

- 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 2VO<sub>2</sub> instead of V<sub>2</sub>O<sub>4</sub>* 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
- M2.** (a)  $\text{FeCl}_3$  accepts electron pairs from water 1
- Hence acts as a Lewis acid 1

[7]

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

Hence acts as a Bronsted-Lowry acid 1

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

Hence less polarising than  $\text{Fe}^{3+}$  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 <sup>2+</sup> or Mn <sup>3+</sup> "Self-catalysing" not allowed	1
(c)	(i)	2CO + 2NO → 2CO <sub>2</sub> + N <sub>2</sub> or 4CO + 2NO <sub>2</sub> → 4CO <sub>2</sub> + N <sub>2</sub> 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
			<b>[10]</b>
<b>M4.</b>	(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 H<sub>2</sub>O and OH<sup>-</sup> if reaction of H<sub>2</sub>O with NH<sub>3</sub> 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]