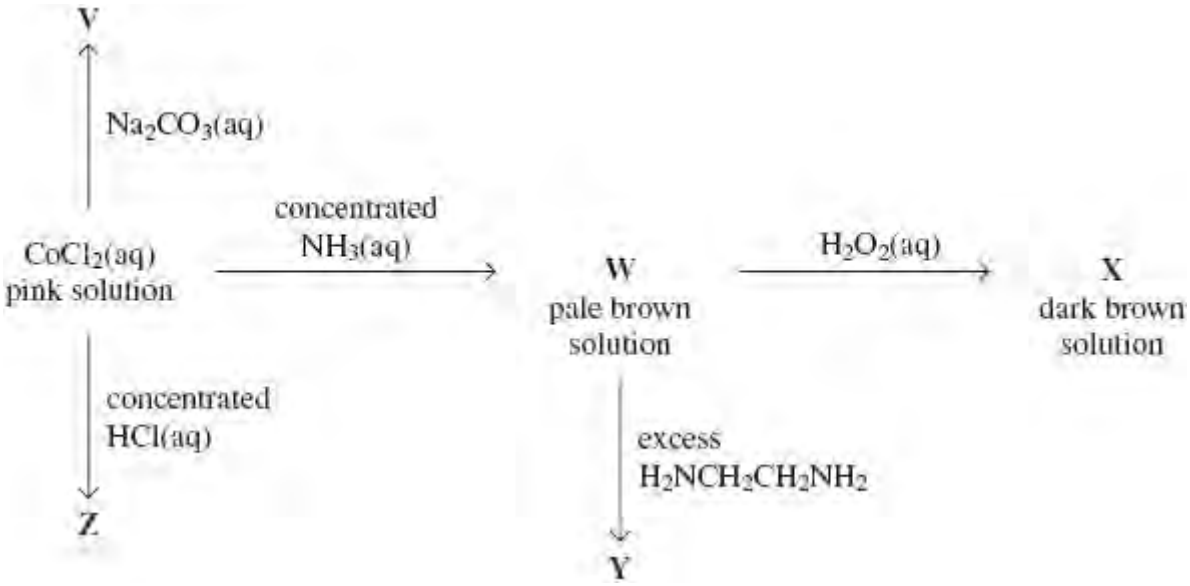
Q1. This question is about some reactions of cobalt compounds.



(a) Give the formula of the complex responsible for the pink colour in aqueous $CoCl_2$ and name its shape.

Formula .....

Name of shape .....

(2)

(b) Give the formula of the cobalt-containing compound **V** and describe its appearance.

Formula .....

Appearance .....

(2)

(c) Write an equation for the reaction that occurs when the pink solution is converted into **W**.

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(2)

(d) Give the formula of the cobalt-containing complex in **X** and state the role of the H_2O_2 in this reaction.

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Formula .....

Role of H_2O_2 .....

(2)

(e) Give the formula of the cobalt-containing complex in **Y** and explain why this complex is more stable than the cobalt-containing complex in **W**.

Formula .....

Explanation .....

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(3)

(f) Identify the cobalt-containing complex in solution **Z** and explain why its co-ordination number is different from that in the pink solution of $CoCl_2$

Complex .....

Explanation .....

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(2)
(Total 13 marks)

Q2. (a) State the electron configuration of a Ti(III) ion and that of a Ti(IV) ion. Explain, in terms of electron configurations and electron transitions, why Ti(III) compounds are usually coloured but Ti(IV) compounds are colourless.

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(5)

(b) Transition metal ions and their complexes can often be identified from their colours. For each of the following, identify a complex ion responsible for the colour of the aqueous solution. Restrict your answers to complexes formed from the elements Cr, Fe, Co and Cu.

A deep blue solution formed in an excess of concentrated aqueous ammonia.

A green solution formed in an excess of aqueous sodium hydroxide.

A yellow–green solution formed in an excess of concentrated hydrochloric acid.

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(c) An experiment is carried out to investigate the rate of the autocatalysed reaction between aqueous potassium manganate(VII) and ethanedioate ions in an excess of dilute sulfuric acid. When these reagents are mixed together, the colour of the reaction mixture gradually fades. The concentration of the manganate(VII) ions is recorded at different times using a spectrometer. The temperature of the reaction mixture is constant.

(i) Give **two** reasons why the use of a spectrometer is the most appropriate method for measuring the concentration of the coloured ions in this experiment.

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(2)

(ii) Sketch a curve to show how you would expect the concentration of manganate(VII) ions to change with time until the colour has faded because the concentration has reached a very low value. Explain the shape of the curve.

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(5)
(Total 15 marks)

Q3. (a) Octahedral and tetrahedral complex ions are produced by the reaction of transition metal ions with ligands which form co-ordinate bonds with the transition metal ion.
Define the term *ligand* and explain what is meant by the term *co-ordinate bond*.

(3)

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(b) (i) Some complex ions can undergo a ligand substitution reaction in which both the co-ordination number of the metal and the colour change in the reaction. Write an equation for one such reaction and state the colours of the complex ions involved.

(ii) Bidentate ligands replace unidentate ligands in a metal complex by a ligand substitution reaction.
Write an equation for such a reaction and explain why this reaction occurs.

(8)

(c) The frequency, *v*, of light absorbed by a transition metal complex ion can be determined using the relationship $\Delta E = hv$. State what is meant by the symbols ΔE and *h*. Give **three** factors which result in a change in the frequency of light absorbed as a result of the reaction of a complex ion.

(5)
(Total 16 marks)

Q4. The characteristic properties of transition metals include complex formation and the formation of coloured ions.

(a) Some complex ions can undergo a ligand substitution reaction in which both the coordination number of the metal and the colour of complex ions change in the reaction.

Write an equation for one such reaction and state the colours of the complex ions involved.

Equation .....

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Colours of complex ions .....

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(4)

(b) The frequency, *v*, of light absorbed by a transition–metal complex ion can be determined using the relationship $\Delta E = hv$.

(i) State what is meant by the symbols ΔE and *h*.

Meaning of symbol ΔE .....

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Meaning of symbol h .....

(ii) Give three factors which may cause the frequency of light absorbed to change when a complex ion reacts.

Factor 1 .....

Factor 2 .....

Factor 3 .....

(5)
(Total 9 marks)

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