Markscheme

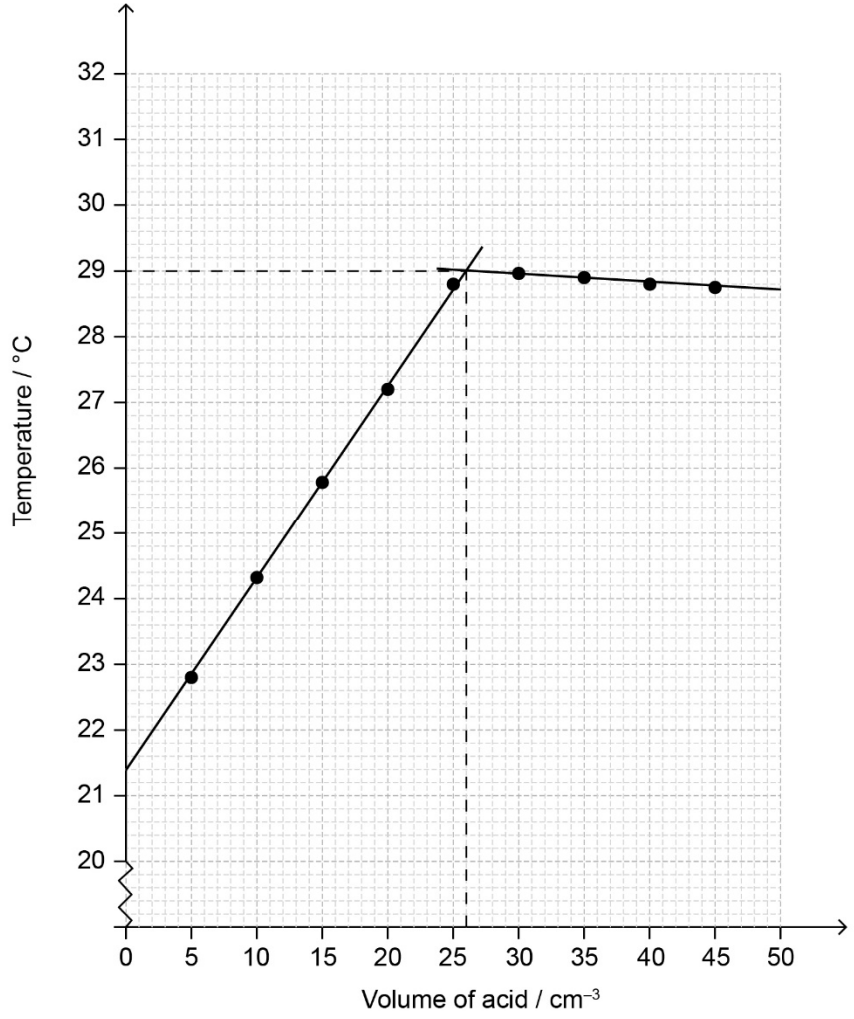
November 2017

Chemistry

Standard level

Paper 2

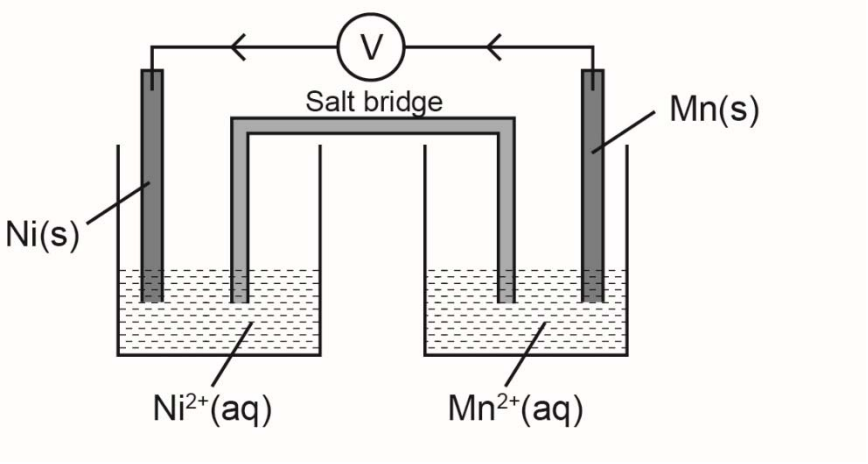
13 pages

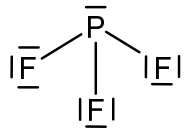
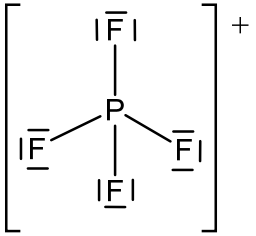
Question			Answers	Notes	Total
1.	a		 21.4 °C ✓	*Accept values in the range of 21.2 to 21.6* °C.	1

Question			Answers	Notes	Total
1.	b		29.0 «°C» ✓	*Accept range 28.8 to 29.2 °C.*	1
1.	c		***ALTERNATIVE 1*** «volume CH_3COOH =» 26.0 «cm^3» ✓ «$[CH_3COOH] = 0.995\ mol\ dm^{-3} \times \frac{50.0\ cm^3}{26.0\ cm^3}$ =» 1.91 «mol dm^{-3}» ✓ ***ALTERNATIVE 2*** «n(NaOH) =0.995 mol $dm^{-3} \times 0.0500\ dm^3$ =» 0.04975 «mol» ✓ «$[CH_3COOH] = \frac{0.04975}{0.0260} dm^3$ =» 1.91 «mol dm^{-3}» ✓	*Accept values of volume in range 25.5 to 26.5 cm^3.* *Award **[2]** for correct final answer.*	2
1.	d	i	«total volume $= 50.0 + 26.0 =$» 76.0 cm^3 ***AND*** «temperature change $29.0 - 21.4 =$» 7.6 «°C» ✓ «$q = 0.0760\ kg \times 4.18\ kJ\ kg^{-1}\ K^{-1} \times 7.6\ K =$» 2.4 «kJ» ✓	*Award **[2]** for correct final answer.*	2

Question			Answers	Notes	Total
1.	d	ii	«n(NaOH) = 0.995 mol dm^{-3} × 0.0500 dm^3 =» 0.04975 «mol» ***OR*** «n(CH_3COOH) = 1.91 mol dm^{-3} × 0.0260 dm^3 =» 0.04966 «mol» ✓ «$\Delta H = -\frac{2.4 \text{ kJ}}{0.04975 \text{ mol}}$ =» −48 / −49 «kJ mol^{-1}» ✓	*Award **[2]** for correct final answer.* *Negative sign is required for M2.*	**2**
