SAMPLE PROBLEMS CHEMISTRY 12 EQUILIBRIUM

Key

1. Equilibrium is considered to be a "dynamic" process because

   a. it occurs in a closed system.
   b. equilibrium can be achieved from either direction.
   c. the forward and reverse reactions continue to occur.
   d. the concentrations of reactants and products are constant.

2. The equilibrium constant expression for the following reaction is

   pure liquid — solid

   $2\,Hg_{(l)} + O_{2(g)} <====> 2\,HgO_{(s)}$

   a. $K_{eq} = \dfrac{1}{[O_2]}$

   b. $K_{eq} = [O_2]$

   c. $K_{eq} = \dfrac{[2\,HgO]}{[O_2][2Hg]}$

   d. $K_{eq} = \dfrac{[HgO]^2}{[Hg]^2[O_2]}$

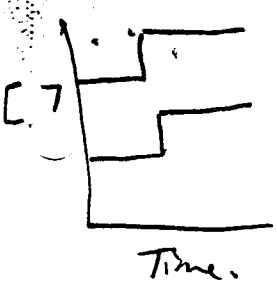
3. In which of the following systems would the tendencies toward minimum enthalpy and maximum entropy be in opposition to each other?

   ΔS → ← ΔH

   A. $Br_{2(l)} + \text{heat} <===> Br_{2(g)}$
   B. $NaOH_{(s)} ===> Na^{+}_{(aq)} + OH^{-}_{(aq)} + \text{heat}$
   C. $2C_{(g)} + 2H_{2(g)} ===> C_2H_{4(g)}$ ▲H is positive
   D. $K_{(s)} + H_2O_{(l)} ===> K^{+}_{(aq)} + OH^{-}_{(aq)} + \frac{1}{2}H_{2(g)}$ ▲H is negative

4. Which of the following reactions will shift left when pressure is increased and when temperature is decreased?

   a. $N_{2(g)} + 2O_{2(g)} + \text{heat} <====> 2NO_{2(g)}$
   b. $N_{2(g)} + 3H_{2(g)} <====> 2NH_{3(g)} + \text{heat}$
   c. $CH_{4(g)} + H_2O_{(g)} + \text{heat} <====> CO_{(g)} + 3H_{2(g)}$ fewer gas reactants, endothermic
   d. $CS_{2(g)} + 4H_{2(g)} <====> CH_{4(g)} + 2H_2S_{(g)} + \text{heat}$



5. Consider the following equilibrium system:

$$FeO_{(s)} + H_{2(g)} <===> Fe_{(s)} + H_2O_{(g)}$$

Which one of the following statements describes the effect that a decrease in volume would have on the position of equilibrium and the $[H_2]$ in the above system?

A. No shift, $[H_2]$ increases.
B. Shift right, $[H_2]$ increases.
C. Shift right, $[H_2]$ decreases.
D. No shift, $[H_2]$ remains constant. ~~both sides, have 1 mol of gas~~

6. Tooth enamel, $Ca_5(PO_4)_3OH$ establishes the following equilibrium:

$$Ca_5(PO_4)_3OH_{(s)} <===> 5Ca_{(aq)}^{2+} + 3PO_{4(aq)}^{3-} + OH_{(aq)}^{-} \downarrow$$

Which one of the following, when added to the above equilibrium system, would result in shift to the right?

A. $H_{(aq)}^{+}$
B. $OH_{(aq)}^{-}$
C. $Ca_{(aq)}^{2+}$
D. $Ca_5(PO_4)_3OH_{(s)}$

7. In which of the following reactions does the tendency towards minimum enthalpy and maximum entropy oppose each other?

a. $3O_{2(g)} \longrightarrow 2O_{3(g)}$	$\Delta S \leftarrow$	$\Delta H = +285$ kJ
b. $1/2N_{2(g)} + O_{2(g)} \longrightarrow NO_{2(g)}$	$\Delta S \leftarrow$	$\Delta H = +34$ kJ
c. $2H_2O_{(g)} \longrightarrow 2H_{2(g)} + O_{2(g)}$	$\Delta S \rightarrow$	$\Delta H = +484$ kJ
d. $P_{4(s)} + 6H_{2(g)} \longrightarrow 4PH_{3(g)}$	$\Delta S \leftarrow$	$\Delta H = +37$ kJ

8. Consider the following equilibrium:

$$2O_{3(g)} <=== 3O_{2(g)} \downarrow \quad K_{eq} = 55$$

If 0.060 mol of $O_{3(g)}$ and 0.70 mol of $O_{2(g)}$ are introduced into a 1.0 L vessel, the

a. $K_{trial} > K_{eq}$ and the $[O_{2(g)}]$ increases.
b. $K_{trial} < K_{eq}$ and the $[O_{2(g)}]$ increases.
c. $K_{trial} > K_{eq}$ and the $[O_{2(g)}]$ decreases.
d. $K_{trial} < K_{eq}$ and the $[O_{2(g)}]$ decreases.

$$K_{eq} = \frac{[O_2]^3}{[O_3]^2} \qquad K_{trial} = \frac{(0.70)^3}{(0.060)^2} = 95$$

$$K_{trial} > K_{eq}.$$

9. $CO_{2(g)} + H_{2(g)} <=\!=\!=> CO_{(g)} + H_2O_{(g)}$ $\frac{1.00\ mol}{2.00\ L} = 0.500\ M$ $\frac{2.00\ mol}{2.00\ L} = 1.00\ M$

1.00 mole of CO_2 and 2.00 moles of $H_{2(g)}$ are placed into a 2.00 litre container. A equilibrum, the [CO] = 0.31 mol/L. based on this data, the equilibrium $[CO_2]$ is:

A. 0.19M
B. 0.31M
C. 0.38M
D. 0.69M

	CO_2	H_2	CO	H_2O
I	.500	1.00M	–	–
C	-.31	-.31M	+.31M	+.31M
E	0.19	0.69	.31M	.31M

10. What is "equal" in a chemical reaction that has reached a state of equilibrium?

Forward and Reverse Reaction Rates

11. Consider the following equilibrium:

$$N_{2(g)} + 3H_{2(g)} <=\!=\!=\!=\!=> 2NH_{3(g)} \quad K_{eq} = 626 \text{ at } 200^\circ C$$

At equilibrium, $[N_2]$ is 1.06 mol/L and $[H_2]$ is 0.456 mol/L. Calculate $[NH_3]$ in the equilibrium mixture.

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} = 626.$$

$$\frac{[NH_3]^2}{(1.06)(0.456)^3} = 626$$

$$\frac{[NH_3]^2}{0.1005} = 626$$

$$[NH_3]^2 = 62.92$$

$$[NH_3] = 7.93\ M$$