Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

Wednesday 8 November 2017 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[30 marks]**.

8817 – 6104

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. How many atoms of nitrogen are there in 0.50 mol of $(NH_4)_2CO_3$?

A. 1

B. 2

C. 3.01×10^{23}

D. 6.02×10^{23}

2. What is the value of **x** when 32.2 g of $Na_2SO_4 \cdot \mathbf{x}H_2O$ are heated leaving 14.2 g of anhydrous Na_2SO_4? $M_r(H_2O) = 18$; $M_r(Na_2SO_4) = 142$.

$$Na_2SO_4 \cdot \mathbf{x}H_2O\,(s) \rightarrow Na_2SO_4\,(s) + \mathbf{x}H_2O\,(g)$$

A. 0.1

B. 1

C. 5

D. 10

3. How many grams of sodium azide, NaN_3, are needed to produce 68.1 dm^3 of $N_2\,(g)$ at STP? Molar volume at STP = 22.7 $dm^3\,mol^{-1}$; $M_r(NaN_3) = 65.0$

$$2NaN_3\,(s) \rightarrow 3N_2\,(g) + 2Na\,(s)$$

A. 32.5

B. 65.0

C. 130.0

D. 195.0

4. What is the sum of the coefficients when the following equation is balanced using the smallest whole numbers?

$$\_\_C_6H_{12}O_6\,(aq) \rightarrow \_\_C_2H_5OH\,(aq) + \_\_CO_2\,(g)$$

A. 4

B. 5

C. 9

D. 10

5. What is the number of protons and the number of neutrons in ^{131}I?

	Protons	Neutrons
A.	53	78
B.	53	131
C.	78	53
D.	131	53

6. Which is the electron configuration of a chromium atom in the ground state?

A. $[Ne]3s^2 3p^6 4s^1 3d^4$

B. $[Ar]3d^3$

C. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$

D. $[Ar]4s^1 3d^5$

7. Which trends are correct across period 3 (from Na to Cl)?

I. Atomic radius decreases
II. Melting point increases
III. First ionization energy increases

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which oxide dissolves in water to give a solution with a pH below 7?

A. MgO

B. Li_2O

C. CaO

D. P_4O_{10}

9. The electronegativity values of four elements are given.

C	N	O	F
2.6	3.0	3.4	4.0

What is the order of **increasing** polarity of the **bonds** in the following compounds?

A. $CO < OF_2 < NO < CF_4$

B. $CF_4 < CO < OF_2 < NO$

C. $NO < OF_2 < CO < CF_4$

D. $CF_4 < NO < OF_2 < CO$

10. Which compound has the shortest C–N bond?

A. CH_3NH_2

B. $(CH_3)_3CNH_2$

C. CH_3CN

D. CH_3CHNH

11. Which of the following series shows increasing hydrogen bonding with water?

A. Propane < propanal < propanol < propanoic acid

B. Propane < propanol < propanal < propanoic acid

C. Propanal < propane < propanoic acid < propanol

D. Propanoic acid < propanol < propanal < propane

12. Which statements are correct for metals?

I. They conduct electricity because they have free moving ions.
II. They consist of a close-packed lattice of positive ions with delocalized electrons.
III. They are malleable because the layers of positive ions can slide over each other.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. Which statement is correct for this reaction?

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H = -26.6\,kJ$$

A. 13.3 kJ are released for every mole of Fe produced.

B. 26.6 kJ are absorbed for every mole of Fe produced.

C. 53.2 kJ are released for every mole of Fe produced.

D. 26.6 kJ are released for every mole of Fe produced.

14. The enthalpy changes for two reactions are given.

$$Br_2(l) + F_2(g) \rightarrow 2BrF(g) \qquad \Delta H = x\,kJ$$
$$Br_2(l) + 3F_2(g) \rightarrow 2BrF_3(g) \qquad \Delta H = y\,kJ$$

What is the enthalpy change for the following reaction?

