Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2018

Chemistry

Standard level

Paper 2

13 pages

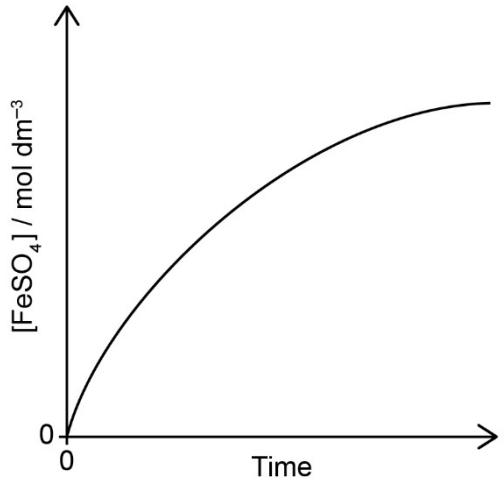
Question			Answers	Notes	Total
1.	a	i	n_{CuSO4} «$= 0.0800\,dm^3 \times 0.200\,mol\,dm^{-3}$» $= 0.0160$ mol ***AND*** n_{Fe} «$= \frac{3.26\,g}{55.85\,g\,mol^{-1}}$» $= 0.0584$ mol ✓ $CuSO_4$ is the limiting reactant ✓	*Do **not** award M2 if mole calculation is not shown.*	**2**
1.	a	ii	***ALTERNATIVE 1:*** «$0.0160\,mol \times 63.55\,g\,mol^{-1} =$» 1.02 «g» ✓ «$\frac{0.872\,g}{1.02\,g} \times 100 =$» 85.5 «%» ✓ ***ALTERNATIVE 2:*** «$\frac{0.872\,g}{63.55\,g\,mol^{-1}} =$» 0.0137 «mol» ✓ «$\frac{0.0137\,mol}{0.0160\,mol} \times 100 =$» 85.6 «%» ✓	*Accept answers in the range 85–86 %.* *Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
1.	b	i	***ALTERNATIVE 1:*** $q = $ **«**$80.0\text{ g} \times 4.18\text{ J g}^{-1}\text{ K}^{-1} \times 7.5\text{ K}$ **=»** 2.5×10^3 **«J»**/2.5 **«kJ»** ✓ **«**per mol of $CuSO_4 = \frac{-2.5\text{ kJ}}{0.0160\text{ mol}} = -1.6 \times 10^2\text{ kJ mol}^{-1}$**»** **«**for the reaction**»** $\Delta H = -1.6 \times 10^2$ **«**kJ**»** ✓ ***ALTERNATIVE 2:*** $q = $ **«**$80.0\text{ g} \times 4.18\text{ J g}^{-1}\text{ K}^{-1} \times 7.5\text{ K}$ **=»** 2.5×10^3 **«J»**/2.5 **«kJ»** ✓ **«**$n_{Cu} = \frac{0.872}{63.55} = 0.0137\text{ mol}$**»** **«**per mol of $CuSO_4 = \frac{-2.5\text{ kJ}}{0.0137\text{ mol}} = -1.8 \times 10^2\text{ kJ mol}^{-1}$**»** **«**for the reaction**»** $\Delta H = -1.8 \times 10^2$ **«**kJ**»** ✓	*Award **[2]** for correct final answer.*	**2**
1.	b	ii	density **«**of solution**»** is 1.00 g cm^{-3} ***OR*** specific heat capacity **«**of solution**»** is $4.18\text{ J g}^{-1}\text{ K}^{-1}$/that of **«**pure**»** water ***OR*** reaction goes to completion ***OR*** iron/$CuSO_4$ does not react with other substances ✓	*The mark for "reaction goes to completion" can only be awarded if 0.0160 mol was used in part (b)(i).* *Do **not** accept "heat loss".*	**1**

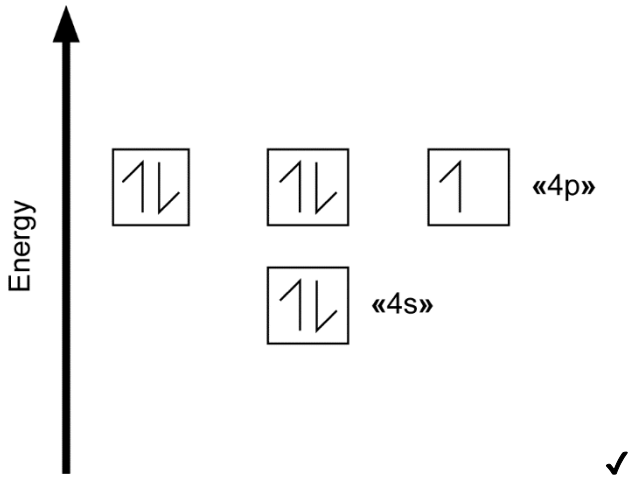
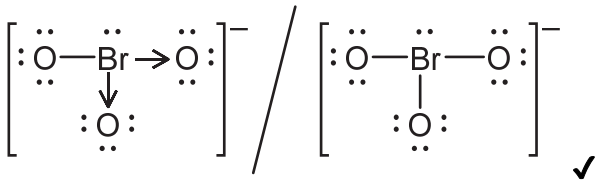
(continued…)

