M1. D

[1]

M2. D

[1]

M3. D

[1]

M4. A

[1]

M5. D

[1]

M6. C

[1]

M7. B

[1]

M8. C

[1]

M9. D

[1]

M10. (a) most powerful reducing agent: Zn; 1

(b) (i) reducing species: Fe^{2+} 1

(ii) oxidising species: Cl_2; 1

(c) (i) standard electrode potential 1.25 V; 1

(ii) equation: $Tl^{3+} + 2\ Fe^{2+} \rightarrow 2Fe^{3+} + Tl$ + balanced; 1

correct direction; 1

(d) (i) moles $KMnO_4 = 16.2 \times 0.0200 \times 10^{-3} = 3.24 \times 10^{-4}$; 1

moles H_2O_2 = Moles $KMnO_4 \times 5 / 2 = 8.10 \times {}^{-4}$; 1

8.10×10^{-4} moles H_2O_2 in 25 cm^3
$8.10 \times 10^{-4} \times 1000 / 25$ in 1000 cm^3 = 0.0324 mol dm^{-3}; 1

hence g dm^{-3} = mol $dm^{-3} \times M_r = 0.0324 \times 34 = 1.10$;
(penalise use of an incorrect H_2O_2 to $KMnO_4$ ratio by two marks) 1

(ii) PV = nRT; 1

hence V = nRT / P
$= 8.10 \times 10^{-4} \times 8.31 \times 298/98000$; 1

$= 2.05 \times 10^{-5}$; 1

units m^3;

(mark consequentially to answers in (c)(i))
(allow correct answers with other units)
(answers to (c)(i) and (ii) must be to 3 significant figures; penalise once only)

1

[14]

M11. A

[1]

M12. (a) reactants brought together / increased concentration on surface or increased collision frequency **(1)**
reactants must be correctly orientated **(1)**
reaction on the surface **(1)**
products desorbed **(1)**
example of a catalysed reaction (not a named process) **(1)**
a suitable catalyst for this reaction **(1)**

penalise incorrect second reactions and catalysts

If absorption too weak reactants not brought together **(1)**
e.g. silver **(1)**
If adsorption too strong products not desorbed **(1)**
e.g. tungsten **(1)**

max 8

(b) Equations:

$Cr_2O_7^{2-}$ +14 H^+ + 6 Fe^{2+} → 6 Fe^{3+} + 2 Cr^{3+} + 7 H_2O **(1)**
Zn + 2 Fe^{3+} → Zn^{2+} +2 Fe^{2+} **(1)**

Method

Titrate measured volume solution against $K_2Cr_2O_7$ **(1)**

Reduce same volume solution with zinc **(1)**

Filter off excess zinc **(1)**

Titrate total Fe^{n+} using $K_2Cr_2O_7$ **(1)**

Percentage Fe^{3+} = 100 × (titre2 - titre1) / titre 2
or equivalent **(1)**

7

[15]

M13. D

[1]

M14. A

[1]

M15. (a) (i) Heterogeneous:- In a different phase to reactants **(1)**
Catalyst:- Increases reaction rate **(1)**
Alternative route or route described **(1)**
Lower E_a **(1)**
Unchanged at end of reaction **(1)** Max 4

(ii) Feature:- QoL Variable oxidation states shown by vanadium **(1)**
Equations $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ **(1)**
$2V_2O_4 + O_2 \rightarrow 2V_2O_5$ **(1)**

7

(b) $VO_2^+ + 4H^+ + 3e^- \rightarrow V^{2+}(aq) + 2H_2O$ **(1)**

$Zn \rightarrow Zn^{2+} + 2e^-$ (given)

$2VO_2^+ + 8H^+ + 3Zn \rightarrow 3Zn^{2+} + 2V^{2+}(aq) + 4H_2O$ **(1)**

2

Mol $KMnO_4$ = mv/1000 = 0.0200 × 38.5/1000 = 7.70 × 10^{-4} **(1)**

Mole ratio MnO_4^- to V(II) = 3:5 deduced

or equation

$5V^{2+} + 3MnO_4^- + 4H^+ \rightarrow 2H_2O + 3Mn^{2+} + 5VO_2^+$ **(2)**

Mol V(II) = 7.70 × 10^{-4} × 5/3 **(1)** = 1.283 × 10^{-3}

Mass V = $1.283 \times 10^{-3} \times 50.9$ **(1)** = 0.0653 g

% V in sample = $0.06532 \times 100/0.160 = 40.8$ **(1)**

6

[15]

M16.D

[1]