1. Which of the following are allotropes of carbon?

1. diamond  2. graphite  3. silicon  4. fullerenes

   a) 1 and 2 only  b) 2 and 3 only  c) 3 and 4 only  d) 1, 2, and 3 only  e) 1, 2, and 4 only

2. Carbon monoxide is a hazardous pollutant because it:

   a) reacts with oxygen to form CO₂.
   b) catalyzes smog formation
   c) facilitates the formation of photochemical smog.
   d) forms a stable complex with hemoglobin.
   e) catalyzes the decomposition of ozone.

3. The oxidation state of nitrogen (given in parentheses) is correct in all the following species except:

   a) NF₃O (+3)  b) NO (+2)  c) N₂O₄ (+4)  d) NH₃ (-3)  e) HNO₃ (+5)

4. In which of the following substances does sulfur exist in the +4 oxidation state.

   a) H₂S  b) Na₂SO₃  c) NaHSO₄  d) Na₂S₄O₆  e) SO₃

5. An ion with a charge of -3 and the electron configuration of argon is:

   a) a gallium ion  b) a phosphide ion  c) a sulfide ion  d) a chloride ion  e) a calcium ion

6. Match the following items.

   ______a) Used as a photographic "fixer"
   1. (CH₃)₂SiCl₂  2. Na₂S₂O₃
   ______b) Used as a detergent additive
   3. SiO₂  4. Na₃P₃O₁₀
   ______c) Used in the manufacture of silicones (lubricants)
   5. NH₃  6. CS₂
   ______d) Used as a paper pulping bleach
   7. SO₂  8. CCl₄
   ______e) Used in the manufacture of rayon and cellophane
   11. NaClO₃  12. HCl

7. Give an example of an acidic oxide and a basic oxide.
8. Complete the following equations.
   a) \( \text{CO}_2 + \text{H}_2\text{O} \rightarrow \)
   b) \( \text{Ca}_3(\text{PO}_4)_2 + 3 \text{H}_2\text{SO}_4 \rightarrow \)
   c) \( \text{CaO} + \text{SO}_3 \rightarrow \)
   d) \( 3 \text{Mg} + \text{N}_2 \rightarrow \)

9. Draw the Lewis Structures of the following compounds and indicate their molecular shape.
   a) \( \text{ClF}_5 \)
   b) \( \text{XeF}_4 \)

10. Sodium thiosulfate, \( \text{Na}_2\text{S}_2\text{O}_3 \), is prepared from sodium sulfite and sulfur.
    \[
    8 \text{Na}_2\text{SO}_3(\text{aq}) + \text{S}(\text{s}) \rightarrow 8 \text{Na}_2\text{S}_2\text{O}_3(\text{aq})
    \]
    How many grams of \( \text{Na}_2\text{S}_2\text{O}_3 \) can be obtained from 25.0 grams of sulfur?

11. Silver metal reacts with nitric acid (\( \text{HNO}_3 \)) to give silver ion and nitric oxide (NO). Write the balanced redox equation for this reaction.

12. Ammonia reacts with oxygen in the presence of a platinum catalyst to give nitric oxide, NO, and water. How many grams of oxygen are required in this reaction to give 5.00 g NO?

13. What is the ground state electron configuration of \( \text{Co}^{2+} \)?
    a) [Ar]3d\(^6\)4s\(^2\)  b) [Ar]3d\(^5\)  c) [Ar]3d\(^7\)  d) [Ar]3d\(^6\)4s\(^1\)  e) [Ar]3d\(^5\)4s\(^2\)
14. What is the maximum oxidation state expected for chromium?
   a) +4       b) +5       c) +6       d) +7       e) +8

15. The bond between a metal cation and a ligand is best classified as a(n)
   a) ionic bond  
   b) nonpolar covalent bond  
   c) polar covalent bond  
   d) coordinate covalent bond  
   e) polydentate bond

16. Give the IUPAC names for the following complexes or ions.
   a) $[\text{AgCl}_4(\text{H}_2\text{O})_2]^-_3$ __________________________________________
   b) $[\text{Cu(NH}_3)_4]\text{SO}_4$ __________________________________________

17. Give formulas for each of the following.
   a) diaquadicyanocopper(II) ion ____________________________________________
   b) potassium hexachloroplatinate (IV) _______________________________________

18. Give the coordination number and oxidation state of the metal ion in each of the following complexes.
   a) $[\text{Ni(NH}_3)_6](\text{ClO}_3)_2$ _______ _______  b) $[\text{Cr(en)}_3]\text{Cl}_3$ _______ _______

19. Which of the following cations would exhibit paramagnetism to the greatest extent?
   a) $\text{V}^{+2}$  
   b) $\text{Cr}^{+2}$  
   c) $\text{Mn}^{+2}$  
   d) $\text{Co}^{+2}$  
   e) $\text{Cu}^{+2}$

20. Draw the cis and trans isomers of the square planar complex, $[\text{Pd(NH}_3)_2\text{Cl}_2]$.

21. The complex $[\text{Fe(H}_2\text{O})_6]\text{Cl}_2$ is paramagnetic. Therefore, which set of terms best describes the complex?
   a) high spin, octahedral  
   b) low spin, pyramidal  
   c) low spin, octahedral  
   d) high spin, tetrahedral  
   e) low spin, tetrahedral
22. Which **one** of the following compounds can exhibit optical activity (that is, have optical isomers)?

