and do not contribute to the product[1] but the rate of enzyme reaction is not known for different factors that affect the rate of reaction. Therefore there is a need for us to investigate a factor that affects the rate of enzyme reaction. In this case we will be investigating temperature, to see how temperature affects the rate of enzyme reaction.

Hypothesis:

I know that to some extent heat will affect the rate of an enzyme reaction because raising the temperature increases the random movement of a molecule as a result the rate of enzyme reaction is increased.

Method:

Trial runs should be conducted before we start our actual experiment. Firstly a tripod stand, gauze and beaker will be set up. A clamp stand will be adjusted to fit a test tube that is to be placed into the beaker; a thermometer will also be placed inside the same beaker, which will be held up by a clamp. In order to carry out the first trial experiment for the 15 degrees Celsius, two different beakers should be filled with water; one beaker is to have ice water and the other have boiling water. A bit of hot water is to be placed into the beaker with the thermometer placed in it, this will read a temperature of about 80 Degrees Celsius to bring the temperature down ice water should be poured into the beaker. Until the temperature stays at a steady 15 degrees Celsius the trail experiment can be continued.

Fresh pig liver will be used in this experiment because catalase enzymes are present in the liver. The pig liver must be cut up into small equal pieces and placed on the electric scale to give a reading of 35 grams. Which is the chosen amount of pig liver that will be used in the experiment. The 35 grams of pig liver ought to be placed into the test tube, which will also be placed in the 15 degrees Celsius beaker of water. This will be left and timed in the beaker for 2 minutes so that the enzymes can accustom themselves to the working environment and the 10 ml of hydrogen peroxide must be poured into the test tube. The 15 degrees Celsius should be kept constant through out the whole experiment so that accurate results can be achieved. After sometime of observing white bubbles are to be seen forming around the pieces of pig liver also the pieces raised and fell to the bottom of the test tube and the surface of the hydrogen peroxide.

For the actual experiment, the same equipments are to be used but different amounts of pig liver ought to be cut. 5 grams of pig liver will be used where the displacement method should be set up. A basin will be filled with water and placed beside the tripod set up. Next a measuring cylinder should be filled to the brim with water and placed up side down in the basin of water, which will be held up with a clamp. A delivery tube connected to a rubber bung will firstly be filled with air by blowing one end of the tube and blocking the other end with the tip of the finger. The tube should then be inserted into the opening of the measuring cylinder.

Once the 10ml of hydrogen peroxide is placed into the test tube with the 5 grams of liver and is timed for 2 minutes, the rubber bung should be inserted into the test tube and also timed for 5 minutes. During this period the same observations should be seen as in the trial experiment. The water level reading was ought to be taken after 5 minutes. For the remaining temperatures .the same method will be carried out.

[1] Roberts, M.B.V. 1986. Biology for Life. Thomas Nelson and Sons Ltd. Great Britain, p.148-l49.

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Apparatus:

- 1x 100°C Thermometer
- 1 x rubber bung
- 1x test tube
- 1x 100ml beaker
- 1x tripod stand
- 2x clamp
- 1x gauze mat
- 1x tweezers
- 1x 600ml beaker

- 1x 100ml measuring cylinder
- 1 x glass-stirring rod
- 1x 50ml measuring cylinder
- 1x delivery tube
- 1L block of ice
- 50ml hydrogen peroxide
- 50g pig liver
- 2L of boiling water
- 1x electric scale

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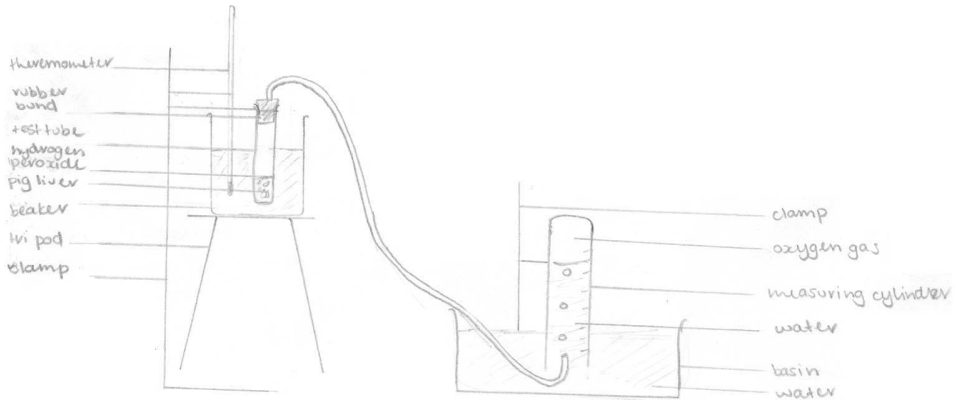
Diagram:



Variables:

1. Liver size: In order to have a fair experiment 5 grams of thinly cut liver pieces was decided to be used. Therefore the pH was kept constant through out the experiment.

2. The amount of hydrogen peroxide: Because a fair experiment was to be conducted, investigating how temperature affects the rate of reaction, it was decided that 5ml of hydrogen peroxide will be used for each five (5) different temperatures.

3. Temperature: Because this experiment is going to investigate how temperature affects the rate of enzyme reaction, the temperatures chosen were 5, 15, 35, 55 & 75 Degrees Celsius. Going from a range of low and high temperatures so that accurate results could be achieved.

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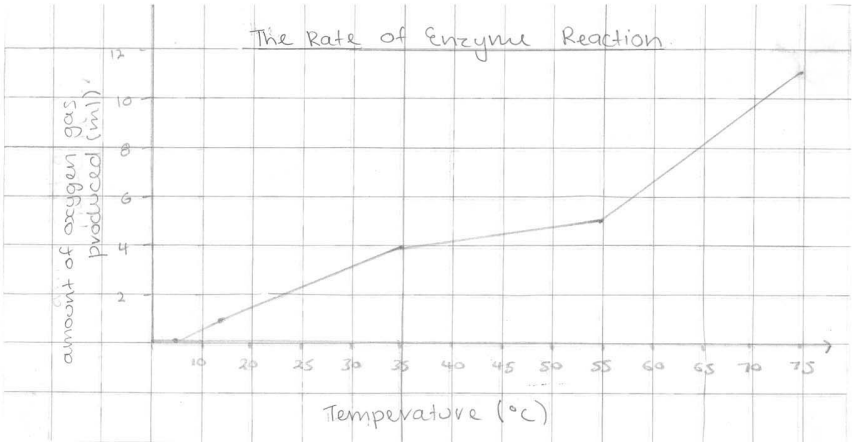
Results:

From doing trail experiments it was found that the rate of enzyme reaction could not be measured. So the displacement method was decided to be the best way to measure the rate of reaction in the actual experiment. It was also found that the pig liver was too thick (10mm) and was too much so we decided to use 5 grams of pig liver instead of 35 grams and have the liver more thinly cut (5mm).

With the displacement set up, bubbles were seen rising to the surface of the water, each time the water level dropped. The gas produced by the catalase enzyme and hydrogen peroxide was oxygen gas that was collected in the measuring cylinder.

It was planned to record all data collected in a table form where temperature, amount of liver, amount of hydrogen peroxide, time for reaction and amount of oxygen gas can be recorded in a way which it is easier to understand. Below are the results obtained from the experiment in table form.

Temperature (degrees Celsius)	Pig Liver (g)	Hydrogen peroxide (ml)	Time for reaction (min)	amount of oxygen gas (ml)
5	5	10	5	0
15	5	10	5	0.5
35	5	10	5	4
55	5	10	5	5
75	5	10	5	11



Comments on results:
From looking at the graph the results show us that from 5 degrees Celsius to 35 degrees Celsius the amount of oxygen gas produced took a moderate climb to 4ml of oxygen gas, from 35 to 55 Degrees Celsius the rate of enzyme reaction slightly increased to 5ml of oxygen gas and from 55 to 75 degrees the rate of enzyme reaction increased steeply to 11ml of oxygen gas being produced.

From the results obtained it is possible to say that my hypothesis was somewhat true. The rate of enzyme reaction increases as temperature increases.

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Explanation:
However from the conclusions that have been drawn, it was later found that the experiment was miss leading, the results that were achieved stated that the higher the temperature the faster the rate of enzyme reaction but it was found that after 45 degrees Celsius most enzymes stop working, this is because enzymes, being proteins, are denatured by heat.[2] With our experiment certain factors would 'have contributed to the results that were achieved. One being the liver being frozen when used in the experiment this would have dropped the temperature down in the test tube, making it a cool temperature than it is suppose to be. Another factor that would have dropped the temperature was the hydrogen peroxide, which was poured into the test tube with liver. The hydrogen peroxide was stored in the fridge and was pored straight into the test tube as soon as it was taken out of the fridge.

Evaluation:
After doing this experiment it was seen that improvements could be made so that accurate results could be achieved and therefore a logical conclusion could be drawn. These improvement factors included filling the delivery tube with air so that when oxygen gas is produced it is pushed through the delivery tube and up the cylinder more rapidly.

Other factors included is to have defrosted liver at room temperature not frozen packaged liver because it contributed to the temperature, varying the temperature therefore inaccurate results will be achieved.
Also to have the hydrogen peroxide at room temperature because when brought out of the fridge the hydrogen peroxide is cool and will also affect the temperature used to carry out the experiment in.
This experiment was time consuming because a range of temperatures had to be used in the experiment, for every temperature a new set of equipment had to be set up. The experiment had to be completed in after school hours as well as in Biology classes. In order to work faster you need to be more organized and assign different tasks for the experiment to different members in the group so that the experiment can take twice as less time.

Bibliography:

Roberts, M.B.V. 1986. Biology for Life. Thomas Nelson and Sons Ltd. Great Britain

Biology class notes

[2] Roberts, M.B.V. 1986. Biology for Life. Thomas Nelson and Sons Ltd. Great Britain, p.149

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Example 11: Nervous system investigation

Scientific investigation—Biology
MYP year 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	4	4	-

Background

As part of a unit on the human nervous system, students were asked to choose one reflex and design an investigation to test empirically the beliefs, misconceptions and scientific ideas they had about a particular reflex. Students were allowed to work in groups, brainstorming ideas and surveying other students' ideas. However, each student was expected to formulate their own hypothesis, design their own investigation and report their results appropriately in an individual laboratory report. Students were also asked to present their results through an oral presentation to the class. This presentation was assessed with a task-specific rubric, which had been designed by the teacher for oral presentations.

This task was assessed using criteria D and E.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
3–4	The student **defines** the purpose of the investigation and provides an **explanation/prediction** but this is not fully developed. The student acknowledges **some of the variables** involved and describes how to manipulate them. The method suggested is **complete** and includes appropriate materials/equipment. The **evaluation** of the method is **partially developed**.

This work achieved level 4 because the student:

- defines the purpose of the investigation and provides an explanation but this is not fully developed or supported by enough evidence
- does not detail the characteristics and the scope of the survey enough to support the hypothesis
- acknowledges some of the variables involved but makes occasional errors when defining them
- evaluates both the method and the results but misses opportunities to acknowledge important sources of error, such as individual variability, order of the administration of the tests, desensitization of the taste buds, effect of dilutions, size of the sample, number of trials, and so on.

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Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
3–4	The student organizes and **transforms** data into **numerical and diagrammatic forms** and presents it using **appropriate communication modes**. The student draws a **conclusion consistent with the data**.

This work achieved level 4 because the student:

- organizes and transforms qualitative data by presenting it in a table, and processes this data into a diagrammatic form
- draws a conclusion that is consistent with the results and acknowledges the limitations of the method in producing reliable data.

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Student work

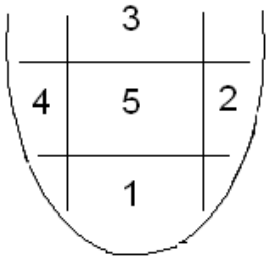
MYP Lab Report

Topic: Taste

Aim: To see in which part of the tongue each person feels more the acid, the sweet and the salt.

Research Question: In which regions does each person feels the different flavors (acid, sweet, salty)?

Hypothesis: The tongue was divided in the following regions:



It is thought that the salt will be tasted by most of the students in regions 1 and 5. The sweet will be more tasted by almost all students in regions 5 and 3. And the acid will be more tasted in regions 2 and 4. These facts are base on the opinion of a set of students surveyed previously who were asked where they mostly feel different flavors.

Variables: controlled (different flavors)

Dependent (regions of tongue)

Independent (flavor tested)

Materials:

- Sugar
- Salt
- Lemon
- Three beakers
- Water
- Three spoons

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Method:

1) First, put a little amount of water in three beakers (make sure they are clean), the same quantity in each one of them. Then, put the lemon juice, the sugar and the salt in each of the beaker. Mixed with a spoon (each beaker with its own spoon) to obtain solutions.
2) Second, use one spoon size to put the solutions in the mouth of each person tested.
3) Take notes of where did the person felt more the taste.
4) Then make him wash his mouth with normal water so all the mixture comes out.
5) In fourth place drop the next mixture in his mouth.
6) Take notes of where did the person felt more the taste.
7) Then make him wash his mouth with normal water.
8) Next repeat the same procedure with the last flavor.
9) Finally repeat all he method with nine more students.

Variables:

- Dependent: Regions.
- Independent: Taste.

Observations:

- Student 1: He felt the salt very much.
- Student 2: He felt very little the sugar.
- Student 3: No observation.
- Student 4: No observation.
- Student 5: He felt the salt so strong that he had to spit it out.
- Student 6: No observation.
- Student 7: He felt all the flavors in the edges of the tongue.
- Student 8: He felt the lemon under the tongue.
- Student 9: He felt the salt all over the tongue. He choose the region where he felt the most.
- Student 10: No observation.

Almost all of the students which tasted salty they spit it out because is was to strong to them and also disgusting.

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Results:

Student	Salty	Sweetie	Acid
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

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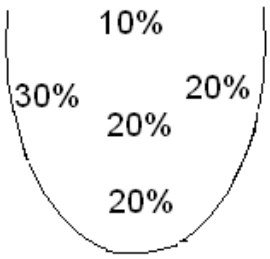
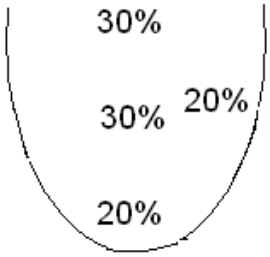
Graphics:

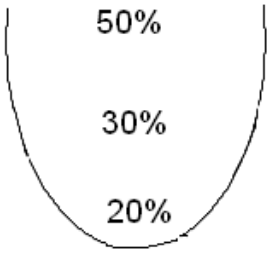
- Acid:



- Sweet:



- Salt:



Conclusion:

The first conclusion seen through the analysis of the drawings above made with the result is that the method is not reliable. This is because all the flavors were tasted almost in the same region with the exception of the acid which was detected at both sides too.

This fact is based in the study of the real evidences taken from theory, which says the following about the region of taste in the tongue,

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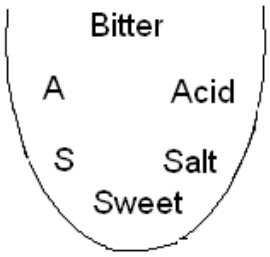

- My hypothesis was partly wrong and partly right. My Statement one said that most of the students would feel the salt in regions 1 and 5. The majority of the students felt it in regions 3 and 5. And two of them felt it in region 2 and other two felt it in region 1.
- The second statement was that almost all the people would feel the sweet in regions 5 and 3. In this case my hypothesis was correct. Most of them (60%) felt it in those regions, it wasn't right.
- Finally my last statement was that students would feel acid in the edges, regions 4 and 2. In this case my hypothesis was correct. But only half of the students felt the lemon in regions 4 and 2. The remaining 50% felt it in regions 1, 3 and 5.

Finally we did almost everything bad in our experiment. We didn't make the proper investigation, so now we can analyze very little. But comparing our results with the results that should have gave us the following happened.

In first place the students should felt acid in the superior side of the tongue. But as we divided the regions differently we got to the conclusion that the 50% of the students felt the acidity in the edges. (We can't know if they were in the superiors or inferiors ones).

Secondly students should have felt the sugar in section. Instead just the 20% felt it there.

Finally the salt should have been felt by students in the inferior side of the tongue. Instead no student felt it in any side (nor superior or inferior).

As we didn't investigated enough we didn't noticed that we should test with bitter as well so we missed it.

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Improvements:

Investigate: We should have made a good investigation because we missed many things which could made our experiment more interesting.

In future investigation:

- Where is supposed the people to feel each flavor.
- Divide the tongue regions according to it.
- Which are the flavors we need to test.

Instead of using a spoon to put in flavors use a hyssop, people don't confuse the flavor in the whole tongue. Why is better a hyssop than a spoon? Because a spoon makes all the mixture spread over the whole tongue however the hyssop makes the mixture stable in one region only and its more neat.

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Example 12: Responding to the environment investigation

Scientific investigation—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	2	-	4	2	*

Background

Students had covered aspects of sensory reflexes and the general structure and function of the human nervous system. They were asked to design an investigation to test one aspect of the sensory nervous system and report their findings. Students were allowed to work in groups brainstorming ideas until they came up with one aspect to test individually.

This task was assessed using criteria B, D, E and F.

Note 1: The names of the subjects tested have been changed to letters to protect their identities.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
1–2	The student **attempts** to communicate scientific information using **some scientific language**. The student presents some of the information in an appropriate form using some symbolic or visual representation when appropriate. The student attempts to acknowledge sources of information but this is **inaccurate**.

This work achieved level 2 because the student:

- communicates scientific information using some scientific language but makes some mistakes in using the correct terminology
- presents some information in an appropriate form but misses the opportunity to include a diagram to illustrate the method, as well as charts or graphs for the results
- attempts to acknowledge sources of information but this is incomplete and does not follow a recognized referencing convention.

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Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
3–4	The student **defines** the purpose of the investigation and provides an **explanation/prediction** but this is not fully developed. The student acknowledges **some of the variables** involved and describes how to manipulate them. The method suggested is **complete** and includes appropriate materials/equipment. The **evaluation** of the method is **partially developed**.

This work achieved level 4 because the student:

- defines the purpose of the investigation, although with some difficulty
- formulates a hypothesis and attempts to explain it using scientific reasoning
- attempts to support the hypothesis with scientifically supported reasoning, but some of the assumptions are incorrect
- identifies most of the variables involved and distinguishes between the dependent and independent ones
- attempts to comment on the reliability of the results and the accuracy of the measurements, including the number of readings and trials
- comments on issues related to the validity of the method used and suggests improvements for further investigations.

Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
1–2	The student **organizes** and presents data using **simple numerical or diagrammatic forms** and draws an **obvious conclusion**.

This work achieved level 2 because the student:

- presents data clearly using a table but misses the opportunity to organize the results into bar charts or histograms and provide a comprehensive analysis of the results (for example, comparison between boys and girls, different age intervals, and so on).

Criterion F: attitudes in science

*(Please note: criterion F is assessed but not moderated.)

The students were assessed on their ability to work cooperatively in groups and keep a safe working environment.

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Student work

Responding To The Environment

Plan…

1. **Aim:** In this experiment, I am going to find out which sensory organ is most sensitive to the environment; by observing how quickly each of them responds to the environment. In this experiment we are going to be comparing 3 different senses, which are touch, sight and hearing. Moreover, we are going to discover whether the age, and health condition of the person, can affect the sensitivity of different organ
2. **Hypothesis:** I predict that in general our sight will be the most sensitive, then the auditory will be second sensitive, and sense of touch will be the least sensitive. In Wikipedia encyclopedia, sense is described as a system that consists of a sensory cell type (or group of cell types) that respond to stimuli within the brain where signals are received and interpreted. When we are doing this experiment, the volunteer would see, hear, or feel that the ruler is falling down, and send the message to the brain, which then gives out the message to catch the ruler and respond. Therefore, the sensitivity (how quickly it responds) of the organ depends on the speed of message that reaches brain and comes back. The shorter the path to brain is, the faster it reacts. In order to have a shorter path to the brain, the organ should be situated near the brain. Therefore sight, which is detected by eyes situated right below brain, would react fastest. The auditory system which is located little bit below eyes would react second fastest. The slowest reaction would come from touch, since we are testing the sense of touch of your arm that is located far below your brain. Moreover, light is much faster than sound waves, and I was pretty sure that sight (vision) would be more sensitive than hearing. Furthermore, I expect all volunteers reaction time to improve within practice. As we know, through neuron, we get to deliver the message or the stimulus from the environment to the brain. When the cells detect the same stimuli, they remember the stimuli. As a consequence when we repeat the same action and provide same stimuli, they react faster as we repeat the experiment continuously.
3. **Apparatus:** 1m ruler, cloth (to cover up your eyes), volunteers, headphone
4. **Plan/Method:**
   - We are going to find out which sensory nerve is the most sensitive to the environment and respond to it (The three different sensory nerves are touch, sight, and hearing).

   How quickly sight reacts to environment

   - Partner holds the ruler so that the part where 0cm is comes to the bottom.
   - Wear headphones so that the results will be accurate.
   - Let your partner drop the ruler
   - Now you are the one who should catch the ruler.
   - Check how quickly you responded to sight (light) by checking the location (distance) of your hand from 0cm.

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How quickly hearing senses react to environment

- Partner holds the ruler so that the bottom part of the ruler (where 0cm is) is pointing the floor.
- Let your partner cover your eyes with a cloth.
- Now your partner shouts "Go!" or "Start!" to inform you when they are dropping the ruler.
- As soon as you hear the word, try to catch the ruler.
- Check how quickly your hearing senses responded to environment by reading the distance of your hand from 0cm.

How quickly tactile sense reacts to environment

- Partner holds the ruler, with its bottom part pointing the floor.
- Cover your eyes, and ear with a cloth
- Your partner slightly hits or pinches you to inform you when they are dropping the ruler.
- As soon as you feel something, you try to catch the ruler.
- Check how quickly your tactile sense responded to environment (use the same method as the experiment above).

5. **Dependent Variables:** What we are going to measure in the experiment is the distance of your hand (where you caught the *ruler*) from the 0cm part of your hand.
6. **Constant Variables**
   - Distance between your hand (how far is it from the ruler) should be kept the same. The further your hand is from the ruler, the slower action you will get since it has more distance to travel and do what it is actually required to. In this experiment we will measure the distance between your hands and
   - Where the volunteer's hand is located (did they start from 0cm?) is another thing that must be kept same. This also has something to do with the location. When your hand is not positioned on 0cm, each and everybody would have different results, which are not accurate. So I have decided to make volunteers hand start from where 0cm of the ruler is.
   - Same ruler should be used for all experiments. All rulers are marked or drawn with slight difference, and if the width of one ruler is thicker than another, it will make the volunteer difficult to catch it, which will affect the result of the experiment.
   - The hand volunteer use for the experiment is another thing to consider. We would need to find out whether the volunteer is left or right handed, and let them use the one that they feel comfortable with. Otherwise, the experiment won't be fair.
   - We should use same volunteer for one set of experiments (one volunteer should be involved in all 3 different experiments) since we are trying to compare three different types of sensory nerves. However each and every human being has slightly different structure of body. One person might have more developed sensory nerve than auditory nerve. Therefore, we should use same volunteer for one set of experiments.

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7. Independent Variables

- We should try a set of experiment to various people to find out how differently grouped people react to the environment (compare the results by grouping the results in different age, sex, nationality, etc…)
- In one set of experiment we should vary types of nerve/body part we are making the volunteers use. In this particular experiment, we are making others use their ears, eyes, and sense.

Doing…

1. For each person we had to carry on 9 different experiments. 3 for vision, another 3 for audition, and the last 3 for the touch in order to get an accurate result. In the table and graph I will write down only the average results.
2. Some people weren't able to catch the ruler. Which shows that the organ they are using is not sensitive enough to catch the ruler within 1 m. For the people who dropped the ruler I would just consider it as 1m.

How sensitive your organs are/how quickly they react to light, sound and feeling

Subjects	Sex	Age	Vision(cm)	Auditory(cm)	Taction(cm)
A	M	11	44	52	51
B	M	11	30	35	30
C	F	11	47	57	58
D	M	11	32	25	46
E	F	12	26	46	29
F	M	12	21	73	22
G	M	12	18	20	14
H	F	12	30	77	27
I	F	12	39	23	14
J	M	13	27	25	22
K	M	13	26	29	19
L	F	14	22	74	41
M	M	14	19	31	56
N	F	15	21	32	16
O	F	15	14	20	17
P	M	15	11	59	49
Q	F	15	51	81	32
R	M	15	13	32	46
S	F	15	17	55	22
T	F	16	26	73	54
U	M	16	25	33	27
V	M	17	22	86	58
W	M	17	15	74	27
X	M	32	18	64	25
Y	M	40	14	38	46

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Concluding…

1. From the results I have found out, I discovered that lots of people have different results. In order to find out which of the results exist in large number, and are general, I had to draw a line on each of the graph to find out which sensory organ is more sensitive than the others.

   = 12 people (vision<taction<auditory)

   = 5 people (taction<vision<auditory)

   = 4 people (vision<auditory<taction)

   = 2 people (taction<auditory<vision)

   = 1 person (vision=taction<auditory)

   = 1 person (auditory<vision<taction)

The result is showing that most of the people's vision is more sensitive than taction, or the auditory system which matches my hypothesis. However, I thought the auditory organ would be more sensitive than taction, but I have actually deviated. The feeling (taction) was more sensitive than the auditory system. I was wondering why. Looking at the results in time sequence, I have found out that the results of most of the people in the experiment have improved as we repeated the experiment as I have though. From this I could predict that the more you carry on the experiment, the better results you will get.

The research I have done tells me that when looking at the falling ruler, stimuli travels to cerebrum by optic nerve. Then the cerebrum judge the situation, and through motor nerve, and contracts the muscle on your hand, so that we will grab the ruler as result. From this result we could tell that the path of auditory nerves transferring messages (stimuli) is more complicated than the optic nerves or taction.

Moreover, I have found out that fatty sheath in the neuron passes the nerve impulses. It means the amount of fatty sheath in the neuron can affect the impulses – the more fatty sheath will increase the speed of reaction. This is proving that most of our classmates have more fatty sheath in their optic nerves than auditory nerves. However there are exceptions. The amount of fatty sheath in our nerves can be different with different people. Some might have more fatty sheath in their auditory nerves than the optic nerves. This shows that different people have different body structure and explain why people got different results.

The data I have collected also shows that the size of the people (which relates to sex, and age as well) we are testing affects the results. The bigger the volunteer is, the slower results you get. According to what I have found out, I guess the bigger your body is, the longer the distance from your brain. Therefore, bigger and taller people had slower reaction. Which explain why female got quicker reaction. Girls in general are smaller than boys.

Resources…

- Michael, Robert. 1996. The Living World. Walton, UK.
- Biology for you
- http://ipcp.edunet4u.net/%7Eteacher07/study0/kky-201.htm

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Evaluation…

1. The results I have collected are reliable since I have tried the same experiment at least three times per each. However, there were some factors that were really hard to keep still, or accurate which caused difficulty in the experiment. The few factors might have affected the results of my data, and make it unreliable.
2. There were some anomalous results. Especially subject W showed that his auditory system is more sensitive than his vision or taction. The conclusion explains why this might have been caused.
3. While I was carrying on with this experiment, I faced various problems. The distance between the fingers before catching the ruler won't be accurate all the time since the fingers cannot stay still for long time, the starting point (the point where we dropped the ruler) wasn't always the same, which might have affected the result as well. Furthermore, when I tested how sensitive others taction is, I had to slightly tap them on the back, and drop the ruler at the same time, but it was really difficult to drop the ruler and tap them at the same time. It was also a very difficult task for me to say go and drop the ruler at the same time. It was also very difficult to control the distance between the person being tested and light and sound that they detect. We didn't measure the distance of the person being tested from me (I shouted go to tell them when the ruler is dropping.) Therefore, the results might have been affected, and won't be as accurate as it should be.
4. If I could do this investigation again, I am sure I could do better. First of all I would use a ruler that is longer than 1m, since some people didn't manage to catch it. Furthermore, we would try to be accurate as we can with the location (position) of the distance from me to the point where volunteer is (to control the distance of sound traveling). Moreover, I would like to try the experiment on various people in different age group so that I would be able to categorize them and find out how age affects the sensitivity of your organs. In addition per person I would try 20 experiments on each of them to get the average, since 3 tries are not accurate enough.

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Example 13: Conductor materials investigation

Scientific investigation—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	6	-	6	6	-

Background

Students had studied the structure of various types of material: metals, crystals, polymers, glasses and ceramics and had looked at the properties of each material and the microscopic arrangement of their atoms and molecules. They then worked independently on investigating the material that would be best used to design and construct a cooking pan and produced a scientific laboratory report of their findings.

This was a worthwhile, traditional comparison-type inquiry, although it was a little limited in the sense that the only variable investigated was the type of material to be used. However, it was well carried out and was written up by students in a full and thoughtful way.

The task was assessed using criteria B, D and E.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
5–6	The student communicates scientific information **effectively** using **scientific language correctly**. The student presents all the information appropriately using symbolic and/or visual representation accurately according to the task. The student acknowledges sources of information **appropriately**.

This work achieved level 6 because the student:

- uses scientific language effectively to communicate scientific ideas, concepts and results of the investigation
- uses an appropriate laboratory-report format to organize and present the investigation
- supports ideas and predictions, and corroborates findings with theoretical information
- presents the information appropriately, using diagrams, tables, graphs and so on, to communicate ideas and findings accurately
- acknowledges sources appropriately using footnotes and a bibliography.

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Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 6 because the student:

- clearly defines the purpose of the investigation and includes theoretical information that supports his/her understanding
- formulates a testable hypothesis and uses scientific reasoning to support the explanation
- identifies the relevant variables of the investigation and explains how to manipulate and control them, and also discriminates between dependent, independent and controlled variables
- evaluates the method, accounting for possible sources of error that could have affected the reliability of the results obtained and the validity of the method
- suggests limitations to the experimental design, and proposes a series of ideas for further inquiry, showing additional thought and insight.

Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
5–6	The student organizes and transforms data into numerical and diagrammatic forms and presents it logically and clearly, using appropriate communication modes. The student **explains trends, patterns or relationships** in the data, comments on the reliability of the data, draws **a clear conclusion** based on the correct interpretation of the data, and explains it using **scientific reasoning**.

This work achieved level 6 because the student:

- uses a variety of ways to organize and transform data in numerical and diagrammatic forms
- provides careful explanations and analysis of the data collected and transformed
- makes predictions based on the results obtained about which of the materials is a better heat conductor, and uses the equation of the line gradient to predict how much energy would be required to heat the water in each container
- explains clearly relationships between the data and the original questions and draws clear and accurate conclusions, commenting on the reliability of the results
- uses in-depth scientific information and reasoning skilfully to support conclusions drawn during the course of the investigation.

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Student work

Which Material is best for Constructing Cooking Pans? (Lab Report)

Research Question: Which of the following three materials heats water best and is hence the best for constructing cooking pans?

1. Glass
2. Aluminium
3. Copper

Variables:

- Independent/Experimental Variable(s)
  - Material used
  - Time taken to heat substance inside each materials
- Dependant Variable(s)
  - Speed at which material conducts heat
  - Temperature of substance inside material during the experiment
- Controlled Variable(s)
  - Amount of water heated inside different materials
  - Mass/amount of material used
  - Amount of time material is heated
  - Starting Temperature of water that will be heated[1].

Background Information:
This lab focuses around the three materials transferring heat from a heat source to a substance inside them. Therefore, before we begin the experiment, it is important to know the background information regarding the transfer of heat between these three materials.

In general, metals are good conductors[2] of heat and are much better conductors of heat than non-metals; which are generally better insulators[3] of heat. This means that ideally, copper and aluminium – which are metals, should heat water faster than glass, which is a non-metal and thus will be weaker at heat transfer or conduction. Glass is a good insulator because it usually has air inside it and air holds heat and prevents it from being conducted.

The reason metals are better conductors than non-metals are because metals have *free electrons*[4]. These free electrons heat the metal and enable the transfer of heat to be swifter than in non-metals. The diagrams below compare non-metals to metals and show how metals have free electrons that enable them to conduct heat better. The black dots represent free electrons:

[1] The starting temperature will be the room temperature at the time and can only be influenced by the atmospheric temperature at the time or day of experiment.
[2] Conduction: "the transfer of heat from one body to another" (Bell), good conductors conduct heat well.
[3] Insulation: the opposite of conduction. Good insulators are bad conductors.
[4] *Free Electrons* are electrons that are not solid, formed particles of a metal and vibrate when the material is heated.

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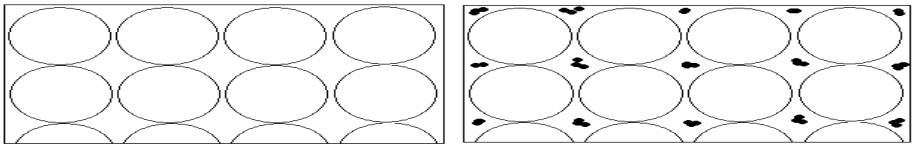

Non-Metal **Metal**

What makes metals conduct heat faster than non-metals is the fact that these free electrons vibrate and heat all parts of the metal at a much faster speed than non-metals.

You can tell how well a material or substance conducts heat by its *Specific Heat Holding Capacity*[5]. Generally, the best conductors have a very low heat holding capacity because this implies that they cannot insulate heat well and thus can conduct it well. We can tell which out of these three materials is likely to be the best or worst heat conductor by examining their heat holding capacities. The following table displays the heat holding capacities of all three materials:

Material	**Heat Holding Capacity**
Glass	9.4J/gºC
Aluminium	8.8J/gºC
Copper	3.8J/gºC

From the table above we can see that copper has the lowest heat capacity which means that it is likely to conduct heat better than all the other materials. Aluminium is likely to be the second best conductor because it has the second lowest heat capacity. Glass is likely to be the best insulator of heat out of these materials because it has the highest heat holding capacity, which means that it can hold heat the best and is not an efficient conductor of heat.

Hypothesis: I predict that copper will be the best conductor of heat out of these three materials and subsequently the best material for constructing cooking pans because of two reasons:

1. it is a metal and metals are good conductors of heat
2. It has the lowest heat holding capacity out of all three materials, which means that it is the least capable of holding heat and the most capable of conducting heat.

[5] The Heat Holding Capacity is how well the substance can hold heat or how well it can insulate.

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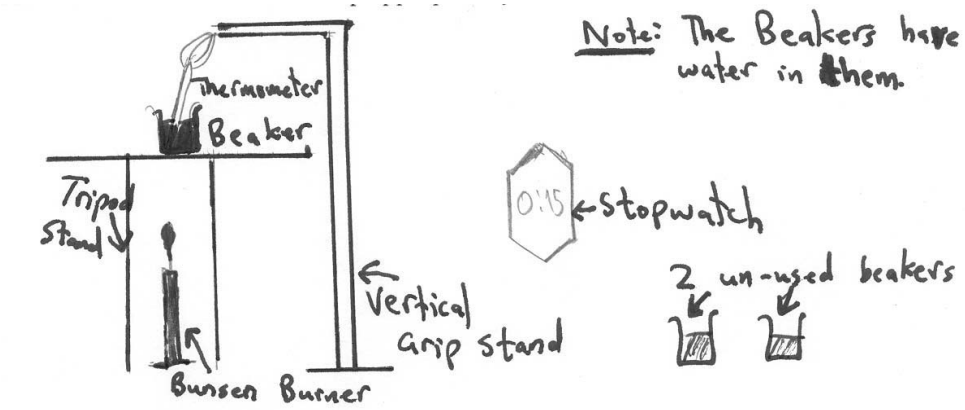
Apparatus:

- 1 mat[6]
- 1 tripod stand
- 1 grill
- 1 glass beaker – 31.2g in mass
- 1 copper beaker – 40.0g in mass
- 1 aluminium beaker – 27.9g in mass
- 1 Bunsen burner
- 3 thermometers[7]
- 4 pairs of safety goggles
- 1 vertical grip stand, to grip the thermometers.
- Gas source
- 1 box of matches
- 1 stopwatch

The apparatus looks as follows when set up appropriately:



Method/Methodology:

1. Collect the apparatus listed above.
2. Put 70ml of water in each of the three beakers. The amount of water is controlled at 70 ml, to make for a fair test and to ensure that no material has extra or less water to heat.
3. Put 1 thermometer in each beaker
4. Measure and record starting temperature, which should be the same as room temperature. This also means that the starting temperature for all materials should be the same. This will not be hard, since room temperature does not vary.
5. Set up apparatus, excluding the 3 beakers
6. Set one of the beakers on the tripod stand
7. Heat the beaker (and the water inside it) using the Bunsen burner.
8. Time the heating of the water and beaker, using the stopwatch, and record temperature after every 30 seconds
9. Repeat this until 5 minutes have passed
10. Repeat 6-10 for the remaining 2 beakers
11. Record data and plot graph.

