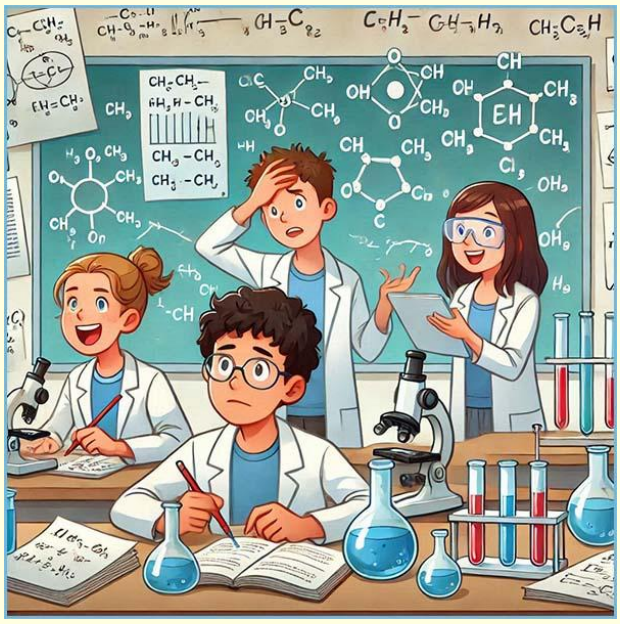
Answer all the questions below as fully as you can then check your answers

1. Explain why aqueous ammonia is considered a weak alkali.



2. Define the term "ligand" in the context of transition metal chemistry.

3. Give the formula of the complex ion formed when excess ammonia is added to a solution containing copper(II) ions and name it.

4. A solution of chromium(III) chloride is green. When a small amount of aqueous ammonia is added, a green precipitate forms.

(a) Write the ionic equation for the formation of the precipitate.

(b) Explain why the precipitate forms.

5. Describe the observations you would make when aqueous ammonia is added drop wise, and then in excess, to a solution of copper(II) sulfate. Write equations for any reactions that occur.

6. Compare and contrast the reactions of aqueous ammonia with solutions of aluminium(III) ions and copper(II) ions.

7. Explain why some metal hydroxides dissolve in excess ammonia while others do not. Use specific examples in your answer.

8. Which of the following is the correct formula for the linear complex formed when excess ammonia is added to silver(I) nitrate solution?

A. $[Ag(NH_3)_2]^+$ B. $[Ag(NH_3)_4]^+$ C. $[Ag(NH_3)_2]^{2+}$ D. $[Ag(NH_3)_4]^{2+}$

Answers

1. Explain why aqueous ammonia is considered a weak alkali.

Answer: Ammonia dissolves in water to form an equilibrium mixture containing ammonium ions (NH_4^+) and hydroxide ions (OH^-):

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

Because the equilibrium lies to the left, only a small proportion of the ammonia molecules present react with water to form OH- ions, hence it's a weak alkali.

2. Define the term "ligand" in the context of transition metal chemistry.

Answer: A ligand is a molecule or ion with a lone pair of electrons that can form a coordinate (dative covalent) bond to a central metal ion.

3. Give the formula of the complex ion formed when excess ammonia is added to a solution containing copper(II) ions and name it.

Answer: $[Cu(NH_3)_4(H_2O)_2]^{2+}$

name: tetraammindiaaquacopper(II)

4. A solution of chromium(III) chloride is green. When a small amount of aqueous ammonia is added, a green precipitate forms.

(a) Write the ionic equation for the formation of the precipitate.

Answer: $[Cr(H_2O)_6]^{3+}{}_{(aq)} + 3NH_{3(aq)} \rightarrow Cr(H_2O)_3(OH)_{3(s)} + 3NH_4^+{}_{(aq)}$

(b) Explain why the precipitate forms.

Answer: Ammonia acts as a base, reacting with the hexaaquachromium(III) ions to remove protons from the coordinated water ligands. This leads to the formation of neutral chromium(III) hydroxide, which is insoluble and precipitates.

5. Describe the observations you would make when aqueous ammonia is added drop wise, and then in excess, to a solution of copper(II) sulfate. Write equations for any reactions that occur.

Answer: Initially, a pale blue precipitate of copper(II) hydroxide forms:

$$[Cu(H_2O)_6]^{2+}{}_{(aq)} + 2NH_{3(aq)} \rightarrow Cu(H_2O)_4(OH)_{2(s)} + 2NH_4^+{}_{(aq)}$$

Upon addition of excess ammonia, the precipitate dissolves to form a deep blue solution containing the tetraamminecopper(II) complex:

$$[Cu(H_2O)_4(OH)_2]_{(s)} + 4NH_{3(aq)} \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}{}_{(aq)} + 2OH^-{}_{(aq)} + 2H_2O_{(l)}$$

6. Compare and contrast the reactions of aqueous ammonia with solutions of aluminium(III) ions and copper(II) ions.

Answer:

Similarities: Both aluminium(III) and copper(II) ions form precipitates of their respective hydroxides upon addition of a limited amount of aqueous ammonia. In both cases, ammonia acts as a base.

Differences: When excess ammonia is added:

The copper(II) hydroxide precipitate dissolves to form the deep blue tetraamminecopper(II) complex ion, $[Cu(NH_3)_4(H_2O)_2]^{2+}{}_{(aq)}$. This is a ligand exchange or substitution reaction.

The aluminium(III) hydroxide precipitate *does not* dissolve in excess ammonia. This is because aluminium hydroxide does not readily form stable ammine complexes in aqueous solution under these conditions.

7. Explain why some metal hydroxides dissolve in excess ammonia while others do not. Use specific examples in your answer.

Answer: The ability of a metal hydroxide to dissolve in excess ammonia depends on the stability of the ammine complex that can be formed. If the ammine complex is sufficiently stable, the equilibrium shifts towards its formation, causing the hydroxide precipitate to dissolve.

Example 1 (Dissolves): Copper(II) hydroxide dissolves because the tetraamminecopper(II) complex, $[Cu(NH_3)_4(H_2O)_2]^{2+}_{(aq)}$, is relatively stable.

Example 2 (Does not dissolve): Aluminium(III) hydroxide does not dissolve significantly because the ammine complexes of aluminium are not stable in aqueous solution under normal conditions. The hydroxide remains precipitated. Chromium(III) hydroxide is another example of a metal hydroxide that does not dissolve in excess ammonia.

8. Which of the following is the correct formula for the linear complex formed when excess ammonia is added to silver(I) nitrate solution?

A. $[Ag(NH_3)_2]^+$ B. $[Ag(NH_3)_4]^+$ C. $[Ag(NH_3)_2]^{2+}$ D. $[Ag(NH_3)_4]^{2+}$

Answer: A