- a) \( \text{Na}_2[\text{CoCl}_4] \)
- b) \( \text{Cr(CO)}_6 \)
- c) \( \text{Co(NH}_3)_4\text{Cl}_2\text{Cl} \)
- d) \( \text{[Co(NH}_3)_6\text{]Cl}_3 \)
- e) \( \text{[Co(en)}_3\text{]}\text{Cl}_3 \)

23. Which of the following molecules can exhibit cis/trans isomerism (may be more than one answer)

- a) \( \text{Pt(NH}_3)_3\text{Br}_3^{+1} \)
- b) \( \text{Co(NO}_2)_4\text{(NH}_3)_2^{-1} \)
- c) \( \text{Ru(NH}_3)_4\text{Br}_2^{2+} \)
- d) \( \text{Co(NH}_3)_5\text{(NO}_2)_2^{+1} \)
- e) \( \text{Cr(NH}_3)_5\text{Cl}^{2-} \)

24. Illustrate using box diagrams, the low spin electron configuration in \( \text{[Fe(CO)}_6]^{+3} \). Indicate which orbitals are used by the ligands and the resulting hybridization.

25. The hexaaquascandium(III) ion, \( \text{Sc(H}_2\text{O)}_6^{+3} \), is colorless. Explain why this might be expected.
1. Which of the following are allotropes of carbon?

1. diamond 2. graphite 3. silicon 4. fullerenes

a) 1 and 2 only  b) 2 and 3 only  c) 3 and 4 only  d) 1,2, and 3 only  e) 1,2, and 4 only

2. Carbon monoxide is a hazardous pollutant because it:
   a) reacts with oxygen to form CO₂.
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   a) H₂S  b) Na₂SO₃  c) NaHSO₄  d) Na₂S₄O₆  e) SO₄

5. An ion with a charge of -3 and the electron configuration of argon is:

   a) a gallium ion  b) a phosphide ion  c) a sulfide ion  d) a chloride ion  e) a calcium ion

6. Match the following items.

   2 a) Used as a photographic "fixer"  1. (CH₃)₂SiCl₂
   4 b) Used as a detergent additive  2. Na₂S₂O₃
   1 c) Used in the manufacture of silicones (lubricants)  3. SiO₂
   11 d) Used as a paper pulping bleach  4. Na₅P₃O₁₀
   6 e) Used in the manufacture of rayon and cellophane  5. NH₃
   6  7. SO₂
   8. CCl₄
   9. NaClO
   10. N₂H₄
   11. NaClO₃
   12. HCl

7. Give an example of an acidic oxide and a basic oxide.

\[
\begin{array}{ll}
\text{Acidic Oxides} & \text{Basic Oxides} \\
\text{CO}_₂ & \text{Li}_₂ \text{O} \\
\text{SiO}_₂ & \text{CaO} \\
\text{P}_₂ \text{O}_₅ & \text{K}_₂ \text{O} \\
\text{Na}_₂ \text{O} & \text{Mg}_₂ \text{O}
\end{array}
\]
8. Complete the following equations.

a) \( \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{C}_2\text{O}_3 \)

b) \( \text{Ca}_3(\text{PO}_4)_2 + 3 \text{H}_2\text{SO}_4 \rightarrow 3 \text{CaSO}_4 + 2 \text{H}_3\text{PO}_4 \)

c) \( \text{CaO} + \text{SO}_3 \rightarrow \text{CaSO}_4 \)

d) \( 3 \text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2 \)

9. Draw the Lewis Structures of the following compounds and indicate their molecular shape.

a) \( \text{ClF}_5 \)

b) \( \text{XeF}_4 \)

10. Sodium thiosulfate, \( \text{Na}_2\text{S}_2\text{O}_3 \), is prepared from sodium sulfite and sulfur:

\[
8 \text{Na}_2\text{SO}_3(\text{aq}) + \text{S}(\text{s}) \rightarrow 8 \text{Na}_2\text{S}_2\text{O}_3(\text{aq})
\]

How many grams of \( \text{Na}_2\text{S}_2\text{O}_3 \) can be obtained from 25.0 grams of sulfur?

\[
\left( \frac{2 \text{S}_2\text{O}_3}{8 \text{S}_2\text{O}_3} \right) \left( \frac{1 \text{mol S}_2\text{O}_3}{2 \text{mol S}} \right) \left( \frac{1 \text{mol Na}_2\text{S}_2\text{O}_3}{1 \text{mol Na}_2\text{S}_2\text{O}_3} \right) \left( \frac{126.9 \text{g Na}_2\text{S}_2\text{O}_3}{1 \text{mol Na}_2\text{S}_2\text{O}_3} \right) = 123.9 \text{g Na}_2\text{S}_2\text{O}_3
\]