1.	e	i	«initially steep because» greatest concentration/number of particles at start ***OR*** «slope decreases because» concentration/number of particles decreases ✓ volume produced per unit of time depends on frequency of collisions ***OR*** rate depends on frequency of collisions ✓		**2**
1.	e	ii	mass/amount/concentration of metal carbonate more in X ***OR*** concentration/amount of CH_3COOH more in X ✓		**1**

Question			Answers	Notes	Total
2.	a		increasing number of protons ***OR*** increasing nuclear charge ✓ «atomic» radius/size decreases ***OR*** same number of shells ***OR*** similar shielding «by inner electrons» ✓ **«**greater energy needed to overcome increased attraction between nucleus and electrons**»**		**2**
2.	b		atomic/ionic radius increases ✓ smaller charge density ***OR*** force of attraction between metal ions and delocalised electrons decreases ✓	*Do **not** accept discussion of attraction between valence electrons and nucleus for M2.* *Accept "weaker metallic bonds" for M2.*	**2**
2.	c		$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$ ✓	*Accept "$P_4O_{10}(s) + 2H_2O(l) \rightarrow 4HPO_3(aq)$" (initial reaction).*	**1**
2.	d		**«**series of**»** lines ***OR*** only certain frequencies/wavelengths ✓ convergence at high**«**er**»** frequency/energy/short**«**er**»** wavelength ✓	*M1 and/or M2 may be shown on a diagram.*	**2**

