

### 5.3 questions ms

1.	(a)	gains electrons (1)	1	[1]
2.	(a)	(i) $\text{Fe}^{2+}$	1	
		(ii) $\text{F}_2\text{O}$	1	
		(iii) $\text{Fe}^{2+}$	1	
		$\text{Cl}^-$	1	
		<i>Use list principle if more than two answers</i>		
	(b)	(i) e.m.f. = $E(\text{rhs}) - E(\text{lhs})$	1	
		= $1.52 - 0.77 = 0.75$		
		<i>(0.75 scores first mark also)</i>	1	
		(ii) $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$	1	
		(iii) Decrease	1	
		<i>(Increase is CE, no further marks)</i>		
		Equilibrium (or reaction) shifts to R	1	
		<i>(or L if refers to half equation in table)</i>		
		<i>(or in favour of more <math>\text{Fe}^{3+}</math>)</i>		
		<i>(or more <math>\text{Fe}^{3+}</math> formed)</i>		
		<i>(or more electrons formed)</i>		
		Electrode potential (for $\text{Fe}^{3+}/\text{Fe}^{2+}$ ) less positive (or decreases)	1	
				[10]
3.	(a)	$\text{Fe}^{2+}$ or Fe(II)	1	
	(b)	(i) 6 or (VI)	1	
		(ii) 3 or (III)	1	
	(c)	(i) 0.5	1	
		(ii) $2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{S}_2\text{O}_8^{2-} \rightarrow 10\text{SO}_4^{2-} + 2\text{MnO}_4^- + 16\text{H}^+$		
		Both $\text{SO}_4^{2-}$ and $\text{MnO}_4^-$ on right	1	
		Balanced	1	
				[13]
4.	(a)	(i) 0.60 V	1	
		(ii) $\text{H}_2\text{O} + \text{H}_2\text{SO}_3 \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	1	

(b)	(i)	$2\text{IO}_3^- + 2\text{H}^+ 5\text{H}_2\text{O}_2 \rightarrow 5\text{O}_2 + \text{I}_2 + 6\text{H}_2\text{O}$	Species	1
			Balanced	1
	(ii)	The concentration of the ions change or are no longer standard or the e.m.f is determined when no current flows		1
	(iii)	Unchanged		1
	(iv)	Increased		1
		Equilibrium $\text{IO}_3^-/\text{I}_2$ displaced to the right		1
		Electrons more readily accepted or more reduction occurs or electrode becomes more positive (Q o L)		1
(c)		$\text{VO}_2^+$		1
		5 or V		1
		$\text{V}^{2+} + 2\text{H}_2\text{O} \rightarrow \text{VO}_2^+ + 4\text{H}^+ 3\text{e}^-$		1

[12]

5.	(a)	Oxidising agents take/remove/accept/gain electrons (1)		
		<i>Not 'electron pair'</i>		1
(b)	(i)	<u><math>\text{Cl}_2(\text{g})</math> at 100 kPa / 1 bar / 1atm (1)</u>		
		<u><math>[\text{Cl}^-] = 1 \text{ molar} / 1\text{M}</math> (1)</u>		
		<i>Allow 1M HCl</i>		
		Temperature = 298K / 25°C (1)		
		Do not use list principle for other incorrect species		
	(ii)	Lower $[\text{Cl}^-]$ or reduce temperature		
		Increase pressure or concentration of $\text{Cl}_2$ (1)		
		<i>CE if change incorrect</i>		
		Equilibrium displace to right (1)		
		or if reduced temperature given, reaction exothermic		
		Allow a correct explanation when no change given		5
(c)	(i)	$\text{Cl}^-$ (1)		
	(ii)	$\text{Fe}^{3+}$ ; (1) $\text{NO}_3^-$ (1)		
		<i>Penalise by list principle</i>		
		<i>Note: <math>\text{H}^+</math> is incorrect</i>		
	(iii)	$\text{V}^{2+}$ , (1) $\text{Fe}^{2+}$ (1)		
		<i>Penalise by list principle</i>		5

[11]

6.	(a)	(Standard) hydrogen (electrode) (1)		1
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- (b) (i) To allow transfer of electrons / provide a reaction surface (1)  
 (ii) 298 K (1)  
Both  $\text{Fe}^{3+}(\text{aq})$  and  $\text{Fe}^{2+}(\text{aq})$  have a concentration of  $1 \text{ mol dm}^{-3}$  (1) (QoL)  
OR  $[\text{H}^+] = 1 \text{ mol dm}^{-3}$   
**NOT zero current or 100 kPa**

