Week 12 Transition metals

**QUESTION 1**

a. Write the electron configurations for the following atoms. You can use the inert gas core abbreviation.

Fe  Co  Ni  Ti

b. Write the electron configurations for the +2 ions for each of these atoms.

**QUESTION 2**

What is the electron configuration of the following transition metal ions? How many unpaired electrons are in each of these?

a. Zn$^{2+}$  b. Co$^{3+}$  c. Mo$^{3+}$  e. Cu$^{2+}$

**QUESTION 3**

What is the electron configuration of the following transition metal ions? How many unpaired electrons are in each of these?

a. Pd$^{2+}$  b. Au$^{3+}$  c. Ti$^{4+}$  d. Fe$^{3+}$

**QUESTION 4**

For the elements scandium through manganese, what is the highest oxidation state equal to?

A. the number of 3$d$ electrons
B. the principal quantum number of the period
C. the total number of 4$s$ and 3$d$ electrons
D. the total number of 4$s$, 3$p$, and 3$d$ electrons
E. none of the above

**QUESTION 5**

Find the coordination number of the metal, the charge of the complex, and the oxidation state of the transition metal ion for the following complexes.

a. Na[Co(NH$_3$)$_2$Br$_4$]
   b. [Fe(CN)$_6$]$^{3-}$
   c. K$_2$[Ni(F$_2$)$_4$]
   d. [Cu(NH$_3$)$_4$]Cl$_2$
   e. [Cr(OH)$_2$]

**QUESTION 6**

What is the coordination number of the metal, the charge of the complex ion, and the oxidation state of the transition metal for the following complexes?

a. Na[Co(EDTA)]
   b. K$_2$[Cd(C$_2$O$_4$)$_2$]
   c. Pt[en]Cl$_2$
   d. [Fe(porphine)]$^+$
   e. Na[Cr(CO$_3$)$_2$(NH$_3$)$_2$]

**QUESTION 7**

Which of the following statements is **false**?

A. When transition metals are oxidized, they lose $s$ electrons before losing $d$ electrons.
B. Many transition metals have more than one oxidation state.
C. Octahedral transition metal complexes can consist of a metal ion surrounded by three bidentate ligands.
D. Transition metal complexes are Lewis acid-base adducts.
E. A total of four ions are formed when [Co(NH$_3$)$_3$Br]Br$_2$ is dissolved in water.
QUESTION 8
Which of the following complexes has a central transition metal that has five electrons in a $d$ subshell?

A. V atom
B. $[\text{Fe(CN)}_6]^{3-}$
C. $[\text{Fe(CN)}_6]^{4-}$
D. MnO$_2$
E. $[\text{Fe(NH}_3)_6]^{3+}$

QUESTION 9
Which of the following species is LEAST likely to act as a ligand in a transition metal complex?

A. C$_2$O$_4^{2-}$
B. F$^-$
C. CH$_4$
D. NH$_3$
E. H$_2$O

QUESTION 10
Which one of the following aqueous solutions will have the same concentration of ions as a 0.1 M solution of MgCl$_2$?

A. 0.1 M $[\text{Fe(H}_2\text{O)}_6]\text{Cl}_3$
B. 0.1 M K$_3[\text{Co(CN)}_6]$
C. 0.1 M Na$_3[\text{CoBr}_6]$
D. 0.1 M Na$_4[\text{CoF}_6]$
E. 0.1 M $[\text{Ni(NH}_3)_4]\text{Br}_2$

QUESTION 11
Which of the following reactions will have a formation constant ($K_f$) with the largest value?

A. $[\text{Co(H}_2\text{O)}_6]^{2+}(\text{aq}) + 6 \text{L(aq)} \rightarrow [\text{Co(L)}_6]^{2+}(\text{aq}) + 6 \text{H}_2\text{O(ℓ)}$ where L = NH$_3$
B. $[\text{Co(H}_2\text{O)}_6]^{2+}(\text{aq}) + 6 \text{L(aq)} \rightarrow [\text{Co(L)}_6]^{2+}(\text{aq}) + 6 \text{H}_2\text{O(ℓ)}$ where L = $\text{H}_2\text{N–CH}_2\text{–CH}_3$
C. $[\text{Co(H}_2\text{O)}_6]^{2+}(\text{aq}) + 6 \text{L(aq)} \rightarrow [\text{Co(L)}_6]^{2+}(\text{aq}) + 6 \text{H}_2\text{O(ℓ)}$ where L = $\text{H}_2\text{O–CH}_2\text{–CH}_3$
D. Co($\text{H}_2\text{O)}_6]^{2+}(\text{aq}) + 3 \text{L(aq)} \rightarrow [\text{Co(L)}_3]^{2+}(\text{aq}) + 6 \text{H}_2\text{O(ℓ)}$ where L = $\text{H}_2\text{N–CH}_2\text{–CH}_2\text{–NH}_2$
E. Co($\text{H}_2\text{O)}_6]^{2+}(\text{aq}) + 2 \text{L(aq)} \rightarrow [\text{Co(L)}_2]^{2+}(\text{aq}) + 6 \text{H}_2\text{O(ℓ)}$ where L = $\text{H}_2\text{N–CH}_2\text{–CH}_2\text{–NH}_2$

QUESTION 12
Which statement is true about a substance with unpaired electrons?

