Chemistry 1066 Exam IV

1. (3 points) Which of the following is the correct expression for the solubility product constant of the nearly insoluble salt $CaCO_3$?

   a) $K_{sp} = [Ca^{2+}] / [CO_3^{2-}]^2$ b) $K_{sp} = [Ca^{2+}][C^{4-}][O^{2-}]^3$

   c) **$K_{sp} = [Ca^{2+}][CO_3^{2-}]$** d) $K_{sp} = [Ca^{2+}][CO_3^{2-}] / [CaCO_3]$

2. (3 points) Calculate the molar solubility of $Ca(OH)_2$. $K_{sp} = 7.9 \times 10^{-6}$

   a) **0.013 M** b) 6.2×10^{-11} M c) 0.020 M d) 0.044 M

3. (3 points) We prepare a solution with the following ion concentrations:

   $[Pb^{2+}] = 1.0 \times 10^{-4}$ M and $[Cl^-] = 0.10$ M

   If K_{sp} for $PbCl_2$ is 1.7×10^{-5}, determine which of the following is true

   a) a precipitate forms b) **a precipitate does not form**

   c) the system is at equilibrium

   d) not enough information is given to decide the answer

4. (4 points) We have 500. mL of a solution with $[Ba^{2+}] = 0.10$ M. How many grams of LiF (25.94 g mol^{-1}) must be added to begin precipitation of BaF_2? (K_{sp} of BaF_2 is 1.7×10^{-6}).

   a) 0.11 g b) **0.053 g** c) 1.3 g d) 3.4×10^{-4} g

5. (3 points) Which one of the following substances, when added to a saturated solution of $CaCO_3$, will decrease the solubility of $CaCO_3$ in the solution?

   a) NaCl b) HCl c) **$CaCl_2$** d) HNO_3

6. (4 points) Calculate $[Ni^{2+}]$ in a solution that was originally 0.10 M Ni^{2+} and 2.0 M NH_3. (K_f for $[Ni(NH_3)_4]^{2+} = 5.6 \times 10^8$

   a) **2.7×10^{-11} M** b) 0.10 M c) 1.60 M

   d) 8.7×10^{-6} M

7. (3 points) We make up 0.10 M solutions of $[Cd(CN)_4]^{2-}$, $[Ni(CN)_4]^{4-}$, $[Ag(CN)_2]^{-}$, and $[Fe(CN)_6]^{2-}$. Which of the following metal ions is highest in concentration?

K_f for $[Cd(CN)_4]^{2-} = 1.3 \times 10^{17}$ K_f for $[Ni(CN)_4]^{2-} = 1.0 \times 10^{31}$

K_f for $[Ag(CN)_2]^{-} = 5.6 \times 10^{18}$ K_f for $[Fe(CN)_6]^{2-} = 7.7 \times 10^{36}$

a) **Cd^{2+}** b) Ni^{2+} c) Ag^{+} d) Fe^{2+}

8. (3 points) The branch of chemistry that specifically examines the transformations between chemical and electrical potential is _____.

a. organic chemistry b. **electrochemistry**

c. qualitative analysis d. biochemistry

9. (2 points) The _____ in an electrochemical cell will be the site of a reaction in which one of the reactants gains electrons.

a. **cathode** b. electrode c. geode d. anode

10. (3 points) In a voltaic cell the electrons in the external circuit will flow from the _____ to the _____.

a. cathode, anode b. electrode, volt meter

c. geode, electrode d. **anode, cathode**

11. (3 points) In the following reaction, which species is the oxidizing agent?

$$I_2(aq) + 2\ S_2O_3^{2-}(aq) \text{ ---> } 2\ I^{-}(aq) + S_4O_6^{2-}(aq)$$

a. I_2 b. $S_2O_3^{2-}$ c. I^{-} d. $S_4O_6^{2-}$

12. (3 points) The cell potential (E_{cell}) which is the voltage between the electrodes of a voltaic cell is also known as the _____.

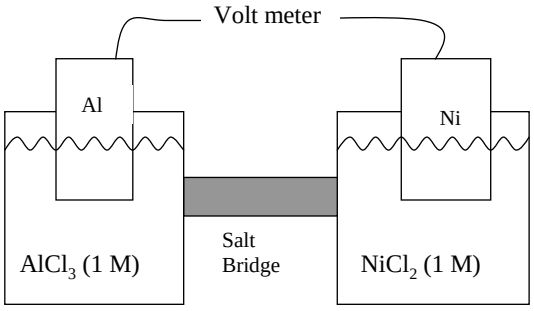
a. galvanic force b. **electromotive force**

c. cell force d. jedi force

13. (3 points) If 2.78E15 moles of electrons flow through a circuit, how much charge in coulombs is transferred?

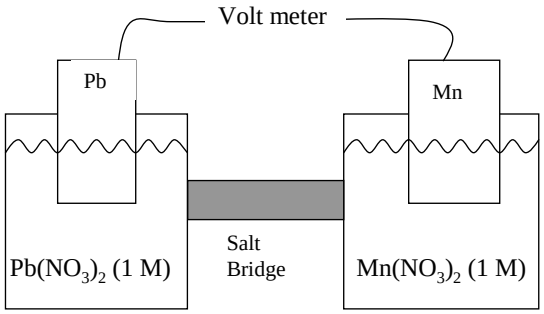
a. 2.68E20 b. 3.73E-21 c. 4.61E-9 d. 2.16E8