Question			Answers	Notes	Total
2.	e	i	Mn ✓		1
2.	e	ii	$Mn(s) + Ni^{2+}(aq) \rightarrow Ni(s) + Mn^{2+}(aq)$ ✓		1
2.	e	iii	wire between electrodes ***AND*** labelled salt bridge in contact with both electrolytes ✓ anions to right (salt bridge) ***OR*** cations to left (salt bridge) ***OR*** arrow from Mn to Ni (on wire or next to it) ✓  	*Electrodes can be connected directly or through voltmeter/ammeter/light bulb, but **not** a battery/power supply.* *Accept ions or a specific salt as the label of the salt bridge.*	2

Question			Answers	Notes	Total
3.	**a**		<table><tr><th></th><th>PF_3</th><th>PF_4^+</th></tr><tr><td>Lewis structure</td><td>  ✓</td><td>  ✓</td></tr><tr><td>Molecular geometry</td><td>trigonal pyramidal ✓</td><td>tetrahedral ✓</td></tr></table>	*Accept any combination of dots, crosses and lines.* *Ignore missing brackets and positive charge.* *Penalize missing lone pairs once only.* *Do **not** apply ECF for molecular geometry.*	**4**
3.	**b**		polar ***AND*** bond polarities/dipoles do not cancel out ***OR*** polar ***AND*** unsymmetrical distribution of charge ✓	*Apply ECF from part (a) molecular geometry.*	**1**

Question			Answers	Notes	Total
4.	**a**		carbon: **«** $\frac{0.4490\text{ g}}{44.01\text{ g mol}^{-1}}$ **»** = 0.01020 **«**mol**»** / 0.1225 **«**g**»** ***OR*** hydrogen: **«** $\frac{0.1840 \times 2}{18.02}$ **»** = 0.02042 **«**mol**»** / 0.0206 **«**g**»** ✓ oxygen: **«**0.1595 – (0.1225 + 0.0206)**»** = 0.0164 **«**g» / 0.001025 **«**mol**»** ✓ empirical formula: $C_{10}H_{20}O$ ✓	*Award **[3]** for correct final answer.*	**3**
4.	**b**		temperature = 423 K ***OR*** $M = \frac{mRT}{pV}$ ✓ **«***M* = $\frac{0.150\text{ g} \times 8.31\text{ JK}^{-1}\text{ mol}^{-1} \times 423\text{ K}}{100.2\text{ kPa} \times 0.0337\text{ dm}^3}$ **»** 156 **«**g mol^{-1}**»** ✓	*Award **[1]** for correct answer with no working shown.* *Accept "pV = nRT **AND** n =* $\frac{m}{M}$*" for M1.*	**2**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>5.</td><td>a</td><td></td><td>
<table>
<tr><th></th><th>Effect</th><th></th><th>Reason</th></tr>
<tr><td>Increasing the volume, at constant temperature</td><td>none/no effect</td><td>AND</td><td>same number of «gas» moles/molecules on both sides ✓</td></tr>
<tr><td>Increasing the temperature, at constant pressure</td><td>moves to left</td><td>AND</td><td>«forward» reaction is exothermic ✓</td></tr>
</table>
</td><td>Award [1 max] if both effects are correct.

