

### Exam IV Sample Problems

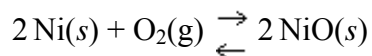
1. The entropy change in a system ( $\Delta S_{\text{sys}}$ ) \_\_\_\_\_ during a spontaneous process.

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

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

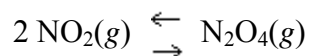
- a.  $-q_{\text{surr}}/T = \Delta S_{\text{surr}}$
- b.  $q_{\text{sys}}/T = \Delta S_{\text{surr}}$
- c.  $-q_{\text{sys}}/T = \Delta S_{\text{surr}}$
- d.  $q_{\text{surr}}/T = \Delta S_{\text{surr}}$

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?



<b>Substance</b>	<b><math>S^\circ</math> (J/mol · K)</b>
Ni(s)	182.1
O <sub>2</sub> (g)	205.0
NiO(s)	37.99

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



given

<i>Substance</i>	$\Delta H^\circ$ (kJ/mol)	$S^\circ$ (J/mol · K)
NO <sub>2</sub> (g)	33.2	240.0
N <sub>2</sub> O <sub>4</sub> (g)	9.2	304.2

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

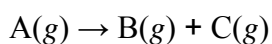
- a. the number of microstates.                      c. kinetic energy.  
b. vibrational energy.                                d. potential energy.

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



has the following standard thermodynamic parameters:

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

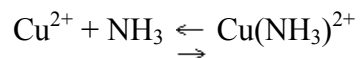
- a. Is the reaction exothermic or endothermic?
- b. Does the positive entropy change make sense? Why?
- c. Is the reaction spontaneous at all temperatures? If not, explain.
- d. If the answer to part (c) is “no”, then calculate the temperature at which the reaction becomes spontaneous.
9. Processes with \_\_\_\_\_ and \_\_\_\_\_ are always spontaneous.
- a.  $\Delta H > 0$  and  $\Delta S < 0$                       c.  $\Delta H > 0$  and  $\Delta S > 0$
- b.  $\Delta H < 0$  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  $25^\circ C$ .

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?



- a.  $Cu^{2+}$
- b.  $NH_3$
- c.  $[Cu(NH_3)_2]^{2+}$
- 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.

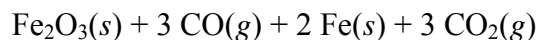
What is the maximum value of  $[Fe^{3+}]$  in pH 8.1 seawater if the  $K_{sp}$  value of  $Fe(OH)_3$  is  $1.1 \times 10^{-36}$ ?

14. (5 points) Calculate the molar solubility and pH of a saturated solution of  $\text{Al}(\text{OH})_3$ .  $K_{\text{sp}}(\text{Al}(\text{OH})_3)=1.9\text{E}-33$ . (HINT: What is the concentration of  $\text{OH}^-$  in pure water?)
15. (4 points) Which of the following compounds will give a saturated solution with the highest concentration of iodide ions ( $\text{I}^-$ )?
- (a)  $\text{BiI}_3$ ;  $K_{\text{sp}} = 8.1 \times 10^{-19}$       (b)  $\text{AuI}$ ;  $K_{\text{sp}} = 1.6 \times 10^{-23}$
- (c)  $\text{AgI}$ ;  $K_{\text{sp}} = 1.5 \times 10^{-16}$       (d)  $\text{CuI}$ ;  $K_{\text{sp}} = 5.1 \times 10^{-12}$
- (e)  $\text{AuI}_3$ ;  $K_{\text{sp}} = 1.0 \times 10^{-46}$
16. (5 points) For  $\text{MgF}_2$  ( $K_{\text{sp}} = 6.4 \times 10^{-9}$ ), if you mix 400. mL of  $1.00 \times 10^{-4} \text{ M Mg}(\text{NO}_3)_2$ , and 500. mL of  $1.00 \times 10^{-4} \text{ M NaF}$ , what will be observed?
- (a) A precipitate forms because  $Q_{\text{sp}} > K_{\text{sp}}$ .
- (b) A precipitate forms because  $Q_{\text{sp}} < K_{\text{sp}}$ .
- (c) No precipitate forms because  $Q_{\text{sp}} = K_{\text{sp}}$ .
- (d) No precipitate forms because  $Q_{\text{sp}} > K_{\text{sp}}$ .
- (e) No precipitate forms because  $Q_{\text{sp}} < K_{\text{sp}}$ .
17. (5 points) Suppose a saturated solution of barium fluoride contains  $1.5 \times 10^{-2} \text{ M F}^-$ . What is the  $K_{\text{sp}}$  value of  $\text{BaF}_2$ ?

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)    c. in the middle  
 b. on the left    d. at the bottom
18. (4 points) Which of the following reagents would you add to increase the water solubility of magnesium hydroxide?

- (a)  $\text{MgCl}_2$                       (b)  $\text{Mg}(\text{OH})_2$                       (c)  $\text{H}_2\text{SO}_4$   
 (d)  $\text{NaOH}$                       (e)  $\text{H}_2\text{O}$

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



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

- a. +3                                      c. +2  
 b. -3                                      d. -2

***Miscellaneous Information and Formulae:***

$$R = 0.082057 \text{ L}\cdot\text{atm}/(\text{mole}\cdot\text{K}) = 8.314 \text{ J}/(\text{mole}\cdot\text{K})$$

$$N_A = 6.0221\text{E}23/\text{mole}$$

$$1 \text{ Faraday (F)} = 9.6485\text{E}4 \text{ coulombs (C)}/(\text{mol}\cdot\text{e}^-) \qquad \Delta G = -n \cdot F \cdot (E_{\text{cell}})$$

$$1 \text{ C}\cdot\text{V} = 1 \text{ J} \qquad 1 \text{ amp (A)} = 1 \text{ C}/\text{sec}$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (R\cdot T/n\cdot F)\cdot(\ln Q) \text{ or at } 298 \text{ K} \quad E_{\text{cell}} = E^\circ_{\text{cell}} - (0.0257\text{V}/n)\cdot\ln(Q)$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (0.0592/n)\cdot(\log_{10} Q) \text{ (when converted from natural log)}$$

$$\text{pH} = -\log[\text{H}^+] \qquad \text{pH} + \text{pOH} = 14.00 \text{ (} 25^\circ\text{C)} \qquad \Delta G = \Delta G^\circ + RT\cdot\ln(Q)$$

$$\text{pH} = \text{pK}_a + \log ([\text{conj. base}]/[\text{acid}])$$