EXAM PAPERS PRACTICE

Boost your performance and confidence with these topic-based exam questions

Practice questions created by actual examiners and assessment experts

Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

Time allowed
195 Minutes

Score /163

Percentage %

CHEMISTRY

Mark Scheme

OCR
AS & A LEVEL

Module 5: Physical chemistry and transiton elements

Question			Answer	Marks	
1	(a)		<table><tr><td>E^{o}</td><td>redox system</td></tr><tr><td>Most negative</td><td>**E**</td></tr><tr><td></td><td>**C**</td></tr><tr><td>Least negative</td><td>**D**</td></tr></table> ✓	1	**ALL** 3 correct for 1 mark
	(b)	(i)	pH = 0 ✓	1	**Guidance**
	(b)	(ii)	H redox system is more negative (e.g. has a more –ve *E* **OR** less +ve *E* **OR** is –ve electrode) **OR** H redox system releases electrons (May be in equation, e.g. $H_2 \rightarrow 2H^+ + 2e^-$) ✓ Equilibrium **shifts** to increase $[H^+]$ **OR** H^+ **OR** standard hydrogen equation **shifts** to increase $[H^+]$ **OR** H^+ ✓	2	**ALLOW ORA**, *ie* Ag redox system (D) has more positive *E* / less negative *E* **ALLOW** equilibrium sign **IGNORE** H is more reactive **ORA** **IGNORE** direction of equilibrium shift
	(b)	(iii)	$H_2 + 2Ag^+ \rightarrow 2Ag + 2H^+$ ✓	1	**ALLOW** multiples e.g. $\frac{1}{2}H_2 + Ag^+ \rightarrow Ag + H^+$ State symbols **NOT** required **ALLOW** equilibrium sign
	(c)	(i)	H_2O ⇌ **HCN** **OH^-** **AND** Base 2 Acid 1 Acid 2 Base 1 ✓ CN^-	1	State symbols **NOT** required **ALLOW** CNH and HO^- (i.e. any order) **ALLOW** 1 **and** 2 labels the other way around. **ALLOW** 'just acid' and 'base' labels throughout if linked by lines so that it is clear what the acid-base pairs are.

Question			Answer	Marks	Guidance
	(c)	(ii)	H^+ reacts with CN^- **OR** HCN forms **OR** equation: $H^+ + CN^- \rightarrow HCN$ (**ALLOW** $\rightleftharpoons$) **OR** CN^- accepts a proton/H^+ **OR** equilibrium shifts right **AND** CN^- is removed ✓	1	**ALLOW** Acid reacts with/removes OH^- ions (to form HCN) **ALLOW** CNH (i.e. any order) **IGNORE** other equilibrium comments
	(d)	(i)	Fuel reacts with oxygen/oxidant to give **electrical** energy**/**voltage✓	1	**ALLOW** named fuel. e.g. hydrogen/H_2; ethanol; methanol, etc **ALLOW** fuel cell requires constant supply of fuel **AND** oxygen/an oxidant **OR** fuel cell operates continuously as long as a fuel **AND** oxygen/an oxidant are added **IGNORE** 'reactants' 'products' and comments about pollution and efficiency
	(d)	(ii)	ethanol is a **liquid OR** is **less** volatile **OR** ethanol is easier to store/transport/stored more safely **OR** hydrogen is explosive/more flammable **OR** ethanol has more public/political acceptance ✓	1	Assume that '**it**' refers to ethanol **ALLOW** ORA throughout **IGNORE** ethanol has a higher boiling point **IGNORE** H_2 is a gas **IGNORE** 'CO_2' **OR** less pollution **IGNORE** comments about efficiency **IGNORE** comments about biomass and renewable
	(d)	(iii)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ ✓	1	Correct species **AND** balancing needed **ALLOW** multiples **ALLOW** C_2H_6O for formula of ethanol **IGNORE** state symbols
	(d)	(iv)	$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ ✓	1	Correct species **AND** balancing needed **ALLOW** multiples, e.g. $3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O$ $_2 + 2H^+ + 2e^- \rightarrow H_2O$ **ALLOW** e (*ie* no −sign) **ALLOW** $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ **OR 3**$O_2 + 6H_2O + 12e^- \rightarrow 12OH^-$ **IGNORE** state symbols

