Le Châtelier's Principle

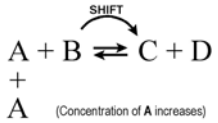
Aim

- to explain how an equilibrium system responds to stress

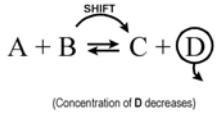
Notes

Le Chatelier's principle - when stress is applied to a system in equilibrium, the reaction will shift in a direction that relieves the stress and a new equilibrium will be established

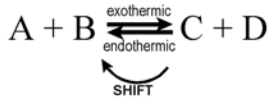
- **applied stresses** - changes in concentration, pressure, or temperature
  - stress caused by change in concentration
    - shift due to increase in concentration of a reactant



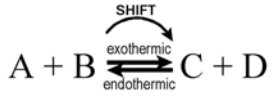
    - shift due to decrease in concentration of a product



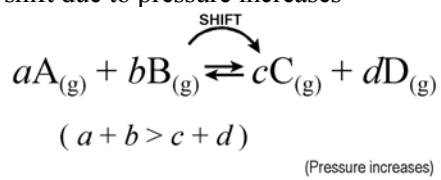
  - stress caused by change in temperature
    - shift due to increase in temperature



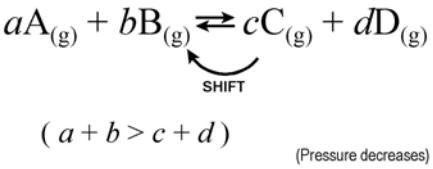
    - shift due to decrease in temperature



  - stress caused by change in pressure
    - shift due to pressure increases



    - shift due to pressure decreases



  - example: Haber process for the manufacture of ammonia

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} + 92\ kJ$$

  - effect of stresses
    - concentration
      - increasing the concentration of nitrogen or hydrogen will increase the rate of the forward reaction
      - removing the product will increase the output. Products can be removed by:
        - formation of a gas
        - formation of a precipitate
        - formation of a nonelectrolyte such as water
    - pressure -affects only gaseous components
      - increased pressure favors the reaction that results in the smaller volume or lower pressure
      - the Haber process has 4 moles of reactant to 2 moles of product, so pressure favors the forward reaction
    - temperature - when temperature is increased the reaction shifts in the direction that will absorb heat
      - an increase in temperature favors an endothermic reaction while a decrease in temperature favors an exothermic reaction
      - the Haber process is exothermic so an increase in temperature favors decomposition of ammonia
    - catalysts - cause equilibrium to be reached faster but produce no net change in equilibrium concentrations because they effect the forward and reverse reactions equally

Answer the questions below by circling the number of the correct response

Base your answers to questions 1 through 3 on the following system at equilibrium:

$2Cl_2(g) + 2H_2O(g) \rightleftharpoons 4HCl(g) + O_2(g)$ $\Delta H = +27$ kcal.

1. If the temperature of the system is increased at a constant pressure, the rate of the forward reaction will
   (1) decrease (3) remain the same
   (2) increase (4) decrease then increase

2. If O_2 is added to the system at a constant pressure and temperature, the number of moles of HCl will
   (1) decrease (3) remain the same
   (2) increase (4) decrease then increase

3. If the pressure on the system is increased at a constant temperature, the value of the equilibrium constant for the reaction will
   (1) decrease (3) remain the same
   (2) increase (4) decrease then increase

4. In the equilibrium reaction: $A(g) + 2B(g) + \text{heat} = AB_2(g)$, the rate of the forward reaction will increase if there is
   (1) an increase in pressure of the reaction vessel
   (2) a decrease in temperature
   (3) an increase in the volume
   (4) a decrease in the concentration of A(g)

5. For a given system at equilibrium, lowering the temperature will always
   (1) increase the rate of reaction
   (2) increase the concentration of products
   (3) favor the exothermic reaction
   (4) favor the endothermic reaction

6. Given the equation $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$. As NaCl(s) dissolves in the solution, the $Ag^+(aq)$ concentration will
   (1) decrease as the amount of AgCl(s) decreases
   (2) decreases as the amount of AgCl(s) increases
   (3) increases as the amount of AgCl(s) decreases
   (4) increases as the amount of AgCl(s) increases

7. Equilibrium is reached in all reversible chemical reactions when the
   (1) forward reaction stops
   (2) reverse reaction stops
   (3) concentrations of reactants and the products become equal
   (4) rates of the opposing reactions become equal

8. Given the reaction at equilibrium: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, if the temperature remains constant, an increase in pressure will
   (1) have no effect on the equilibrium
   (2) shift the equilibrium to the right
   (3) shift the equilibrium to the left
   (4) change the value of the equilibrium constant

9. Given the reversible reaction $A(g) + B(g) \rightleftharpoons C(g)$ at equilibrium. If the concentration of A is increased at constant temperature and pressure, which will also increase?
   (1) the rate of the forward reaction
   (2) the value of the equilibrium constant
   (3) the activation energy
   (4) the concentration of B

10. Given the reaction at equilibrium: $2SO_2(g) + O_2 = 2SO_3 + 47$ kcal, the amount of $SO_3(g)$ will increase if there is
    (1) an increase in temperature
    (2) a decrease in pressure
    (3) an increase in concentration of $SO_2(g)$
    (4) a decrease in concentration of $O_2(g)$

11. Given the reaction at equilibrium: $2AB(g) + \text{heat} = A_2(g) + B_2(g)$, the equilibrium will shift to the right when the
    (1) temperature increases (3) pressure increases
    (2) temperature decreases (4) pressure decreases

12. Given the reaction at equilibrium: $N_2(g) + 3H_2(g) = 2NH_3(g) + \text{heat}$, which change will increase the amount of $NH_3(g)$ in the system?
    (1) an increase in the concentration of $N_2(g)$
    (2) an increase in temperature
    (3) a decrease in pressure
    (4) a decrease in the concentration of $H_2(g)$