Final Exam · Chemistry 01200
Winter 2006

Part 1: Multiple-choice questions (2 points each)

1. For the reaction, $2\ SO_2(g) + O_2(g) \equiv 2\ SO_3(g)$, at 450.0 K the equilibrium constant, K_c, has a value of 4.62. A system was charged to give these initial concentrations, $[SO_3]$ = 0.254 M $[O_2]$ = 0.00855 M, $[SO_2]$ = 0.500 M. In which direction will it go?
   a . to the left
   b. to the right or the left depending on the pressure
   c. it will remain at the same concentrations
   d to the right
   e. to the right or the left depending on the volume

2. Which one of the following reactions is accompanied by an ***increase*** in entropy?

   a. $ZnS(s) + 3/2\ O_2(g) \rightarrow ZnO(s) + SO_2(g)$
   b. $BaO(s) + CO_2(g) \rightarrow BaCO_3(s)$
   c. $Na_2CO_3(s) + CO_2(g) + H_2O(g) \rightarrow 2\ NaHCO_3(s)$
   d. $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
   e. $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$

3. In a particular study of the reaction described by the equation,

$$2\ CH_4O(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g),$$

the rate of consumption of $O_2(g)$ is 0.400 mol L^{-1} s^{-1}. What is the rate of formation of $H_2O(g)$ in the study?

   a. 0.300 mol L^{-1} s^{-1}
   b. 0.400 mol L^{-1} s^{-1}
   c. 0.800 mol L^{-1} s^{-1}
   d. 0.533 mol L^{-1} s^{-1}
   e. 1.33 mol L^{-1} s^{-1}

4. In the reaction, $HClO_3 + N_2H_4 \equiv ClO_3^- + N_2H_5^+$, which one of the sets below lists both of the ***base*** species involved in the equilibrium?

   a. ClO_3^-, N_2H_4
   b. $HClO_3$, N_2H_4
   c. $HClO_3$, ClO_3^-
   d. $HClO_3$, $N_2H_5^+$
   e. N_2H_4, $N_2H_5^+$

5. Given the following: 0.20 M $NaOH(aq)$ 0.20 M $HCl(aq)$
A mixture is made using 50.0 ml of the NaOH and 25.0 ml of the HCl. What is its pH at 25.0 ^{o}C?

a. 13.00
b. 12.52
c. 12.82
d. 7.00
e. 13.30

6. Will a precipitate of MgF_2 form when 300 mL of 1.1 x 10^{-3} M $MgCl_2$ solution is added to 500 mL of 1.2 x 10^{-3} M NaF? The K_{sp} of MgF_2 is 6.6 x 10^{-9}.

a. yes, because the ion product, $Q_{sp} > K_{sp}$
b. no, because the ion product, $Q_{sp} = K_{sp}$
c. yes, because the ion product, $Q_{sp} < K_{sp}$
d. no, because the ion product, $Q_{sp} > K_{sp}$
e. no, because the ion product, $Q_{sp} < K_{sp}$

7. A galvanic cell consists of an $Ag(s)/Ag^{+}(aq)$ half cell and a $Cu(s)/Cu^{2+}(aq)$ half cell connected by a salt bridge. Reduction occurs in the silver half cell. The cell can be represented **in cell notation** as

a. $Cu(s)/Cu^{2+}(aq)// Ag^{+}(aq)/Ag(s)$
b. $Ag(s)/Ag^{+}(aq)/Cu(s)/Cu^{2+}(aq)$
c. $Cu(s)/Cu^{2+}(aq)//Ag(s)/Ag^{+}(aq)$
d. $Ag^{+}(aq)/Ag(s)//Cu(s)/Cu^{2+}(aq)$
e. $Cu^{2+}(aq)/Cu(s)//Ag(s)/Ag^{+}(aq)$

8. A compound contains a transition metal coordination complex. This coordination complex consists of one iron(III) ion with three $C_2O_4^{2-}$ ions attached as ligands. Which formula below correctly describes a compound that would fit the description?

a. $Fe(C_2O_4)_3$
b. $[Fe(C_2O_4)_3]Cl_3$
c. $Fe(C_2O_4)_3](SO_4)_3$
d. $Ca_3[Fe(C_2O_4)_3]$
e. $K_3[Fe(C_2O_4)_3]$

9. Identify the missing species in the nuclear equation given

$^{211}_{82}Pb \rightarrow ???? + ^{0}_{-1}e$

a. $^{211}_{83}Bi$
b. $^{211}_{81}Tl$
c. $^{212}_{82}Pb$
d. $^{210}_{82}Pb$
e. $^{210}_{83}Bi$

10 The equilibrium constant, K_c, for the system, $CaO(s) + CO_2(g) \equiv CaCO_3(s)$, is

a. $K_c = [CO_2]$
b. $K_c = [CaCO_3]/([CaO] \times [CO_2])$
c. $K_c = 1/[CO_2]$
d. $K_c = [CaCO_3]/[CaO]$
e. $K_c = ([CaO] \times [CO_2])/[CaCO_3]$

Part 2: Workout problems. Show your reasoning to receive credit (10 points each).