[6] Made of cork, to prevent any safety hazards when heating

[7] So that each thermometer can be used for a different material. This ensures that each thermometer is at the same temperature when the experiment begins. This measure provides for a fair test.

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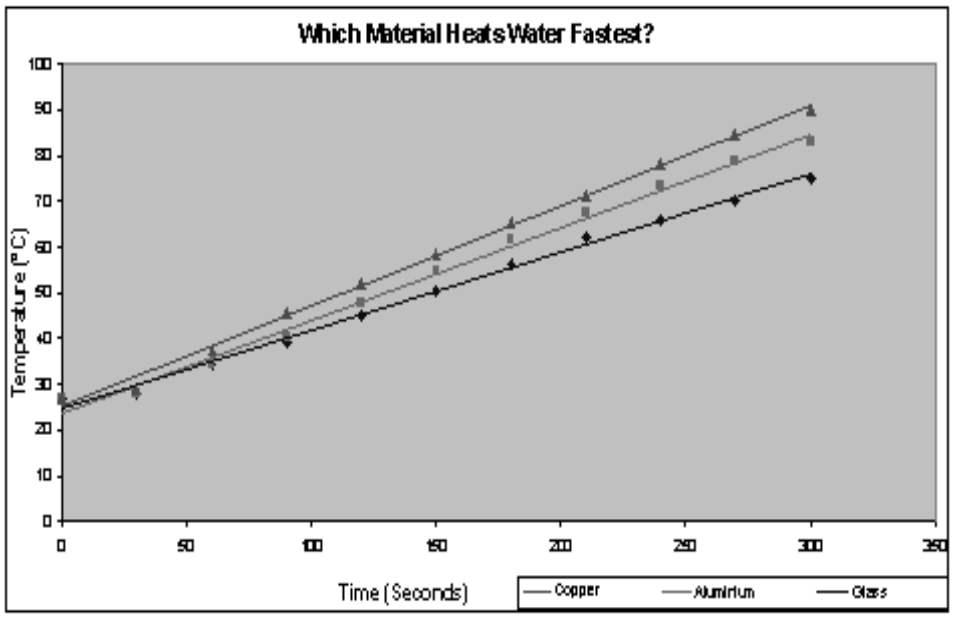
Data Collection:

The following table displays and compares the recorded temperature of each material during heating:

Time (Seconds)	Temperature of Glass Beaker (ºC)	Temperature of Aluminium Beaker (ºC)	Temperature of Copper Beaker (ºC)
0	27.0	27.0	27.0
30	28.0	28.0	29.0
60	34.0	34.0	37.5
90	39.0	40.5	45.5
120	45.0	47.5	52.0
150	50.5	55.0	58.5
180	56.5	61.5	65.5
210	62.0	67.5	71.5
240	66.0	73.5	78.0
270	70.5	79.0	84.5
300	75.0	83.0	90.0

Data Analysis: The following graph displays the data in the table above in a visual manner.



The graph above clearly shows that copper heat water fastest out of the three materials. The linear trend lines on the graph shows that although the water in all materials starts off at room temperature, it ends up at a different temperature after 5 minutes are up.
The graph clearly shows that the non-metal glass is the poorest conductor of heat, whilst the metals are better at heating water. We can elaborate on this point by finding out how much energy it took for each material to conduct heat. Ideally, if a material is a good conductor, it will require less energy to conduct heat through it and if it is a good insulator, it will take

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more energy to conduct heat through it. This can also be used as a way to check the general trend of our data. For example, if aluminium requires the least energy to conduct heat then we know that our data has been incorrectly recorded or our experiment has been incorrectly executed. Ideally, copper should require the least energy to conduct heat (seeing as it is the bets conductor of heat, according to the graph above).

To calculate how much energy each material requires to conduct heat we use the formula:

Energy needed = mass x heat holding capacity of material x temperature change

The mass of each material was determined prior to executing this experiment. Similarly, the heat holding capacity of each material was investigated prior to this experiment being executed. The temperature change represents the difference between the starting temperature and the final temperature of the water inside each beaker. It can be found by the following method:

Temperature change = final temperature – starting temperature

The mass of each material is measured in grams and therefore the heat holding capacity of each material is notated in J/gºC. The energy required to heat material is as follows:

Glass:

Temperature change = final temperature – starting temperature
Temperature change = 75 – 27
Temperature Change = 48

Energy needed = mass x heat holding capacity of material x temperature change
Energy needed = 31.2 x 9.4 x 48
Energy needed = 14077.44 Joules

Aluminium:

Temperature change = final temperature – starting temperature
Temperature change = 83-27
Temperature Change = 56

Energy needed = mass × heat holding capacity of material × temperature change
Energy needed = 27.9 x 8.8 x 56
Energy needed = 13650.56 Joules

Copper:

Temperature change = final temperature – starting temperature
Temperature change = 90-27
Temperature Change = 63

Energy needed = mass × heat holding capacity of material × temperature change
Energy needed = 40.0 x 3.8 x 63
Energy needed = 9576 Joules

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The following table compares the energy required to conduct heat through each of these materials in this experiment:

Material	Energy Required to Conduct Heat (Joules)
Glass	14077.44
Aluminium	13650.56
Copper	9576

We can see from the table above that it took copper the least amount of energy to conduct heat. This verifies our results and thus proves that copper is indeed the best heat conductor out of these three materials.

We can elaborate even more on our results by finding out how much energy it took the water inside each material to heat up. Unlike the previous analysis of the energy needed for each specific material to conduct heat, this analysis focuses on how much energy the water inside each material used. This means that we will be calculating the energy used by the water, as opposed to the material. Ideally, the better the conductor, the more energy it will use to heat the water inside it. This is because the water inside a conductive material is heated more and this causes a larger temperature change which leads to more energy being used.

Let us now verify our data once more using the calculations for the amount of energy used by the water inside each material.

For our experiment, to calculate how much energy the water inside each material used, we use the following formula:

Energy used = mass of water x heat holding capacity of water x temperature change

The material in this case is water, since it is what is being heated. The mass of the material is 70g, because we determined this at the beginning of our experiment when we stated that 70ml of water would be used inside each container. 70ml converts to 70g in mass because:

1g = 1ml

The heat holding capacity of the material (water) is 4.2J/g^{o}C. This means that it takes 4.2 Joules to heat 1 gram of water so that it alters its temperature by 1^{o}C.

The temperature change represents the difference between the starting temperature and the final temperature of the water inside each beaker. It can be found by the following method:

Temperature change = final temperature – starting temperature

The following are the calculations of the energy required to heat the water inside each of the beakers:

Glass:

Temperature change = final temperature – starting temperature
Temperature change = 75 – 27
Temperature Change = 48
Energy used = mass x heat holding capacity of material x temperature change
Energy used = 70 x 4.2 x 48
Energy used = 14112 Joules

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Aluminium:

Temperature change = final temperature – starting temperature
Temperature change = 83-27
Temperature Change = 56

Energy used = mass x heat holding capacity of material x temperature change
Energy used = 70 x 4.2 x 56
Energy needed = 16464 Joules

Copper:

Temperature change = final temperature – starting temperature
Temperature change = 90-27
Temperature Change = 63

Energy used = mass x heat holding capacity of material x temperature change
Energy used = 70 x 4.2 x 63
Energy needed = 18522 Joules

The following table compares the energy required to heat the water inside each of the materials:

Material	**Energy Required to Heat Water (Joules)**
Glass	14122
Aluminium	16464
Copper	18522

We can see from the table above the water inside the copper container used the most energy to be heated. This verifies our results once again and proves that copper is indeed the best heat conductor out of these three materials because the water inside it heated the most and used the most energy to heat up.

Having verified our data, we can now predict which material would have boiled the water first and whether or not the trend of data in our graph stays the same as the temperature increases by finding the linear equation representing the data for each material. For this we must first determine the *gradient of our data*[8]. This can be done by taking two co-ordinates from the graph or table and labelling the first co-ordinate as (x1,y1) and the second co-ordinate as (x2,y2). For example, if the temperature of the water in the glass beaker is 28ºC after 30 seconds, since the time taken is the independent variable[9] and the temperature of the substance inside each material is the dependant variable[10], the co-ordinates of this point will be (30,28). The gradient of a line of data can be calculated as follows:

Gradient = (y2-y1) / (x2-x1)

[8] The rate at which our data (the temperature of the water inside each material) increases.
[9] X=independent variable
[10] Y=dependant variable

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To find a linear equation of a set of data you also need the *y-intercept of the data*[11]. Since our data is measured from when the temperature is 27ºC, the y-intercept of all the data will be 27. Below is a calculation of the slope of data of each material along with the formation of the equation of the data of each material. I have taken the co-ordinates of the starting and final temperature of the water in each substance since these are the only two co-ordinates that are certain to be consistent with the trend of data in the case of each material.

Glass:
Co-ordinate 1 (x1,y1) = (0,27)
Co-ordinate 2 (x2,y2) = (300,75)

gradient = (y2-y1) / (x2-x1)
gradient= (75-27) / (300-0)
gradient= 48 / 300
gradient = 0.16 or 4/25

Equation : y=4/25x+27 [12]

Aluminium:
Co-ordinate 1 (x1,y1) = (0,27)
Co-ordinate 2 (x2,y2) = (300,83)

gradient= (y2-y1) / (x2-x1)
gradient = (83-27) / (300-0)
gradient = 56 / 300
gradient = 0.187 or 14/75

Equation : y=14/75x+27 [13]

Copper:
Co-ordinate 1 (x1,y1) = (0,27)
Co-ordinate 2 (x2,y2) = (300,90)

gradient= (y2-y1) / (x2-x1)
gradient= (90-27) / (300-0)
gradient = 63 / 300
gradient = 0.21 or 21/100

Equation : y=21/100x+27 [14]

We can now use these equations to find which material will boil water fastest. Since we want to find the **time** at a certain temperature we will solve for x. The following is the time it will take for the water in each material to boil (water boils at 100ºC).

[11] The point at which the data crosses the y-axis, or in this case, the point at which we being our experiment.
[12] Y=temperature of substance inside material, X=time (Seconds)
[13] Y=temperature of substance inside material, X=time (Seconds)
[14] Y=temperature of substance inside material, X=time (Seconds)

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Glass:
Y = 100 [15]

$$Y=4/25x+27$$
$$100=4/25x+27$$
$$100-27=4/25x$$
$$73=4/25x$$
$$73=0.16x \quad [16]$$
$$73/0.16=x$$
$$456.25=x$$

Time taken to boil water: 456 seconds, or 7 minutes and 36 seconds

Aluminium:
Y = 100

$$y=14/75x+27$$
$$100=14/75x+27$$
$$100-27=14/75x$$
$$73=14/75x$$
$$73=0.187x \quad [17]$$
$$73/0.187=x$$
$$390.397=x$$

Time taken to boil water: 390 seconds, or 6 minutes and 30 seconds

Copper:
Y = 100

$$Y=21/100x+27$$
$$100=21/100x+27$$
$$100-27=21/100x$$
$$73=21/100x$$
$$73=0.21x \quad [18]$$
$$73/0.21=x$$
$$347.62=x$$

Time taken to boil water: 348 seconds, or 5 minutes and 48 seconds

The following table shows how long it would take each material to boil the water within it:

Material	Time taken to boil water (seconds)
Glass	456
Aluminium	390
Copper	348

From the table above, we can tell that copper will be the fastest material to boil water. Since most cooking evolves around boiling water, it is now safe to say that copper is the best material out of the three above to use for construction of cooking pans.

[15] We know the value of Y as being 100 because this is the temperature at which water boils.
[16] 4/25=0.16
[17] 14/75=0.187
[18] 21/100=0.21

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Conclusion and Evaluation: My results from this experiment show that my hypothesis was validated, because copper turned out to be the best conductor of heat and thus the best material for use in constructing cooking pots and pans. Further calculations showed us that as the temperature increases, it takes copper the least amount of time to boil water; 348 seconds, in comparison to 390 and 456 for aluminium and glass respectively. Clearly, copper conducts heat much better than the other two materials, with aluminium being the second best conductor of heat and glass being the worst.

The possible sources of error in my lab were as follows:

- I used beakers of different masses. This did not have any impact on my results and they turned out to be as expected. However, the fact that the copper beaker was heavier than the aluminium beaker means that it was thicker and this influenced the way heat was conducted through this material.
- We did not cover the beakers when heating them and heat could have escaped from the top and slowed down the heating process of the water in each beaker.
- We only measured the temperature increase for 5 minutes. It is possible that copper could have slowed down heating water as the temperature neared 100ºC and it is possible that glass could have continued heating at the same rate. Although this is unlikely, it could have happened and we did not examine its effects.

The limitations of my lab were as follows:

- We only had three materials with which to conduct our experiment. Had we had more, we could have made our conclusion based on a wide variety of data.
- We had rather small containers. If we had larger containers we could have examined a larger temperature change and examined a greater level of heat conduction.
- We were not able to obtain containers of the same mass. We were only able to use the containers available and this limited our data from being fully accurate and it limited our test from being fully fair.

If I were to do this lab again I would:

- Use beakers of the same mass (or try to at least; depending on whether or not the materials are available in the same mass), to prevent any distortion of the correct results.
- Cover the beakers so as to prevent heat loss.
- Measure how long it takes the beakers to heat water to a certain temperature as opposed to simply how hot the water gets in a certain amount of time. This will give the same conclusion but it makes it easier to analyse results.
- Use many more materials as opposed to just three. This would make for a more balanced conclusion, which will have taken into account the heat holding capacities of many materials.

Questions for Further Research: For further research I would suggest that we examine other metals and how fast they heat water. Perhaps we could use another liquid instead of water; for example, oil. This is because oil is used in cooking as well, and it would be useful to examine how each material heats oil, because oil has a different boiling point to water[19].

Works Cited

Bell, Kenneth J. "Heat Conduction." Macmillan Encyclopaedia of Chemistry. 1997 ed.

Johnson, Keith. Physics for You. Stanley Thornes (Publishers) Limited; Cheltenham, 1996.

[19] The boiling point of oil is 70ºC as compared to the boiling point of water; 100ºC.

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Example 14: Trolley acceleration investigation

Scientific investigation—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	5	-	-

Background

As part of a unit on motion, students developed their understanding about the main ideas of velocity and acceleration. Simulation software and associated exercises were used so that they could study velocity and acceleration using "time-lapse" simulations. Students were able to solve problems involving velocities and acceleration using the appropriate formulae.

Students were familiar with data-logging equipment and this enabled them to measure instantaneous velocities.

Students were asked to examine a factor of their choice that they believed would affect the acceleration rate of a trolley travelling down a ramp. No additional verbal or written instructions were given to guide their investigations. Students were allowed 1 hour and 30 minutes to design, plan and carry out their investigations. They used their knowledge and skills in information and communication technology to process and transform raw data into suitable tables and graphs using a spreadsheet.

The task was assessed using criterion D.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 5 because the student:

- clearly defines the purpose of the investigation
- formulates a testable hypothesis, stating the prediction, but fails to develop an explanation for his/her reasoning
- identifies the relevant variables and explains how to manipulate them
- provides a clear evaluation of the method, accounting for the reliability of the results on the basis of the statistical analysis of lineal regression R2, but fails to provide an explanation of his/her understanding of this concept or how this value was obtained, and there is no explanation or calculation that supports this in the experiment write-up

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Student work

Science Practical – Acceleration of a Trolley

Aim

To determine the effect that mass has on the acceleration of a trolley. I will test this by first recording the acceleration of a normal trolley. Following this I will attach a one kilogram weight to the trolley and then record its acceleration.

Hypothesis

I hypothesise that the more mass added to the trolley the faster it will accelerate. I hypothesise this since I believe the heavy weights will help to pull the trolley down the ramp faster.

Independent Variable

The independent variable in this practical is the weight of the trolley. If the mass of the trolley was not altered it would not be possible to determine the affect that mass has on acceleration.

Dependent Variable

The dependent variable in this practical is the rate at which the two trolleys of different masses accelerated.

Controlled Variables

Surface of Ramp – In order to obtain the most accurate results as possible it will be necessary to keep the surface of the ramp constant. This can be done by using the same ramp each time.

Slope of Ramp – If the results are to be accurate it will be crucial to ensure that ramp is of a constant gradient when recording data. This can be done by not touching the ramp or the box which is elevating it from the work bench until all data has been recorded.

Trolley Used – It is important to use the same trolley to record all of the data. If a different trolley is used, it may have a slightly different mass and hence affect the results.

Way in which trolley is released at top of ramp – The way in which the trolley is released from the top of the ramp could greatly affect the results. In order to obtain accurate results it will be necessary to release the trolley in the same way each time. This can be achieved by taking the hand which is holding onto the trolley directly off of it so as to avoid applying any added force.

Equipment, Hardware and Software Used.

