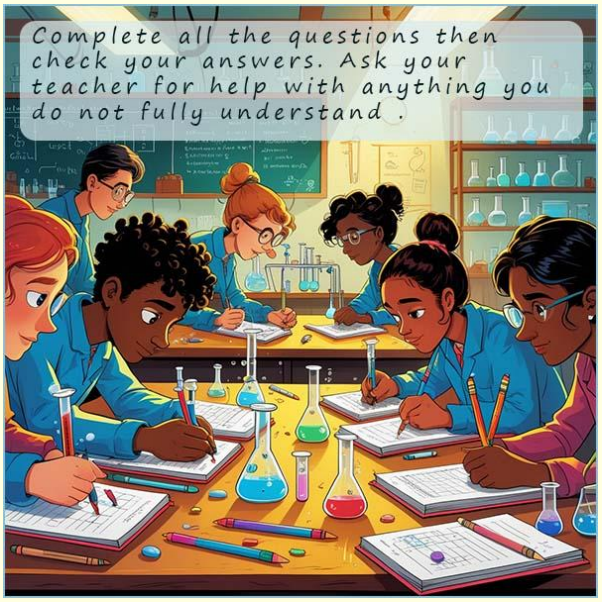
Answer all the questions below as fully as you can then check your answers



1. When hexaaquacopper(II) reacts with ammonia, what happens to the shape of the complex?

A. Changes from octahedral to tetrahedral

B. Remains octahedral

C. Changes from octahedral to square planar

D. Becomes linear

2. Which of the following ligands is bidentate?

A. Cl^- B. NH_3 C. H_2O D. $NH_2CH_2CH_2NH_2$

3. Which of the following factors explains why $[Cu(en)_3]^{2+}$ is more stable than $[Cu(H_2O)_6]^{2+}$ when it forms from this copper(II) sulfate solution?

A. Chelate effect and entropy increase

B. Decrease in coordination number

C. Presence of stronger hydrogen bonds

D. Reduced ionic charge

4. Write a balanced chemical equation for the ligand substitution reaction that occurs when hexaaquacobalt(II) reacts with concentrated HCl.

5. Explain why ligand substitution reactions with polydentate ligands result in more stable complexes compared to monodentate ligands.

6. Predict the outcome of this scenario:
A solution of hexaaquairon(III) ions reacts with thiocyanate ions (SCN^-). What colour change would you expect and why?

7. Compare the geometry and colour changes observed during the following reactions:

a. Reaction of hexaaquacobalt(II) with concentrated HCl.

b. Reaction of hexaaquacopper(II) with concentrated HCl.

8. Using Le Chatelier's Principle, explain how you can reverse the ligand substitution reaction between hexaaquacobalt(II) and chloride ions.

9. Discuss the role of ligand size and charge in determining the final geometry of a metal complex during a substitution reaction.

10. Calculate the total number of coordinate bonds formed in a $[Cr(en)_3]^{3+}$ complex.

11. Why do ligand substitution reactions involving ethylenediamine or EDTA tend to have very large equilibrium constants?

12. Why does the addition of excess ammonia to $[Cu(H_2O)_6]^{2+}$ initially form a pale blue precipitate before dissolving to form a deep blue solution?
Answer: Initially, ammonia reacts with the copper(II) complex, precipitating copper(II) hydroxide due to deprotonation of water ligands. Excess ammonia then forms $[Cu(NH_3)_4(H_2O)_2]^{2+}$, which dissolves and gives the deep blue colour.

Answers

1. When hexaaquacopper(II) reacts with ammonia, what happens to the shape of the complex?

A. Changes from octahedral to tetrahedral

B. Remains octahedral

C. Changes from octahedral to square planar

D. Becomes linear

Answer: B

2. Which of the following ligands is bidentate?

A. Cl^- B. NH_3 C. H_2O D. $NH_2CH_2CH_2NH_2$

Answer: D

3. Which of the following factors explains why $[Cu(en)_3]^{2+}$ is more stable than $[Cu(H_2O)_6]^{2+}$ when it forms from this copper(II) sulfate solution?

A. Chelate effect and entropy increase

B. Decrease in coordination number

C. Presence of stronger hydrogen bonds

D. Reduced ionic charge

Answer: A

4. Write a balanced chemical equation for the ligand substitution reaction that occurs when hexaaquacobalt(II) reacts with concentrated HCl.

Answer:

$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$

5. Explain why ligand substitution reactions with polydentate ligands result in more stable complexes compared to monodentate ligands.
Answer: Polydentate ligands form multiple coordinate bonds to the metal ion, leading to an increase in entropy and forming highly stable ring-like structures. This is known as the chelate effect.

6. Predict the outcome of this scenario:
A solution of hexaaquairon(III) ions reacts with thiocyanate ions (SCN^-). What colour change would you expect and why?
Answer: The solution turns blood red due to the formation of the $[Fe(SCN)]^{2+}$ complex. This occurs because SCN^- substitutes water ligands and forms a highly colored complex.

7. Compare the geometry and colour changes observed during the following reactions:

a. Reaction of hexaaquacobalt(II) with concentrated HCl.

b. Reaction of hexaaquacopper(II) with concentrated HCl.
Answer:

Hexaaquacobalt(II): Geometry changes from octahedral to tetrahedral; colour changes from pink to blue.

Hexaaquacopper(II): Geometry changes from octahedral to tetrahedral; colour changes from blue to green.

8. Using Le Chatelier's Principle, explain how you can reverse the ligand substitution reaction between hexaaquacobalt(II) and chloride ions.
Answer: By diluting the solution, the concentration of Cl^- decreases. This shifts the equilibrium back towards the reactants ($[Co(H_2O)_6]^{2+}$), resulting in a colour change from blue to pink.

9. Discuss the role of ligand size and charge in determining the final geometry of a metal complex during a substitution reaction.
Answer: Larger ligands, like Cl^-, cause repulsion, limiting the number of ligands around the metal ion and leading to a tetrahedral geometry. Smaller ligands, like H_2O or NH_3, allow for closer packing, maintaining an octahedral geometry. Charge also influences repulsion; highly charged ligands may reduce the number of possible ligands due to electrostatic repulsion.

10. Calculate the total number of coordinate bonds formed in a $[Cr(en)_3]^{3+}$ complex.
Answer: Each ethylenediamine (en) ligand forms 2 coordinate bonds. With 3 en ligands, the total number of coordinate bonds is $3 \times 2 = 6$.

11. Why do ligand substitution reactions involving ethylenediamine or EDTA tend to have very large equilibrium constants?
Answer: These reactions involve replacing monodentate ligands with polydentate ligands, resulting in increased entropy (more particles formed) and highly stable chelate rings, which drive the equilibrium strongly towards the product side.

12. Why does the addition of excess ammonia to $[Cu(H_2O)_6]^{2+}$ initially form a pale blue precipitate before dissolving to form a deep blue solution?
Answer: Initially, ammonia reacts with the copper(II) complex, precipitating copper(II) hydroxide due to deprotonation of water ligands. Excess ammonia then forms $[Cu(NH_3)_4(H_2O)_2]^{2+}$, which dissolves and gives the deep blue colour.