



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

1. Which of the following statements is correct about a ligand?

- A. A ligand is a Lewis acid.
- B. A ligand donates a pair of electrons to a central transition metal ion.
- C. A ligand is always negatively charged.
- D. A ligand forms ionic bonds with the central metal ion.



2. What is the coordination number of the complex  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ ?

- A. 2
- B. 4
- C. 6
- D. 8

3. Which geometry is most common for six-coordinate transition metal complexes?

- A. Square planar
- B. Linear
- C. Octahedral
- D. Tetrahedral

4. In the complex  $\text{K}_4[\text{Fe}(\text{CN})_6]$ , the oxidation state of iron (Fe) is:

- A. +1
- B. +2
- C. +3
- D. +4

5. Which of the following complexes has a square planar geometry?

- A.  $[\text{Cu}(\text{NH}_3)_4]^{2+}$       B.  $[\text{Fe}(\text{CN})_6]^{3-}$       C.  $[\text{Ni}(\text{CO})_4]$       D.  $[\text{PtCl}_4]^{2-}$

Fill-in-the-Blanks to complete the sentences below:

6. Ligands are \_\_\_\_\_ bases, while central transition metal ions are Lewis \_\_\_\_\_.

7. The complex  $[\text{Ag}(\text{NH}_3)_2]^+$  has a \_\_\_\_\_ geometry, while  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  has a \_\_\_\_\_ geometry.

8. The ligand "aqua" refers to the molecule \_\_\_\_\_ when it acts as a ligand in a coordination compound.

9. Explain the difference between a complex and a coordination compound.

10. What factors determine the coordination number of a transition metal ion in a complex?

11. Why does  $[\text{FeF}_6]^{3-}$  have a coordination number of 6 while  $[\text{FeCl}_4]^-$  has a coordination number of 4?

12. Match the ligand to its name when acting in a complex:

Ligand
Water ( $H_2O$ )
Ammonia ( $NH_3$ )
Cyanide ion ( $CN^-$ )
Hydroxide ion ( $OH^-$ )
Chloride ion ( $Cl^-$ )

Name
Ammine
Chloro
Cyano
Aqua
Hydroxo

True or false?

13. In all coordination compounds, the bonding between the central metal ion and ligands is ionic.

14. Octahedral complexes are more common than square planar complexes for first-row transition metals.

15. The geometry of  $[Ni(CO)_4]$  is tetrahedral, and it is a neutral complex.

16. Determine the overall charge of the complex  $[Cr(H_2O)_4Cl_2]$  if the charge on the chromium ion is +3.

17. In the complex  $K_4[Fe(CN)_6]$ , calculate the charge on the  $[Fe(CN)_6]$  complex ion if the charge on Fe is +2.

18. Given the complex  $[Co(NH_3)_6]^{3+}$ , draw the structure and identify the type of bonds present.

## Answers

1. Which of the following statements is correct about a ligand?
- A. A ligand is a Lewis acid.
  - B. A ligand donates a pair of electrons to a central transition metal ion.
  - C. A ligand is always negatively charged.
  - D. A ligand forms ionic bonds with the central metal ion.

Answer: B

2. What is the coordination number of the complex  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ ?
- A. 2      B. 4      C. 6      D. 8

Answer: C

3. Which geometry is most common for six-coordinate transition metal complexes?
- A. Square planar      B. Linear      C. Octahedral      D. Tetrahedral

Answer: C

4. In the complex  $\text{K}_4[\text{Fe}(\text{CN})_6]$ , the oxidation state of iron (Fe) is:
- A. +1      B. +2      C. +3      D. +4

Answer: B

5. Which of the following complexes has a square planar geometry?
- A.  $[\text{Cu}(\text{NH}_3)_4]^{2+}$       B.  $[\text{Fe}(\text{CN})_6]^{3-}$       C.  $[\text{Ni}(\text{CO})_4]$       D.  $[\text{PtCl}_4]^{2-}$

Answer: D

Fill-in-the-Blanks to complete the sentences below:

6. Ligands are \_\_\_\_\_ bases, while central transition metal ions are Lewis \_\_\_\_\_.

Answer: Lewis, acids

7. The complex  $[\text{Ag}(\text{NH}_3)_2]^+$  has a \_\_\_\_\_ geometry, while  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  has a \_\_\_\_\_ geometry.

Answer: linear, square planar

8. The ligand "aqua" refers to the molecule \_\_\_\_\_ when it acts as a ligand in a coordination compound.

Answer: water ( $\text{H}_2\text{O}$ )

9. Explain the difference between a complex and a coordination compound.

Answer: A complex consists of a central transition metal ion surrounded by ligands bonded through coordinate covalent bonds. A coordination compound includes the complex along with any counter ions present to balance the overall charge.

10. What factors determine the coordination number of a transition metal ion in a complex?

Answer: The coordination number is determined by the size of the metal ion, the size of the ligands, the charge on the ligands, and electrostatic repulsion between ligands.

11. Why does  $[\text{FeF}_6]^{3-}$  have a coordination number of 6 while  $[\text{FeCl}_4]^-$  has a coordination number of 4?

Answer: Fluoride ions ( $\text{F}^-$ ) are smaller than chloride ions ( $\text{Cl}^-$ ), allowing six fluoride ions to fit around the  $\text{Fe}^{3+}$  ion, whereas only four larger chloride ions can fit due to steric hindrance.

12. Match the ligand to its name when acting in a complex:

Ligand	Name
Water ( $\text{H}_2\text{O}$ )	Ammine
Ammonia ( $\text{NH}_3$ )	Chloro
Cyanide ion ( $\text{CN}^-$ )	Cyano
Hydroxide ion ( $\text{OH}^-$ )	Aqua
Chloride ion ( $\text{Cl}^-$ )	Hydroxo

True or false?

13. In all coordination compounds, the bonding between the central metal ion and ligands is ionic.

Answer: False (The bonding is coordinate or dative covalent.)

14. Octahedral complexes are more common than square planar complexes for first-row transition metals.

Answer: True

15. The geometry of  $[\text{Ni}(\text{CO})_4]$  is tetrahedral, and it is a neutral complex.

Answer: True

16. Determine the overall charge of the complex  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]$  if the charge on the chromium ion is +3.

Answer: The two chloride ions each have a charge of -1, so the total charge of the complex is:

$$+3 (\text{Cr}^{3+}) - 2 (-1 \text{ from } 2 \text{ Cl}^-) = +1$$

17. In the complex  $\text{K}_4[\text{Fe}(\text{CN})_6]$ , calculate the charge on the  $[\text{Fe}(\text{CN})_6]$  complex ion if the charge on Fe is +2.

Answer: Each cyanide ion ( $\text{CN}^-$ ) has a charge of -1, so the total charge is:

$$+2 (\text{Fe}^{2+}) + 6(-1 \text{ from } \text{CN}^-) = -4$$

18. Given the complex  $[\text{Co}(\text{NH}_3)_6]^{3+}$ , draw the structure and identify the type of bonds present.

Answer: The structure consists of a cobalt ion surrounded by six ammonia ligands arranged octahedrally. The bonds between cobalt and ammonia are coordinate covalent bonds.