$$BrF(g) + F_2(g) \rightarrow BrF_3(g)$$

A. $x - y$

B. $-x + y$

C. $\frac{1}{2}(-x + y)$

D. $\frac{1}{2}(x - y)$

15. What is the enthalpy change, in kJ, of the following reaction?

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

Bond	**Bond enthalpy / kJ mol^{-1}**
N≡N	945
H–H	436
N–H	391

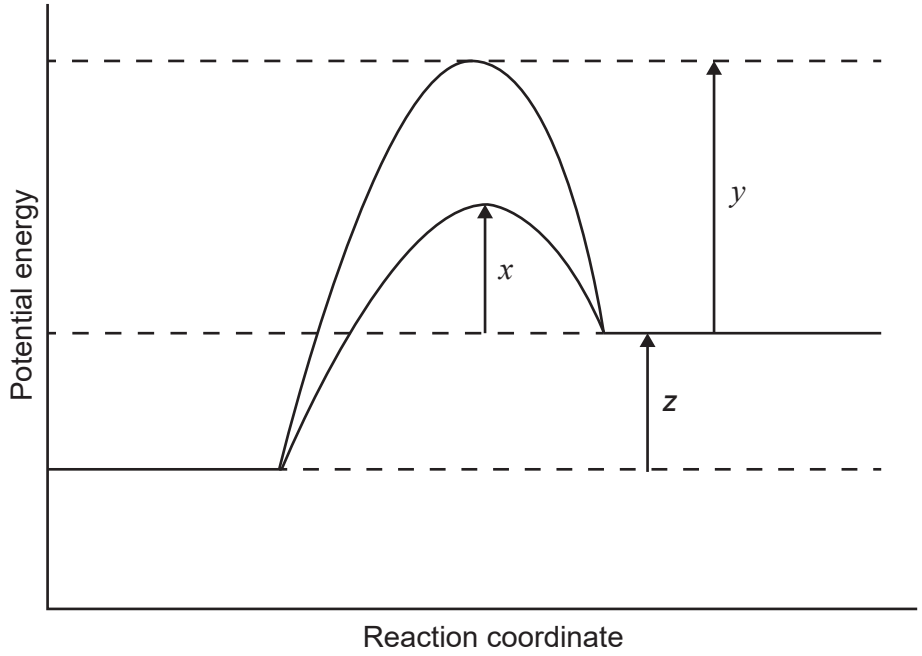
A. $(6 \times 391) - [(3 \times 436) + 945]$

B. $(3 \times 391) - (436 + 945)$

C. $-[(3 \times 436) + 945] + (3 \times 391)$

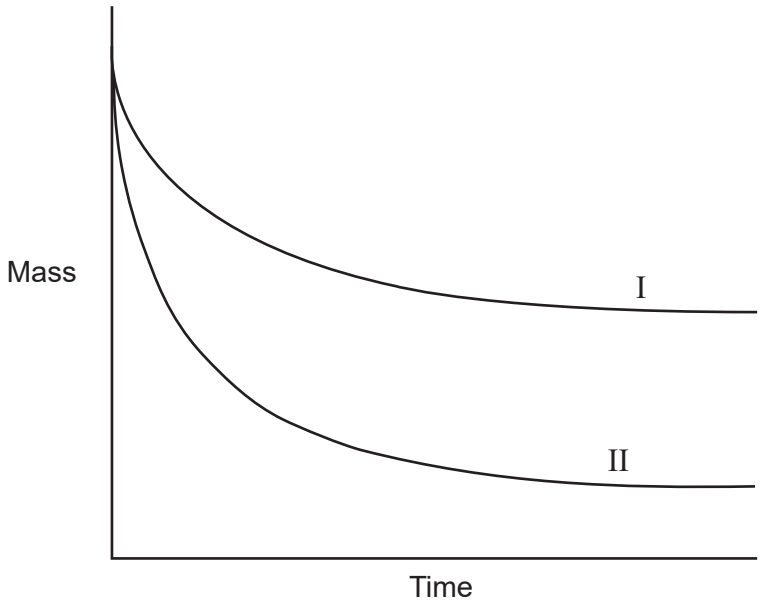
D. $-(6 \times 391) + [(3 \times 436) + 945]$

16. The diagram shows the energy profile for a catalysed and uncatalysed reaction.
Which represents the enthalpy change, ΔH, and the activation energy, E_a, for the **catalysed** reaction?



	ΔH	E_a (catalysed reaction)
A.	z	$x + z$
B.	z	$z + y$
C.	$-z$	x
D.	$z + x$	x

17. Excess magnesium powder was added to a beaker containing hydrochloric acid, HCl(aq). The mass of the beaker and its contents was recorded and plotted against time (line I).



Which change could give line II?