Reason for increasing volume:
Accept “concentration of all reagents reduced by an equal amount so cancels out in K_c expression”.
Accept “affects both forward and backward rates equally”.</td><td>2</td></tr>
<tr><td>5.</td><td>b</td><td>i</td><td>HCO_3^- AND H_2O ✓</td><td></td><td>1</td></tr>
<tr><td>5.</td><td>b</td><td>ii</td><td>species that has one less proton/H^+ ion «than its conjugate acid»
OR
species that forms its conjugate acid by accepting a proton
OR
species that is formed when an acid donates a proton ✓</td><td>Do not accept “differs by one proton/H^+ from conjugate acid”.</td><td>1</td></tr>
<tr><td>5.</td><td>b</td><td>iii</td><td>oxide ion/O^{2-} ✓</td><td></td><td>1</td></tr>
</table>

Question			Answers	Notes	Total
5.	**c**		insufficient data to make generalization ***OR*** need to consider a **«**much**»** larger number of acids ***OR*** hypothesis will continue to be tested with new acids to see if it can stand the test of time ✓ **«**hypothesis is false as**»** other acids/HCl/HBr/HCN/transition metal ion/BF_3 do not contain oxygen ***OR*** other acids/HCl/HBr/HCN/transition metal ion/BF_3 falsify hypothesis ✓ correct inductive reasoning **«**based on limited sample**»** ✓ **«**hypothesis not valid as**»** it contradicts current/accepted theories/Brønsted-Lowry/Lewis theory ✓		**2 max**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>6.</td><td>a</td><td>i</td><td>oxidation/redox AND acidified «potassium» dichromate(VI)
OR
oxidation/redox AND «acidified potassium» manganate(VII) ✓</td><td>Accept “acidified «potassium» dichromate” OR “«acidified potassium» permanganate”.
Accept name or formula of the reagent(s).</td><td>1</td></tr>
<tr><td>6.</td><td>a</td><td>ii</td><td>ALTERNATIVE 1 using $K_2Cr_2O_7$:
Compound A: orange to green AND secondary hydroxyl
OR
Compound A: orange to green AND hydroxyl oxidized «by chromium(VI) ions» ✓

Compound B: no change AND tertiary hydroxyl «not oxidized by chromium(VI) ions» ✓

ALTERNATIVE 2 using $KMnO_4$:
Compound A: purple to colourless AND secondary hydroxyl
OR
Compound A: purple to colourless AND hydroxyl oxidized «by manganese(VII) ions» ✓

Compound B: no change AND tertiary hydroxyl «not oxidized by manganese(VII) ions» ✓</td><td>Award [1] for “A: orange to green AND B: no change”.
Award [1] for “A: secondary hydroxyl AND B: tertiary hydroxyl”.

Accept “alcohol” for “hydroxyl”.

Award [1] for “A: purple to colourless AND B: no change”
Award [1] for “A: secondary hydroxyl AND B: tertiary hydroxyl”.
Accept “purple to brown” for A.</td><td>2</td></tr>
<tr><td>6.</td><td>a</td><td>iii</td><td><table><tr><th>Compound</th><th>Number of signals</th><th>Ratio of areas</th></tr><tr><td>A</td><td>5 ✓</td><td>6:1:1:1:1 ✓</td></tr><tr><td>B</td><td>4 ✓</td><td>6:1:1:2 ✓</td></tr></table></td><td>Accept ratio of areas in any order.
Do not apply ECF for ratios.</td><td>4</td></tr>
</table>

Question			Answers	Notes	Total
6.	**b**		*Initiation:* $Br_2 \xrightarrow{UV\ /hv/heat} 2Br\bullet$ ✓ *Propagation:* $Br\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HBr$ ✓ $C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$ ✓ *Termination:* $Br\bullet + Br\bullet \rightarrow Br_2$ ***OR*** $C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$ ***OR*** $C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ ✓	*Reference to UV/hv/heat not required.* *Accept representation of radical without • (eg, Br, C_2H_5) if consistent throughout mechanism.* *Accept further bromination.* *Award **[3 max]** if initiation, propagation and termination are not stated or are incorrectly labelled for equations.* *Award **[3 max]** if methane is used instead of ethane, and/or chlorine is used instead of bromine.*	**4**