

Markscheme

November 2018

Chemistry

Standard level

Paper 2

13 pages

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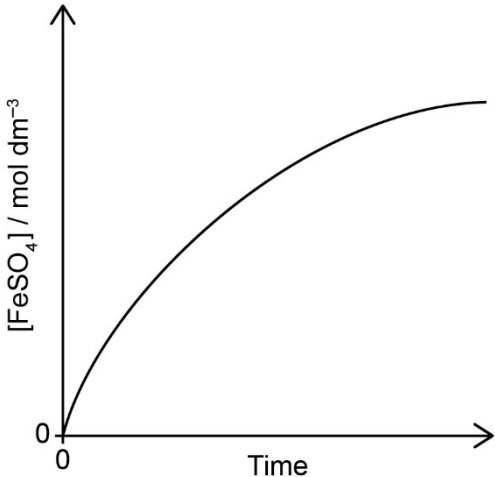
Question			Answers	Notes	Total
1.	a	i	$n_{\text{CuSO}_4} \llcorner = 0.0800 \text{ dm}^3 \times 0.200 \text{ mol dm}^{-3} \llcorner = 0.0160 \text{ mol } \mathbf{AND}$ $n_{\text{Fe}} \llcorner = \frac{3.26 \text{ g}}{55.85 \text{ g mol}^{-1}} \llcorner = 0.0584 \text{ mol } \checkmark$ CuSO ₄ is the limiting reactant \checkmark	Do not award M2 if mole calculation is not shown.	2
1.	a	ii	ALTERNATIVE 1: $\llcorner 0.0160 \text{ mol} \times 63.55 \text{ g mol}^{-1} = \llcorner 1.02 \text{ g} \llcorner \checkmark$ $\llcorner \frac{0.872 \text{ g}}{1.02 \text{ g}} \times 100 = \llcorner 85.5 \llcorner \% \llcorner \checkmark$ ALTERNATIVE 2: $\llcorner \frac{0.872 \text{ g}}{63.55 \text{ g mol}^{-1}} = \llcorner 0.0137 \llcorner \text{ mol} \llcorner \checkmark$ $\llcorner \frac{0.0137 \text{ mol}}{0.0160 \text{ mol}} \times 100 = \llcorner 85.6 \llcorner \% \llcorner \checkmark$	Accept answers in the range 85–86 %. Award [2] for correct final answer.	2

Question			Answers	Notes	Total
1.	b	i	<p>ALTERNATIVE 1:</p> <p>$q = \llcorner 80.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ K}^{-1} \times 7.5 \text{ K} \Rightarrow 2.5 \times 10^3 \llcorner \text{J} \llcorner / 2.5 \llcorner \text{kJ} \llcorner \checkmark$</p> <p>$\llcorner \text{per mol of CuSO}_4 = \frac{-2.5 \text{ kJ}}{0.0160 \text{ mol}} = -1.6 \times 10^2 \text{ kJ mol}^{-1} \llcorner$</p> <p>$\llcorner \text{for the reaction} \llcorner \Delta H = -1.6 \times 10^2 \llcorner \text{kJ} \llcorner \checkmark$</p> <p>ALTERNATIVE 2:</p> <p>$q = \llcorner 80.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ K}^{-1} \times 7.5 \text{ K} \Rightarrow 2.5 \times 10^3 \llcorner \text{J} \llcorner / 2.5 \llcorner \text{kJ} \llcorner \checkmark$</p> <p>$\llcorner n_{\text{Cu}} = \frac{0.872}{63.55} = 0.0137 \text{ mol} \llcorner$</p> <p>$\llcorner \text{per mol of CuSO}_4 = \frac{-2.5 \text{ kJ}}{0.0137 \text{ mol}} = -1.8 \times 10^2 \text{ kJ mol}^{-1} \llcorner$</p> <p>$\llcorner \text{for the reaction} \llcorner \Delta H = -1.8 \times 10^2 \llcorner \text{kJ} \llcorner \checkmark$</p>	<p><i>Award [2] for correct final answer.</i></p>	2
1.	b	ii	<p>density $\llcorner \text{of solution} \llcorner$ is 1.00 g cm^{-3}</p> <p>OR</p> <p>specific heat capacity $\llcorner \text{of solution} \llcorner$ is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$/that of $\llcorner \text{pure} \llcorner$ water</p> <p>OR</p> <p>reaction goes to completion</p> <p>OR</p> <p>iron/CuSO₄ does not react with other substances \checkmark</p>	<p><i>The mark for “reaction goes to completion” can only be awarded if 0.0160 mol was used in part (b)(i).</i></p> <p><i>Do not accept “heat loss”.</i></p>	1

(continued...)