- 1x Laptop
- 1x 2 planks of wood joined by masking tape
- 1x Trolley
- 2x Light Gate
- 1x Solid Interrupt Card
- 1x Data logger
- 1x Timing Software
- 1x Microsoft Excel
- 1x Ruler
- 2x Boss Head Clamps
- 2x Retort Stands

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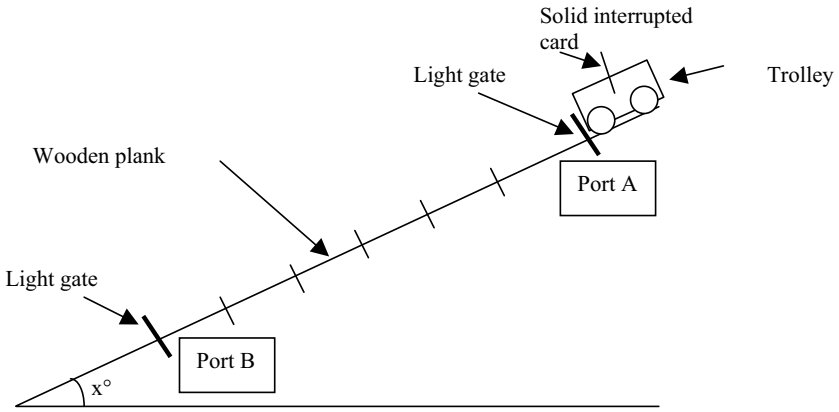
Method



1. Elevate one end of wooden plank (Laptop cable box is sufficient).
2. Connect cables to laptop. Plug other end of cables into separate power points. Connect data logger into back of laptop.
3. Plug one light gate into port A of the data logger and the other into port B.
4. Screw one retort stand into the bench and stand the other next to the plank of wood. Screw one boss head clamp on both retort stands.
5. Secure one light gate in the boss head clamp by screwing it into position. Do the same for the second light gate. Make sure that the light gate at the top of the ramp is plugged into port A in the data logger and that the one at the bottom of the ramp is plugged into port B.
6. Make an interrupt card of any length (preferably between 10 and 15 centimetres). Mark the middle of the card with a pen. Tape this to the trolley. Ensure that the interrupt card will pass through both light gates.
7. Measure the distance between both light gates. At first make sure that the light gates are no less than 50 centimetres apart. Mark every five centimetre intervals on the wooden plank either going up or down the plank.
8. Turn on the power for the data logger and laptop. Log on. Double click the icon labelled Science Laboratory Timer located in the Novell launch window. Enter the length of the interrupt card. Click single
9. Click the red record button ensuring. Hang onto the trolley at the top of the ramp making sure that the interrupt card is slight back from the first light gate to avoid accidentally triggering it off. Line up the trolley so that it will travel in a straight line and pass through both light gates. Make sure that a partner is at the other end of the ramp ready to catch the trolley.
10. When all is ready let go of the trolley. Make sure that someone catches the trolley at the other end.
11. Before releasing the trolley again slide the lower portable retort stand five centimetres up the plank. Once this has been done follow the same process to record the rest of the data. (Tip – After obtaining each piece of data write the distance between both of the light gates in the comment column.)
12. Once finished obtaining all the data add a one kilogram weight to the same trolley.
13. Move the portable retort stand holding light gate B back to the 60 centimetre mark on the plank. Open up a new document in the Science Laboratory Timer program. Follow the same method as used to obtain the data from when there was no weight on the trolley.

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Conclusion

Having looked at the results obtained I can conclude that a trolley with a smaller mass will accelerate at the same rate as that of a trolley with a greater mass. The reason that neither of the trolleys came close to accelerating at 9.8 m/s^2 was because of friction created between the wheels and ramp. Another reason that trolleys did not reach 9.8m/s was because they were not dropped directly down. The data obtained disproves my hypothesis.

Discussion

At first I was surprised to discover that both trolleys of different masses accelerated at roughly the same rate. I had thought from the outset of the practical that either one or the other would accelerate substantially faster than the other. However I have thoroughly checked my data tables and have found no outliers which would greatly affect the appearance of my graph. Not long after this I realised that our teacher had explained to the class that two objects of different masses would accelerate at the same rate depending on the surface area of each one. As of this moment both of the graphs made sense to me and I concluded that changing the mass of a trolley does not greatly affect the rate at which it accelerates. The reason that the two trolleys accelerated at the same rate was because the same amount of gravitational pull was acting on both trolleys. Furthermore the fact that I used the same trolley each time also played a major role in the trolleys accelerating at the same rate. If I had have used a different trolley with wider wheels, more friction would have been created and hence it would have accelerated at a slower rate.

I think that my results are fairly accurate since there are no major outliers in the data tables. The value of R^2 in both of the graphs also gives an indication as to whether or not my results are accurate. The closer the value is to 1.0 the more accurate the data is. Therefore the fact that my values of R^2 were fairly close to 1.0 help to further suggest that my results were correct. Of the two sets of results the more accurate is that when a l kg weight was added to the trolley. It is more accurate since the R^2 value is closer to 1.0. It would have been very difficult to obtain perfect results since it would mean that all variables would have to be controlled precisely. Therefore that fact that my results were slightly inaccurate does not greatly bother me. Another indication that my results are fairly accurate is the fact that the acceleration of the two trolleys only differed by 0.06 units.

One way in which this experiment could be improved would be to place a ruler in front of the trolley before it was to be released. When desired the ruler could be lifted directly upwards to allow the trolley to accelerate down the ramp. This simple step would help to avoid people applying force to the trolley when letting it accelerate down the ramp and hence slightly more accurate results would be obtained.

Another way in which this experiment could be improved would be to calculate the acceleration of three or more different weighted trolleys rather than just two. This would help to confirm any suspicions that those conducting the practical may have. For example if I had have added 5 kilograms to the trolley and found that it had accelerated at roughly the same rate as the other two had I could safely conclude that changing the mass does not affect the acceleration.

One final way in which the practical could be improved would be to use a friction less air ramp, so that the friction force does not affect the acceleration. This might make the results more accurate.

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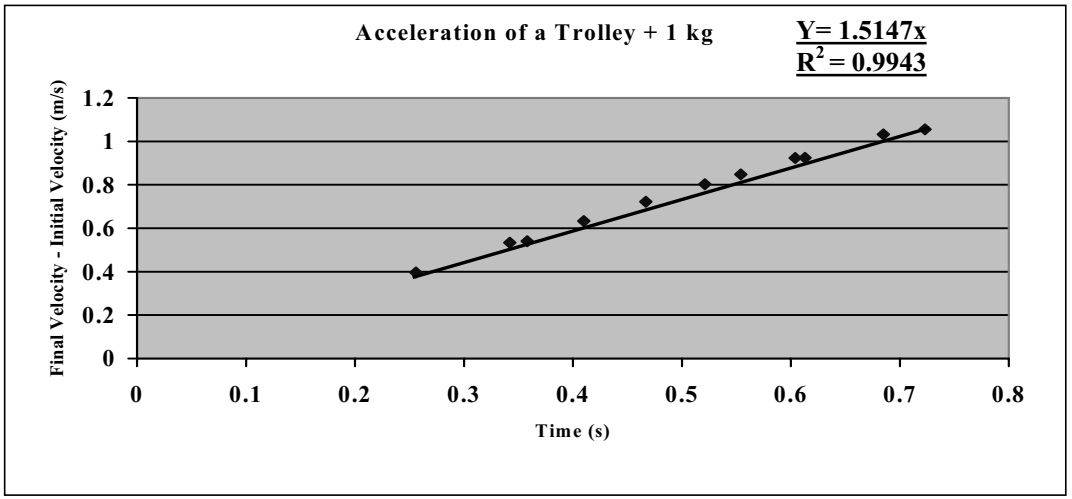
Acceleration of a Trolley – 1 kg Weight Added

Distance Between Light Gates (m)	Initial Velocity (m/s)	Final Velocity (m/s)	Time from A to B (s)	Vb-Va (m/s)
0.60	0.380	1.435	0.723	1.055
0.55	0.401	1.433	0.685	1.032
0.50	0.451	1.375	0.613	0.924
0.45	0.395	1.318	0.604	0.923
0.40	0.419	1.267	0.554	0.848
0.35	0.402	1.205	0.521	0.803
0.30	0.409	1.131	0.467	0.722
0.25	0.416	1.049	0.410	0.633
0.20	0.427	0.967	0.358	0.540
0.15	0.415	0.949	0.342	0.534
0.10	0.413	0.809	0.256	0.396



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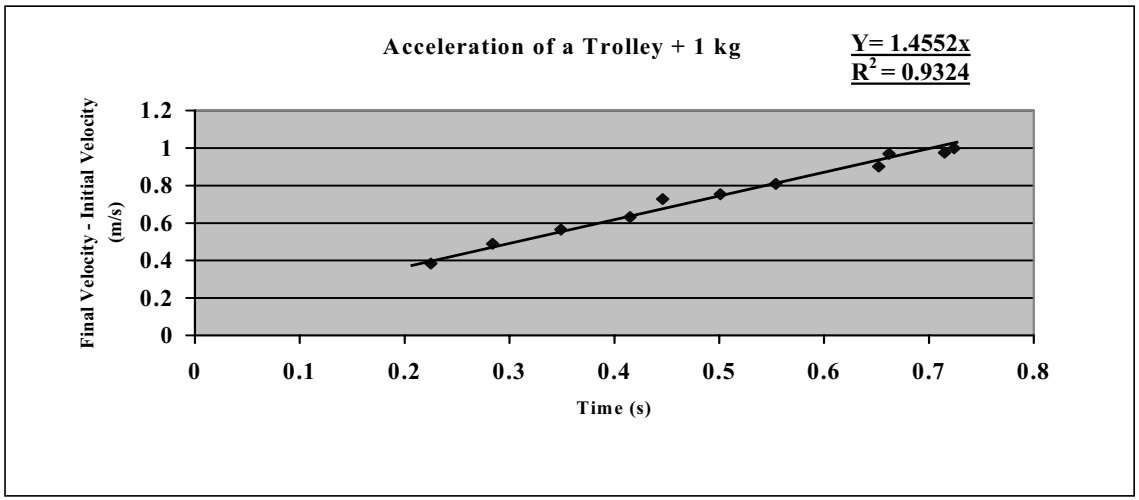
Acceleration of a Trolley – No Added Weight

Distance Between Light Gates (m)	Initial Velocity (m/s)	Final Velocity (m/s)	Time from A to B (s)	Vb-Va (m/s)
0.60	0.391	1.389	0.724	0.998
0.55	0.398	1.373	0.715	0.975
0.50	0.411	1.380	0.662	0.969
0.45	0.407	1.308	0.652	0.901
0.40	0.421	1.229	0.554	0.808
0.35	0.414	1.168	0.501	0.754
0.30	0.403	1.131	0.446	0.728
0.25	0.423	1.055	0.415	0.632
0.20	0.416	0.981	0.349	0.565
0.15	0.412	0.901	0.284	0.489
0.10	0.420	0.804	0.225	0.384



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Example 15: Efficiency of machines laboratory report

Scientific investigation—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	-	-	-	6	2	-

Background

As part of a unit on mechanics, students had investigated the concepts of energy, power and efficiency. Examples of engines, electric motors, light bulbs, refrigerators, and so on were used to discuss energy transformations. Students were asked to design a scientific investigation to investigate the efficiency of simple machines. They had to design, plan and carry out their investigations independently and produce a scientific laboratory report of their findings.

The task was assessed using criteria D and E.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion D: scientific inquiry

Maximum level: 6

Achievement level	Descriptor
5–6	The student **defines** the purpose of the investigation, **formulates a testable hypothesis** and **explains** the hypothesis using scientific reasoning. The student identifies the relevant variables and **explains how to manipulate** them. The student **evaluates** the method commenting on its **reliability** and/or **validity**. The student suggests improvements to the method and makes suggestions for further inquiry when relevant.

This work achieved level 6 because the student:

- clearly defines the purpose of the investigation
- formulates a testable hypothesis and explains it, giving a scientifically plausible basis and accounting for sound and heat energy lost through sound and friction
- clearly identifies the relevant variables involved, distinguishing between independent and dependent variables
- provides a comprehensive explanation of how to manipulate each of the variables involved.

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Criterion E: processing data

Maximum level: 6

Achievement level	Descriptor
1–2	The student **organizes** and presents data using **simple numerical or diagrammatic forms** and draws an **obvious conclusion**.

This work achieved level 2 because the student:

- organizes and presents most data using a simple table but omits to show some of the raw data (that is, distance)
- draws a conclusion that is consistent with the data
- misses the opportunity to collect more data to validate the results and does not include repeat readings with the same apparatus or use different apparatus to repeat the trials.

Note to teachers

To fully assess criterion E: processing data, the task should provide students with enough opportunities to demonstrate that they can organize and process data efficiently. Therefore, in cases where students design their own investigations it is important to remind them to collect sufficient data for further analysis and processing.

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Student work

Efficiency of Machines

Purpose of Experiment:

By doing this laboratory activity, we seek to demonstrate through a number of experiments that machines are not completely efficient. We are unraveling the daily-life commercial tie which states that (e.g.) the newest vacuum cleaner model x exhibits more output energy than initially put in. Efficiency is a term that determines a machine's ability to transfer input work into output work, recorded as a percentage. If a machine has a high percentage, it means that it almost no energy is lost to the useful purpose. A low percentage means a machine loses a lot of energy on aspects that are not useful mechanics. (Continued in hypothesis)

Hypothesis:

I believe that no system can have 100% efficiency. In the perfect system, you would have no energy lost applying work onto something. However, it turns out that energy can be lost even if this machine cranks a little. Sound energy. Energy is conserved; no energy can be destroyed, it is just transformed into another energy form. So from that mechanical energy as your input, perhaps only a small percentage is actually used to perform mechanical energy, the rest gone through heat and sound. (Internal combustion engines are only 30% efficient) It is impossible to create a machine that doesn't produce the slightest amount of friction (which turns into heat or a reaction of an external force) and sound, thus without losing any amount of energy to the cause. I predict none of the systems in our experiment will score a 100%, and I'm sure none will ever on this planet.

Variables:

Force (due to gravity): the Force is necessary to calculate work, which is necessary to calculate efficiency. Output Force is independent, and is controlled merely by selecting weights of different weight, providing the force due to gravity. However, the input energy might need more force compared to the output energy to get the object moving, due to friction and so. So the input Force is dependent.

Distance: The distance is another variable required to work out the work. This, as the weight, is completely under our control, when we set it as an input variable. We decide how much for example, a pulley should be pulled on. The output result, however, is out of our control, dependent upon the input. For example, on a lever where the fulcrum is more towards the weight, the weight will raise less distance then you eventually pressed down.

Work, Dependent variable: Work is the variable that is dependent, for it's value relies on Distance and Weight. We have little control over its value, which needs to be worked out by using independent variables.

Variables in Efficiency

Efficiency = **Force input** x **Distance input** / **Force output** x **Distance output**

Ind. Dep. Dep. Ind.

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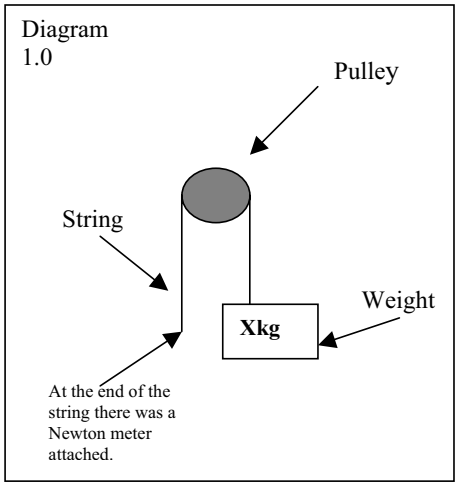
Procedures:

Materials:
- Pulley System Experiments
  - A pulley, attachable to edge of table
  - Newtonometer
  - Meter Stick
  - Weights of Different weight (20N, l0N, 5N)
- Lever System Experiments
  - Improvised Fulcrum
  - Newtonometer
  - Meter Stick as balance
  - Small Ruler
  - Weights of Different weight (5N, 3N, 2N)

Pulley:

Planning out the experiments came of course before setting them out. We drew rough sketches in our notebooks of possible experiments. Primarily, we went for the pulley systems, and our objective was to try out three pulley systems with different configurations, as to prove our hypothesis on a broader scale. A computerized version would look like this: (Notice: this diagram has been designed on the PC in cooperation with my group-mates)



The Experiment was set out in this fashion to collect all the necessary variables to calculate this machine's efficiency. The Weight was used to provide the Force Output. The Force input was calculated by attaching a Newtonometer at the opposite end of the string, which gave results. The Input distance was recorded by measuring how much the string was pulled down. The Output distance was recorded by measuring how much the string holding the weight was pulled up. Combining these results gave you a Work output and a Work input. Divide the output by the input, and you get efficiency.

This same experiment was done thrice with variable weights, so we could confirm this machine as "not completely" efficient. Then we'd get the results together, and determine the efficiencies of the system.

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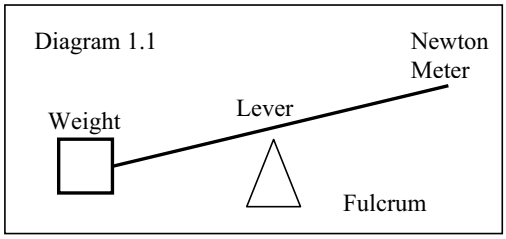
Lever:

This experiment we sketched out after we've completed the pulley tests. Levers consist of a fulcrum, and a long object rested upon it. The object in question, which has to be moved, is resting on one end of a ruler, and a finger would push down on the other end. It's how a seesaw works, fundamentally. The machine's objective is to reverse the direction of motion from down to up. In the perfect system, you'd only have to apply as much force as the object has as weight, and it would rise as much as you pressed down. However, it turns out that due to friction you're going to need a little more input energy over output. This solidifies the hypothesis stating that no machine can be perfect even more.

This diagram of the Lever (also created in cooperation with the group) roughly and basically describes what was going on. We did this experiment thrice as well, with different weights and different fulcrum position ratios. (A little bit more towards the weight, or perhaps a little less).

The Force input was calculated by using the Newtonometer. The Force output was calculated using the weights mass, and timing it by gravity (10) to figure out. The Input distance is how much the lever is pushed down, and the output distance is how much it was raised with the weight on top of it.



Results Collected:

This table is a summary of all our results:

Test No.	Pulley Sys?	Lever Sys?	Input Work Force	Output Work Force	Efficiency (%)	Weight Used
1	x		60 N*Cm	57 N*Cm	95	20N
2	x		50 N*Cm	48 N*Cm	96	10N
3	x		25 N*Cm	21 N*Cm	84	5N
4		x	25 N*Cm	15 N*Cm	60	5N
5		x	1.6 N*Cm	1.52 N*Cm	95	2N
6		x	5.6 N*Cm	4.2 N*Cm	75	3N

x = System Used

Analysis of Data Collected:

As you can clearly see by looking at the results collected in this handy table above, there is no machine apparent with an efficiency of 100%. Some got close to it, but none ever made it. This is because any sound produced, the pulley made a little cranking noise, or any heat created due to

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friction, the number will drop from a 100% to something less. But because it's practically impossible to remove those two factors from a machine, no machine can be 100%.

The pulleys were all pretty efficient. I can speculate as to why. You pull down, and the thing goes up as much as you've pulled. Work is about how much an object moves from its origin. But it also includes the force required. The pulley loses its 100% efficiency from the Input Force, which has to be higher than the output due to the sound it creates, and the friction it must tackle.

