

Q1. This question is about the use of transition metals as catalysts.

(a) State how a catalyst speeds up a chemical reaction.

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(2)

(b) State the characteristic property of transition metals that enables them to act as catalysts in redox reactions.

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(1)

(c) In the Contact Process for the conversion of sulfur dioxide into sulfur trioxide, vanadium(V) oxide acts as a heterogeneous catalyst.

(i) Write **two** equations to show how the catalyst is involved in this reaction.

Equation 1

Equation 2

(2)

(ii) Suggest **one** reason why poisoning reduces the effectiveness of a heterogeneous catalyst.

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(1)

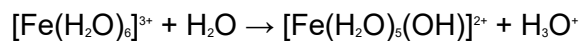
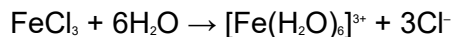
(iii) Suggest how poisoning of a catalyst, used in an industrial process, can be minimised.

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(1)

(Total 7 marks)

Q2. When anhydrous iron(III) chloride is added to water the following reactions occur.



(a) State the type of acidity shown by FeCl_3 and by $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ in these reactions. Explain your answers.

(4)

(b) Explain why the pH of a solution of iron(II) chloride is higher than that of a solution of iron(III) chloride of the same concentration.

(2)

(c) Transition metals have variable oxidation states. This is an important factor in their ability to act as heterogeneous and homogeneous catalysts.

(i) Vanadium(V) oxide acts as a heterogeneous catalyst in the Contact Process. Write equations to show the role of vanadium(V) oxide in this process.

(ii) In aqueous solution, Fe^{2+} ions act as a homogeneous catalyst in the reaction between I^- and $\text{S}_2\text{O}_8^{2-}$ ions. Give one reason why the reaction is slow in the absence of a catalyst. Write equations to show how Fe^{2+} ions act as a catalyst for this reaction.

(7)

(Total 13 marks)

Q3. (a) State what is meant by the term *homogeneous* as applied to a catalyst.

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(1)

(b) (i) State what is meant by the term *autocatalysis*.

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- (ii) Identify the species which acts as an autocatalyst in the reaction between ethanedioate ions and manganate(VII) ions in acidic solution.

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(2)

- (c) When petrol is burned in a car engine, carbon monoxide, carbon dioxide, oxides of nitrogen and water are produced. Catalytic converters are used as part of car exhaust systems so that the emission of toxic gases is greatly reduced.

- (i) Write an equation for a reaction which occurs in a catalytic converter between two of the toxic gases. Identify the reducing agent in this reaction.

Equation

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Reducing agent

- (ii) Identify a transition metal used in catalytic converters and state how the converter is constructed to maximise the effect of the catalyst.

Transition metal

How effect is maximised

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(5)

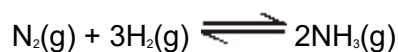
- (d) The strength of the adsorption of reactants and products onto the surface of a transition metal helps to determine its activity as a heterogeneous catalyst.

- (i) Explain why transition metals which adsorb strongly are not usually good catalysts.

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- (ii) Explain why transition metals which adsorb weakly are not usually good catalysts.

- Q4.** (a) In the Haber Process for the manufacture of ammonia, the following equilibrium is established in the presence of a heterogeneous catalyst.



Identify the heterogeneous catalyst used in this process and state what is meant by the term *heterogeneous*.

A heterogeneous catalyst can become poisoned by impurities in the reactants. Give one substance which poisons the heterogeneous catalyst used in the Haber Process and explain how this substance poisons the catalyst.

(5)

- (b) State what is observed when an excess of aqueous ammonia reacts with an aqueous iron(II) salt. Write an equation for this reaction.

(4)

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(Total 9 marks)

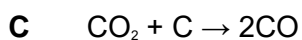
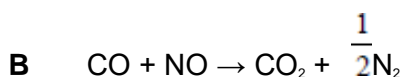
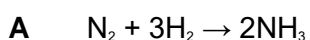
Q5. (a) State and explain the effect of a catalyst on the rate and on the equilibrium yield in a reversible reaction. (5)

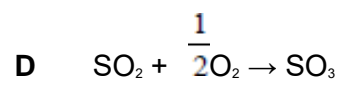
(b) Explain the terms *heterogeneous* and *active sites* as applied to a catalyst. Give **two** reasons why a ceramic support is used for the catalyst in catalytic converters in cars. Explain how lead poisons this catalyst. (7)

(c) In aqueous solution, Fe²⁺ ions act as a homogeneous catalyst in the reaction between I⁻ and S₂O₈²⁻ ions. Give **one** reason why the reaction is slow in the absence of a catalyst. Write equations to show how Fe²⁺ ions act as a catalyst for this reaction. (5)

(Total 17 marks)

Q6. In which one of the following reactions is a heterogeneous catalyst **not** used?





(Total 1 mark)