(Question 1b continued)

Question			Answers	Notes	Total
1.	b	iii	<p>ALTERNATIVE 1:</p> $\llcorner 0.2 \text{ }^\circ\text{C} \times \frac{100}{7.5 \text{ }^\circ\text{C}} \Rightarrow 3\%/0.03 \checkmark$ $\llcorner 0.03 \times 160 \text{ kJ} \llcorner = \llcorner \pm \llcorner 5 \llcorner \text{ kJ} \llcorner \checkmark$ <p>ALTERNATIVE 2:</p> $\llcorner 0.2 \text{ }^\circ\text{C} \times \frac{100}{7.5 \text{ }^\circ\text{C}} \Rightarrow 3\%/0.03 \checkmark$ $\llcorner 0.03 \times 180 \text{ kJ} \llcorner = \llcorner \pm \llcorner 5 \llcorner \text{ kJ} \llcorner \checkmark$	<p>Accept values in the range 4.1–5.5 «kJ».</p> <p>Award [2] for correct final answer.</p>	2

Question			Answers	Notes	Total
1.	c	i	 <p>initial concentration is zero AND concentration increases with time ✓ decreasing gradient as reaction proceeds ✓</p>		2
1.	c	ii	<p>«draw a» tangent to the curve at time = 0 ✓ «rate equals» gradient/slope «of the tangent» ✓</p>	Accept suitable diagram.	2
1.	c	iii	<p>piece has smaller surface area ✓</p> <p>lower frequency of collisions OR fewer collisions per second/unit time ✓</p>	Accept "chance/probability" instead of "frequency". Do not accept just "fewer collisions".	2

Question			Answers	Notes	Total
2.	a		CH ₃ CH(OH)CH ₃ ✓	Accept the full or condensed structural formula.	1
2.	b		« $\frac{1.00 \text{ g}}{(12.01 \times 3 + 1.01 \times 8 + 16.00) \text{ g mol}^{-1}} \Rightarrow 0.0166$ «mol CH ₃ CH(OH)CH ₃ » ✓ «0.0166 mol × 6.02 × 10 ²³ molecules mol ⁻¹ × 8 atoms molecule ⁻¹ = » 8.01 × 10 ²² «atoms of hydrogen» ✓	Accept answers in the range 7.99 × 10 ²² to 8.19 × 10 ²² . Award [2] for correct final answer.	2
2.	c		secondary AND OH/hydroxyl is attached to a carbon bonded to one hydrogen OR secondary AND OH/hydroxyl is attached to a carbon bonded to two C/R/alkyl/CH ₃ «groups» ✓	Accept "secondary AND OH is attached to the second carbon in the chain".	1
2.	d	i	«potassium/sodium» manganate(VII)/permanganate/KMnO ₄ /NaMnO ₄ /MnO ₄ ⁻ OR «potassium/sodium» dichromate(VI)/K ₂ Cr ₂ O ₇ /Na ₂ Cr ₂ O ₇ /Cr ₂ O ₇ ²⁻ ✓		1
2.	d	ii	-2 ✓		1
2.	d	iii	propanone/propan-2-one/CH ₃ COCH ₃ ✓		1

Question			Answers	Notes	Total
3.	a	i	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ OR $[Ar] 4s^2 3d^{10} 4p^5$ ✓	Accept 3d before 4s.	1
3.	a	ii		Accept double-headed arrows.	1
3.	b			Accept dots, crosses or lines to represent electron pairs.	1

