Mark schemes

Q1.

(a) **M1** $E^\ominus$ V^{3+} (/V^{2+}) > $E^\ominus$ Zn^{2+} (/ Zn)

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

M2 $E^\ominus$ V^{2+}(/V) < $E^\ominus$ Zn^{2+} (/ Zn)

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

2

(b) Mg

Only

1

(c) EMF = (+) 0.78 (V)

Fe(s) I Fe^{2+}(aq) II VO^{2+}(aq), H^+(aq), V^{3+}(aq) I Pt(s)

Allow Fe(s) I Fe^{2+}(aq) II VO^{2+}(aq), V^{3+}(aq) I Pt(s)
Ignore state symbols

Fe(s) → Fe^{2+}(aq) + 2 e^-

Ignore state symbols

3

(d) **M1** n MnO_4^- = 29.43 × 10^{-3} × 0.0200 = 5.89 × 10^{-4} mol

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

M2 = M1 × $\frac{5}{3}$

M3 mass NH_4VO_3 = 9.81 × 10^{-4} × 116.9 = 0.1147 g

M3 = M2 × 116.9

M4 % purity = $\frac{0.1147\times100}{0.151}$ = 76.0 %

M4 = M3 × $\frac{100}{0.151}$

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) $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

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
$Ba + H_2SO_4 \rightarrow BaSO_4(s) + H_2$
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 Pa and V = 348×10^{-6} m^3

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

M3 n = 0.01405 mol

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

M4 = M3 x $\frac{2}{5}$

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

M5 = 0.832 ÷ M4

M6 A_r of metal = 148.0 - (2 × 14 +2 × 48) = 24(.0) = Mg

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

6

(e) **M1** $Na + Al + 2\,H_2 \rightarrow NaAlH_4$

M2 contains oppositely charged ions/ Na^+ and AlH_4^- ions

M3 strong attraction between (oppositely charged) ions

3

(f) $3\ NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3\ H_2O$

Allow multiples and ignore state symbols

1

(g) $Li^+ + CoO_2 + e^- \rightarrow Li^+(CoO_2)^-$

Allow Li(CoO_2) 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) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

Allow $Mg + 2\ H^+ \rightarrow Mg^{2+} + H_2$

Ignore state symbols

allow multiples

1

[5]

Q4.

(a) $O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$

1

(b) $CH_3OH + H_2O \rightarrow CO_2 + 6\ H^+ + 6\ e^-$

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) $2\ Ag + ZnO \longrightarrow Zn + Ag_2O$

ignore state symbols

1

(d) $O_2(g) + 2\ H_2O(l) + 4\ e^- \rightarrow 4\ OH^-(aq)$

ignore state symbols

allow multiples

1

E⦵ = (+) 0.4(0) (V)

1

(e) same <u>overall</u> reaction

or

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

1

[6]