Qualitative Equilibrium Problems

8. Consider the reaction:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$
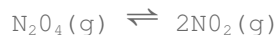
$$\Delta H° = 59 \text{ kJ}$$
$$Keq = 0.87 \text{ at } 55°C$$

What is the effect of each of these changes upon the concentration of N_2O_4 at equilibrium?
(a) increasing the temperature
(b) increasing the volume
(c) adding more $NO_2(g)$ to the system without changing pressure or temperature
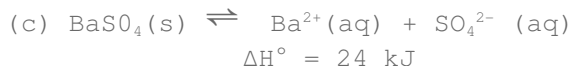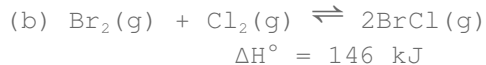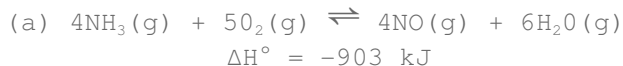(d) adding He gas to the container
(e) adding a catalyst

9. Answer questions (a, b, d, e) for $H_2O(g)$ in this reaction as you did for N_2O_4 in Problem 8.
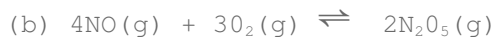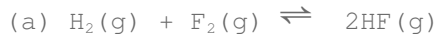
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons H_2O(g)$$

$$\Delta H° = -238 \text{ kJ}$$
$$Keq = 1 \times 10^{40} \text{ at } 25°C$$

10. How can you increase the concentration of the product(s) in each of these reactions by varying the temperature and pressure (caused by volume change)?

(a) $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$
$$\Delta H° = -903 \text{ kJ}$$

(b) $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$
$$\Delta H° = 146 \text{ kJ}$$

(c) $BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$
$$\Delta H° = 24 \text{ kJ}$$

11. Write the equilibrium expressions (Keq) for each of these reactions.

(a) $H_2(g) + F_2(g) \rightleftharpoons 2HF(g)$

(b) $4NO(g) + 3O_2(g) \rightleftharpoons 2N_2O_5(g)$

(c) $BaCO_3(s) \rightleftharpoons BaO(s) + CO_2(g)$

(d) $Na_2CO_3 \bullet 10H_2O(s) \rightleftharpoons Na_2CO_3 \bullet H_2O(s) + 9H_2O(g)$

12. The equilibrium constants for three different reactions are
(a) $K = 1.5 \times 10^{12}$
(b) $K = 0.15$
(c) $K = 4.3 \times 10^{-15}$.
In which reaction is:
(a) the ratio of product to reactant large
(b) the ratio of product to reactant small

13. Does the Equilibrium constant for the reaction:

$$Br_2(1) = Br_2(g)$$

increase or decrease as temperature increases? Explain.

15. The graph, shows the concentration of all three species of the system plotted against time under a given set of conditions.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$
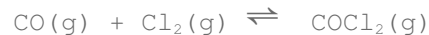
(a) How much time was required for the system to reach equilibrium?
(b) Approximate the value of Keq using the concentrations at t = 17 s
(c) Explain the changes 20 s after the initiation of the reaction
(d) What change in conditions might have been imposed on the system 30 s after the initiation of the reaction?
(e) Are any events taking place between the interval of 15 s and 20 s? Explain.
(f) What change may have taken place at t = 45 s?
(g) What differences would you have noted if a catalyst had been present during the entire course of this reaction?
(h) List the changes you might impose on this system if you wanted to produce a maximum amount of $COCl_2$
(i) How could you account for the differences in the value of K at different points on the graph