The efficiency of a lever however, is quite interesting, changing when the fulcrum is placed differently every time. The fulcrum has a large effect on the efficiency of the lever. When it is placed beautifully in the center of the balance stick, the lever system is going to be pretty efficient. The distances traveled for input and output will be similar, and so will the results for input and output force, as seen in test no. 5. However, in tests number 4 and 6, the fulcrums were moved away and towards the weight. When the fulcrum is more towards the weight, it made the work *easier,* but as a result, the weight moved less than you initially put in, causing an upset in the efficiency. When the fulcrum is moved away from the fulcrum, the job becomes a bit harder, but the weight moves more than your finger moved.

Conclusion and Further Study:

It is obvious and apparent, from the results that we have collected, and other sources, that on the planet Earth, it is impossible to obtain a machine completely 100% efficient. Friction is always apparent, and friction creates heat and can act as an external force, and so interrupt even more with the efficiency of things. Then, there's also the problem of the sound energy lost during mechanical operations. Any sound created needs some sort of energy to exist; even the most faint vibration could cause mechanical energy to transform some of its value to sound energy. It's as clear as that, conclusively: Machines lose mechanical energy to other forms. Our experiments prove it, our text books say it, who wants to put forward an argument?

But of course, our results are possibly faulty, hopelessly hindered by inadequate equipment. Well, the equipment was okay enough to perform the experiments, but forget about pinpoint accuracy in our results. The Newtonometers were terrible. The little label which displayed the values could be moved up and down, so I had no positive idea which way it needed to be positioned to display the correct result. And of course, you'd need a magnifying scope to locate exactly where the Newtonometer is resting its indicator on. So if we had better Newtonometers, as a consequence we would have had more accurate results.

Then, it is also worth complaining the lack of proper fulcrums. We had to use an improvised fulcrum, which was rather unsuitable, for it took great effort to place the meter stick completely balanced on the inconvenient upper surface. (We used the holding rack for bunches of weights as fulcrums) The fulcrum caused myself great frustration when the meter stick always slid off.

All together, the school's equipment was operable, but when it came down to accuracy, well, I guess we just had to do with what we results we got. I mean, at least we proved that no machine can possible be 100% efficient.

As a further study, which should not particularly be performed by students but rather by astronauts, I am really curious what would be the case of a pulleys and levers working in the vacuum of space, with the surface of the pulley and the lever's fulcrum and other components being of near to zero friction (ice perhaps). Basically, I think experiments should be designed whose purpose it is to create the first ever "perfect" machine. But then again, as a classroom further study, it's kind of hard to suggest anything because the enquiry has been answered by our results and backed by real scientists anyways before us. Perhaps you could go deeper into the significances of the different types of energy, which taps from the mechanical energy. Design experiments to see if noisier systems are more efficient than rough-surfaced systems.

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Example 16: Air pollution in Santiago essay

Essay—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	4	4	-	-	-	-

Background

Students were given the question "Should a government's obligation to protect the environment take precedence over its obligation to promote economic growth?" They were asked to research this question using a real local or global case and then write an essay to discuss their thinking in terms of how science is applied and used in a specific local example.

The student whose work is reproduced here chose the topic of air pollution in the Chilean capital, Santiago. The essay discusses the causes of air pollution in general and its effects on the health of the people of Santiago and the local environment in particular. The social, economic and historical backgrounds are used to support the argument of the interactions between science and society in a developing country.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
3–4	The student describes how science is applied to addressing a specific local or global issue. The student **describes some** of the benefits **or** limitations of science in addressing the issue. The student **describes** how science and its applications interact with at least **one** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 4 because the student:

- describes how products of the application of science and technology (such as the copper industry, mines and smelters, power plants and motor vehicles) contribute to much of the pollution of Santiago
- describes how these applications affect the air quality in Santiago and the health of the individuals who live there
- describes the plans of the Chilean government to reduce and control emissions.

This work did not achieve a level 5–6 because the student does not explain how science is applied to the specific issue of controlling and reducing emissions, and what the benefits and limitations of science are in addressing this issue.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
3–4	The student communicates scientific information using **scientific language**. The student presents most of the information appropriately using symbolic and/or visual representation according to the task. The student acknowledges sources of information **with occasional errors**.

This work achieved level 4 because the student:

- effectively uses a range of scientific language to present ideas and information, and, for the most part, the presentation of these ideas is clear and correct
- acknowledges sources in a separate bibliography, but makes occasional errors and does not reference sources within the text.

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Student work

Chemistry—Air Pollution in Santiago (Speech)

History and Causes of the Situation

From 1973 until 1990, Chile had a military government. This government viewed environmental protection as detrimental to economic growth, and featured a free- market economy according to non- interventionist principles. Exports were encouraged, and mining and forestry became Chile's leading exports. In 1990, a democratic government came into power, and the economy boomed. As a result of the quickly growing economy, energy consumption increased, leading to a decrease in environmental health.

The air pollution in Santiago is due to both fixed and mobile sources. Currently, Chile is the largest producer of copper in the world, and the mines and smelters of this industry are producing much of the pollution. Polluting materials that were previously bound to rock are exposed to the air and water during the mining process. Smelters, which concentrate the ore that is mined release additional chemicals into the air. There are over 5 million residents in Santiago, and there are over 1.6 million vehicles, which are responsible for 53% of the air pollution. Santiago's severe traffic problems cause fuel to be burned for long periods of time. While hydropower provides most of Santiago's electricity, coal has served as a back- up in times of need. Industries, motor vehicles, and power plants are the culprits in Santiago, emitting many dangerous chemicals for the residents to breathe.

Chile's topography and climate only further the problem. Santiago is located in an enclosed valley, with the Andes mountains to the east and the Cordillera de la Costa mountains to the west. Limited wind and a little rainfall do not sufficiently disperse chemical emissions, and they remain concentrated over the city. Conditions are worst in winter, when the wind and rainfall levels are at their lowest.

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Chemicals in the Air

The ever- present smog over Santiago is also known as ground- level ozone. It is anthropogenic, or man- made. Smog is produced when Volatile Organic Compounds and Nitrogen oxides are broken down and free oxygen molecules combine with oxygen in the air, forming ozone, with a formula of O3. These Volatile Organic Compounds are produced when gasoline and oil are evaporated. The smell at gas stations is a result of their evaporation. Nitrogen oxides, especially nitrogen dioxide, are produced by oil and gas as well, however the combustion of those substances is what produces it, not the evaporation. Motor vehicles are the primary sources. Particulate matter is small particles in the air that are either solid or liquid. Main sources of particulate matter are trucks, power plants, and in Santiago's case, mines. Santiago has a major issue with PM-10 particles, which are especially harmful because they are tiny enough to penetrate the lower lungs. Lead is commonly produced by smelters, and it accumulates in the body's systems, causing a wide variety of problems ranging from behavioral disorders to anemia and organ problems. Ninety- five percent of carbon monoxide is emitted by motor vehicles when fuel is not burned completely. Heavy traffic congestion in Santiago results in large emissions of carbon monoxide, and industries with incinerators and boilers also emit substantial amounts. Sulfur dioxide is caused by the burning of coal and oil fuels and by the smelting processes for metals. It is particularly harmful to those with existing diseases. Arsenic, a poison, is also emitted in Santiago. Citizens living in Chile, especially those living in Santiago, are extremely susceptible to many dangerous chemicals.

Health Issues as a Result

Residents in Santiago suffer from many different ailments caused by bad air. Even if one is only exposed to ground level ozone for 6 hours, symptoms of chest pain, coughing, nausea, and repiratory inflammation begin to appear. Those that are constantly breathing in polluted air have much more serious consequences. The respiratory system is particularly damaged, but the circulatory system, nervous system, and digestive system can be impaired as well. Children and the elderly are the most susceptible to health problems associated with air pollution. Children can experience slowed growth, and chronic illnesses are more likely in polluted areas. Air pollution aggravates previous health problems, and many chronich illnesses, such as asthma are encouraged. Following is a list of common health problems. The primary pollutants that are responsible for the ailments are given as well.

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Effect on the Environment

Air pollution has serious effects on the environment in addition to its serious effects on humans. Nitrogen dioxide contributes to acid rain and eutrophication, which occurs when there are too many nutrients in bodies of water. Chemicals in the air harm animals as well as human beings in many of the same ways. Pollution encourages global warming and the greenhouse effect as well. Smog traps Santiago in a thermal bubble during winter. Ground-level ozone, nitrogen oxides, and sulfur dioxide are greenhouse gases, which are a potential threat to our globe.

Actions Against Air Pollution

Article 19.8 of Chile's constitution promises citizens the right to live in an environment free from contamination. The government has decided to take action against their air pollution problem, according to the "polluter pays" principle. This principle, initiated in 1994, provides economic incentives and direct regulations as remedies. Ricardo Lagos, Chile's president elected in January 2000, has shown strong concern for the environment, creating the "Atmospheric Decontamination and Prevention Plan," which primarily restricts bus travel in Santiago and the use of leaded gas. Motors and certain fuels that are especially detrimental have been banned. Incentives have led to a decrease in traffic, and public transportation has become more common and useful for residents. Industries have had strict regulations placed on them so that they are closely monitored and shut down during periods of high contamination in the city. An alert system throughout the city warns citizens of pollution levels so that they might protect themselves better.

Clearly, Santiago's people are becoming aware of their serious problem and are doing something about it. Hopefully, they will return Santiago to a healthy state for the people and the environment. It will take a long time to heal Santiago, but industries and vehicles must be regulated to ensure safety for the people and the environment.

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Example 17: Mercury pollution essay

Essay—Chemistry
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	6	5	-	-	-	-

Background

As part of a unit on metals, students had researched the causes and consequences of the pollution of heavy metals. Students had to select one metal: mercury, cadmium, lead thallium or beryllium, and write an essay to describe and explain its uses and applications. They had to discuss the benefits as well as the potential health and environmental hazards associated with their chosen metal. Students were given time in class to do their research and to discuss their findings with peers and teachers. They were also given homework time to write drafts of the essay.

Students were given 1 hour and 30 minutes to write the essay in class under teacher supervision; they were allowed to consult their notes and resources but could not talk to each other or the teacher.

The essay was assessed using criteria A and B.

Note 1: As the work was done under examination conditions, the student's essay was handwritten; it has been retyped here to facilitate reading.

Note 2: All orthographical or content errors remain as per the original work.

Note 3: For copyright reasons the graph from "Mercury yesterday and today" could not be included.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
5–6	The student **explains** how science is applied to addressing a specific local or global issue. The student **explains some** of the benefits **and** limitations of science in solving the issue. The student **discusses** how science and its applications interact with **some** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 6 because the student:

- provides a thoughtful analysis of the interdependence of science, society and the environment
- gives a clear, well-resourced and detailed account of the uses and applications of mercury and critically analyses the benefits and limitations of the use of mercury in a range of areas (medicine, agriculture, metallurgic industry, combustibles and so on)
- explains how science, through medicine and the pharmaceutical industry, developed cures for mercury poisoning
- provides a balanced discussion, offering a range of scientifically supported arguments for and against the use and application of mercury within the social, economic, environmental and ethical perspectives.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
5–6	The student communicates scientific information **effectively** using **scientific language correctly**. The student presents all the information appropriately using symbolic and/or visual representation accurately according to the task. The student acknowledges sources of information **appropriately**.

This work achieved level 5 because the student:

- effectively communicates scientific information using a range of scientific language correctly
- presents his/her ideas and information in an appropriate form, using symbolic and visual representation to illustrate these ideas
- uses footnotes and references sources, but does not follow a recognized referencing convention consistently and makes some occasional mistakes.

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Student work

POLLUTION BY MERCURY

Today's world ecological situation is highly unfriendly. Morality of the society and the environment's state are interdependent. Recently lots of people don't understand that freedom of nature management is limited by natural laws of life development, moral and legal standards. Such attitude to the environment was observed during the whole XX century. But such ideology of boundless use of nature is immoral and destructive.

One of the modern problems is the problem of heavy metals' presence in men's life. I have met this problem many times at chemistry lessons and the problem of the Earth pollution by mercury really attracted my attention. I found out that large amount of fish can accumulate mercury getting into water with industrial factories' wastes. So, in 1953 - 1969 a lot of facts of fish poisoning took place in Japan. After a new term "Minamata disease" has appeared.[1] And I realized that same situation may occur in my country as well. Now I know there is a problem. The main source of environment polluting by mercury in Kazakhstan is Pavlodar chemical plant. Earlier it was exploited to produce sodium hydrate and coals brought from Ekibastuz. At that time mercury accession into atmosphere came to 14-63 tones, accession into water – about 3 tones, accession with sludge was 129 tones.[2] However, everything is connected in nature. The fact that this problem is spread far from my home can't decrease my anxiety about it because the Earth is our common home, it will be the home of future generations.

To answer the question "What is mercury?" I have read some scientific literature and have got a lot of interesting facts.

Now I know, mercury (lat. Hydrargyrum), Hg, is chemical element of II group of the periodical system with atomic number 80 and atom mass 200.59. The usual condition is silver liquid metal. Its density is 13.5 g/m^3, melting point is -38.86 °C, boiling temperature is 356.66 °C. At high temperature and at electric discharge mercury fumes radiate bluish green light rich in UV. Mercury is stable element and used in thermometers, monometers, gas-discharge devices and in producing Cl and NaOH. Alloys of mercury with metals are called amalgams. Mercury and majority of its compounds are poisonous.

I also learned a lot of positive aspects of using mercury in humans' life. It was known at least 1500 B.C.; people were good at getting it from cinnabar. Mercury was used in Egypt, India, Mesopotamia and China; it was held as the most important initial matter in producing life extending compounds called pills of immortality. In the IV – III B.C. Aristotle and Teofrast mentioned mercury as liquid silver (from the Greek "water" and "silver").

The first written certificates of use of mercury in eastern countries are given in ancient Chinese records where it is marked that 500 B.C. mercury was used as a medical product and life prolongation remedy, and vermilion – for preparation of red ink. In the I century B.C. ancient Greeks used vermillion as a pigment, but Aristotle also marked use of mercury in religious ceremonies and at treatment of some skin disease.

Avicenna has generalized views and experience of the Greek, Roman, Arabian, Indian and Chinese doctors in his principal book "The Canon of The Medical Science". In medieval Europe this book was an obligatory manual for doctors.

In the middle of the XVI century German monk – alchemist Bertold Schwartz used mercury for stabilization of invented by him saltpeter gunpowder for the first time. (It was widely applied in military and peace purposes.) Later, in 1799, mercury fulminate was received – the initiating explosive that was used in detonators and that is known as "rattling mercury".

The first physical devices with mercury filling were Torricelli's barometer (1643) and the thermometer of Fahrenheit (1720).

1 www.ecolife.ru –popular scientific magazine
2 "Pollution of environment by mercury and methods of demercuryzation" (authors Granovskii E.I., Hasenova S.K., Darisheva A.M., Frolova V.A.), Kitab, Almaty 2001.
3 "Great Encyclopedia 2000 (2 CD)", Cyril & Methodius, Moscow

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Negative influence made by mercury pollution was becoming apparent locally for a long period of time. Fast growth of man-made mercury wastes into environment due to burning mineral fuel was caused by the beginning of the industrial era. Careful scientific researches of physical and chemical properties of mercury had brought to new discoveries: for example, discovery of the process of synthesis of polyvinylchloride (1835), invention of a luminescent light source (T.Edison, 1891).

In 1892 the way of obtaining of chlorine and hydrate of sodium by electrolysis of NaCl on the mercury cathode was patented in Sweden.

In 1900 organomercuric compounds were synthesized. They were used as fungicides and means of grain treatment. Later similar compounds were used to create special paints, which particularly protected underwater designs from biofouling. Scientists made a round of other discoveries in favour of positive use of mercury.

Nowadays mercury and its compounds are used widely in various industries, agriculture and medicine. Besides, presence of this element at this or that amount (which usually is not determined) in any ore and combustible mineral raw material causes uncontrollable involving mercury into different technological processes.

As for me, people took too great interest in mercury's structure, positive use, so they have forgot about negative sides of use of this element.

According to the latest evaluation the world manufacturing of this metal has reached the point of 10000 tones a year. The percent of reused mercury is 20-25%. The forecast on 2005 is 11000 tones of manufactured mercury a year, the percent or reused mercury – 25-30%. It means that only one third of manufactured mercury is used second time. And what about the rest?

Total emission of mercury into air is estimated at 6000-7500 tones a year, including 3600-4500 tones a year from man-made sources. Total man-made emission into environment is 9000-10000 tones a year.

Graph

Over high toxicity of mercury its concentrations in different natural surroundings are standardized. When humans break the natural boundaries of transformation of Earth’s nature they risk make irreversible changes in fundamental characteristics. In the end these changes can cause that human’s power over nature will stand against human. That’s why it’s important to safe permissible boundaries of nature management.

Permissible concentrations of mercury in environment

Area	Maximum Concentration Limit
Atmosphere	0,0003 mg/m^3
Water (household)	0,0005 mg/dm^3
Water (fish farming)	0,00001 mg/dm^3
Soil	2,1 mg/kg

Source: http://www.ineco.obninsk.org/danger.html

Pic. “Mercury yesterday and today” N.R.Mashyanov, "Mineral", N 1, 1999

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Mercury can get into water as a result of leaching it out of rocks in the area of mercury fields, as a result of decomposition of water organisms accumulating mercury. Significant amount of mercury get into water with industrial factories' wastes, which produce paints, pesticides, medicines, some sorts of explosives. Thermoelectric power station working on coal produce great amount of mercury compounds into atmosphere which spread as dry or moist fall-out.

I want to write about the influence of mercury on human's organism. I think that this aspect can show how people harm themselves breaking the norms of morality.

People have received knowledge about danger of the mercury influence on human's organism long time before, probably, when men were first exposed to long contacts with mercury steams while developing deposits. More dangerous to health is extraction of disperse gold and silver from ores by amalgamation. Similar technology consists in careful hashing of auric breed with mercury. Then the mercury is boiled in a metal vessel until its full evaporation. So, in XVI century Central and South American silver-miners' life duration was about 6 months. These are not normal phenomena. Slighting attitude to consequences of mercury use resulted in failure. It is necessary to think carefully how one's business may act upon environment, people, other means of all living things surviving before it is run. But humans unfortunately hadn't obeyed such rules of ethics for many years in the past.

The main ways of getting of mercury into human's organism are breathing in the steams of metal mercury, breathing in its volatile compounds or aerosols and using polluted by methylated mercury food (mainly fish and seafood).

