

A2 SECTION 2 - INORGANIC 2 - PRACTICE QUESTIONS

1

Due to their electron arrangements, transition metals have characteristic properties including catalytic action and the formation of complexes with different shapes.

- (a) Give **two other** characteristic properties of transition metals. For each property, illustrate your answer with a transition metal of your choice.

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(4 marks)

- (b) Other than octahedral, there are several different shapes shown by transition metal complexes. Name **three** of these shapes and for each one give the formula of a complex with that shape.

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(6 marks)

(c) It is possible for Group 2 metal ions to form complexes. For example, the $[\text{Ca}(\text{H}_2\text{O})_6]^{2+}$ ion in hard water reacts with EDTA^{4-} ions to form a complex ion in a similar manner to hydrated transition metal ions. This reaction can be used in a titration to measure the concentration of calcium ions in hard water.

(i) Write an equation for the equilibrium that is established when hydrated calcium ions react with EDTA^{4-} ions.

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(1 mark)

(ii) Explain why the equilibrium in part (c) (i) is displaced almost completely to the right to form the EDTA complex.

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(3 marks)

(iii) In a titration, 6.25 cm^3 of a $0.0532 \text{ mol dm}^{-3}$ solution of EDTA reacted completely with the calcium ions in a 150 cm^3 sample of a saturated solution of calcium hydroxide. Calculate the mass of calcium hydroxide that was dissolved in 1.00 dm^3 of the calcium hydroxide solution.

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(3 marks)

2

Iron is an important element in living systems. It is involved in redox and in acid–base reactions.

(a) Explain how and why iron ions catalyse the reaction between iodide ions and $\text{S}_2\text{O}_8^{2-}$ ions. Write equations for the reactions that occur.

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(5 marks)

(b) Iron(II) compounds are used as moss killers because iron(II) ions are oxidised in air to form iron(III) ions that lower the pH of soil.

(i) Explain, with the aid of an equation, why iron(III) ions are more acidic than iron(II) ions in aqueous solution.

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(3 marks)

- (ii) In a titration, 0.321 g of a moss killer reacted with 23.60 cm³ of acidified 0.0218 mol dm⁻³ K₂Cr₂O₇ solution.

Calculate the percentage by mass of iron in the moss killer. Assume that all of the iron in the moss killer is in the form of iron(II).

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(5 marks)

- (c) Some sodium carbonate solution was added to a solution containing iron(III) ions. Describe what you would observe and write an equation for the reaction that occurs.

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(3 marks)

3

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

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(1 mark)

(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 marks)

(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

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 marks)

4

(a) Using complex ions formed by Co^{2+} with ligands selected from H_2O , NH_3 , Cl^- , $\text{C}_2\text{O}_4^{2-}$ and EDTA^{4-} , give an equation for each of the following.

(i) A ligand substitution reaction which occurs with no change in either the co-ordination number or in the charge on the complex ion.

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(ii) A ligand substitution reaction which occurs with both a change in the co-ordination number and in the charge on the complex ion.

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(iii) A ligand substitution reaction which occurs with no change in the co-ordination number but a change in the charge on the complex ion.

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(iv) A ligand substitution reaction in which there is a large change in entropy.

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(8 marks)

(b) An aqueous solution of iron(II) sulphate is a pale-green colour. When aqueous sodium hydroxide is added to this solution a green precipitate is formed. On standing in air, the green precipitate slowly turns brown.

(i) Give the formula of the complex ion responsible for the pale-green colour.

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(ii) Give the formula of the green precipitate.

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(iii) Suggest an explanation for the change in the colour of the precipitate.

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(4 marks)

5

This question is about a product, Kwik Kleen, sold for unblocking clogged waste pipes of sinks in the home. The product consists of pure, powdered, solid sodium hydroxide, NaOH, a base. The instructions for use state 'Wearing gloves and eye protection, add 100g of Kwik Kleen to 1 litre (1 dm³) of cold water and pour into the blocked drain. The solution will get warm. Always add Kwik Kleen to water rather than water to Kwik Kleen.'

(a) Write an ionic equation for the reaction that occurs when sodium hydroxide is added to water. Give the appropriate state symbols.

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(2 marks)

(b) The pack says that Kwik Kleen is 'super strength'. Comment on the use of the term 'strength' in relation to sodium hydroxide dissolving in water.

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(1 mark)

(c) Is it realistic to claim that solid sodium hydroxide is 'super strength' compared with other products consisting of solid sodium hydroxide?

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(2 marks)

(d) Give the sign of ΔH for this reaction. Is it exothermic or endothermic?