Question			Answer	Marks	Guidance
	(d)	(v)	oxidation: C from –2 to +4 '+' sign **not** required ✓ reduction: O from 0 to –2 ✓	**2**	**ALLOW** 2– and 4+ **ALLOW** $C^{2-} \rightarrow C^{4+}$ **ALLOW** 0 and 2– **ALLOW** $O^{0} \rightarrow O^{2-}$ **ALLOW** 1 mark if correct oxidation numbers shown for **BOTH** C and O but wrong way around (*ie* C on reduction line and O on oxidation line) **IGNORE** O_2 reduced **IGNORE** any reference to electron transfer (*not in question*)
			Total	**13**	

Question			Answer	Marks	Guidance
2	(a)		**Equations can be in either order** $Na_2O + H_2O \rightarrow 2NaOH$ ✓ $NaFeO_2 + 2H_2O \rightarrow Fe(OH)_3 + NaOH$ ✓	**2**	**ALLOW** multiples throughout **IGNORE** state symbols **ALLOW** $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$ **DO NOT ALLOW** equations with uncancelled species. e.g. $Na_2O + 2H_2O \rightarrow 2NaOH + H_2O$ **ALLOW** $2NaFeO_2 + H_2O \rightarrow Fe_2O_3 + 2NaOH$ **OR** $_2 + H_2O \rightarrow Fe_2O_3 + 2Na^+ + 2OH^-$ ✓

2NaFeO

Question			Answer	Marks	Guidance
	(b)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 33.7%, award **6 marks.** **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- amount $S_2O_3^{2-}$ used = $0.1000 \times \frac{25.50}{1000}$ = **2.550×10^{-3}** (mol) ✓ amount I_2 = 2.550×10^{-3} **÷ 2** **1.275×10^{-3}** (mol) ✓ amount CrO_4^{2-} **2/3 ×** 1.275×10^{-3} **OR** 1.275×10^{-3} **÷ 1.5** = **$8.5(00) \times 10^{-4}$** (mol) ✓ amount CrO_4^{2-} in original 1000 cm^3 = **40 ×** $8.5(00) \times 10^{-4}$ = **$3.4(00) \times 10^{-2}$** mol ✓ Mass of Cr/Cr^{3+} in ore = **52.0** × $3.4(00) \times 10^{-2}$ g **1.768 g** ✓ Percentage Cr in ore = $\frac{1.768}{5.25} \times 100$ = **33.7%** ✓ **MUST** be to **one** decimal place (in the question)	**6**	***FULL ANNOTATIONS MUST BE USED*** **IF** a step is omitted but subsequent step subsumes previous, then award mark for any missed step **Working: at least 3 SF throughout until final % mark** BUT ignore trailing zeroes, ie for 0.490 allow 0.49 --- **ECF** answer above **÷ 2** **ECF** answer above **÷ 1.5** **ECF** answer above **×** 40 **ECF** answer above × 52.0 **IMPORTANT**: The last two marks are **ONLY** available by using 52.0 for Cr --- **Common ECFs:** **0.8%** x 40 missing 5 marks (scaling error) **0.84%** x 40 missing 4 marks (scaling error and 2 DP) **33.68%** 5 marks (2 DP) **16.8%** 5 marks (divide Cr somewhere by 2) **144.9%; 72.5%** 4 marks (**Final 2 marks unavailable**) Use of $M(Fe(CrO_2)_2)$ = 223.8 instead of $M(Cr)$.

Question			Answer	Marks	Guidance
	(c)		*Overall*: $_4^{2-}$ + 3I$^-$ + 4H$_2$O → Cr^{3+} + 1½ I$_2$ + 8OH$^-$ ✓ CrO *Half equations*: $_4^{2-}$ + 4H$_2$O + 3e$^-$ → Cr^{3+} + 8OH$^-$ ✓ CrO 2I$^-$ → I$_2$ + 2e$^-$ ✓	3	**ALLOW multiples and equilibrium signs throughout** **IGNORE** state symbols throughout e.g. 2CrO$_4^{2-}$ + 6I$^-$ + 8H$_2$O → 2Cr^{3+} + 3I$_2$ + 16OH$^-$ **ALLOW** equation using H$^+$. i.e. CrO $_4^{2-}$ + 3I$^-$ + 8H$^+$ → Cr^{3+} + 1½ I$_2$ + 4H$_2$O **OR** 2CrO$_4^{2-}$ + 6I$^-$ + 16H$^+$ → 2Cr^{3+} + 3I$_2$ + 8H$_2$O **ALLOW** CrO$_4^{2-}$ half equation using H$^+$. i.e. $_4^{2-}$ + 8H$^+$ + 3e$^-$ → Cr^{3+} + 4H$_2$O CrO
			Total	**11**	