14. (4 points) What is the expected E°_{cell} for the following Al-Ni cell based on standard cell potentials. (see table in appendix)



a. -1.662 b. -0.257 **c. +1.405** d. -1.148

15. (4 points) Calculate the expected ΔG° for the Pb-Mn cell in the following diagram, based on standard cell potentials. (see table in appendix)



a. 1.059 V b. -204.4 kJ c. 4.89E-2 kJ d. 1.02E5 J

16. (4 points) Calculate the E_{cell} value at 298 K for the cell based on the following reaction when $[Fe^{3+}] = [Cr^{2+}] = 1.05 \times 10^{-3}$ *M* and $[Fe^{2+}] = [Cr^{3+}] = 8.17 \times 10^{-4}$ *M* at 298 K.

$$Fe^{3+}(aq) + Cr^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cr^{3+}(aq)$$

a. **1.20 V** b. 1.29 V c. 1.39 V d. 1.00 V

17. (4 points) How long does it take to deposit a 3.33 μm thick coating of gold on a circular surface that is 4.0 cm in diameter at a constant current of 25 A? The density of gold is 19.3 g/cm.

$$Au^{3+}(aq) + 3\ e^- \rightarrow Au(s)$$

a. 2.5 s b. 2.2 s c. 13.0 s **d. 4.7 s**

18. (2 points) Standard half-reaction potentials are typically referenced to the _____.

a. Cu^{2+} reduction b. platinum reduction

c. **H^+ reduction** d. Ag^+ reduction

19. (2 points) The cell potential of a voltaic cell will decrease when _____.

a. **the concentration of reacting species become depleted**

b. the rate constant for the forward reaction is no longer constant

c. the ΔG for the reaction changes from positive to negative

d. the value of the Faraday constant begins to decline

20. (3 points) A 45 amp current applied to a circuit for 3.5 min will transfer _____ electrons.

a. 9.8E-2 mol b. 10.2 mol c. 1.6E-3 mol d. 6.1E2 mol

21. (4 pts) A solid containing tetrahedral $CuCl_4^{2-}$ ions strongly absorbs red light (λ = 800 nm), whereas the corresponding $CoCl_4^{2-}$ compound absorbs orange light (λ = 680 nm). Calculate the energy (Joule) of the compound with the larger Δ_0.

a) 2.48 E-19 J b) 2.92 E-19 J c) 5.50 E-18 J d) 1.57 E -18 J

22. (4 pts) Rubies and sapphires are both corundum (Al_2O_3) minerals. Rubies (red) have Cr substituted for Al and Sapphires (blue) have Fe or Ti substituted for Al in the octahedral holes. Which of the following statements is true regarding the Δ_o of these two minerals based on their visible colors?

a) Rubies have the largest Δ_o, since the transmitted light has the shortest wavelength

b) Sapphires have the largest Δ_o, since the transmitted light has the smallest frequency

c) **Rubies have the largest Δ_o, since the transmitted light has the longest wavelength**

d) Sapphires have the largest Δ_o, since the transmitted light has the longest wavelength

23. (3 pts) Zn^{2+} ions in crystal fields usually produce colorless minerals. Why might this be true?

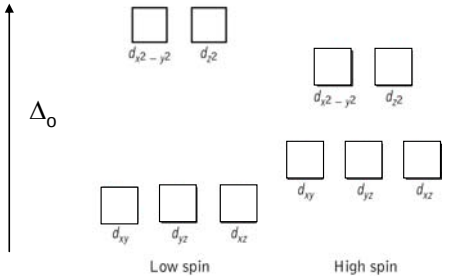
a) Zn^{2+} has no electrons in d-orbitals

b) Zinc is not a transition element

c) Zn^{2+} is isoelectronic with Ar

d) **Zn^{2+} has a complete set of d-electrons**

24. (3 pts) How many unpaired electrons will there be in high-spin Co^{2+}?



a) 1 b) 2 **c) 3** d) 4 e) 5

25. (3 pts) The bonding in solid-state metals can be described as

a) non-existent.
b) a covalent network.
c) **sea of valence electrons.**
d) highly directional.

26. (3 pts) The quantity of heat that is needed to raise the temperature of a sample of a substance 1.00 Kelvin is called its

a) **heat capacity** b) specific heat capacity c) enthalpy
d) calorimetry e) kinetic energy

27. (5 points, Extra credit)
What is the minimum cathode potential versus the SHE necessary to plate silver:

$$Ag^{+}(aq) + 1\ e^{-} \rightarrow Ag(s)$$

from a solution containing both Ag^{+} and NH_3 in which, because most of the silver ions are complexed as $Ag(NH_3)_2^{+}$, the concentration of free silver is 1.10E-5 mol L^{-1}?

a. 0.7996 **b. 0.506** c. 0.536 d. 0.822

Miscellaneous Information:

1 Faraday (F) = 9.6485E4 coulombs (C)/(mol·e^{-}) $C = n \cdot F$ $\Delta G = -n \cdot F \cdot (E_{cell})$

1 C·V = 1 J 1 amp (A) = 1 C/sec

$E_{cell} = E°_{cell} - (R \cdot T/n \cdot F) \cdot (\ln Q)$ or at 298 K $E_{cell} = E°_{cell} - (0.0592/n) \cdot (\log_{10} Q)$

$pH = -\log_{10} [H_3O^{+}]$

pK_w (298 K) = 14.00 $N_A = 6.0221E23\ mol^{-1}$

$pK_w = pH + pOH$ $pK_w = pK_a + pK_b$

$pH = pKa + \log_{10} ([base]/[acid])$ $x_{\pm} = (-b \pm (b^2 - 4ac)^{1/2})/2a$

$\Delta G° = \Delta H° - T \cdot \Delta S°$ R(gas constant) = 8.314 J/(mol·K) = 0.0821 L·atm/(mol·K)