CHEMISTRY 16
EXAM IV

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(Version I)

An optical scoring machine will grade this examination. The machine is not programmed to accept the correct one of two sensed answers and will not sense answers which are lightly marked. Mark your answer sheet carefully with a No. 2 soft lead pencil and erase any undesired marks COMPLETELY. Avoid making any extraneous marks on the answer sheet other than the information requested below.

On the answer sheet:

1. Print your name in the space for NAME (last name first, circle your last name).

2. In the space marked SUBJECT print your student number.

3. In the space marked HOUR print Summer II `98.

Check to see that you have 20 examination questions, periodic table and scratch paper when the exam begins.

HAND IN ONLY THE ANSWER SHEET.

Useful Equations and Constants:

$K_w = 1.0 \times 10^{-14}$ at 25°C

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CHOOSE THE ONE BEST ANSWER

1. A solution is saturated with $AlPO_4$. Addition of which of the following will cause a decrease in the solubility of $AlPO_4$?
   HNO_3 $AlCl_3$ Na_3PO_4 NaCl

   A. All will cause an increase.
   B. HNO_3
   C. Na_3PO_4 and NaCl
   D. HNO_3, $AlCl_3$, and Na_3PO_4
   E. $AlCl_3$ and Na_3PO_4

2. The pH of a saturated solution of $Mn(OH)_2$ is:
   $K_{sp}(Mn(OH)_2)=1.9\times10^{-13}$

   A. 9.86
   B. 7.61
   C. Not enough information need concentration of $Mn(OH)_2$.
   D. 13.32
   E. 4.44

3. The molar solubility of BiI_3 in 0.067M KI is:
   $K_{sp}(BiI_3)=8.0\times10^{-19}$

   A. 6.7×10^{-2} M
   B. 2.7×10^{-15} M
   C. 5.4×10^{-20} M
   D. 1.2×10^{-17} M
   E. 3.1×10^{-7} M

4. Lanthanum iodate $La(IO_3)_3$ has $K_{sp}=6.2\times10^{-12}$. When the following solutions are mixed, which will **NOT** cause precipitation of $La(IO_3)_3$?

   A. 100. mL of 0.125 M $La(NO_3)_3$ with 100. mL of 0.050 M $NaIO_3$
   B. 50. mL of 0.125 M $La(NO_3)_3$ with 50. mL of 0.050 M $NaIO_3$
   C. 10. mL of 0.0050 M $La(NO_3)_3$ with 10. mL of 0.0050 M $NaIO_3$
   D. 50. mL of 0.00050 M $La(NO_3)_3$ with 50. mL of 0.0050 M $NaIO_3$
   E. All will cause precipitation of $La(IO_3)_3$.

5. A solution is 0.050 M in each of the cations Ag^+ and Mg^{+2}. Solid Na_2CO_3 is added to the solution to precipitate the ions as carbonates and to separate Ag^+ from Mg^{+2}. What concentration of CO_3^{-2} should be maintained to precipitate as much of the Ag^+ as possible without precipitating the Mg^{+2}?
($K_{sp}(MgCO_3)=1\times10^{-5}$; $K_{sp}(Ag_2CO_3)=8.1\times10^{-12}$)

A. 3×10^{-9} M
B. 1×10^{-8} M
C. 2×10^{-4} M
D. 3×10^{-3} M
E. 1×10^{-10} M

6. Which of the following reagents can be used to distinguish between Hg_2^{+2} and Hg^{+2}? (HINT: Use solubility rules)

A. Addition of H_2S/in 0.3 M HCl
B. Addition of $(NH_4)_2CO_3$/in NH_3/NH_4Cl
C. Addition of HCl
D. Addition of H_2S/in NH_3/NH_4Cl
E. Addition of HNO_3

7. A solution is originally 4.2×10^{-5} M in each of the metal ions Co^{+2}, Fe^{+2} and Ag^+. Solid Na_2S is added such that the S^{-2} concentration becomes 1.4×10^{-19}M. Which of the metal ions will precipitate as the metal sulfide?
$K_{sp}(CoS)=4.0\times10^{-21}$
$K_{zp}(FeS)=6.0\times10^{-18}$
$K_{sp}(Ag_2S)=6\times10^{-50}$

A. Ag^+
B. Co^{+2} and Fe^{+2}
C. Co^{+2} and Ag^+
D. Fe^{+2}
E. Co^{+2}, Fe^{+2} and Ag^+

8. In the metal complex salt $K_4[Ru(CN)_4(SCN)_2]$, the oxidation state (charge) on the ruthenium is _____ while the coordination number is _____.