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(2 marks)

(e) Explain why it is safer to add sodium hydroxide to water than vice versa. _____

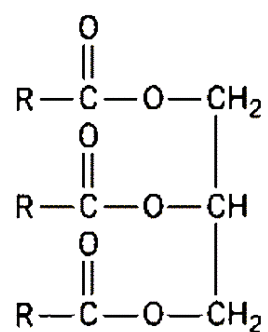
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(2 marks)

- (f) Calculate the concentration in mol dm⁻³ of a solution containing 100g of sodium hydroxide in 1 dm³ of solution.

(1 mark)

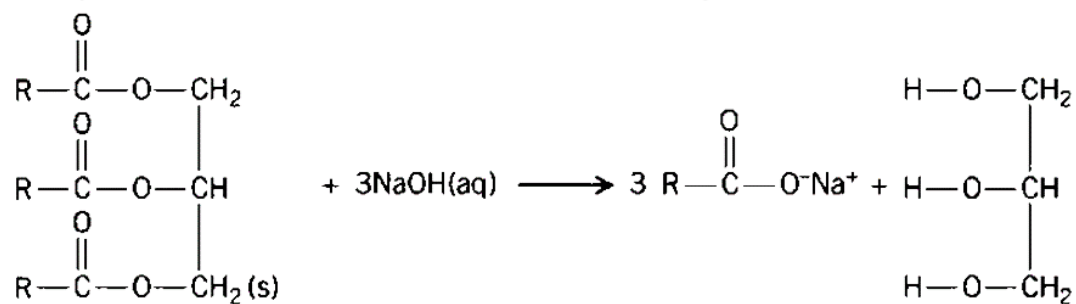
- (g) Part of the action unblocking action depends on the reaction of the sodium hydroxide solution with solid fat (resulting from cooking) to form soluble products. Fat contains esters such as:



Where R is a long chain alkyl group, such as C₁₇H₃₅.
Calculate the relative molecular mass of the fat.

(1 mark)

(h) The equation for the reaction of the fat with sodium hydroxide is



(i) Calculate the maximum number of grams of fat that could be dissolved by 1 dm³ of the sodium hydroxide solution.

(2 marks)

(ii) Why is this unlikely to be the case in practice?

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(2 marks)

(i) Explain why RCOO⁻Na⁺ is more soluble in water than the original fat.

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(1 mark)

6

A co-ordinate bond is formed when a transition metal ion reacts with a ligand.

(a) Explain how this co-ordinate bond is formed.

[2 marks]

(b) Describe what you would observe when dilute aqueous ammonia is added dropwise, to excess, to an aqueous solution containing copper(II) ions.
Write equations for the reactions that occur.

[4 marks]

- (c) When the complex ion $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ reacts with 1,2-diaminoethane, the ammonia molecules but not the water molecules are replaced.

Write an equation for this reaction.

[1 mark]

- (d) Suggest why the enthalpy change for the reaction in Question 8.3 is approximately zero.

[2 marks]

- (e) Explain why the reaction in Question 8.3 occurs despite having an enthalpy change that is approximately zero.

[2 marks]

7

Table 5 shows observations of changes from some test-tube reactions of aqueous solutions of compounds **Q**, **R** and **S** with five different aqueous reagents. The initial colours of the solutions are not given.

Table 5

	$\text{BaCl}_2 + \text{HCl}$	$\text{AgNO}_3 + \text{HNO}_3$	NaOH	Na_2CO_3	HCl (conc)
Q	no change observed	pale cream precipitate	white precipitate	white precipitate	no change observed
R	no change observed	white precipitate	white precipitate, dissolves in excess of NaOH	white precipitate, bubbles of a gas	no change observed
S	white precipitate	no change observed	brown precipitate	brown precipitate, bubbles of a gas	yellow solution

- (a) Identify each of compounds **Q**, **R** and **S**.
You are **not** required to explain your answers.

[6 marks]Identity of **Q** _____

Identity of **R** _____

Identity of **S** _____

(b) Write ionic equations for each of the positive observations with **S**.

[4 marks]

8 (a) Define the term transition metal.

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(1 mark)

(b) Explain why scandium, Sc, is classified as a d-block element but not as a transition metal element.

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(2 marks)

9 (a) Explain what is meant by the terms:

complex ion

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ligand

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(2 marks)

(b) Complete the electron configuration of:

(i) Cu atom

$1s^2, 2s^2$

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(1 mark)

(ii) Cu^{2+} ion

$1s^2, 2s^2$

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(1 mark)

(c) Consider the hexaaquachromium(III), $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$, complex.

(i) Draw the shape of this complex.

(1 mark)

(ii) Name the shape of this complex.

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(1 mark)