3

- (c) +1.34 V (1)  
 $2 \text{MnO}_4^- + 5 \text{H}_2\text{SO}_3 \rightarrow 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-} + 3 \text{H}_2\text{O} + 4 \text{H}^+$   
 Correct species / order (1)  
 Balanced and cancelled (1)  
**Allow one for  $2 \text{MnO}_4^- + 5 \text{H}_2\text{SO}_3 \rightleftharpoons 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-}$**

3

- (d) (i)  $\text{Ce}^{4+}(\text{aq})$  (1)  
 (ii)  $\text{VO}_2^+(\text{aq})$  (1);  $\text{Cl}_2$  (1)  
**Penalise additional answers to zero**

3

- (e)  $\text{Pt} | \text{Fe}^{2+}(\text{aq}), \text{Fe}^{3+}(\text{aq}) || \text{Ce}^{4+}(\text{aq}), \text{Ce}^{3+}(\text{aq}) | \text{Pt}$   
 Correct species (1)  
 Correct order (1)  
**Deduct one mark for each error**

2

[12]

7. (a) Cell e.m.f.: 1.93 (v) CE if negative value given (1)  
 Half equation:  $\text{Mg} \rightarrow \text{Mg}^{2+} + 2 \text{e}^-$  (1)  
 or  $\rightleftharpoons$   
**Ignore state symbols**  
**Mark on after an AE**

2

- (b) Change in e.m.f.: increases (1)  
**Mark on even if incorrect**

*Explanation:* Equilibrium displaced to  $\text{Mg}^{2+}$  or to the left (1)  
**cell reaction or overall reaction goes to the right**  
**Electrode is more negative or E decreases**  
**or gives more electron**  
**or forms more  $\text{Mg}^{2+}$  ions**  
**Mark separately**

3

(c) Cell e.m.f. :  $-0.84$  (V) (1)

*Explanation:* Fe is giving electrons **or** forming  $\text{Fe}^{2+}$   
**or** reaction goes in the reverse direction (1)

**Mark on after AE**

2

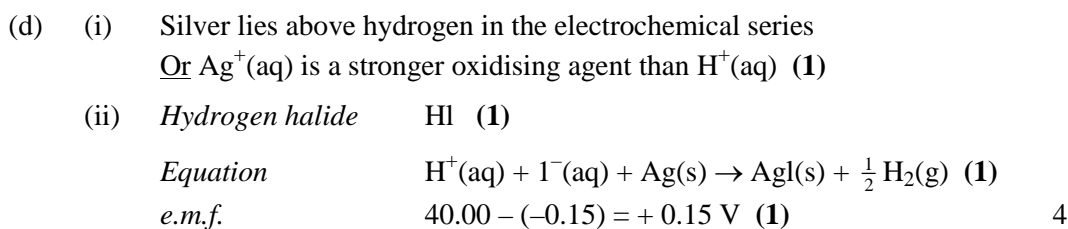
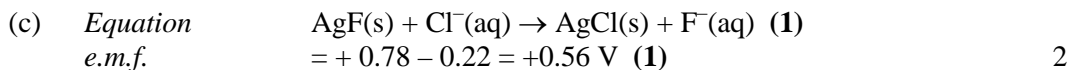
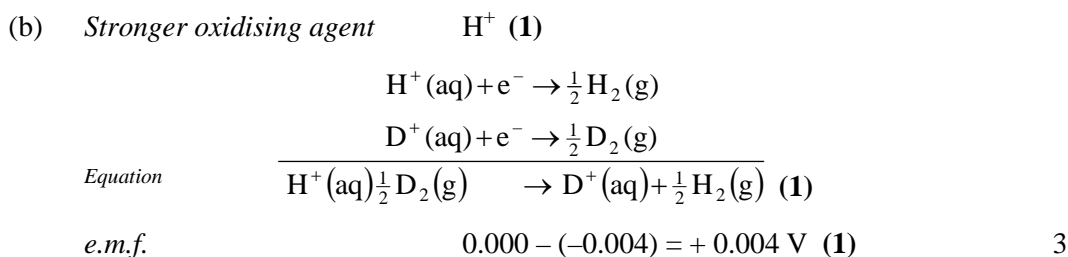
**N.B. In (a) and (c) mark on if no value given,  
 but CE in both (a) and (c) if e.m.f. = 0**