11. Silver metal reacts with nitric acid (HNO\(_3\)) to give silver ion and nitric oxide (NO). Write the balanced redox equation for this reaction.

\[
3 \text{H}(\dot{\text{E}}) + 3 \text{Ag}^{3+} + \text{HNO}_3 \rightarrow 3 \text{Ag}^{+} + \text{NO} + 2 \text{H}_2\text{O}
\]

12. Ammonia reacts with oxygen in the presence of a platinum catalyst to give nitric oxide, NO, and water.

How many grams of oxygen are required in this reaction to give 5.00 g NO?

\[
5 \text{Ag}^{3+} \left( \frac{3 \text{mol NO}}{4 \text{mol Ag}^{3+}} \right) \left( \frac{2 \text{mol O}_2}{3 \text{mol Ag}^{3+}} \right) = 6.67 \text{g O}_2
\]

13. What is the ground state electron configuration of Co\(^{2+}\)?

a) [Ar]3d\(^4\)4s\(^2\)  b) [Ar]3d\(^5\)  c) [Ar]3d\(^7\)  d) [Ar]3d\(^6\)4s\(^1\)  e) [Ar] 3d\(^5\)4s\(^2\)
14. What is the maximum oxidation state expected for chromium?
   a) +4          b) +5          c) [+]6          d) +7          e) +8

15. The bond between a metal cation and a ligand is best classified as a(n)
   a) ionic bond           d) coordinate covalent bond
   b) nonpolar covalent bond e) polydentate bond
   c) polar covalent bond

16. Give the IUPAC names for the following complexes or ions.
   a) $[\text{AgCl}_2(\text{H}_2\text{O})_2]^+$  Di AQUA TETRACHLOROARGENATE (I)
   b) $[\text{Cu(NH}_3)_4]\text{SO}_4$  TETRAAMMINE COPPER (II) SULFATE

17. Give formulas for each of the following.
   a) diaquadicyanocopper(II) $\text{[Cu(LCN)}_2(\text{H}_2\text{O})_2]\text{] NEUTRAL}$
   b) potassium hexachloroplatinate (IV) $\text{K}_2[\text{PtCl}_6]$  

18. Give the coordination number and oxidation state of the metal ion in each of the following complexes.
   a) $[\text{Ni(NH}_3)_6](\text{ClO}_4)_2$  $\omega$  +2
   b) $[\text{Cr(en)}_3]\text{Cl}_3$  $\omega$  +3

19. Which of the following cations would exhibit paramagnetism to the greatest extent?
   a) $\text{V}^{2+}$  b) $\text{Cr}^{2+}$  c) $\text{Mn}^{2+}$  d) $\text{Co}^{2+}$  e) $\text{Cu}^{2+}$

20. Draw the cis and trans isomers of of the square planar complex, $[\text{Pd(NH}_3)_2\text{Cl}_2]$.

21. The complex $[\text{Fe(H}_2\text{O})_6]\text{Cl}_2$ is paramagnetic. Therefore, which set of terms best describes the complex?
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   b) low spin, pyramidal
   c) low spin, octahedral
   d) high spin, tetrahedral
   e) low spin, tetrahedral

\[\begin{array}{ccc}
1 & 1 & 1 \\
1 & 1 & 1 \\
1 & 1 & 1
\end{array}\]
22. Which one of the following compounds can exhibit optical activity (that is, have optical isomers)?

a) Na₂[CoCl₄]  
d) [Co(NH₃)₆]Cl₂  
b) Cr(CO)₆  
(e) [Co(en)₃]Cl₃  
c) Co(NH₂)₆Cl₂Cl

23. Which of the following molecules can exhibit cis/trans isomerism (may be more than one answer)

a) Pt(NH₃)₄Br⁺  
d) Co(NH₃)₅(NO₂)⁺  
b) Co(NO₃)₄(NH₃)₂  
e) Cr(NH₃)₆Cl²⁻  
c) Ru(NH₃)₄Br₂⁻

24. Illustrate using box diagrams, the low spin electron configuration in [Fe(CO)₆]⁺³. Indicate which orbitals are used by the ligands and the resulting hybridization.

LOW SPIN IMPLIES STRONG FIELD, SO THE 5d ELECTRONS IN Fe⁺³ WILL OCCUPY THE FIRST 3 ORBITALS

\[
\text{Fe}^{+3} \text{ in } [\text{Fe(CO)}_6]^+^3 \quad \begin{array}{c}
3d \\
4s \\
4p \\
4d
\end{array}
\]

AVAILABLE FOR \( d^2s^2p^3 \) BONDS (USED BY LIGANDS)

25. The hexaquaascandium(III) ion, Sc(H₂O)₆⁺³, is colorless. Explain why this might be expected.

\[
\text{Sc}^{+3} \equiv [\text{Ar}] \quad \text{THIS ION HAS NO "d" ELECTRONS WHOSE TRANSITIONS ARE REQUIRED FOR ABSORPTION OF VISIBLE LIGHT.}
\]