Mercury causes toxic and mutagen effects even in little doses as well on humans and on embryo. So, people harm their future children too.

The period of partial ejection of mercury from human's organism takes about 76 days. So people not just harm the environment, but slowly kill themselves on the global level. That's why I think it's one of the global problems. Maybe, humans think if a problem doesn't touch them, they can continue bad for nature activity. However, everything is connected in our world, and everyone depends on the condition of the nature. Breaking the natural laws, natural consecution of actions, causing damage to environment, men and women harm themselves and become similar to suicides.

Fortunately, medicine along with chemistry and pharmaceutics have already worked out how to cure mercury poisoning of humans and how to clean environment from mercury.

Cure of mercury intoxication consists in using of the antidotes forming inactive complexes with mercury and strengthening its remove from tissues.

Mercury and mercury residua and compounds are processed and buried today.

Offered by scientists vacuum sublimation is one of the most non-polluting and effective methods of recycling of natural and technical raw materials containing mercury and other toxic elements. It has no analogues in the world practice and allows to reduce emission of mercury with gases in 400 – 4000 times.

I want to add some data about refinement of rivers and lakes. The best way is to move silts and soils away and recycle them. The difficulty is in the high cost, what is another social problem. As for me, rather rich people and companies should make donations into funds which will do all the work cooperating with government.

In addition I can suppose my unusual approach to cleaning water from mercury. If some sorts of fish and water organism can accumulate mercury, people should breed these species. Some years after, to the point of their death, they should be taken off, recycled and buried.

There are some non-toxic compounds, for example, sulfur, 20% solution of bleaching powder, soap-soda solution, that allow to remove mercury from object or reduce its concentration to sanitary norm within short period of time. I'm sure it's highly important to know such compounds and solutions. They can help managing the problem locally. Everyone can save environment this way.

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Now I can say that science knows a lot about mercury, about its negative influence upon all living things, about solutions of the problem. But today there is a problem of insufficient information distribution. Every human has a right to get necessary information about the ecology in the world and in the area where he lives, about any harmful for nature activity. My personal suggestion:

- Publish special mercury pollution related editions of magazines cooperating with Ministries of education and health;
- Shoot some TV programs about harm of heavy metals, especially mercury and show it on national channels;
- Give a talk or round-table discussion in educational institutions and in Internet;
- Conduct advertising campaigns, which main slogan will be “Mercury free environment”

I believe all that is very important, because if people don’t know what they should struggle with, they can't protect themselves and help others. Information can help to develop spiritual culture in society. I think, every man have to take part in realization of my plan.

In my work I proved that the problem of pollution by mercury is a question “To be or not to be?” and showed some solutions, including my own. I consider the problem should alarm everyone, make people think if they really want their offspring to live on dirty, polluted, useless planet. From the earliest times people used mercury. It was helpful, becoming our enemy. Using mercury in a proper manner, we have an opportunity to rebuild the former relations between a man and this chemical element.

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Example 18: Genetically modified foods essay

Essay—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	4	4	-	-	-	-

Background

Students had spent two weeks studying a unit on genetic engineering principles and applications and were asked to write an essay about the advantages and disadvantages of genetically modified (GM) food. They were provided with articles copied from scientific journals and spent one class period researching the topic in the computer lab and on the Internet prior to writing the essay.

Students were given 80 minutes to write the essay in class under teacher supervision; they were allowed to consult their notes and photocopied articles but could not talk to each other or the teacher.

The essay was assessed using criteria A and B.

Note 1: As the work was done under examination conditions, the student's essay was handwritten; it has been retyped here to facilitate reading.

Note 2: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
3–4	The student describes how science is applied to addressing a specific local or global issue. The student **describes some** of the benefits **or** limitations of science in addressing the issue. The student **describes** how science and its applications interact with at least **one** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 4 because the student:

- presents both sides of the issue with equal clarity, and supports and addresses the inherent limitations of scientific knowledge with regards to this topic
- describes the application of science (in this case, biotechnology) in the production of GM foods.

This work did not achieve a level 5 because the student describes rather than explains the application of science in the production of GM foods.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
3–4	The student communicates scientific information using **scientific language**. The student presents most of the information appropriately using symbolic and/or visual representation according to the task. The student acknowledges sources of information **with occasional errors**.

This work achieved level 4 because the student:

- effectively uses a range of scientific language to present ideas and information, and for the most part, the presentation of these ideas is clear and correct
- acknowledges sources of information within the text and lists those sources in a separate bibliography.

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Student work

Advantages and Disadvantages of GM Food

Science had developed and evoluted that now it is able to create a total new organisms, which did not exist in the past. The process in which to make these plants is called genetic engineering or genetic modification using biotechnology. It involves the wanted characteristics moving its gene from a living organism where they have its naturally, to another living organism that the characteristics are wanted. There are genetically engineered plants that are eatable, and they are classified as genetically engineered food (GEF) or genetically modified food (GMF). Some examples of GMF are maize, tomatoes, potatoes and meats. In this paper, it will be going to state the advantages and disadvantages of GMF, including the short-term benefits and long-term disadvantages, proving whether the GMF should be kept and more should be produced or rather should be banned. Also, the ethical issues with cultural influences of GMF and contribution and limitation of integrated how science interweaved GMF into society, will going to be discussed.

To begin with, GMF has a lot of benefits, especially to the farmers, governments and of course, to all people in the world. Farmers would have to pay less for pesticides because GM plants are often pest-resistance, which also lead to the reduction of storage costs, therefore, it reduces the cost of whole cultivation and environmental damage. Also, growing GM crops that are able to withstand salinity and drought can reduce farmers' economic burden on costs involved in soil reclamation[1]. It is very important for all people in the world as well, since GMF is able to increase the crop yields to feed the world population, which reduce some starvation occurring in the world. This shows that science contribute help eliminate world's one of the major issue that people are suffering for long time. On top of that, science had made the same type of food containing totally new and improved nutrient components such as increasing the protein content of rice[2]. This mean that people are able to gain more nutrients by eating the same type of food, and be healthier. Thus, there are quite a lot of advantages in creating and consuming GMF.

On the other hand, all things have front and back side of the subject, and GMF is not the exceptional. To give out some disadvantages, it could be noticed that majority of disadvantages related to GMF is long-term. Firstly, opposite to the reduction use of pesticide, however, the use of herbicides would increase because of greater herbicide resistance of GMF. The use of great amount of herbicides lead to residual damage, which is known as "artificial evolution" of plants that is resistant to natural pest, and some bacterias with resistance to antibiotics. Secondly, the hazardous effects to people will be from the newly introduced proteins, the DNA vaccines from meat industry might lead some people to suffer from allegy and illness. The sarcastic fact about GMF is that people are able to obtain more nutrients from GMF but they also have risks of getting illness from those nutrients. However, there is no scientific and medical evidence to say that GMF is unsafe for people to consume it[3]. So, it might not be the way to say straight away that GMF should be banned, though some loss would be made in the aglicultural-department industry sector because of reduced chemical inputs, which is pesticides. That means, GMF have both advantages and disadvantages on environment, health and economy.

Moving on to the main issue, that whether GMF should be kept and more produced or should be banned, from some people's opinion, they are highly appreciated because of their tastes. The some groups that getting benefits from the production of GMF are people, government and farmers.

[1] http://Scope.educ.washington.edu/gmfood/
[2] http://challenge.uhome.net/gmfood.htm
[3] http://challenge.uhome.net/gmfood.htm

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However, some people are hesitant to buy those food because of the lack of labelling provided. People are demanding to know whether they have the rights to learn what is contained in GMF that they want to buy. This is the main ethical reason of this topic because farmers and governments refuse to label them for their own benefits while people, especially vegetarians who worry about eating food that contain genes from animals, for religious and also health or possively other reasons[4]. This is where the science is still limited because there are still doubts and unsure of the health problems that GMF have in potential, thus the producers of GMF is hesitating to label the food. Some people just refuse to buy GMF because they do not want to consume scientifically created plants or crops, which this is also the ethical issues for the world to whether people should consume more scientifically created things. Thus, no distinct answer could be drawn at the moment in this world, whether people should be consumed, or be banned.

In conclusion, GMF are very useful in some areas, which satisfies people, save the world from starvation and let the producers to be more economically wealthy. However, there is always some negative issues that are needed to be solved in the near future, such as science should prove that GMF is safe to consume and they should also improve on the medicals to cure the allegy and illnesses that are caused by eating GMF. Thus, it is unable to decide that GMF should be banned or should be consumed at this point, but possibly science would be able to solve in the near future.

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Example 19: The Human Genome Project essay

Essay—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	6	4	-	-	-	-

Background

A unit on "genetics" was introduced to students through the study of nucleic acids and DNA. Students became familiar with the function, chemical composition and structure of the DNA molecule. They constructed different models of the double helix to show their understanding of the structure, function and topological relationships. The study of the application of science and molecular biology was explored in the study of karyotypes as pre-natal diagnosis to detect genetic diseases, the use of recombinant DNA technology in biotechnology in the development of genetically modified organisms, and the relevance of the advent of molecular biology techniques in the advances of the Human Genome Project.

Students had to choose one of two topics: "The Human Genome Project "(HGP) or "Genetic Engineering" and then write an essay to submit as part of their internal assessment. They had to explain how science was used and examine its benefits and limitations. Students were expected to discuss the interactions between science applications and social and/or ethical factors.

Students had one week of lessons in the library where they had access to a variety of resources for their research. An additional week of homework time was allowed for essay writing. Prior to the due date, students were allowed to submit their drafts to the teacher for comments.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
5–6	The student **explains** how science is applied to addressing a specific local or global issue. The student **explains some** of the benefits **and** limitations of science in solving the issue. The student **discusses** how science and its applications interact with **some** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 6 because the student:

- explains how science, through the development of molecular biology techniques such as polymerase chain reaction (PCR), contributes to the advances and progress of the Human Genome Project (HGP)
- describes and explains how other applications of molecular biology (such as fingerprinting) are applied in criminology, forensic science and determining identity
- explains how biotechnology and the development of genetically modified organisms has affected agriculture, the economy, life and society

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- examines the use of the knowledge gained through HGP in medicine, such as the early diagnosis of genetic diseases
- weighs up the benefits and limitations of these applications in society through a balanced discussion that includes social, economic, cultural and ethical factors
- discusses controversial ethical issues related to human rights, confidentiality and data protection, against the advancement of science and the management of the evolution of species.

Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
3–4	The student communicates scientific information using **scientific language**. The student presents most of the information appropriately using symbolic and/or visual representation according to the task. The student acknowledges sources of information **with occasional errors**.

This work achieved level 4 because the student:

- uses scientific language to present ideas and information, and, for the most part, the presentation of these ideas is done correctly
- acknowledges sources in a separate bibliography but makes occasional errors and does not reference sources within the text.

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Student work

The Human Genome Project Essay

The Human Genome Project was officially launched in October of 1990 and was expected to last for fifteen years or until the year 2005. However since then, the world has seen a significant improvement in technology and it was for this reason that the project's completion date was changed to the year 2003. The project is an endeavour by many of the world's developed counties including the United States of America, Japan, Canada, the United Kingdom, Australia and France to achieve two very important goals which will inevitably provide all human beings with a better understanding of the human genome.

The first major objective was to produce a number of detailed maps with the exact location of every one of the estimated 30,000 genes in a human as well as genomes present in other organisms such as yeast and bacteria. The information acquired by the study of non human genomes is helping in the analysis of the human genome. Whilst on the other hand the second major objective was to discover the way in which the coded information found in DNA is arranged. This would then allow scientists to identify all of the genes present in a human. Other goals which were set at the beginning of the project included the improvement of tools for data analysis, the ability to store the information on databases and to be able to address any ethical, legal and social issues that the project could possibly create.

Although the Human Genome Project has not been completed it already impacted on the world in a both positive and negative way. In addition to this there have and will be many controversial issues generated from the Human Genome Project. I will discuss some of the impacts on that the Human Genome Project has had on society including the issues that have been generated.

Since the commencement of the Human Genome Project there has been a considerable improvement in technology. One example of such an improvement was when a biochemist by the name of Doctor Mullis invented the polyrnerase chain reaction. This invention allows the slightest amount of DNA to be duplicated numerous times so that it can be properly tested. This can be useful in the field of forensic science. For instance if a criminal left a small amount of DNA at a crime scene it could be duplicated through the use of the polyrnerase chain reaction process so that it could be tested. If this technological advance had not been made then small amounts of DNA could not be tested and as a consequence many criminals would have escaped detection. In this case, genetic research has made a contribution by making the world a safer place.

By gaining a better understanding of plant and animal genomes through the Human Genome Project farmers have been able to produce plants and animals which are more resistant to diseases. This has significantly reduced the cost of agriculture but more importantly has provided the consumer with foods that are more nutritious and pesticide free. At this point in time a handful of farmers have begun to use bioengineered seeds that are proving successful in growing insect and drought resistant crops which require very little or no pesticide whatsoever. The farmers who have trialled these seeds have seen an increase in production. This has been due to a reduction in waste because their crops and herds are much healthier. In the case of agriculture, genetics research has made a contribution by allowing farmers to produce more quality produce and hence earn a higher yearly income.

Another benefit achieved due to the Human Genome Project involves the mapping of genes which will one day allow us to eliminate genetic disorders. Genetic disorders can be inherited from a family member at conception through egg and sperm cells or can form within ones body cells. Some examples of genetic disorders are heart disease, cystic fibrosis and Down syndrome. In many cases genetic disorders can be life threatening. For instance it is known that 28 percent of all infant deaths in Australia are due to several types of genetic factors while 50 percent of all miscarriages are due to chromosomal abnormalities. In addition to this it is estimated that around 50 percent of the Australasian population will at some stage during their life be affected by a genetic disorder. Taking

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into mind these startling facts about genetic disorders there is no doubt that something needs to be done. Since the commencement of the human genome project in 1990, 12,315 genes have been mapped with 1,618 of these having been found to cause a genetic disorder when faulty. With this information it is hoped that not in the too distant future there will be ways in which to prevent or even eliminate genetic disorders. A process called gene therapy is at this stage being trialled and if successful may be the way of the future in preventing and eliminating genetic disorders. In this case, genetic research is expected to contribute to society by minimising the number of reported cases of genetic disorders.

It is said that the information attained during the Human Genome Project will help mankind to gain a better understanding of human evolution. This would allow us to trace our existence back many thousands of years which would greatly help us to clarify the knowledge that we already have. This would be a major contribution to anthropologists.

Despite the benefits already achieved and the projected benefits of the Human Genome Project there is a question as to whether or not the benefits will have come at too much of a cost. It has been said that the Human Genome Project at the point of completion will have cost six billion dollars Australian for fifteen years of research. Some argue that this money could have been spent more wisely such as using it build more hospitals or even to buy medical supplies or food for people living in third world countries. This is the perfect example of a limitation of science, being that scientific research often comes at a cost. In some peoples view they see one of the negatives associated with the Human genome project as the high expenditure involved. This is a moral consideration as to whether it is best to spend large sums of money on the Human Genome Project or elsewhere such as in third world countries.

It will be crucial to ensure that only people who have been given permission to access someone's genetic information are allowed to do so. If a person's genetic information was made widely available there would be a great deal of room left open for discrimination. For instance, an employer may discover that a person has a high probability of suffering from a genetic disorder and for this reason decide not to employ them. Another instance would be if an insurer discovered a person had a high probability of suffering from a genetic disorder and as a consequence decided not to insure them fully. If the issue of privacy was not addressed this would be one of the negative impacts on society caused through the Human Genome Project. This is a moral and ethical consideration.

The patenting of genes may also be an issue that could result due to the research conducted in the Human Genome Project. If the time came when people could patent genes it would become a nightmare. This is due to the fact that large pharmaceutical companies could patent genes that were found to cure a particular genetic disorder and hence they could charge large sums of money. This would see most people who would be unable to afford the high priced genes denied the right to be cured. If this issue was not addressed then it would become one of the negatives caused through the Human Genome Project. This would be a health consideration since many people would not be able to afford the treatment and hence there would be people suffering from curable diseases.

An ethical and very controversial issue which has been raised as a result of the Human Genome Project is whether to test people for genetic disorders that are incurable. If such tests were carried out and then the results were given to the patients they may become depressed and continually worrying about when they will develop the incurable disorder. It is therefore thought that tests would be best conducted for curable and preventable diseases. Some feel if incurable disorders were found to be present in some people that they should have the right to know so they can fulfil their goals and make arrangements before they are affected.

Another ethical issue is whether or not genetic information should be given to family members who did not ask for the information for themselves but may be at risk of developing, or passing on a genetic disorder? Some people hold the opinion that families should be informed about the risk of them developing a disorder so that they have second thoughts as to whether or not to have children

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who may also suffer from the disorder. However others believe that families should be not told since they may live a life of fear.

Many cultures believe that humans should not interfere with our genes in order to eliminated or prevent disorders. They believe we are all given an allocated time on earth and that it is wrong to try and change our genes so as to live longer.

After having weighed up the positives, negatives and issues related to the Human Genome Project I firmly believe that the efforts of the past thirteen years are doing more good than bad. As I have mentioned the Human Genome Project has seen society benefit in many ways including the advancement in technology such as the PCR process, the improvement of agriculture and the mapping of human genes so that one day we will be able to prevent and eliminate genetic disorders. Of all these benefits there is no doubt that the mapping of human genes so that genetic disorders can be prevented and eliminated is the most important. Not only will this knowledge benefit today's generation but will also benefit future generations. Therefore I think that the expense of the human genome project is not an issue since the knowledge gained will one day put an end to all genetic disorders and hence create a healthier population.

However at the same time it must be kept in mind that although the genetic blue print of genes is near completion it will be many more years until we will be able to look at a person's genes and learn everything about them. It is estimated that it will be another fifty years until we gain a full understanding of human genes.

There is no denying the fact that there are many issues that have and are expected to arise in the future. However I think that it is important to stress the fact that the Human Genome Project Organisation has acknowledged that many issues will be generated due to their research. Consequently, they have set aside a share of their total budget to address the many issues. Therefore I do not believe that the issues should be used to judge as to whether or not the Human Genome Project is a good thing since it is more than likely that they will be addressed at some stage.

In conclusion I think that the Human Genome Project has to this date proven a success not only in taking mankind one step closer to eliminating genetic disorders but also in many other areas which I have discussed.

