M1. (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) = $7.70 \times 10^{-4} \times 5/3$ **(1)** = 1.283×10^{-3}

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

% V in sample = 0.06532 × 100/0.160 = 40.8 **(1)**

6

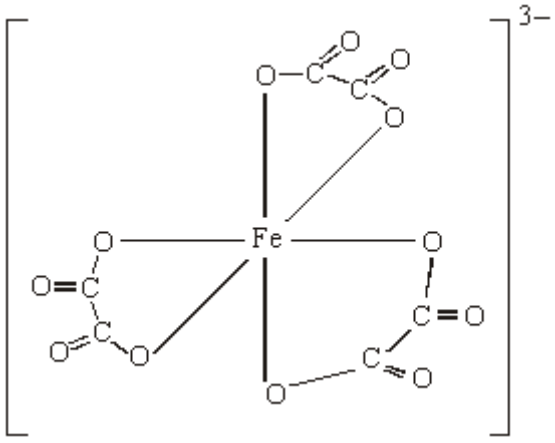
[15]

M2. (a) (i) Two **(1)** lone pair donor / electron pair donor **(1)** atoms

Allow:– forms two co-ordinate bonds **(1)**

NOT atom with two lone pairs

(ii)



(not essential)

*Correct ligand structure **(1)***
penalise any error
*Six correct O–Fe bonds **(1)***
*Correct charge **(1)***
N.B. Penalise the second mark if arrow from Fe shown
N.B. Ignore charges on atoms

5

(b) (Substitution of a monodentate ligand by a) bi or multidentate ligand **(1)** giving a more stable complex **(1)** or with an increase in entropy / disorder or forming a ring / cage complex / structure (crab like)

2

(c) (i) $[AgCl_2]^-$ or $AgCl_2^-$ **(1)**

(ii) Chloride or Cl^- big or large or repel **(1)**
NOT Cl_2 or Cl^+ or Cl
Allow 'chlorine ion'

2

(d) (i) (Both) ions are negative or ions repel or High E_a **(1)**

(ii) *Meaning of the term autocatalytic:* A product of the reaction acts as a catalyst **(1)**

NOT a self catalysing reaction (0)

Catalyst: Mn^{2+} or Mn^{3+} **(1)**

(iii) Mn^{2+} converted into Mn^{n+} or Mn^{2+} oxidised **(1)**
Mn^{n+}/oxidised species then <u>oxidises/reacts with $C_2O_4^{2-}$</u> **(1)**

5

[14]

M3. (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:

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

M4. D

[1]

M5. (a) High E_a: $S_2O_8^{2-}$ repels I^- **or** both ions negative **(1)**
$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$ **(1)**
$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ **(1)**
N.B. Ignore additional incorrect equations

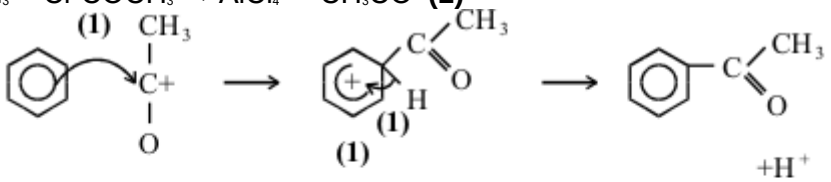
Vanadium is a transition element **or** Magnesium is not a transition element **(1)**

Vanadium has variable oxidation states **(1)**

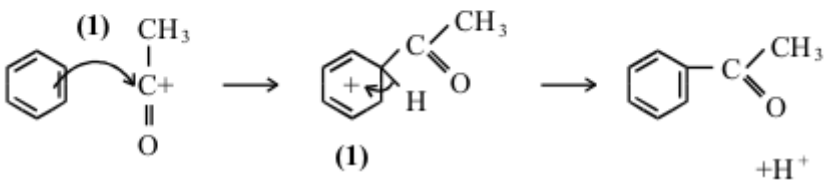
Magnesium only forms Mg^{2+}, **or** has only one oxidation state **(1)**
N.B. Score two marks for "Only vanadium has variable oxidation states"

6

(b) $AlCl_3 + Cl\text{-}COCH_3 \rightarrow AlCl_4^- + CH_3CO^+$ **(1)**



or



$H^+ + AlCl_4^- \rightarrow AlCl_3 + HCl$ **(1)**
Lewis acid: $AlCl_3$ accepts electron pair
N.B. penalise incorrect acyl chloride by one
N.B. penalise chloroethane by two marks i.e. first equation mark, attack on benzene mark

NH_4Cl: Not a catalyst **(1)**

$FeCl_3$: A catalyst **(1)**
has a low energy vacant shell
or has spaces or vacancies in d shell
or has a partially filled d shell
or able to accept an electron pair
or can form $FeCl_4^-$ **(1)**

9

[15]