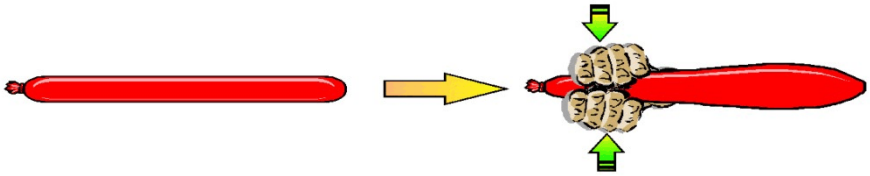
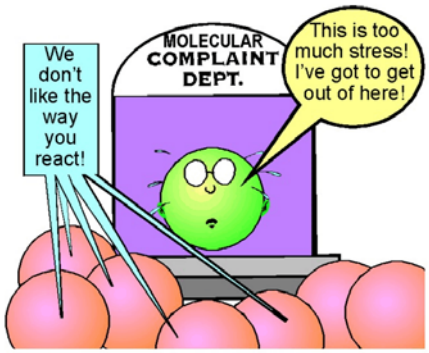
Relieving Stress in Chemistry

You squeeze a long balloon on one side. Air moves toward the other side causing the balloon to bulge. As a result, the pressure is reduced on the side where you are squeezing. The air moves in a way that relieves the pressure. See below.





All systems respond in a way that relieves stress. Pressure is an example of a stress. Chemical reactions respond in a way that relieves stress too. This is known as ***Le Chatelier's principle***. According to 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 include changes in concentration, pressure, or temperature. Following are descriptions of how reactions at equilibrium respond to these specific stresses:

Change in Concentration

➤ shift due to increase in concentration of a reactant

$$A + B \overset{\text{SHIFT}}{\rightleftharpoons} C + D$$
$$+$$
$$A \quad \text{(Concentration of A increases)}$$

➤ shift due to decrease in concentration of a product

$$A + B \overset{\text{SHIFT}}{\rightleftharpoons} C + \textcircled{D}$$

(Concentration of **D** decreases)

Change in Temperature

➤ shift due to increase in temperature

$$A + B \underset{\text{endothermic}}{\overset{\text{exothermic}}{\rightleftharpoons}} C + D$$

SHIFT

(Temperature increases)

➤ shift due to decrease in temperature

$$A + B \overset{\text{SHIFT}}{\underset{\text{endothermic}}{\overset{\text{exothermic}}{\rightleftharpoons}}} C + D$$

(Temperature decreases)

Change in Pressure

➤ shift due to pressure increases

$$aA_{(g)} + bB_{(g)} \overset{\text{SHIFT}}{\rightleftharpoons} cC_{(g)} + dD_{(g)}$$

$$(a + b > c + d)$$

(Pressure increases)

➤ shift due to pressure decreases

$$aA_{(g)} + bB_{(g)} \underset{\text{SHIFT}}{\rightleftharpoons} cC_{(g)} + dD_{(g)}$$

$$(a + b > c + d)$$

(Pressure decreases)

Le Chatelier's principle applies only to reversible reactions at equilibrium, but it gives some insight into end reactions as well. When a precipitate, a gas, or water forms the reaction is not reversible. These are products that are not available for reaction. When they form, it is as if the concentration of one of the products in an equilibrium system is reduced to zero by removing it as soon as it is produced. Le Chatelier predicts that the reaction will shift in the direction of forming more product.

Continue ☞

Answer the questions below based on your reading and on your knowledge of chemistry.

1. For each of the following, what effect would an increase in pressure have on equilibrium?
   a. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ _____
   b. $4H_2(g) + CS_2(g) \rightleftharpoons CH_4(g) + 2H_2S(g)$ _____
   c. $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$ _____
   d. $H_2(g) + F_2(g) \rightleftharpoons 2HF(g)$ _____
   e. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ _____
2. For each of the following, what effect would an increase in temperature have on equilibrium?
   a. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92$ kJ _____
   b. $C(s) + H_2O(g) + \text{heat} \rightleftharpoons CO(g) + H_2(g)$ _____
   c. $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) + \text{heat}$ _____
   d. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + \text{heat}$ _____
   e. $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$ $\Delta H = 55.8$ kJ _____
3. For the reaction, $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ [$\Delta H = 52.7$ kJ], what effect will each of the following have on equilibrium?
   a. Addition of $H_2(g)$ _____
   b. Removal of $I_2(g)$ _____
   c. Increase in temperature _____
   d. Increase in pressure _____
   e. Addition of $HI(g)$ _____
4. Explain LeChatelier's principal based on collision theory. _____

5. If heat speeds up all reactions, both forward and reverse, why does it effect equilibrium? _____