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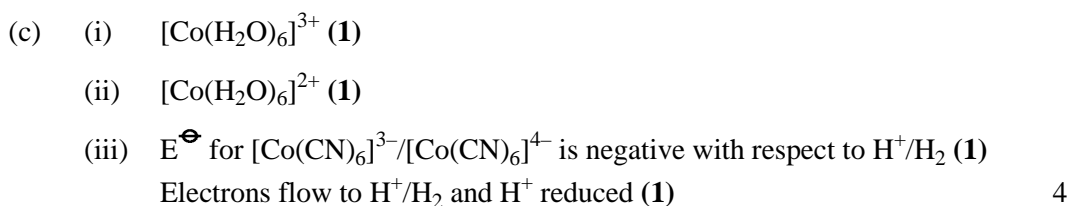
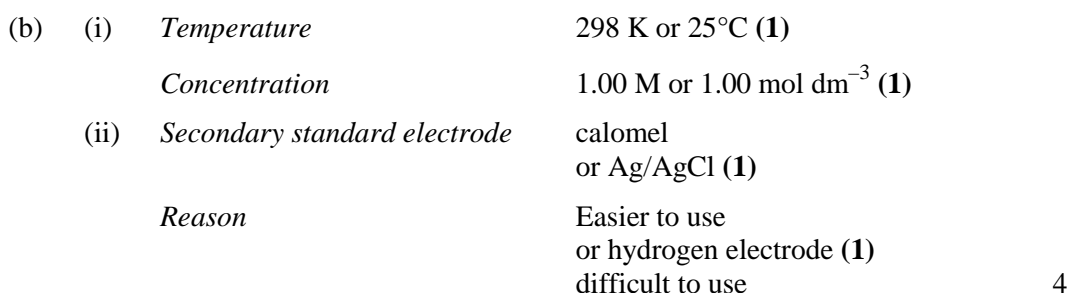
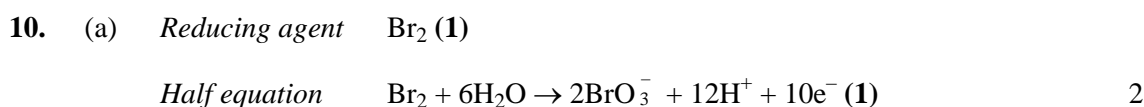
8. (a) (i) (standard) hydrogen (electrode) / hydrogen half cell **not**  
 hydrogen cell (1) 2  
 reference electrode / electrode to which others are compared (1)
- (ii)  $0.00(\text{V})$  / 0 / zero (1) 1
- (b) (i)  $\text{emf} = -0.14 - (-0.25)$   
 $= +0.11 \text{ V}$  / allow  $0.11 \text{ V}$  **not**  $-0.11 \text{ V}$  (1) 1
- (ii) electrode D /  $\text{Sn}^{2+}$  / Sn / tin / right hand electrode (1) 1
- (iii)  $\text{Ni} + \text{Sn}^{2+} \rightarrow \text{Ni}^{2+} + \text{Sn}$  (ignore state symbols) (1) 1
- (c) (i)  $\text{e.m.f} = -0.44 - (-0.14) = -0.30 \text{ (V)}$  / emf for cell is – ve  
 comparison of standard electrode potentials (1)  
 +ve e.m.f for feasible reaction / tin is a weaker reducing agent  
 $\therefore$  would not occur (1)  
 if correct  $\Delta G$  argument used, allow both marks 2
- (ii) manganese will decrease in size / disappear / eaten away / dissolves /  
 solution turns (pale) pink (1)  
 effervescence / bubbles (of colourless gas) / fizzing **not** gas  
 given off (1)  
 reaction likely to occur is  $\text{Mn} + (2)\text{H}^+ \rightarrow \text{Mn}^{2+} + \text{H}_2$  (1)  
**or** the same ideas expressed in words  
 +ve e.m.f. /  $+1.18 \text{ V}$  / Mn is strong reducing agent / has  
 large – ve  $E^\ominus$  (1)  
 (**not** just Mn is more reactive) 4

[12]

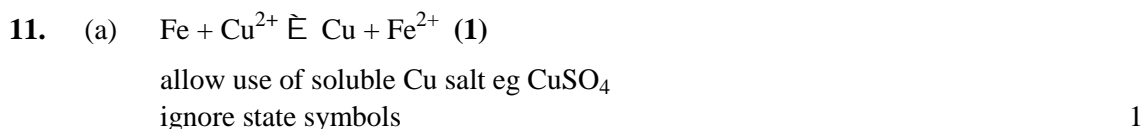
9. (a) oxidising agent accepts electrons (1) 1



[10]



[10]