Question			Answer	Marks	Guidance
3	(a)		**Definition** The e.m.f. (of a half-cell) compared with/connected to a (standard**)** hydrogen half-cell/(standard**)** hydrogen electrode ✓ **Standard conditions** *Units essential* Temperature of 298 K / 25ºC **AND** (solution) concentrations of 1 mol dm^{-3} **AND** pressure of 100 kPa **OR** 10^5 Pa **OR** 1 bar ✓	**2**	As alternative for e.m.f., **ALLOW** voltage **OR** potential difference **OR** p.d. **OR** electrode potential **OR** reduction potential **OR** redox potential **ALLOW** /(standard) hydrogen cell **IGNORE** S.H.E. (as abbreviation for standard hydrogen electrode) **ALLOW** 1M **DO NOT ALLOW** 1 mol **ALLOW** 1 atmosphere/1 atm **OR** 101 kPa **OR** 101325 Pa
	(b)	(i)	$2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$ ✓	**1**	State symbols **not** required **ALLOW** ⇌ provided that reactants on LHS
	(b)	(ii)	**Assume Cu^{2+}|Cu OR Cu half cell unless otherwise stated.** $[Cu^{2+}]$ decreases **OR** < 1 mol dm^{-3} **AND** Equilibrium (shown in table) shifts to left ✓ more electrons are released by Cu ✓ The cell has a bigger **difference** in *E* ✓	**3**	***FULL ANNOTATIONS MUST BE USED*** **----------** **ALLOW** $[Cu^{2+}]$ less than standard concentration/1 mol dm^{-3} **DO NOT ALLOW** water reacts with Cu^{2+} **OR** Cu **ALLOW** *E* (for Cu^{2+}|Cu) is less positive / more negative /decreases **IGNORE standard** electrode potential (*Cell no longer standard*) **IGNORE** $E^{\ominus}$ decreases **CARE** **DO NOT ALLOW** statements about silver *E* changing (**CON**) **IGNORE** just 'cell potential increases' (in the question) *The final mark is more subtle and is a consequence of the less positive E value of the copper half cell*

	(c)	**(i)**	no/less CO_2 **OR** H_2O is **only** product **OR** greater efficiency ✓	**1**	**IGNORE** less pollution **IGNORE** less carbon emissions **IGNORE** less fossil fuels used **IGNORE** no/less greenhouse gas **OR** no global warming (*H_2O vapour is a greenhouse gas)*
	(c)	**(ii)**	liquefied/as a liquid **AND** under pressure/pressurised ✓	**1**	**IGNORE** adsorption or absorption **IGNORE** low temperature **DO NOT ALLOW** liquidise *processes are described in the question*
	(d)	**(i)**	E = –2.31 (V) ✓	**1**	– sign **AND** 2.31 **required** for the mark
	(d)	**(ii)**	$4Al(s) + 4OH^-(aq) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al(OH)_4^-(aq)$ species ✓ balance ✓	**2**	**IGNORE** state symbols **ALLOW** multiples **ALLOW** 1 mark for an equation in which OH^- are balanced but have not been cancelled, e.g. $4Al(s) + 16OH^-(aq) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al(OH)_4^-(aq) + 12OH^-(aq)$ **ALLOW** 1 mark if charge on $Al(OH)_4$ is omitted, i.e $4Al(s) + 4OH^-(aq) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al(OH)_4(aq)$ **ALLOW** 1 mark for an 'correct equation' reversed, i.e. $4Al(OH)_4^-(aq) \rightarrow 4Al(s) + 4OH^-(aq) + 3O_2(g) + 6H_2O(l)$
			Total	**11**	