A. Doubling the mass of powdered Mg

B. Using the same mass of Mg ribbon

C. Increasing the temperature

D. Using the same volume of more concentrated HCl

18. What will happen if the pressure is increased in the following reaction mixture at equilibrium?

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

A. The equilibrium will shift to the right and pH will decrease.

B. The equilibrium will shift to the right and pH will increase.

C. The equilibrium will shift to the left and pH will increase.

D. The equilibrium will shift to the left and pH will decrease.

19. 10.0 cm^3 of an aqueous solution of sodium hydroxide of pH = 10 is mixed with 990.0 cm^3 of distilled water. What is the pH of the resulting solution?

A. 8

B. 9

C. 11

D. 12

20. Which statement is **incorrect** for a 0.10 $mol\,dm^{-3}$ HCOOH solution?

A. pH = 1

B. $[H^+] << 0.10\,mol\,dm^{-3}$

C. $[HCOO^-]$ is approximately equal to $[H^+]$

D. HCOOH is partially ionized

21. What are the oxidation states of chromium in $(NH_4)_2Cr_2O_7(s)$ and $Cr_2O_3(s)$?

	$(NH_4)_2Cr_2O_7(s)$	**$Cr_2O_3(s)$**
A.	+7	+3
B.	+6	+3
C.	+6	+6
D.	+7	+6

22. Which of the following is a redox reaction?

A. $3Mg(s) + 2AlCl_3(aq) \rightarrow 2Al(s) + 3MgCl_2(aq)$

B. $SiO_2(s) + 2NaOH(aq) \rightarrow Na_2SiO_3(aq) + H_2O(l)$

C. $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$

D. $2NaHCO_3(aq) \rightarrow Na_2CO_3(aq) + CO_2(g) + H_2O(l)$

23. What is the reaction type and major product at the **anode** (positive electrode) when molten sodium chloride is electrolysed using platinum electrodes?

	Reaction type	Product
A.	reduction	Cl_2
B.	oxidation	Cl_2
C.	reduction	Na
D.	oxidation	Na

24. What is the major product of the reaction between HCl and but-2-ene?

A. 1,2-dichlorobutane

B. 2,3-dichlorobutane

C. 1-chlorobutane

D. 2-chlorobutane

25. Which compound can be oxidized when heated with an acidified solution of potassium dichromate(VI)?

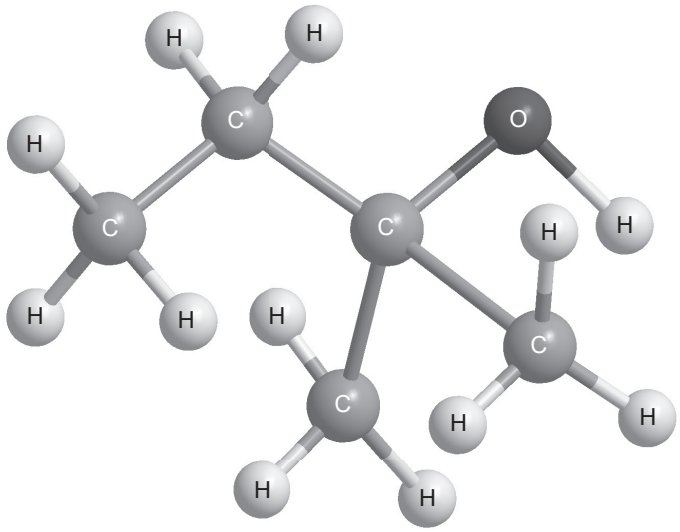
A. $CH_3C(O)CH_2CH_3$

B. $CH_3CH_2CH(OH)CH_3$

C. $(CH_3)_3COH$

D. $CH_3(CH_2)_2COOH$

26. What is the name of this compound, using IUPAC rules?



A. 3-methylbutan-3-ol

B. 2-ethylpropan-2-ol

C. 2-methylbutan-2-ol

D. 3-methylbutan-2-ol

27. Which type of reaction occurs between an alcohol and a carboxylic acid?

A. Addition

B. Oxidation

C. Esterification

D. Polymerization

28. How many structural isomers of C_6H_{14} exist?

A. 4

B. 5

C. 6

D. 7

29. What information is provided by ^{1}H NMR, MS and IR for an organic compound?

I. ^{1}H NMR: chemical environment(s) of protons
II. MS: fragmentation pattern
III. IR: types of functional group

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

30. A student performs an acid-base titration using a pH meter, but forgets to calibrate it. Which type of error will occur and how will it affect the quality of the measurements?

A. Random error and lower precision

B. Systematic error and lower accuracy

C. Systematic error and lower precision

D. Random error and lower accuracy