Q1.(a) Explain how the electron pair repulsion theory can be used to deduce the shape of, and the bond angle in, PF_3

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(6)

(b) State the full electron configuration of a cobalt(II) ion.

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(1)

(c) Suggest **one** reason why electron pair repulsion theory **cannot** be used to predict the shape of the $[CoCl_4]^{2-}$ ion.

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(1)

(d) Predict the shape of, and the bond angle in, the complex rhodium ion $[RhCl_4]^{2-}$.

Shape .....

Bond angle .....

(2)

(Total 10 marks)

Q2. The pigment 'Cobalt Yellow' contains an octahedral complex of cobalt(III) and nitrate(III) ions (NO_2^-). Analysis shows that Cobalt Yellow contains 13.0% of cobalt, 18.6% of nitrogen and 25.9% of potassium by mass. The remainder is oxygen.

(a) Use these data to calculate the empirical formula of Cobalt Yellow. Show your working.

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(3)

(b) Deduce the structural formula of the cobalt-containing ion in Cobalt Yellow.

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(1)
(Total 4 marks)

Q3. Transition metals and their complexes have characteristic properties.

(a) Give the electron configuration of the Zn^{2+} ion.
Use your answer to explain why the Zn^{2+} ion is **not** classified as a transition metal ion.

Electron configuration .....

Explanation .....

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(2)

(b) In terms of bonding, explain the meaning of the term *complex*.

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(2)

(c) Identify **one** species from the following list that does **not** act as a ligand. Explain your answer.

H_2 O^{2-} O_2 CO

Not a ligand.....

Explanation .....

(2)

(d) The element palladium is in the d block of the Periodic Table. Consider the following palladium compound which contains the sulfate ion.

$[Pd(NH_3)_4]SO_4$

(i) Give the oxidation state of palladium in this compound.

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(1)

(ii) Give the names of two possible shapes for the complex palladium ion in this compound.

Shape 1 .....

Shape 2 .....

(2)
(Total 9 marks)

Q4. 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)

(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)

(c) It is possible for Group 2 metal ions to form complexes. For example, the $[Ca(H_2O)_6]^{2+}$ 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)

(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)

(iii) In a titration, 6.25 cm^3 of a 0.0532 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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(Extra space) .....

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(3)
(Total 17 marks)

Q5.(a) Explain the meaning of the terms *ligand* and *bidentate* as applied to transition metal complexes.

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(2)

(b) Aqueous cobalt(II) ions react separately with an excess of chloride ions and with an excess of ammonia.

For each reaction, draw a diagram to illustrate the structure of, the shape of and the charge on the complex ion formed.

In each case, name the shape and indicate, on the diagram, a value for the ligand-metal-ligand bond angle.

(6)

(c) The complex ion formed in aqueous solution between cobalt(II) ions and chloride ions is a different colour from the $[Co(H_2O)_6]^{2+}$ ion.

Explain why these complex ions have different colours.

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(3)

(d) In aqueous ammonia, cobalt(II) ions are oxidised to cobalt(III) ions by hydrogen peroxide. The H_2O_2 is reduced to hydroxide ions.

Calculate the minimum volume of 5.00 mol dm^{-3} H_2O_2 solution required to oxidise the Co^{2+} ions in 9.87 g of $CoSO_4.7H_2O$

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(5)
(Total 16 marks)