(Question 1b continued)

Question			Answers	Notes	Total
1.	b	iii	***ALTERNATIVE 1:*** «$0.2\ °C \times \frac{100}{7.5\ °C}$ =» 3 %/0.03 ✓ «0.03 × 160 kJ» = «±» 5 «kJ» ✓ ***ALTERNATIVE 2:*** «$0.2\ °C \times \frac{100}{7.5\ °C}$ =» 3 %/0.03 ✓ «0.03 × 180 kJ» = «±» 5 «kJ» ✓	*Accept values in the range 4.1–5.5 «kJ».* *Award **[2]** for correct final answer.*	**2**

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

Question			Answers	Notes	Total
2.	a		$CH_3CH(OH)CH_3$ ✓	*Accept the full or condensed structural formula.*	1
2.	b		«$\frac{1.00\ g}{(12.01\times 3+1.01\times 8+16.00)\ g\ mol^{-1}}$ =» 0.0166 «mol $CH_3CH(OH)CH_3$» ✓ «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)/$K_2Cr_2O_7$/$Na_2Cr_2O_7$/$Cr_2O_7^{2-}$ ✓		1
2.	d	ii	−2 ✓		1
2.	d	iii	propanone/propan-2-one/CH_3COCH_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		*Geometry:* trigonal/pyramidal ✓ *Reason:* three bonds ***AND*** one lone pair ***OR*** four electron domains ✓ *O–Br–O angle:* 107° ✓	*Accept "charge centres" for "electron domains".* *Accept answers in the range 104–109°.*	3
3.	d	i	$BrO_3^-(aq) + 6e^- + 6H^+(aq) \rightarrow Br^-(aq) + 3H_2O(l)$ correct reactants and products ✓ balanced equation ✓	*Accept reversible arrows.*	2
3.	d	ii	$BrO_3^-(aq) + 6Fe^{2+}(aq) + 6H^+(aq) \rightarrow Br^-(aq) + 3H_2O(l) + 6Fe^{3+}(aq)$ ✓		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 =» $\frac{[SO_3]^2}{[SO_2]^2[O_2]} / \frac{0.500^2}{0.200^2 \times 0.300}$ /20.8 ✓ reaction quotient/Q/20.8/answer < K_c/280 ***OR*** mixture needs more product for the number to equal K_c ✓ reaction proceeds to the right/products ✓	*Do **not** award M3 without valid reasoning.*	3

Question			Answers	Notes	Total
6.	a		*Butanoic acid:* $CH_3CH_2CH_2COOH\,(aq) + H_2O\,(l) \rightleftharpoons CH_3CH_2CH_2COO^-\,(aq) + H_3O^+\,(aq)$ ✓ *Ethylamine:* $CH_3CH_2NH_2\,(aq) + H_2O\,(l) \rightleftharpoons CH_3CH_2NH_3^+\,(aq) + OH^-\,(aq)$ ✓		**2**
6.	b		*Any two of:* butanoic acid forms more/stronger hydrogen bonds ✓ butanoic acid forms stronger London/dispersion forces ✓ butanoic acid forms stronger dipole–dipole interaction/force ✓	*Accept "butanoic acid forms dimers"* *Accept "butanoic acid has larger M_r/hydrocarbon chain/number of electrons" for M2.* *Accept "butanoic acid has larger «permanent» dipole/more polar" for M3.*	**2 max**
6.	c		$CH_3CH_2NH_3^+\,CH_3CH_2CH_2COO^-$ ***OR*** $CH_3CH_2CH_2COO^-\,CH_3CH_2NH_3^+$ ***OR*** $CH_3CH_2CH_2COO^-\,H_3N^+CH_2CH_3$ ✓	*The charges are not necessary for the mark.*	**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*** «$\Delta H^{\ominus} = \Delta H_f^{\ominus}$(products) − $\Delta H_f^{\ominus}$(reactants) = −84 kJ − 52 kJ =» −136 «kJ» ✓		1

Question			Answers	Notes	Total
7.	d		*Accurate:* 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 ✓ *Approximate:* 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» ✓		**2**