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Example 20: Sex selection technique essay

Essay—Biology
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	6	6	-	-	-	-

Background

Students had been studying human reproduction and were asked to investigate a specific human reproduction technique that is currently available. Students then had to write an essay to describe the principles, benefits and limitations of the technique. They were expected to discuss the implications of the technique, considering at least one of the following factors: social, economic, political, environmental, cultural or ethical, and had to acknowledge all sources of information using an appropriate referencing system.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
5–6	The student **explains** how science is applied to addressing a specific local or global issue. The student **explains some** of the benefits **and** limitations of science in solving the issue. The student **discusses** how science and its applications interact with **some** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 6 because the student:

- provides a detailed description of the principles behind the sex-selection technique and clearly explains how science has come up with a solution to the problem of sex selection through chromosome sorting
- explains the benefits of this technique to prevent diseases linked to the X chromosome
- explains the limitations of the technique in terms of the financial implications
- discusses the technique from the economic, cultural and ethical perspectives, assessing its advantages and predicting its problems if it were to be used widely in different countries around the world.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
5–6	The student communicates scientific information **effectively** using **scientific language correctly**. The student presents all the information appropriately using symbolic and/or visual representation accurately according to the task. The student acknowledges sources of information **appropriately**.

This work achieved level 6 because the student:

- effectively communicates scientific information using scientific language correctly
- presents his/her ideas in an appropriate form
- uses footnotes and references his/her sources in an organized and well-documented bibliography.

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Student work

Sex Selection Using the "MicroSort" Technique

There have been many attempts through history to finding a way to choose the desired gender of a child, There is a new method of choosing this. This method is the "Microsort" technique.

The chromosome of the sperm fertilizing the egg decides the gender of a child. If the sperm carries a Y-chromosome, then the child turns out to be a male. If the sperm carries an X-chromosome, then the offspring is female.[1] The Microsort technique separates the sperm carrying the X-chromosome from the sperm carrying the Y-chromosome and uses the sperm containing the chromosome of desired gender to fertilize an egg.

The method is based on that the X-chromosome contains more DNA than the Y-chromosome. The DNA difference can be measured and sorted by using a flow cytometer, which is an instrument used to measure characteristics of individual cells.[2] After the sperm cells are sorted, the enriched sample, or the portion of sperm that contains an increased number of sperm cells of the desired gender, is tested for purity by a method called "fluorescence in situ hybridization"(FISH), which can identify whether a sperm contains an X-or Y-chromosome. The FISH method identifies X- and Y-chromosomes by using DNA probes that attach to either type of chromosome and emits a red color for X-chromosomes and a greenish color for Y-chromosomes. The purity is determined by identifying and counting the sperm.

There are some different possibilities for fertilization of an egg after the sperm is sorted. In *intracytoplasmic sperm injection* (ICSI), a sperm is injected directly into an egg cell. In *intrauterine insemination* (IUI), a sperm sample is directly deposited into the uterus to attain fertilization and pregnancy. In *in vitro fertilization* (IVF), sperm cells are placed in a dish together with unfertilized eggs. The embryos can then be transferred into the uterus or preserved using cryopreservation, which means the embryo, can be used later.[3] Of all of the mentioned methods, most pregnancies were achieved after intrauterine insemination.[4] A method which is called preimplantation genetic diagnosis (PGD), can also be used, and it allows to check if the baby is going to be the desired gender. PGD takes plays a couple of days after fertilization, and a cell is taken from an embryo and the DNA is analyzed. If test shows that the embryo is of the undesired gender, it can be rejected[5].

Although the microsort website claims that the microsort technique is not associated with any medical or health problems, there are other sources who have concerns about mutation from certain parts of the procedure. The babies born so far have been "normal and healthy" according to a journal published from microsort.[6] The only problem with the procedure is that it's not 100% that the child will be the desired sex. The statistics for having a girl by using microsort is 91% and the chance of having a boy through using microsort is 76%. Another problem is when a sperm and an egg have united, the resulting embryos have been transferred to a woman's uterus, and the fertilized egg starts to grow in a fallopian tube above the uterus. This case then has to be solved by a surgery. There are also some trials that end in miscarriages.[7]

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[1] www.microsort.com
[2] www.microsort.com
[3] www.microsort.com
[4] www.microsort.com
[5] www.bbc.co.uk/dna/h2g2/alabaster/A939918
[6] www.microsort.com
[7] http://www.sciencenews.org/sn_arc98/11_28_98/Bob2.htm

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The history of the procedure is not a very long one. The procedure using a flow cytometer to sort the sperm cells was originally developed by Dr. Lawrence Johnson at the US Department of Agriculture for animal use. The Genetics and IVF Institute (GIVF) and Dr. Johnson further improved the technology to enable for use in humans. The first baby born using the new technology was in 1996.[8]

The GIVF does not allow all couples to have sex selection. They have limited it to families, which are "unbalanced", (which means that they have many children of one sex and would like to have a baby of the opposite sex), and couples of which the mother is a carrier of an x-linked disease. An x-linked disease means that there is an inherited deficiency on the X-chromosome, which means that only the male offspring will be affected. Females can also be affected in the way that they can be carriers of the disease, which means that they carry the disease on to the next generation without usually showing any symptoms of the disease themselves. Only the male offspring is affected, because they are built up one x- and one y-chromosome, and when the x-chromosome is damaged, they are ill. The females are carriers, because they have two X-chromosomes, and if they inherit the damaged chromosome from their mother, they still have another healthy one.[9]

An example of an x-linked disease is Ornithine transcarbamylase deficiency (OTC), which is the most common disease of the urea cycle. The urea cycle is a sequence of steps that uses enzymes to change the extra protein in food, which the body does not need, into a waste that can be removed from the body through the urine.[10] In OTC, the enzyme Ornithine is deficient of missing and this means that the cycle does not work properly and that amounts of ammonia accumulates in the blood.

OTC can be diagnosed through checking the blood for excessive amounts of ammonia and level of amino acids. When a person has OTC there is also an abnormally high level of oronate in the urine, and citrulline is absent in the blood. The two last named substances distinguishes OTC from the other Urea Cycle Disorders, which are caused by other enzymes being deficient or missing completely.[11]

The symptoms of OTC are the same as for the other Urea Cycle Disorders; vomiting, lack of appetite, drowsiness, and hepatomegaly (when liver is abnormally enlarged). However, the symptoms vary a lot, depending on the seriousness of the deficiency. The most visible symptoms in children with moderate enzyme deficiency is hyperactivity and vomiting after protein-rich meals. If OTC is not detected, the person will have seizures, have permanent brain damage, turn into coma, and eventually die. Some individuals can survive into adulthood and these usually suffer lethargy, loss of appetite, they can't think clearly, they sleep more than usual, and vomit. Even though OTC is X-linked, the disease can also affect heterozygote woman (woman that are carriers and have one defect x-chromosome). However, this is not usual and the woman only show mild symptoms of the disease. only males can be fully affected by the disease, so the microsort techniques helps reducing the odds of having an ill baby, if a female is being chosen.[12]

[8] www.microsort.com
[9] http://www.hhmi.org/genetictrnil/e120.html
[10] http://www.vanhom.bc.ca/html/wellness_amdc_findout_urea_whatis.html
[11] http://www.covaidoctors.com/diseases/o/o9.php#Standard Therapies:
[12] http://www3.ncbi.nlm.nih.gov/htbin-post/Omim/dispmim?311250#INHERITANCE

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As already pointed out, the microsort technique is very expensive. One sorted vial of sperm costs $2,300 and there are many other associated fees, such as the required consultations (Microsort patient consultation $200), the storing of the semen (cryopreservation $200 per vial) and the actual fertilization.(e.g. IUI micro sort full monitoring $3,450).[13] An example of a total cost of the whole procedure (including travelling and accommodation) is $5,134.00, which were the costs of a frustrated American woman.[14]

The microsort technique is also not spread out through the world. Microsort is only available in the USA, so couples that want to use the technique have to travel to the US to get it done. In addition, other methods of sex selection, for example PGD is not allowed in many countries, like for example the UK.

However, there are also debates on whether sex selection should be allowed or not. There are some who believe that sex selection should only be available for couples where an x-linked disease could be transmitted, and some who believe that it should also be allowed for "balancing" families, as it is today, in the US. An American study has shown that 81% of woman and 94% of men wanted their first child to be a boy.[15] This is a reason to why feminists oppose sex selection, as they believe that it pushes the men into a leading role right away and make the woman small sisters. There are also some pro-life groups that oppose the PGD method of sex selection, as they think of the embryo as a living human.

There is also a discussion going on about whether it is right to have the power to decide so much over the child. If the desired sex of the child is female, the pressure on the girl to really be the perfect little girl might be harder. This links to that some people say that sex selection is the "first step to designer children".[16] These people worry about that the parents are going to treat their children as consumer goods, and not like human beings.

There is also an economic perspective. There are people who want to make money out of the technique of choosing the gender of the child. This can for example be seen through microsort's high prices. Of course, they have to make enough money to compensate for the wages and all the equipments, and so on, but they advertise the technique as a normal consumer product. The market for fertility and infertility is big, and many want to be able to choose the sex of their child, so there is lots of money to make there. There is also a big market for sex selection when it comes to livestock, because dairy farmers want cows and beef farmers obviously want bulls.[17]

There is also a cultural perspective to sex selection. If sex selection would have been offered in Asia, like India, more males would have been born. In the Asian countries, the culture says that boys are more honorable and are the purpose of a marriage. Males are also preferred because they are supposed to offer better financial situations. The belief that males are better is influenced by the Sanskrit literature, which says that the males are more valuable.[18] Sex selection exists there, but in the form of abortion and infanticide. If microsort would have been introduced and allowed here (and been cheaper), there would probably be less abortions and infanticide. However, the already increasing male/female ratio would get bigger.

[13] www.microsort.com
[14] http://www.futurepundit.com/archives/000186.html
[15] www.bbc.co.uk/dna/h2g2/alabaster/A939918
[16] http://www.sciencenews.org/sn_arc98/11_28_98/Bob2.htm
[17] http://www.devbio.com/article.php?id=185
[18] http://www.devbio.com/article.php?id=185

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If the microsort technique would be allowed and open to most people, then first, the ratio of male/female would increase, especially in Asia. On a long-term basis, this could mean that there would be lack of females and there would be more stride between the males over the females. This could also contribute to changing the views of the society, to for example more sexist, because of the preference of males. However, this would probably not be so much of in the western part of the world, as studies have shown that most families want balancing.

In addition, spreading the technique would also help clearing the paths for other things that changes and plays with nature in a similar way, for example further research and development on creating "designer babies" and probably cloning. If sex selection would be allowed everywhere, many would probably start thinking that it cannot possible be that bad, if they are not already experiencing bad things with the sex selection.

A suggestion that could help finding the microsort practice a place in society without major opposition would be to restrict the use to only couples who really needed it, for example if there was a risk of transmitting an x-linked disorder to the child or the family was extremely unbalanced. Then the technology wouldn't be so wide spread, and it could not be used to choose the gender of a child only because of dreams. There would probably also be less problems; the problem with male/female wouldn't become more serious.

The Microsort sex selection technique links clearly in with *Homo Faber* and *Community and Ser*vice. It relates to *Homo Faber*, because the technique was developed and created to solve the problems of many people, and that demonstrates the people behind the technique's ability to change things. The technique also has an impact on society in that way they provide help to couples with risk of transmitting an x-linked disease to their male offspring, so they instead can have a daughter. The link to *Community and Service* is that the technique is something that clearly demonstrates that the people behind it clearly had an interest in today's world and they showed a social awareness by finding a solution to some people's problems with X-linked diseases and family "balancing". The people behind the technique served the community.

My personal opinion on this topic is that the sex selection technique should only be allowed in those cases where there is a high risk of x-linked disease running in the family such as haemophilia, OCR disease, color blindness, etc. However, I think that balancing the family is not a good reason for sex selection although it is preferable to abortion or infanticide and I would recommend it for those countries that have these practices.

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Example 21: Electric generators essay

Essay—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	4	4	-	-	-	-

Background

As part of a topic on electricity and magnetism, students were asked to investigate how a better understanding of electricity and magnetism has contributed to the development of different applications for life and society. They then had to write a "one world" essay that explored one specific application. Students were expected to discuss how this application interacted with one of the following factors: social, economic, political, environmental, cultural, or ethical. They also had to demonstrate their understanding of the role of science in society.

Students were given two weeks of class time to work on this essay. They were expected to acknowledge all sources of information using a recognized referencing convention.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
3–4	The student describes how science is applied to addressing a specific local or global issue. The student **describes some** of the benefits **or** limitations of science in addressing the issue. The student **describes** how science and its applications interact with at least **one** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 4 because the student:

- describes how electricity is produced by a magnetic field (Faraday electromagnetic induction)
- describes the use of electromotive force in the development of electric generators
- describes some of the limitations of gas-powered electric generators, making reference to noise pollution and its effect on the environment.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
3–4	The student communicates scientific information using **scientific language**. The student presents most of the information appropriately using symbolic and/or visual representation according to the task. The student acknowledges sources of information **with occasional errors**.

This work achieved level 4 because the student:

- communicates scientific information using scientific language that is mostly correct
- presents his/her ideas and information in an appropriate form
- makes some occasional mistakes when referencing sources and does not follow a recognized referencing convention consistently.

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Student work

The Electric Generator

During the early 1800's, many scientists didn't believe that magnetism was directly related to electricity. They were convinced that the two topics were independent, and that they were not to be connected to eachother. In 1821, a Danish physics proffesor Hans Oersted accidentally proved to his physics class that these two topics directly connected. Using this theory, a man named Michael Faraday decided to take this study a bit further. This study changed the lives of all of us, and if it wasn't invented we would be living absolutely different to what we are living now.

10 years after the so called "accident" Oersted had, Faraday came up with a powerful idea, which seemed futile at the time. In 1931, he built the worlds first electric generator using magnets, copper wire, a hand crank, a couple of conductors, and his own gifted mind. He made it so that when you turned the hand crank, the copper wire attached to a disk would spin in between a double magnet. Because copper is an electric conductor, and it was moving through the magnet's magnetic field, it inducted, hence creating an electric current because of the potential difference. To make it a continuous generator, he added a commutator, which touched the copper wire on two sides and had a gap between it, and when the wire spinned, it switched polarization, making it possible to create a potential difference constantly, making it an exellent generator. Taking this excellent invention, us homo-sapiens adapted this generator so it uses gas to power the crank instead of rotating it yourself so you can produce your own power. In hydroelectric dams, turbines pushed by water turn the "crank" which produces clean energy.

Although gas powered electric generator may be a good invention if the main power supply of your house cuts off, or you need to power an appliance outside of your house the machine still has its drawbacks. Because the gas motor usually uses cheap fuel for example diesel, the motor makes a huge amount of noise, and when many of these are used at the same time in one neighborhood (when there is a power cut) it can produce great amounts of noise pollution. The diesel engine creates excessive amounts of pollution just as trucks do as well. This great invention may be handy when you need it, but environmentally, it has its drawbacks.

Most of today's power plants that are powered by water, steam, or gas turbines use Faradays method on a larger scale to distribute power to our homes, letting us have electricity. Our lives today absolutely revolve electricity, computers, stoves, printers, cellular telephones, and even toasters; there are thousands of appliances that require electricity to work. How do we use all these things? It all comes down to Faraday and the first electric generator, without this invention we would have been living in the dark with candles to light up our houses.

Personally. I think people should take this invention as an example, and think about the future. We have to open our minds just like Faraday did, and think of possible solutions to the problems of the world. People say to learn from your mistakes, but you also have to learn from jobs well done in the past. Without faraday's invention, we would be living in darkness.

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Example 22: Electricity from fossil fuels essay

Essay—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	6	4	-	-	-	-

Background

As part of a unit on electricity, students had explored the connection between electricity and energy. Students were expected to develop an understanding of the relationship between electricity and fossil fuels. They were asked to examine the issue and analyse it from at least one of the following perspectives: social, economic, political, environmental, cultural or ethical. They then had to write an essay to show their understanding of how scientific ideas can be applied and used to solve a specific problem and analyse their limitations within the societal context.

Students had to devise a plan for their essays and present these to their teacher. They were allowed to use resources from the school library and the Internet and were given class time to work on their essays.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
5–6	The student **explains** how science is applied to addressing a specific local or global issue. The student **explains some** of the benefits **and** limitations of science in solving the issue. The student **discusses** how science and its applications interact with **some** of the following factors: social, economic, political, environmental, cultural and ethical.

This work achieved level 6 because the student:

- clearly explains how electricity is applied and used in life
- explains the benefits and limitations of using fossil fuels for energy, placing particular emphasis on the consequences of using non-renewable resources
- explains some of the benefits and limitations of using alternative sources of energy
- discusses the implications of using non-renewable and renewable sources of energy from the social, economic and environmental perspectives.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
3–4	The student communicates scientific information using **scientific language**. The student presents most of the information appropriately using symbolic and/or visual representation according to the task. The student acknowledges sources of information **with occasional errors**.

This work achieved level 4 because the student:

- communicates his/her understanding of scientific information using scientific language
- uses symbols and graphs to illustrate his/her ideas appropriately
- acknowledges sources of information, but makes occasional errors when referencing web sites and omits quotes or paraphrases.

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Student work

INTRODUCTION

Over the years, humans have become dependant on different forms of energy, to the point where we now rely on it for our survival. Today energy lights our cities, powers our cars and planes, and helps heat our houses, along with providing power to use our computers and televisions. When we get out of the bed in the morning and switch on the light, we are relying on energy to light up the bulb. The simplest way of defining energy is 'the ability to do work'. Different forms of transportation, such as planes and cars transform energy into work. Even though we rely on energy to live our lives and to make our life easier, there are a lot of negative points about some forms of energy.

FOSSIL FUELS & ALTERNATVE FORMS OF ENERGY

Most of our energy today comes from what we call "fossil fuels". Fossil fuels come in three forms, which are gas, coal, and oil. So how did fossil fuels come about? Fossil fuels where created from the remains of prehistoric animals and plants. When these ancient animals and plants died they became decomposed and eventually became buried under many layers of mud, rock and sand. Over millions of years they became decomposed into organic materials, otherwise know as fossil fuels. They type of fossil fuel created depended on the combination of plants and animals decomposed in a certain area, how long the plant and animal debris had been buried for, and the temperature and pressure values during the time which everything decomposed.

