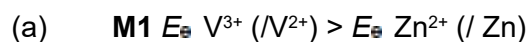
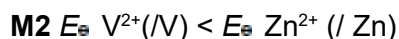


Mark schemes

Q1.



OR EMF of reaction between V^{3+} and $\text{Zn} = (+)0.50 \text{ V}$



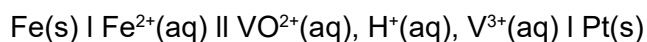
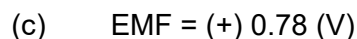
OR EMF of reaction between V^{2+} and $\text{Zn} = -0.44 \text{ V}$

2



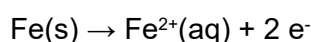
Only

1



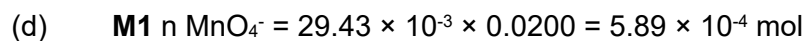
Allow $\text{Fe(s)} \mid \text{Fe}^{2+}(\text{aq}) \parallel \text{VO}^{2+}(\text{aq}), \text{V}^{3+}(\text{aq}) \mid \text{Pt(s)}$

Ignore state symbols



Ignore state symbols

3



$$\text{M2 } n \text{V}^{2+} = 5.89 \times 10^{-4} \times \frac{5}{3} = 9.81 \times 10^{-4} \text{ mol}$$

$$\text{M2} = \text{M1} \times \frac{5}{3}$$

$$\text{M3 } \text{mass NH}_4\text{VO}_3 = 9.81 \times 10^{-4} \times 116.9 = 0.1147 \text{ g}$$

$$\text{M3} = \text{M2} \times 116.9$$

$$\text{M4 \% purity} = \frac{0.1147 \times 100}{0.151} = 76.0 \%$$

$$\text{M4} = \text{M3} \times \frac{100}{0.151}$$

Allow 75.9 or 76.2 %

Answer to 3 significant figures

4

[10]

Q2.

- (a) More shells

OR

more energy levels.

*Allow Ca has 4 shells and Mg has 3 shells**Do not accept more outer shells**Ignore shielding**Ignore subshells/orbitals/more electrons*

1

- (b)
- $\text{Mg(s)} + \text{H}_2\text{O(g)} \rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$

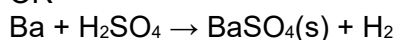
*State symbols required**Allow multiples*

1

- (c)
- M1**
- (Ba is more reactive) because
- outer/valence
- electrons further from nucleus/less attracted to the nucleus/lost more easily

M2 Insoluble barium sulfate (is formed)

OR

**M3** Barium sulfate prevents further reaction (with sulfuric acid)

OR

Barium gets coated with barium sulfate (so no more barium reacts)

3

- (d)
- M1**
- $P = 100\,000\text{ Pa}$
- and
- $V = 348 \times 10^{-6}\text{ m}^3$

$$\text{M2 } n = \frac{PV}{RT} \text{ or } \frac{100\,000 \times 348 \times 10^{-6}}{8.31 \times 298}$$

$$\text{M3 } n = 0.01405\text{ mol}$$

$$\text{M4 } n \text{ metal nitrate} = 0.01405 \times \frac{2}{5} = 5.62 \times 10^{-3}\text{ mol}$$

$$\text{M4 } = \text{M3} \times \frac{2}{5}$$

$$\text{M5 } M_r \text{ metal nitrate} = \frac{0.832}{5.62 \times 10^{-3}} = 148(.0)$$

$$\text{M5 } = 0.832 \div \text{M4}$$

$$\text{M6 } A_r \text{ of metal} = 148.0 - (2 \times 14 + 2 \times 48) = 24(.0) = \text{Mg}$$

M6 = M5 - 124 and identity of a metal with 2+ oxidation state

6

- (e)
- M1**
- $\text{Na} + \text{Al} + 2\text{H}_2 \rightarrow \text{NaAlH}_4$

M2 contains oppositely charged ions/ Na^+ and AlH_4^- ions**M3** strong attraction between (oppositely charged) ions

3

- (f) $3 \text{ NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{Na}_3\text{PO}_4 + 3 \text{ H}_2\text{O}$
Allow multiples and ignore state symbols
 1
- (g) $\text{Li}^+ + \text{CoO}_2 + \text{e}^- \rightarrow \text{Li}^+(\text{CoO}_2)^-$
Allow Li(CoO₂) as product
 1
- (h) The electrode reactions can be reversed (by applying a reverse potential)
Allow reaction is reversible (by applying a reverse potential)
 1
- [17]**

Q3.

- (a) Allow to complete the circuit
 Or
 Allow ions to move (between half cells)
Allow to maintain electrical neutrality
Do not accept electrons flowing
 Potassium/sodium nitrate or any soluble ionic compound that does not react with H^+ or magnesium ions or chloride ions
Allow any soluble ionic compound that does not react with acid or magnesium ions or chloride ions
 2
- (b) No change
 1
- (c) EMF increases
 1
- (d) $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
Allow $\text{Mg} + 2 \text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2$
Ignore state symbols
allow multiples
 1
- [5]**

Q4.

- (a) $\text{O}_2 + 4 \text{H}^+ + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O}$ 1
- (b) $\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 6 \text{H}^+ + 6 \text{e}^-$ 1
- (c) 1.23 (V) 1
- (d) Reactants supplied continuously
Allow fuel continuously supplied
Allow continuous supply of chemicals 1
- (e) Methanol (is liquid so) can be stored easily or transported easily
More energy can be produced from 1 cm³ of methanol (liquid) than from 1 cm³ of hydrogen (gas)
Ignore references to safety and cost
Do not accept no greenhouse gas emissions 1
- [5]**

Q5.

- (a) MnO_2 1
- (b) allows ions to move/flow/transfer
ignore to allow current/charge to flow
*do **not** accept electrons to flow*
or
 to complete the circuit
or
 acts as a salt bridge 1
- (c) $2 \text{Ag} + \text{ZnO} \rightarrow \text{Zn} + \text{Ag}_2\text{O}$
ignore state symbols 1
- (d) $\text{O}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l}) + 4 \text{e}^- \rightarrow 4 \text{OH}^-(\text{aq})$
ignore state symbols
allow multiples 1
- $E^\ominus_{\text{ohbar}} = (+) 0.4(0) \text{ (V)}$ 1
- (e) same overall reaction
or
 $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$ 1
- [6]**