Exam IV Sample Problems

1. The entropy change in a system (ΔS_{sys}) _____ during a spontaneous process.

a. is positive
b. is negative
c. is zero
d. All three of the above answers are possible.

2. (3 points) $\Delta S_{surroundings}$ is related to heat (enthalpy) in the system by:

a. $-q_{surr}/T = \Delta S_{surr}$
b. $q_{sys}/T = \Delta S_{surr}$
c. $-q_{sys}/T = \Delta S_{surr}$
d. $q_{surr}/T = \Delta S_{surr}$

3. If 3.500 g of Ni are reacted with excess oxygen to form nickel oxide (NiO), what is the standard entropy change for the reaction?

$$2\,Ni(s) + O_2(g) \rightleftharpoons 2\,NiO(s)$$

Substance	***S*° (J/mol · K)**
Ni(s)	182.1
O_2 (g)	205.0
NiO(s)	37.99

4. At what temperature (K) is the given reaction at equilibrium? Assume $\Delta H°$ and $S°$ do not change with temperature.

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

given

Substance	**$\Delta H°$ (kJ/mol)**	**$S°$ (J/mol · K)**
$NO_2(g)$	33.2	240.0
$N_2O_4(g)$	9.2	304.2

5. (3 points) Boltzmann derived the relationship, $S = k\ln W$ where W is:

a. the number of microstates.
b. vibrational energy.
c. kinetic energy.
d. potential energy.

6. A molecule of chlorine has energy microstates involving _____, _____, and _____ modes of motion.

a. translational, rotational, kinetic energy
b. kinetic energy, potential energy, translational
c. rotational, vibrational, potential energy
d. translational, rotational, vibrational

7. If 1 mol of ice melts at its melting point of 273 K, the entropy change for the ice is 22.0 J/K. If the ice melts in someone's hand at 34°C, what is the change in the entropy of the universe? The enthalpy of fusion for ice is 6.01 kJ/mol.

8. A reaction

$$A(g) \rightarrow B(g) + C(g)$$

has the following standard thermodynamic parameters:

$$\mathbf{\Delta H^\circ_{rxn} = 40.0\ kJ/mol} \text{ and } \mathbf{\Delta S^\circ_{rxn} = 80.0\ J/mol \cdot K.}$$

a. Is the reaction exothermic or endothermic?

b. Does the positive entropy change make sense? Why?

c. Is the reaction spontaneous at all temperatures? If not, explain.

d. If the answer to part (c) is "no", then calculate the temperature at which the reaction becomes spontaneous.

9. Processes with _____ and _____ are always spontaneous.

a. $\Delta H > 0$ and $\Delta S < 0$

b. $\Delta H < 0$ and $\Delta S < 0$

c. $\Delta H > 0$ and $\Delta S > 0$

d. $\Delta H < 0$ and $\Delta S > 0$

10. (4 pts) Determine the pH and pOH of 0.250 L of a buffer that is 0.0250 *M* boric acid and 0.0200 *M* sodium borate; pK_{a1} for H_3BO_3 = 9.00 at 25°C.

11. (3 pts) Which of the following salts forms aqueous solutions with pH = 7?

a. Na_2S
b. NaBr
c. $NaClO_2$
d. $NaNO_2$

12. (4 points) In the following reaction, which species is the Lewis acid?

$$Cu^{2+} + NH_3 \rightleftarrows Cu(NH_3)^{2+}$$

a. Cu^{2+}
b. NH_3
c. $[Cu(NH_3)]^{2+}$
d. None of these is an acid.

13. (5 points) Some scientists have proposed adding Fe(III) compounds to large expanses of the open ocean to promote the growth of phytoplankton that would in turn remove CO_2 from the atmosphere through photosynthesis. The average pH of open ocean water is 8.1. What is the maximum value of $[Fe^{3+}]$ in pH 8.1 seawater if the K_{sp} value of $Fe(OH)_3$ is 1.1 E-36?

14. (5 points) Calculate the molar solubility and pH of a saturated solution of $Al(OH)_3$. $K_{sp}(Al(OH)_3)$=1.9E-33. (HINT: What is the concentration of OH^- in pure water?)

15. (4 points) Which of the following compounds will give a saturated solution with the highest concentration of iodide ions (I^-)?

(a) BiI_3; $K_{sp} = 8.1 \times 10^{-19}$ (b) AuI; $K_{sp} = 1.6 \times 10^{-23}$

(c) AgI; $K_{sp} = 1.5 \times 10^{-16}$ (d) CuI; $K_{sp} = 5.1 \times 10^{-12}$

(e) AuI_3; $K_{sp} = 1.0 \times 10^{-46}$

16. (5 points) For MgF_2 ($K_{sp} = 6.4 \times 10^{-9}$), if you mix 400. mL of 1.00×10^{-4} M $Mg(NO_3)_2$, and 500. mL of 1.00×10^{-4} M NaF, what will be observed?

(a) A precipitate forms because $Q_{sp} > K_{sp}$.

(b) A precipitate forms because $Q_{sp} < K_{sp}$.

(c) No precipitate forms because $Q_{sp} = K_{sp}$.

(d) No precipitate forms because $Q_{sp} > K_{sp}$.

(e) No precipitate forms because $Q_{sp} < K_{sp}$.

17. (5 points) Suppose a saturated solution of barium fluoride contains 1.5×10^{-2} *M* F^-. What is the K_{sp} value of BaF_2?

17. (4 points) Glancing at a periodic table, where do you expect to find elements that are good oxidizing agents?

a. on the right (except for extreme right)
b. on the left
c. in the middle
d. at the bottom

18. (4 points) Which of the following reagents would you add to increase the water solubility of magnesium hydroxide?

(a) $MgCl_2$ (b) $Mg(OH)_2$ (c) H_2SO_4

(d) NaOH (e) H_2O

19. (4 points) In the smelting of iron from iron oxide according to the equation

$$Fe_2O_3(s) + 3\ CO(g) + 2\ Fe(s) + 3\ CO_2(g)$$

what is the *change* in oxidation number for iron?

a. +3
b. –3
c. +2
d. –2

Miscellaneous Information and Formulae:

R = 0.082057 L·atm/(mole·K) = 8.314 J/(mole·K)

N_A = 6.0221E23/mole

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

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 $E_{cell} = E°_{cell} - (0.0257V/n) \cdot \ln(Q)$
$E_{cell} = E°_{cell} - (0.0592/n) \cdot (\log_{10} Q)$ (when converted from natural log)

$pH = -\log[H^+]$ pH + pOH = 14.00 (25°C) $\Delta G = \Delta G^o + RT \bullet \ln(Q)$

pH = pKa + log ([conj.base]/[acid])