A. -4; ten
B. +4; six
C. +2; six
D. +3; four
E. None of the above are correct.

9. For the metal complex ion given in question #8, what type(s) of isomerism is(are) possible?

A. linkage and ionization
B. ionization and geometric
C. geometric
D. linkage and geometric
E. linkage

10. Optical isomers (enantiomers) are possible for which of the following metal complex ions?

A. fac-$[Pt(NH_3)_3Br_3]^+$
B. mer-$[Pt(NH_3)_3Br_3]^+$
C. $[Pt(NH_3)_5Br]^{+3}$
D. cis-$[Pt(en)_2BrCl]^{+2}$
E. trans-$[Pt(en)_2BrCl]^{+2}$

11. Use crystal field theory to decide which of the complexes below will have five unpaired electrons.

A. $[Fe(CN)_6]^{-3}$
B. $[FeI_6]^{-3}$
C. $[Mn(H_2O)_6]^{+2}$
D. $[CoF_6]^{-4}$
E. Both B and C.

12. The metal complex $[Ni(NH_3)_2Br_2]$ is diamagnetic while the metal complex $[TiF_6]^{-3}$ is paramagnetic with one unpaired electron. Valence bond theory predicts that the Ni will use _____ hybrid orbitals during bonding while the Ti will use _____ hybrid orbitals.

A. sp^3; sp^3d^2
B. sp; d^2sp^3
C. dsp^2; sp^3d^2
D. dsp^2; d^2sp^3
E. d^2sp^3; sp^3

13. An octahedral "d^6" metal complex with weak field ligands will have _____unpaired electrons while an octahedral "d^7" metal complex with strong field ligands will have _____ unpaired electrons.

A. four; one
B. zero; three
C. six; seven
D. zero; one
E. four; three

14. In an octahedral complex the metal _____ orbital(s) is(are) raised in energy to a greater extent than the other d orbitals because _____.

A. d_{xy}, d_{xz} and d_{yz}; the negatively charged ligands point in between the lobes.
B. d_{x2-y2} and d_{z2}; the negatively charged ligands point directly at their lobes.
C. d_{z2}; it has a different shape and energy than the rest.
D. d_{x2-y2} and d_{z2}; they are filled with electrons while the other d-orbitals are empty.
E. None of the above are true. All of the metal d-orbitals have the same energy.

15. An aqueous solution of an ionic compound was colored. Which of the following salts could **NOT** be the ionic compound?
(HINT: Consider the electronic configuration of the metal cation.)

A. $Mg(NO_3)_2$
B. $Zn(ClO_4)_2$
C. $ScCl_3$
D. $Cr(C_2H_3O_2)_2$
E. Answers A, B, and C.

16. Cadium cations Cd^{+2} form a soluble metal complex ion $[Cd(NH_3)_4]^{+2}$ upon the addition of ammonia. The molar solubility of CdS in 2.0 M NH_3 is:
$K_{sp}(CdS)=3.6\times10^{-29}$; $K_f[Cd(NH_3)_4]^{+2}=4.0\times10^{6}$

A. 6.0×10^{-15} M
B. 0.50 M
C. 2.5×10^{-12} M
D. 1.4×10^{-20} M
E. 4.8×10^{-11} M

17. Chromium (III) cations are amphoteric but do not form ammonia complexes. Which of the following statements is TRUE?

A. Solid $Cr(OH)_3$ will dissolve in an excess of ammonia.
B. Solid $Cr(OH)_3$ will not dissolve in an excess of sodium hydroxide.
C. $Cr(OH)_3$ will not dissolve in acidic solutions (pH<4).
D. Solid $Cr(OH)_3$ will not form on addition of a limited amount of ammonia to $Cr^{+3}(aq)$.
E. Solid $Cr(OH)_3$ will dissolve in an excess of sodium hydroxide.

18. The **equilibrium concentration** of Ag^+ is 3.3×10^{-8} M in a 0.15 M solution of the metal complex $[Ag(CN)_2]^-$. The numerical value of K_f for $[Ag(CN)_2]^-$ is:

A. 2.7×10^{17}
B. 1.0×10^{21}
C. 4.2×10^{19}
D. 3.0×10^{-9}
E. 1.4×10^{14}

19. Which of the following statements pertaining to spontaneity is **TRUE**?

A. All endothermic reactions are spontaneous.
B. A decrease in entropy on going from reactants to products favors a spontaneous reaction.
C. All exothermic reactions are spontaneous.
D. A reaction spontaneously moves toward equilibrium.
E. All reactions accompanied by an increase in entropy are spontaneous.

20. Which of the following processes is accompanied by a **decrease** in entropy?

A. $CuCl(s) \rightarrow Cu^+(aq) + Cl^-(aq)$
B. $2\ H_3PO_4(s) \rightarrow P_2O_5(s) + 3\ H_2O(g)$
C. $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$
D. $3\ S(s) + 2\ H_2O(g) \rightarrow 2\ H_2S(g) + SO_2(g)$
E. Both A and C.