Question			Answers	Notes	Total
3.	c		<p><i>Geometry:</i> trigonal/pyramidal ✓</p> <p><i>Reason:</i> three bonds AND one lone pair OR four electron domains ✓</p> <p><i>O–Br–O angle:</i> 107° ✓</p>	<p><i>Accept “charge centres” for “electron domains”.</i></p> <p><i>Accept answers in the range 104–109°.</i></p>	3
3.	d	i	<p>$\text{BrO}_3^- (\text{aq}) + 6\text{e}^- + 6\text{H}^+ (\text{aq}) \rightarrow \text{Br}^- (\text{aq}) + 3\text{H}_2\text{O} (\text{l})$</p> <p>correct reactants and products ✓</p> <p>balanced equation ✓</p>	<p><i>Accept reversible arrows.</i></p>	2
3.	d	ii	<p>$\text{BrO}_3^- (\text{aq}) + 6\text{Fe}^{2+} (\text{aq}) + 6\text{H}^+ (\text{aq}) \rightarrow \text{Br}^- (\text{aq}) + 3\text{H}_2\text{O} (\text{l}) + 6\text{Fe}^{3+} (\text{aq})$ ✓</p>		1

Question			Answers	Notes	Total
4.	a		nuclear charge/number of protons/ Z_{eff} increases «causing a stronger pull on the outer electrons» ✓ same number of shells/«outer» energy level/shielding ✓	Accept “atomic number” for “number of protons”.	2
4.	b	i	isoelectronic/same electronic configuration/«both» have 2.8 ✓ more protons in Na^+ ✓		2
4.	b	ii	Any one of: brittle ✓ high melting point/crystalline/solid «at room temperature» ✓ low volatility ✓ conducts electricity when molten ✓ does not conduct electricity at room temperature ✓	Do not accept soluble in water. Ignore any chemical properties.	1 max

5.	a		all «species» are in same phase ✓	Accept “all species are in same state”. Accept “all species are gases”.	1
5.	b		«reaction quotient/ $Q \Rightarrow \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} / \frac{0.500^2}{0.200^2 \times 0.300} / 20.8 \checkmark$ reaction quotient/ $Q/20.8/\text{answer} < K_c/280$ OR mixture needs more product for the number to equal $K_c \checkmark$ reaction proceeds to the right/products ✓	Do not award M3 without valid reasoning.	3

Question		Answers	Notes	Total
6.	a	<p><i>Butanoic acid:</i> $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) \checkmark$</p> <p><i>Ethylamine:</i> $\text{CH}_3\text{CH}_2\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{CH}_2\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq}) \checkmark$</p>		2
6.	b	<p><i>Any two of:</i> butanoic acid forms more/stronger hydrogen bonds \checkmark butanoic acid forms stronger London/dispersion forces \checkmark butanoic acid forms stronger dipole–dipole interaction/force \checkmark</p>	<p><i>Accept “butanoic acid forms dimers”</i> <i>Accept “butanoic acid has larger M_r/hydrocarbon chain/number of electrons” for M2.</i> <i>Accept “butanoic acid has larger «permanent» dipole/more polar” for M3.</i></p>	2 max
6.	c	<p>$\text{CH}_3\text{CH}_2\text{NH}_3^+ \text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-$ OR $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- \text{CH}_3\text{CH}_2\text{NH}_3^+$ OR $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- \text{H}_3\text{N}^+\text{CH}_2\text{CH}_3 \checkmark$</p>	<i>The charges are not necessary for the mark.</i>	1

Question		Answers	Notes	Total
7.	a	«electrophilic» addition/A _E OR reduction ✓	Accept "hydrogenation".	1
7.	b	«(-286 kJ) + (-1411 kJ) => -1697 «kJ» ✓		1
7.	c	«-1697 kJ + 1561 kJ => -136 «kJ» OR « $\Delta H^\ominus = \Delta H_f^\ominus(\text{products}) - \Delta H_f^\ominus(\text{reactants}) = -84 \text{ kJ} - 52 \text{ kJ} => -136 \text{ «kJ»} \checkmark$ » ✓		1

Question		Answers	Notes	Total
7.	d	<p><i>Accurate:</i> no approximations were made in the cycle OR values are specific to the compounds OR Hess's law is a statement of conservation of energy OR method is based on a law OR data in table has small uncertainties ✓</p> <p><i>Approximate:</i> values were experimentally determined/had uncertainties OR each value has been determined to only three/four significant figures OR different sources have «slightly» different values for enthalpy of combustion OR law is valid until disproved OR law of conservation of energy is now conservation of mass–energy OR small difference between two quite large terms «leads to high percentage uncertainty» ✓</p>		2