

- M1.** (a) Alternative route
Allow mechanism outlined
allow forms intermediate species 1
- Lower activation energy 1
- (b) Variable oxidation state
allow changes oxidation states 1
- (c) (i) $\text{SO}_2 + \text{V}_2\text{O}_5 \rightarrow \text{SO}_3 + \text{V}_2\text{O}_4$
allow 2VO₂ instead of V₂O₄ 1
- $\text{O}_2 + 2\text{V}_2\text{O}_4 \rightarrow 2\text{V}_2\text{O}_5$ 1
- (ii) Poison attaches to surface
Allow blocks active site/surface
Decreases surface area 1
- (iii) Purify reactants
Allow remove impurities 1

[7]

- M2.** (a) FeCl_3 accepts electron pairs from water 1
- Hence acts as a Lewis acid 1

$[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ donates protons 1

Hence acts as a Bronsted-Lowry acid 1

(b) The Fe^{2+} ion has a smaller charge to size ratio 1

Hence less polarising than Fe^{3+} or less weakening effect on O-H bonds 1

(c) (i) $\text{V}_2\text{O}_5 + \text{SO}_2 \rightarrow \text{V}_2\text{O}_4 + \text{SO}_3$ 1

$\text{V}_2\text{O}_4 + \text{O}_2 \rightarrow \text{V}_2\text{O}_5$ 1

(ii) Both ions are negative or ions repel 1

$2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$ Species 1

Balanced 1

$2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$ Species 1

Balanced 1

[13]

M3. (a) A catalyst in the same phase/phase as the reactants 1

(b) (i) A reaction in which a product acts as a catalyst 1

- (ii) Mn^{2+} or Mn^{3+}
"Self-catalysing" not allowed 1
- (c) (i) $2CO + 2NO \rightarrow 2CO_2 + N_2$
 or $4CO + 2NO_2 \rightarrow 4CO_2 + N_2$
C not allowed as a product 1
- Reducing agent CO 1
- (ii) Pt, Pd or Rh 1
- Deposited on a ceramic honeycomb or matrix or mesh or sponge 1
- To increase surface area of catalyst 1
- (d) (i) Reactants cannot move on surface or products not desorbed or
 Active sites blocked 1
- (ii) Reactants not brought together or
 No increase in reactant concentration on catalyst surface or
 Reactants not held long enough for a reaction to occur or
 Reactant bonds not weakened 1

[10]

- M4.** (a) Iron 1
- Heterogeneous; catalyst in a different phase from
 that of the reactants 1
- Poison; a sulphur compound (allow sulphur) 1
- Poison strongly adsorbed onto active sites/ blocked

		1
	Poison not desorbed or reactants not adsorbed or catalyst surface area reduced	
		1
(b)	Pale green solution	1
	Green precipitate formed	1
	Insoluble in excess ammonia	1
	Equation:	
	e.g. $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow [\text{Fe}(\text{H}_2\text{O})_4(\text{OH})_2] + 2\text{NH}_4^+$ Species	1
	Balance	1
	<i>NB Allow equations with H₂O and OH⁻ if reaction of H₂O with NH₃ also given</i>	
		Max 4

[9]

- M5.** (a) effect on reaction rate: catalyst provides an alternative reaction route.; 1
- with a lower E_a ; 1
- more molecules able to react or rate increased; 1
- equilibrium: forward and backward rates changes by the same amount; 1
- hence concentration of reactants and products constant or yield unchanged; 1
- (b) heterogeneous: catalyst in a different phase or state to that of

the reactants; 1

active site: place where reactants adsorbed or attached or bond etc.; 1

reaction occurs or an explanation of what happens;
(allow absorbed) 1

reasons: large surface area;
reduce cost or amount of catalyst; 2

catalyst poison: lead adsorbed;
lead not desorbed or site blocked;
(lead adsorbed irreversibly scores both of these marks) 2

(c) reaction slow as: both ions negatively charged or ions repel; 1

$2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$ Species;
Balanced; 2

$2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$ Species ;
Balanced; 2

[17]

M6.C

[1]