Each type of fossil fuel plays a very important part in the generation process of energy. Coal today is mainly used in power plants to create electricity. Coal comes in the form of a black rock. It is known that half of the U.S.A is powered by power plants, which burn coal to produce power. On the other hand, oil is used to power all of our transportation machines: it powers our cars, planes, and boats. Today oil is used so much, that countries are finding it hard to get the required amount each year, which their country uses. This is why today countries buy oil off other countries with a high supply of oil, such as Saudi-Arabia, so that they can keep up with the demand. The third fossil fuel is natural gas. Natural gas is colourless, shapeless and in its normal form, odorless. Natural gas is one of the most important fuels we have access to. It provides us with energy for heating, cooking and for other household appliances. Natural gas is mainly made up of a chemical called methane, a simple, compound that has a carbon atom surrounded by four hydrogen atoms. Methane is highly flammable and burns almost completely. This is why gas companies add a chemical to gas which smells, so that you know if you have a gas leak in your house.

Using fossil fuels to produce energy is preferred than using other energy sources as fossil fuels are cheap to use. Thus governments don't have to spend a lot on energy production. Environmentally, oil and coal are products, which pollute the earth, as gas is a cleaner product. Besides that the amount of fossil fuel left in the earth is slowly reducing. Once we have used it all up it will be gone, and it will be millions of years before fossil fuels are around again. Soon we will have to find an alternative power source.

Besides fossil fuels being a form of energy, there are many other different ways. Other forms of energy are types such as Biomass Energy, Geothermal Energy, Hydro Power, Nuclear Energy, Solar Energy, Wind Energy and Transportation Energy. Solar Power can create energy all the time, providing that the solar panels are always facing direct sunlight. Hydro Power uses the ocean's water to create energy. Wind Energy creates energy through using wind. Biomass Energy is created through the use of dead trees, crops, sawdust, etc. All these other forms of energy are renewable and at the current time, there is no shortage for these energy sources.

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So why don't we use these energy sources? Even though many of these other forms of energy types are more 'cleaner' than using fossil fuels, they are more expensive and most of them don't produce the same amount of work-output which fossil fuels create. This is why governments don't want to invest loads of money in something, which won't produce a large amount of energy.

THE DEBATE OVER ENERGY SOURCES

Soon the world will be facing a low supply of fossil fuels. Scientists have estimated that the world's supply of fossil fuels will be drastically low by the year 2100. They are being depleted slowly because of the severe amount the world uses each year. As a final point, fossil fuels are not renewable. When everything's gone, it will be gone. It will take millions of years before fossil fuels ever exist again. This is why scientists are stressing the fact that we should be starting to use other ways of producing energy, which are renewable. But people disagree with this as renewable source of energy have their disadvantages as well. Many renewable energy sources require a large area of land to produce a reasonable amount of electricity. This would result in the environment around the energy production facilities to be affected. Other energy sources use toxic chemicals in their production for energy, which can have a big impact on the environment if there are any leaks. Besides all these reasons the biggest reason why governments do not invest in renewable energy sources is because of the small amount of energy output, which they produce. On a hot sunny day, it is known that California needs 55,000 Megawatts of electricity. On a cold winter day this would be a totally greater number. If we took all the solar power production facilities in the world, they could only produce enough solar cells to produce 350 Megawatts in one day. Also, the cost of producing 350 Megawatts of electricity using solar power, it would cost four times more expensive than using a natural gas-fired power plant. Many people ask the question 'Why should governments invest money in an energy source which produces very little work output but is very expensive?'.

Another debate over the fossil fuels being used as an energy source other than using alternative energy sources is the fact that fossil fuels can create pollution. The pollution generated through the use of fossil fuels is, in itself, affecting the environment through effects such as the ozone depletion. This is more directly related to coal and oil, as natural gas is a non-pollutant. Coal creates pollution through the emissions given out of coal power plants, and oil pollutes the environment through the emissions, which cars and planes emit. Organisations such as Green Peace are trying to persuade governments to stop using more and more fossil fuel sources for energy and instead use environmentally friendly sources. I personally believe that instead of protesting, we should we working together to try to find other ways of creating an efficient, reliable source of energy.

Another fact is that governments don't want to change from using fossil fuels, as sources such as oil help the world's economy.

ENERGY FOR TRANSPORTATION

A huge amount of the fossil fuels today are used to power our transport technology, such as planes and cars. Over me past few years scientists have been working on electrical cars to try and reduce emissions. When trains where changed from coal powered to electrical powered, there was a huge difference in the amount of pollution they emitted. Today trains like the TGV in France, run on electrical power, and are very reliable and are very environmentally friendly. This was a similar situation to when the first electrical car was created. Even though electrical cars have reduced the amount of emissions there are still negative point against them. The points against electrical cars are: they are not truly zero emission vehicles, use Pb Acid Batteries and this has generated a new Pb pollution. Other battery types are too expensive to use. Also on journeys where you could not recharge your car, you would need a huge battery to keep you car powered. The pros of using an electrical car are: it improves engine efficiency, and reduces urban air pollution.

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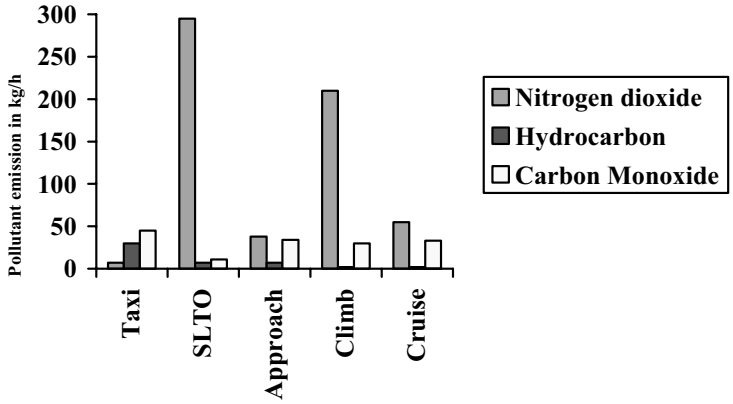
Besides cars, aircrafts have also had a big impact on the environment. Aircrafts are powered by jet fuel, which is from oil. Aircrafts emit big amounts of emissions during take-off and during the climb stage of the flight. The pollutant emission for the General Electric Engine CF6-50C can be seen in diagram 1.



Data from Wilson Liu – Southampton University

The amount of emissions given off during each stage of flight depends merely on the engine setting. On take-off an engine is set to 1000% power, climb – 85%, taxiing (idle power) – 70%, and approach 30%. For descent the aircraft's engine are at idle power so the engine setting would be also 7%. Due to the fact the aviation industry is growing quite fast, many organisations and scientists have pointed out that other ways of powering aircrafts in flight have to be found, to lower aircraft emissions. This has mainly been the job of NASA who have come up with a number of ways which could be adapted to aircrafts in the future. Solar power has been an idea, an has been tried out, but has proved to be unreliable.

Recently a new idea has been brought up which has been named the "The Zero CO_2 Emissions Technology Project". In this project NASA are trying to figure out how hydrogen can be used to power jet engines on an aircraft. This would stop aircrafts form releasing emissions and the only waste would be pure water.

SOCIETY'S INDIFFERENCE TO A WORLD PROBLEM

The effects on the ozone layer and also global warming, due to the use of fossil fuels are happening because of society's view on the problem. Obviously if we want to decrease the amount of pollution in the air, the only-we can do this is through trying to stop using huge amounts of electricity and to stop using our cars for example, for unnecessary journeys. There are people who drive their car somewhere, when it would take them 10 minutes to walk. Some people use so much electricity when they are not even using it. We need to conserve energy if we want to tackle this world problem.

Today we live in a very greedy world, where we rely on fossil fuels so much that one-day countries will go to war over the last amounts, if that isn't happening already. The U.S.A consumes more fossil fuels that in can properly supply in a year. I believe this is a reason for why George Bush is so eager to start a war with Iraq, because he wants access to the country's oil Why go to war, waste oil to power tanks and jet aircrafts, when we can keep that supply of fossil fuel, to help power other, more important things.

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We are consuming so much fossil fuel that our future generations will face the problem, which we left them. This is why I believe we should conserve our resources and find other reliable and inexpensive energy sources in the meantime. But, this is not going to happen because who is going to pay more for an electric car when a normal fuel-powered car can give the same performance for a cheaper price. Who will pay more for something because it is going to save our environment and help our future generations? The majority of our society believes that 'if its not going to happen in my lifetime, why should I be bothered'. That's the world we live in, a greedy unequal place.

CONCLUSION

If we look at the facts, it took 65 million years for fossil fuels to be created. They are not renewable, and once there gone, it will take probably another 65 million years before we have them again. So, sooner or later we are going to be looking for alternative ways to produce energy. Today, hydrogen is being looked into and could be a possible future energy source to produce electricity. Another idea is Solar Powered Satellites, whereby there could be huge solar power satellites orbiting the earth picking up the suns rays. The satellites could then be transformed into electricity and beamed down to earth using microwaves or some other form of transmission. Microwaves would be a good idea because this wouldn't affect the atmosphere.

I believe that we should stay ahead of this world problem and find a solution to it now. There is no use to wait until the problem has reached its climax stage, as this will most probably cause havoc. It is now time to solve this problem once and for all.

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Example 23: Transport and storage of radioactive waste essay

Essay—Physics
MYP year: 5

Criterion	A	B	C	D	E	F
Level achieved	1	2	-	-	-	-

Background

Students were asked to write a research essay in response to a review of teacher-selected web sites. They were provided with four Internet sources about radioactive waste and were given tips for evaluating the accuracy of each source prior to researching the topic. They then worked independently on researching, planning and developing the essays. Students were expected to summarize various viewpoints of the issue and include a discussion about radioactive waste disposal, as well as a formal evaluation of the recommended web sites.

Although this is a very relevant and interesting topic, it should be noted that the way it was presented to students did not encourage them to explore how science is applied and used in society.

The essay was assessed using criteria A and B.

Note: All orthographical or content errors remain as per the original work.

Assessment

Criterion A: one world

Maximum level: 6

Achievement level	Descriptor
1–2	The student **describes** how science is applied to addressing a specific local or global issue. The student **states some** of the benefits **or** limitations of science in addressing the issue.

This work achieved level 1 because the student:

- attempts to describe the way science is applied to the problem of transportation and disposal of radioactive waste but is unsuccessful, and does not develop ideas based on scientific application
- states some of the benefits and limitations of science with regards to the transportation and disposal of radioactive waste, but does not elaborate on them.

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Criterion B: communication in science

Maximum level: 6

Achievement level	Descriptor
1–2	The student **attempts** to communicate scientific information using **some scientific language**. The student presents some of the information in an appropriate form using some symbolic or visual representation when appropriate. The student attempts to acknowledge sources of information but this is **inaccurate**.

This work achieved level 2 because the student:

- uses limited scientific information and language to convey ideas and understanding
- does not reference ideas or information within the text to the sources of information used.

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Student work

THE TRANSPORT AND STORAGE OF RADIOACTIVE WASTES

(I used more then the four sites listed because I found relevant information outside of them.)

Transportation and storage of radioactive waste is described by agreeing companies as completely safe and reliable. They show how accidents are avoided and issues about radiation affecting health and environment are irrelevant. However, opposing companies and organisations state clear statistics of environmental damage and health impact.

The most popular way of disposing of the waste is by geologic burial. First the waste is immobilised in an insoluble matrix like synthetic rock. It is then sealed inside a corrosion-resistant container which is then buried underground or in a stable rock structure. The container is surrounded with a backfill such as bentonite clay.

Organisations against radioactive waste disposal and radiation altogether are concerned for the environment. By cleaning one site and transporting the waste to another burial site you are not getting rid of the pollution. The land they use becomes unaccesible to humans and animals. The land can not be developed by humans and there isn't much land left in the world that can simply be put aside for burial of radioactive wastes. It is slowly killing off the last of our untouched environments. This simply can not go on forever. Also, CAN claims that dumping is a potential act of racial and socioeconomic justice. They have proven that dumping sites are generally poor, rural or home of people of colour.

Transportation of radioactive waste must comply to very strict standards. For example trucks from the Yankee Atomic Electric Company are 3 inches thick and steel encased. They may only travel on specific routes and their drivers undergo very thorough training. All trucks are equipped with state of the art safety equipment and efficient procedures are at hand if there is an accident. However, these sites that promise transportation of radioactive wastes is completely safe do not give statistics or records of any accidents.

Organisations like Greenpeace and CAN claim that the damage a major accident would have is not worth the risk. The radiation that would leak out in a spillage would dramatically affect the environment and the health of people living in surrounding cities. Radiation has been proven to cause birth deformities, cancer, change your genetic structure and other diseases. CAN claims that radiation has been released into rivers and surrounding cities have reported a major increase in miscarriages, cancer and premature death. Both websites show pictures of accidents and spillage's which have killed off surrounding environment. They also state issues in the cost of dealing with the radioactive waste. There is a lot of money involved with the people who must check all the trucks and ensure that everything is safe. The substances must be handled with extreme care, which takes a lot of time and effort. Overall opposing organisations provide a broader overview and discuss all relative information.

If I were asked to vote on the issue I would vote against transportation and storage of the radioactive waste, especially in South Australia. There are many other forms of renewable energy, like solar, that can be used without a waste product. It is known to the public that no matter what agreeing companies promise there is always a risk of accidents and the radiation spilt would kill the environment and potentially people. I would vote against radiation all over the world and especially in my home state.

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Appendix

Moderation and monitoring of assessment: examples of completed forms

The following are examples of a completed Form F3.1 (moderation) and a completed Form F4.4 (monitoring of assessment).

These forms have been completed using student work contained in this teacher support material, so that teachers can see examples of what type of work is appropriate to include in a sample, and examples of forms filled out for sciences.

The first form, Form F3.1, is used for moderation. Teachers fill out eight of these forms—one per student—and include the corresponding student work in the sample.

The second form, Form F4.4, is used for monitoring of assessment, specifically the monitoring of assessment service used for evaluation visits or general advice. (If you are using the monitoring of assessment service "prior to moderation", please ensure that you use Form F4.2. Filling out this form is similar to filling out Form F3.1.) Teachers should fill out a Form F4.4 for each task that they send and include the corresponding student work in the sample. For evaluation visits or general advice, teachers may wish to send the tasks recommended for moderation. However, they are not required to adhere to this guideline.

Please note that these are examples and are not prescriptive. All moderation and monitoring of assessment samples should be compiled by following the instructions set out in the MYP *Sciences guide*.

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FORM F3.1

MIDDLE YEARS PROGRAMME

Moderation coversheet: subjects

*Please complete a copy of this form for **each** folder of work submitted to IBCA.*

*Please ensure that the material being submitted for moderation conforms to the requirements set out in the relevant guide. All the criteria **must be assessed twice** within the folder accompanying this form with the exception of **language B** where there should be **one** assessment against criteria A and B, and **physical education** where there should be **one** assessment against criterion B. One achievement level must be recorded on the coversheet for those criteria that are not moderated.*

School name: Treetops International School **School code:** 008899

Student's name/number: John Smith **Subject:** Biology

The student is (please tick box): ☑ comparatively good average comparatively weak

Nature and title of assessment task		Criteria							
		A	B	C	D	E	F	G	H
1. Genetically modified foods essay	Teacher	4	4						
	Moderator								
2. The Human Genome Project essay	Teacher	6	4						
	Moderator								
3. Rate of enzyme reaction investigation	Teacher				4	2			
	Moderator								
4. Nervous system investigation	Teacher				4	4			
	Moderator								
5. Genetics test	Teacher			5					
	Moderator								
6. Ecology test	Teacher			6					
	Moderator								

Please use the reverse of this form or separate sheets to identify the conditions under which each piece of work was done (project, classroom test, end-of-term examination, etc), the amount of support provided, any special circumstances, and general/specific information on the student. Provide any information that may assist the moderators in determining how the criteria were applied.

Name of teacher: Jane Riley

Signature of teacher: *J Riley* Date: 14 April 2007

Names of teachers involved in internal standardization for the subject:

Emma Clarke, David Brown

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FORM F3.1

TEACHER'S COMMENTS:

Task 2: The Human Genome Project essay

As stated in the background information, students had two weeks to complete this task. However, John was given an extra week to complete the task as he missed a week of school through a sport competition.

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FORM F4.4

MIDDLE YEARS PROGRAMME

Monitoring of assessment task coversheet: subjects

Evaluation visit/general advice or guidance

*Please complete a copy of this form for **each** task included in the sample. Only one copy is needed to accompany the work of the four students.*

This form should be used to document the application of the criteria and the award of achievement levels for each criterion. If additional criteria to the MYP criteria are used, then these must be indicated clearly: please include a copy of the criterion descriptors used in the form of a rubric or grid that shows your school's application of the subject criteria for the task. In addition, use the table below to record the criterion levels awarded to each student for the task against the relevant criteria.

School name: Treetops International School **School code:** 008899

Subject: Chemistry

The sample is from (please tick box): year 3 years 4/5 ☑

Title of task: Investigating fuels laboratory report	
Criteria used	**Information on the application of the criterion**
D	The students were assessed on their ability to design a scientific investigation to compare two fuels for their energy output. Students had to design and carry out scientific investigation, formulate a hypothesis, manipulate variables, suggest a method and evaluate reliability and validity of the method.
E	The students were assessed on their ability to organize, process and transform data obtained from the investigation, commenting on its reliability and drawing a conclusion supported by scientific reasoning.
F	Students were assessed on their ability to work effectively in the laboratory, collaborating with their peers and contributing to a safe working environment.

Students' names		**Criteria**							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1. Mark Williams	Teacher				4	3	4		
	Assessor								
2. Carol Simpson	Teacher				5	4	6		
	Assessor								
3. Lesley Rooney	Teacher				6	6	6		
	Assessor								
4. Brian Murphy	Teacher				3	3	2		
	Assessor								

Please use the reverse of this form or separate sheets to provide information on the nature of the task, as well as any background information that may assist the assessor in determining how the criteria were applied.

Name of teacher: Laura Lawson *Date: 14 October 2007*

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FORM F4.4

Nature of the task and background information

Note on student 2:

I have included all of the background information relevant to this practical in a separate "background information" folder.

However, Brian needed extra assistance in the laboratory because he suffers from attention deficit disorder (ADD) and was given more guidance, assistance and time to complete the task than the rest of the class. Also, the technician was present throughout the practical, supervising and ensuring all students' safety.

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