- (b) (i)  $\text{Fe(s)} \mid \text{Fe}^{2+}(\text{aq}) \parallel \text{Cu}^{2+}(\text{aq}) \mid \text{Cu(s)}$   
 junctions correct **(1)**  
 ignore state symbols  
 allow alternative symbols for salt bridge  
 allow if junctions are correct but order is wrong providing  
 metals on each side of salt bridge are the same ie  $\text{Fe} \mid \text{Fe}^{2+}$  not  $\text{Fe} \mid \text{Cu}^{2+}$   
 order of species correct **(1)**  
 do not give this mark if cell reversed 2
- (ii) e.m.f. =  $+0.34 - (-0.44)$   
 $= +0.78 \text{ V}$  **(1)**  
 must have + sign  
 allow  $-0.78 \text{ (V)}$  if reverse cell given in (i) 1
- (c) (i) e.m.f for cell must be positive for reaction to occur / be feasible / **(1)**  
 spontaneous **or**  $\Delta G$  must be negative)  
 $\text{Cu(s)} + 2\text{H}^+ \rightarrow \text{products}$   
 e.m.f =  $-0.34 \therefore$  won't happen /  
 sensible comparison of the magnitude of  $E^\ominus$  for the electrodes  
 eg 'Cu electrode more positive than hydrogen electrode  $\therefore$  won't work' **(1)**  
 $\text{Cu(s)} + \text{NO}_3^- + 4\text{H}^+ \rightarrow \text{products}$   
 e.m.f =  $+0.96 - 0.34 = +0.62 \therefore$  can occur /  
 similar sensible comparison **(1)** 3
- (ii)  $3\text{Cu} + 2\text{NO}_3^- + 8\text{H}^+ \rightarrow 3\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$   
 species **(1)**  
 balanced – this mark dependent on first mark **(1)** 2
- (d) (i)  $2\text{Fe} + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{Fe}^{2+} + 4\text{OH}^-$  **or**  $2\text{Fe(OH)}_2$  **(1)**  
 ignore state symbols 1
- (ii) anode (only give this mark if explanation attempted) **(1)**  
 Fe loses  $\text{e}^-$  ( $\therefore$  negative pole) / oxidation occurs **(1)**  
 this mark dependent on anode for first mark 2
- (iii) e.m.f. =  $+0.06 \text{ V}$  or reference to  $E^\ominus$  for electrodes **(1)**  
 reasoned argument **(1)**  
 eg positive  $\therefore$  should occur / difference so small that reaction unlikely 2

[14]

12. (a) *Name* hydrogen electrode (1)  
*Conditions* 1 M H<sup>+</sup>(aq) or 1 M HCl(aq) or 0.5 M H<sub>2</sub>SO<sub>4</sub>(aq) (1)  
 298 K (1)  
 Hydrogen gas at 1 bar or 100 kPa (1) 4
- (b) (i) *E*<sup>⊖</sup> value 1.21 v (1)  
*Equation* S<sub>2</sub>O<sub>8</sub><sup>2-</sup> + 2Ag → 2SO<sub>4</sub><sup>2-</sup> + 2Ag<sup>+</sup> [2]  
 (ii) *Change, if any, in electrode potential* Less positive or decrease (1)  
*Explanation* Equilibrium displaced to the left (1)  
 More electrons released (1) 6

[10]

13. (i) Oxidising agents  
 Cu<sup>2+</sup>(aq) (1), H<sub>2</sub>O<sub>2</sub>(aq) (1), Cl<sub>2</sub>(aq) (1) (3)  
 if Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> (aq) is included, deduct one mark
- (ii) 2I<sup>-</sup> → I<sub>2</sub> I(-1) → I(0) (1)  
 Mn<sup>2+</sup> → MnO<sub>4</sub><sup>-</sup> Mn(II) → Mn(VII) (1)  
 Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> → 2CrO<sub>4</sub><sup>-</sup> no change (penalised above)  
 Cl<sub>2</sub> → ClO<sup>-</sup> Cl(0) → Cl(1) (1)
- (iii) Cu<sup>2+</sup>(aq) + I<sup>-</sup>(aq) + e<sup>-</sup> → Cu<sup>+</sup>(s) (1)  
 I<sup>-</sup>(aq) → ½ I<sub>2</sub>(aq) + e<sup>-</sup> (not reverse) (1)  
 H<sub>2</sub>O<sub>2</sub>(aq) + 2H<sup>+</sup>(aq) + 2e<sup>-</sup> → 2H<sub>2</sub>O (1) (1)  
 Mn<sup>2+</sup>(aq) + 4H<sub>2</sub>O (1) → MnO<sub>4</sub><sup>-</sup> (aq) + 8H<sup>+</sup>(aq) + 5e<sup>-</sup> (not reverse) (1)  
 ½ Cl<sub>2</sub>(aq) + e<sup>-</sup> → Cl<sup>-</sup> (aq) (1)  
 ½ Cl<sub>2</sub>(aq) + 2OH<sup>-</sup>(aq) → ClO<sup>-</sup>(aq) + H<sub>2</sub>O(l) + e<sup>-</sup> (not reverse) (1)  
 Penalise missing or incorrect state symbols once only  
 (12 MAX)

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[11]