11. If a radioactive sample of a newly discovered element, coronium, decays to the point where the activity is 40.0 percent of its original activity in 44.0 years, what is the half-life of the nuclide?

12. For the reaction, $3\ B + C \rightarrow E + 2\ F$, some initial rate measurements were carried out and data for three runs are shown below

run #	[B]	[C]	rate, mol L^{-1} s^{-1}
1	0.100	0.250	0.000250
2	0.200	0.250	0.000500
3	0.100	0.500	0.00100

Write the rate law for the reaction and calculate the rate constant.

13. At 60 ^{o}C the value of K_w is 9.5×10^{-14}. Considering this, what is the calculated value for the pH of a solution made by dissolving 1.00 g of sodium hydroxide in enough water to make 500 ml of solution at this temperature?

14. A buffer contains benzoic acid, a monoprotic acid $HC_7H_5O_2$ ($K_a = 6.28 \times 10^{-5}$, 0.250 M), and sodium benzoate $NaC_7H_5O_2$ (0.400 moles/liter). 25 mL of a 0.5 M HCl(*aq*) solution was added to 500 ml of this buffer solution. Calculate the original pH for the buffer solution, and calculate the new pH after HCl was added to it

15. Using the data:

$$C_2H_4(g),\ \Delta H_f^o = +51.9\ \text{kJ mol}^{-1},\ S^o = 219.8\ \text{J mol}^{-1}\ \text{K}^{-1}$$
$$CO_2(g),\ \Delta H_f^o = -394.0\ \text{kJ mol}^{-1},\ S^o = 213.6\ \text{J mol}^{-1}\ \text{K}^{-1}$$
$$H_2O(l),\ \Delta H_f^o = -286.0\ \text{kJ mol}^{-1},\ S^o = 69.96\ \text{J mol}^{-1}\ \text{K}^{-1}$$
$$O_2(g),\ \Delta H_f^o = 0.00\ \text{kJ mol}^{-1},\ S^o = 205\ \text{J mol}^{-1}\ \text{K}^{-1}$$

Calculate the maximum amount of useful work that can be obtained, at 25.0 ^{o}C, from the process:

$$C_2H_4(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 2\ H_2O(l)$$

16. The solubility of scandium(III) fluoride, ScF_3, in pure water is 2.0 x 10^{-5} moles per liter. Calculate the value of K_{sp} for scandium(III) fluoride from this data.

17. The K_{sp} of calcium fluoride CaF_2 (Molar mass 78.0 g) is 3.9 x 10^{-11}. A 0.420 g sample of NaF (Molar mass 42.0 g) and a 1.110 g sample of calcium chloride $CaCl_2$ (Molar mass 111. 0 g) were added to a 1.000 liter volumetric flask, and distilled water was added to the mark. After placing the stopper and shaking the flask to dissolve as much chemicals as would dissolve, how many grams of precipitate, if any, would be formed?

18. A galvanic cell is composed of these two half cells, with the standard reduction potentials shown

$Co^{2+}(aq) + 2e^- \equiv Co(s)$ -0.28 volt

$Cd^{2+}(aq) + 2e^- \equiv Cd(s)$ -0.40 volt

The actual concentrations are: $Co^{2+}(aq)$ = 0.00100 M, Cd^{2+} = 0.100 M. What is the free energy change associated with this particular design?

R=8.31 J/Kmol **$T_K = T_{°C} + 273.15$**
$\Delta G° = \Delta H° - T\Delta S°$ $\Delta G° = -RT\ln K$ $\Delta G = \Delta G° + RT\ln(Q)$
$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$ $\Delta S° = \Sigma n_p \Delta S°_{products} - \Sigma n_r \Delta S°_{reactants}$
$\Delta G° = \Sigma n_p \Delta G°_{products} - \Sigma n_r \Delta G°_{reactants}$ $\Delta H° = \Sigma n_p \Delta H°_{products} - \Sigma n_r \Delta H°_{reactants}$
pH + pOH = 14.00 pH = –log [H^+] pOH = –log [OH^-]

Henderson–Hasselbach: $\mathbf{pH = p_{Ka} + \log\frac{[A^-]}{[HA]}}$

R = 8.31 J/Kmol $T_K = T_{°C} + 273$ $K_aK_b = 10^{-14}$ $[H^+][OH^-]=K_w$
$\Delta G° = -nFE°$ **F = 96,485 Coulombs/mole**
N_A = 6.02214 x 10^{23}/mole h = 6.626 x 10^{-34} J·s c = 3.0 x 10^8 m/s e = –1.602 x 10^{-19} coulomb

$$\mathbf{E = E° - \frac{RT}{nF}\ln(Q) \qquad E = E° - \frac{0.0591}{n}\log(Q) \qquad E = \frac{-work}{charge} = \frac{-w}{q}}$$

current: I = charge/time = q/t 1.0 A = 1.0 coul/sec
Kinetics:
0th order: $[A] = -kt + [A]_0$ 1st order: $\ln[A] = -kt + \ln[A]_0$
Radioactivity: $\ln(N/N_0) = -kt$ $k = 0.693/t_{1/2}$
Spectrochemical series: Strong field: CN^-, NO_2^-, ethylenediamine **Weak field:** F^-, Cl^-, Br^-, I^-