A. It will be slightly attracted to a magnet.
B. It will be slightly repelled by a magnet.
C. It will be permanently magnetic.
D. It will be brightly colored.
E. It will be nonmetallic.

QUESTION 13
Which one of the following complex ions will be paramagnetic?

A. $[\text{Fe(H}_2\text{O)}_6]^{2+}\text{(low spin)}$
B. $[\text{Fe(H}_2\text{O)}_6]^{3+}\text{(low spin)}$
C. $[\text{Co(H}_2\text{O)}_6]^{3+}\text{(low spin)}$
D. $[\text{Zn(H}_2\text{O)}_4]^{2+}$
E. $[\text{Cu(H}_2\text{O)}_4]^+$
QUESTION 14

Which of the following transition metal complexes will be attracted to a magnetic field?

A. [Zn(H$_2$O)$_6$]$^{2+}$ (weak ligand field)
B. [Mn(H$_2$O)$_6$]$^{2+}$ (weak ligand field)
C. [TiCl$_4$] (weak ligand field)
D. [Ru(NH$_3$)$_6$]$^{2+}$ (strong ligand field)
E. [Ag(NH$_3$)$_4$]$^{2+}$ (strong ligand field)

QUESTION 15

Which one of the following compounds would interact with a magnetic field?

A. [Zn(NH$_3$)$_4$]Cl$_2$
B. CaSO$_4$
C. [Cu(H$_2$O)$_4$]Br
D. [Co(en)$_3$]Cl$_3$ (low spin)
E. K[FeCl$_4$]

QUESTION 16

a. A transition metal ion complex absorbs blue light of 450 nm. What color is the solution of this complex?
b. A transition metal ion complex absorbs yellow light of 565 nm. What color is the solution of this complex?
c. A transition metal ion complex absorbs red light of 670 nm. What color is the solution of this complex?

QUESTION 17

Which one of the following compounds is likely to be colorless?

A. [Zn(OH$_2$)$_6$]$^{2+}$
B. [Cu(OH$_2$)$_6$]$^{2+}$
C. [Fe(OH$_2$)$_6$]$^{2+}$
D. [Cr(OH$_2$)$_6$]$^{2+}$
E. [Ni(OH$_2$)$_6$]$^{2+}$

QUESTION 18

The absorption of three solutions of transition metal ion complexes is measured. The results are given below. Which solution has the largest crystal field splitting? Which one has the smallest?

I. absorption = 720 nm
II. absorption = 500 nm
III. absorption = 615 nm

QUESTION 19

The colors of three aqueous solutions of transition metal complexes are given below. Which solution is expected to have the largest crystal field splitting? Which one has the smallest?

I. blue
II. green
III. yellow

QUESTION 20

a. If an octahedral transition metal complex with a d$^2$ electron configuration absorbs light of wavelength equal to 650 nm, what is the magnitude of the crystal field splitting parameter, $\Delta$?
b. What is the energy on kJ/mol?
QUESTION 21

The crystal field splitting energy for a complex is 160 kJ/mol. What wavelength of light does this complex absorb?

A. 750 nm (red light)
B. 550 nm (green light)
C. 124 nm (ultraviolet light)
D. 400 nm (blue light)
E. 600 nm (orange light)

QUESTION 22

For the octahedral complexes below determine the following: How many $d$ electrons are associated with the central metal ion? Draw the energy level diagram of the crystal field and determine the number of unpaired electrons in each complex.

a. $\text{[FeCl}_6^{3-}$ (high spin)
b. $\text{[Fe(NO}_2)_6^{3-}$ (low spin)
c. $\text{Mo(NH}_3)_6^{2+}$ (high spin)

QUESTION 23

$\text{Cr(OH}_2)_6^{3+}$ is violet, while another monodentate ligand, L, produces a green $\text{CrL}_6^{3+}$ complex. Which of the following statements is incorrect?

A. The octahedral crystal field splitting $D_0$ is smaller for $\text{CrL}_6^{3+}$ than it is for $\text{Cr(OH}_2)_6^{3+}$. 
B. $\text{Cr(OH}_2)_6^{3+}$ absorbs violet light.
C. $\text{Cr(OH}_2)_6^{3+}$ has three unpaired electrons.
D. $\text{CrL}_6^{3+}$ has three unpaired electrons.
E. The position of $\text{H}_2\text{O}$ in the spectrochemical series is higher (stronger field) than the position of L (weaker field).