Question			Answer	Marks	Guidance
4	(a)		$Fe_2O_3 + 3Cl_2 + 10OH^- \rightarrow 2FeO_4^{2-} + 6Cl^- + 5H_2O$ ✓✓ First mark for all 6 species Second mark for balancing	2	**ALLOW** multiples **ALLOW** oxidation half equation for two marks $Fe_2O_3 + 10OH^- \rightarrow 2FeO_4^{2-} + 5H_2O + 6e^-$ Correct species would obtain 1 mark – *question: equation for oxidation* **ALLOW variants forming H^+ for 1 mark, e.g:** $Fe_2O_3 + 3Cl_2 + 5OH^- \rightarrow 2FeO_4^{2-} + 6Cl^- + 5H^+$ $Fe_2O_3 + 3Cl_2 + 5OH^- \rightarrow 2FeO_4^{2-} + 5HCl + Cl^-$
	(b)		$Ba^{2+}(aq) + FeO_4^{2-}(aq) \rightarrow BaFeO_4(s)$ ✓	1	Balanced **ionic** equation **AND** state symbols required **DO NOT ALLOW** +2 or –2 for ionic charges
	(c)		**Reason can ONLY be correct from correct reducing agent** **----------** ***reducing agent***: I^- **OR** KI ✓ I^- adds/donates/loses electrons **AND** to FeO_4^{2-} **OR** to $BaFeO_4$ **OR** to Fe(VI) or to Fe(+6) ✓ ***ALLOW** Fe(6+) **OR** Fe^{6+}*	2	**IGNORE** H^+ **OR** acidified **ALLOW** iodide/potassium iodide but **DO NOT ALLOW** iodine **ALLOW** I^- loses electrons **AND** to form I_2 **ALLOW** Fe(6+) **OR** Fe^{6+}

	(d)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 51.8%, award **4 marks.** --- $n(S_2O_3^{2-})$ used = $0.1000 \times \frac{26.4}{1000} = 2.64 \times 10^{-3}$ (mol) ✓ $n(FeO_4^{2-}) = ½ \times 2/3 \times 2.64 \times 10^{-3} = 8.8(0) \times 10^{-4}$ (mol) ✓ Mass $BaFeO_4$ in sample $= 8.8 \times 10^{-4} \times 257.1$ g = 0.226248 g ✓ % purity = $\frac{0.226248}{0.437} \times 100 = 51.8\%$ ✓ **MUST** be to **one** decimal place (in the question) --- As an alternative for the final two marks, **ALLOW**: Theoretical amount of $BaFeO_4 = \frac{0.437}{257.1} = 0.00170$ (mol) ✓ % purity = $\frac{8.8 \times 10^{-4}}{1.70 \times 10^{-3}} \times 100 = 51.8\%$ ✓	**4**	***FULL ANNOTATIONS MUST BE USED*** --- For alternative answers, look first at common **ECFs** below. Then check for **ECF** credit possible using working below **IF** a step is omitted but subsequent step subsumes previous, then award mark for any missed step --- **Working must be to at least 3 SF throughout until final % mark** **BUT** ignore trailing zeroes, ie for 0.880 allow 0.88 **ECF** answer above × ½ × 2/3 This mark may be seen in 2 steps via I_2 but the mark is for both steps combined **ECF** 257.1 × answer above **ECF** $\frac{\text{answer above}}{0.437} \times 100$ **ALLOW** 51.7% FROM 0.226 g $BaFeO_4$ (earlier rounding) --- **Common ECFs:** No × 2/3 for $n(FeO_4^{2-})$: % purity = 77.7%/77.6% 3 marks No ÷ 2 for $n(FeO_4^{2-})$: % purity = 25.9% 3 marks 24.6 used instead of 26.4: % purity = 48.2% 3 marks

	(e)		**gas**: O_2 ✓ **precipitate**: $Fe(OH)_3$ ✓ **equation**: $2FeO_4^{2-} + 5H_2O \rightarrow 1½O_2 + 2Fe(OH)_3 + 4OH^-$ **OR** $2FeO_4^{2-} + H_2O + 4H^+ \rightarrow 1½O_2 + 2Fe(OH)_3$ ✓	**3**	**DO NOT ALLOW** names **IGNORE** a balancing number shown before a formula **ALLOW** $Fe(OH)_3(H_2O)_3$ **ALLOW** multiples **ALLOW** $2FeO_4^{2-} + 11H_2O \rightarrow 1½O_2 + 2Fe(OH)_3(H_2O)_3 + 4OH^-$
			Total	**12**	