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Chemistry

Standard level

Paper 2

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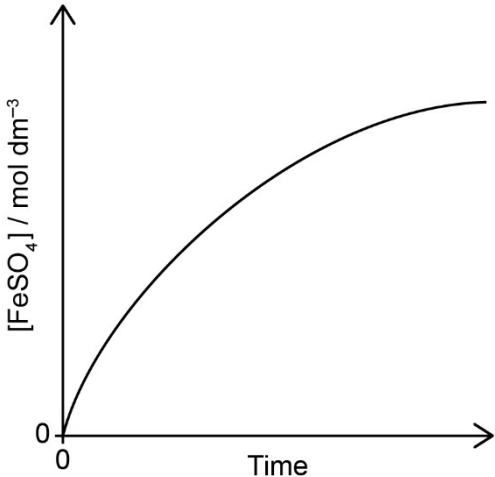
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N18/4/CHEMI/SP2/ENG/TZ0/XX/M

Question			Answers	Notes	Total
1.	a	i	n_{CuSO_4} «$= 0.0800\,dm^3 \times 0.200\,mol\,dm^{-3}$» $= 0.0160\,mol$ **AND** n_{Fe} «$= \dfrac{3.26\,g}{55.85\,g\,mol^{-1}}$» $= 0.0584\,mol$ ✔ $CuSO_4$ 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» ✔ «$\dfrac{0.872\,g}{1.02\,g} \times 100 =$» 85.5 «%» ✔ ***ALTERNATIVE 2:*** «$\dfrac{0.872\,g}{63.55\,g\,mol^{-1}} =$» 0.0137 «mol» ✔ «$\dfrac{0.0137\,mol}{0.0160\,mol} \times 100 =$» 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 g × 4.18 J g^{-1} K^{-1} × 7.5 K =» 2.5 × 10^3 «J»/2.5 «kJ» ✔ «per mol of $CuSO_4$ = $\dfrac{-2.5 \text{ kJ}}{0.0160 \text{ mol}}$ = −1.6 × 10^2 kJ mol^{-1}» «for the reaction» ΔH = −1.6 × 10^2 «kJ» ✔ **ALTERNATIVE 2:** q = «80.0 g × 4.18 J g^{-1} K^{-1} × 7.5 K =» 2.5 × 10^3 «J»/2.5 «kJ» ✔ «n_{Cu} = $\dfrac{0.872}{63.55}$ = 0.0137 mol» «per mol of $CuSO_4$ = $\dfrac{-2.5 \text{ kJ}}{0.0137 \text{ mol}}$ = −1.8 × 10^2 kJ mol^{-1}» «for the reaction» ΔH = −1.8 × 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 J g^{-1} 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

(Question 1b continued)

Question			Answers	Notes	Total
1.	b	iii	**ALTERNATIVE 1:** «0.2 °C × $\frac{100}{7.5\ °C}$ =» 3 %/0.03 ✔ «0.03 × 160 kJ» = «±» 5 «kJ» ✔ **ALTERNATIVE 2:** «0.2 °C × $\frac{100}{7.5\ °C}$ =» 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		« $\dfrac{1.00\,g}{(12.01 \times 3 + 1.01 \times 8 + 16.00)\,g\,mol^{-1}}$ =» 0.0166 «mol $CH_3CH(OH)CH_3$» ✔ «0.0166 mol $\times$ 6.02 $\times$ 10^{23} molecules mol^{-1} $\times$ 8 atoms molecule^{-1} = » 8.01 $\times$ 10^{22} «atoms of hydrogen» ✔	*Accept answers in the range 7.99 $\times$ 10^{22} to 8.19 $\times$ 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/$Q =$» $\dfrac{[SO_3]^2}{[SO_2]^2\,[O_2]}/\dfrac{0.500^2}{0.200^2 \times 0.300}/20.8$ ✔ 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		«$(-286\,\text{kJ}) + (-1411\,\text{kJ}) =$» -1697 «kJ» ✓		1
7.	c		«$-1697\,\text{kJ} + 1561\,\text{kJ} =$» -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 «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