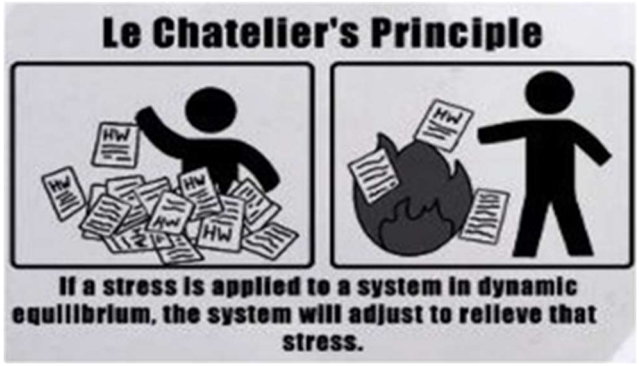


1. What is meant when it is said that a reaction is at equilibrium? Has the reaction stopped? Is a reaction the goes to completion an equilibrium reaction?

2. If an equilibrium reaction has a very high K value, will the reaction be fast or slow? Explain.

3. What is the relation between $K_c$, $K_p$, and Q? Name a way you can add stress to the system that changes the states of the system. Do these stresses change the equilibrium constant? Why or why not?

4. Write the expressions for K and $K_p$ for the following reactions. Also, in which reactions is K = Kp? Why?
    a. $2\ NH_3\ (g) + CO_2\ (g) \rightleftarrows N_2CH_4O\ (s) + H_2O\ (g)$

    b. $2\ NBr_3\ (s) \rightleftarrows N_2\ (g) + 3\ Br_2\ (g)$

    c. $2\ KClO_3\ (s) \rightleftarrows 2\ KCl\ (s) + 3\ O_2\ (g)$

    d. $CuO\ (s) + H_2\ (g) \rightleftarrows Cu\ (l) + H_2O\ (g)$

5. At 35°C, $K = 1.6 \times 10^{-5}$ for the following reaction:

$$2NOCl_{(g)} \rightleftarrows 2\ NO_{(g)} + Cl_{2(g)}$$

Calculate the concentrations of all species at equilibrium for each of the following original mixtures.

    a. 2.0 moles of pure NOCl in a 2.0 L flask.

b. 2.0 moles of NO and 1.0 mole of $Cl_2$ in a 1.0L flask.

c. 1.0 mole of NOCl and 1.0 mole NO in a 1.0L flask.

d. 3.0 moles of NO and 1.0 mole of $Cl_2$ in a 1.0 L flask.

e. 2.0 moles of NOCl, 2.0 moles of NO, and 1.0 mole of $Cl_2$ in a 1.0 L flask.

f. 1.00 mole/liter concentration of all three gases

6. Define Le Chatelier's Principle. For the following equilibrium, state if and why the stress will shift the system in any way. This theoretical decomposition is **endothermic**.

$$A\,(g) \leftrightharpoons B\,(g) + C\,(g)$$

   a. What is Le Chatelier's Principle?

   b. Increasing the concentration of C.

   c. Decreasing the pressure of the system.

   d. Increasing the temperature of the system.

   e. Adding a catalyst.

7. How will the equilibrium position of the gas-phase reaction be affected if the volume of the reaction vessel changes? Are there reactions that will not have their equilibria shifted by a change in volume? Explain. Why does changing the pressure in a rigid container by adding an inert gas not shift the equilibrium position for a gas-phase reaction?

8. Consider the reaction:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$$

How will the equilibrium position shift if:

a. Water is added, doubling the volume?

b. Silver nitrate is added? (AgSCN is insoluble)

c. NaOH is added? (again, think about solubility)

d. Iron(III) nitrate is added?

9. A sample of $N_2O_4$ (g) is placed in an empty cylinder at 25 degrees Celsius. After equilibrium is reached, the total pressure is 1.5 atm, and 16% (by moles) of the original $N_2O_4$ (g) has dissociated to $NO_2$ (g).
    a. Calculate the value of $K_p$ for this dissociation reaction at 25 degrees Celsius.

    b. If the volume of the cylinder is increased until the total pressure is 1.0 atm (the temperature of the system remains constant), calculate the equilibrium pressure of $N_2O_4$ (g) and $NO_2$ (g).

    c. What percentage (by moles) of the original $N_2O_4$ (g) is dissociated at the new equilibrium position (total pressure = 1.00 atm)?

10. A 4.72-g sample of methanol ($CH_3OH$) was placed in an otherwise empty 1.00-L flask and heated to 250.℃ to vaporize the methanol. Over time the methanol vapor decomposed by the following reaction:

$$CH_3OH\,(g) \leftrightharpoons CO\,(g) + 2\,H_2\,(g)$$

After the system has reached equilibrium, a tiny hole is drilled in the side of the flask allowing gaseous compounds to effuse out of the flask. Measurements of the effusing gas show that it contains 33.0 times as much $H_2$ as $CH_3OH$. Calculate K for this reaction at 250.℃.

11. Ammonia is produced by the Haber process, in which nitrogen and hydrogen are reacted directly using an iron mesh impregnated with oxide as a catalyst. For the reaction:

$$N_2\,(g) + 3\,H_2\,(g) \leftrightharpoons 2\,NH_3\,(g)$$

Equilibrium constants as a function of temperature are:

300℃, $4.34 \times 10^{-3}$

500℃, $1.45 \times 10^{-5}$

600℃, $2.25 \times 10^{-6}$

Is the reaction exothermic or endothermic? Explain.