# Equilibrium 9.5

Le Chatelier's Principle

## Le Chatelier's Principle

When a system at equilibrium is subjected to a stress, the equilibrium will shift in order to reduce that stress.

**The only three stresses are changes in:**

1) Pressure.
2) Concentrations.
3) Temperature.

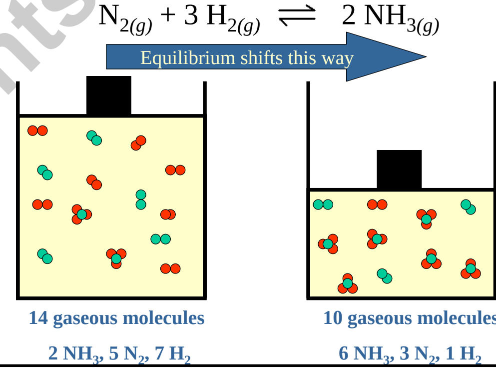
## Stress from Increasing Pressure

If the **pressure** on a system at equilibrium is **increased,** the equilibrium will **shift** toward the side with **fewer moles of gas** to reduce that stress.

This changes the equilibrium concentrations, but it **does not** change the Equilibrium Constant ($K_{eq}$).

## Stress from Increasing Pressure

$$N_{2(g)} + 3\ H_{2(g)} \rightleftharpoons 2\ NH_{3(g)}$$



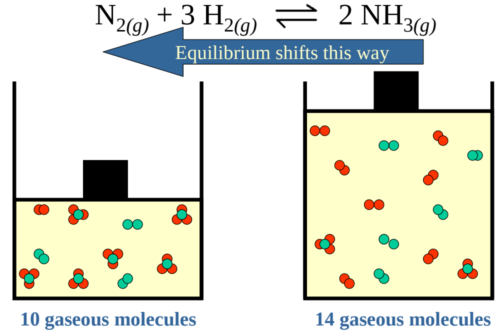

## Stress from Decreasing Pressure

If the **pressure** on a system at equilibrium is **decreased,** the equilibrium will **shift** toward the side with **more moles of gas** to reduce that stress.

This changes the equilibrium concentrations, but it **does not** change the Equilibrium Constant ($K_{eq}$).

## Stress from Decreasing Pressure

$$N_{2(g)} + 3\ H_{2(g)} \rightleftharpoons 2\ NH_{3(g)}$$



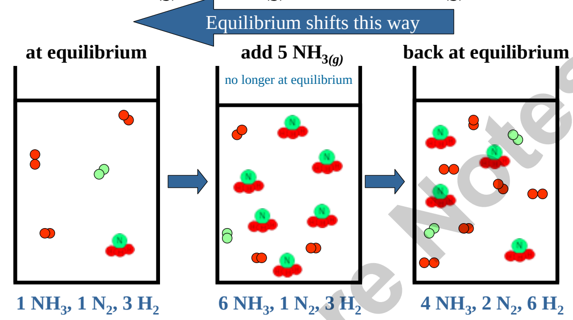
## Stress from Increasing Concentrations

If the **concentration** of one of the species in an equilibrium system is **increased**, the equilibrium will **shift** in the direction that will **reduce the concentration** of that species.

This increases the equilibrium concentrations, but it does not change the Equilibrium Constant ($K_{eq}$).

## e.g.) Adding more $NH_3$ to the system

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)}$$



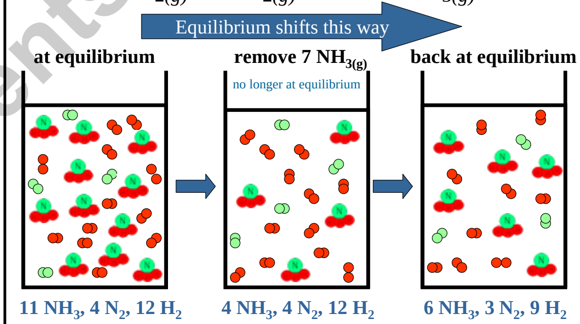

## Stress from Decreasing Concentrations

If the **concentration** of one of the species in an equilibrium system is **decreased**, the equilibrium will shift in the direction that will **increase the concentration** of that species.

This decreases the equilibrium concentrations, but it does not change the Equilibrium Constant ($K_{eq}$).

## e.g.) Removing $NH_3$ from the system

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)}$$




## Stress from Changing Temperature

This is the <u>only stress</u> that <u>changes the equilibrium constant</u> ($K_{eq}$).

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} + \text{heat}$$

Cooling (taking heat away) shifts the equilibrium in the direction that produces heat.

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} + \text{heat}$$

Adding heat (increasing the temperature) shifts the equilibrium in the direction that absorbs heat.

## Ex) $Q$ and Le Chatelier

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\,NO_{(g)}$$

Ex) A chemist mixes 80% $N_{2(g)}$ and 20 % $O_{2(g)}$, by moles, in a vacuum and finds that the total pressure is 1.0 atm at 25°C. ($K_p = 1.0 \times 10^{-30}$)

a) Find the initial partial pressure of each gas
b) Find the equilibrium partial pressures at 25°C.
c) If the temperature increases to 2127 °C ($K_p = 0.0025$), find the new equilibrium concentrations.

## Ex) *Q* and Le Chatelier (cont.)

a) Find initial partial pressures

## Ex) *Q* and Le Chatelier (cont.)

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\ NO_{(g)}$$

b) Find the equilibrium partial pressures

| | $P_{N_2}$ | $P_{O_2}$ | $P_{NO}$ |
|---|---|---|---|
| **I**nitial | | | |
| **C**hange | | | |
| **E**quilibrium | | | |

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\ NO_{(g)}$$

## Ex) *Q* and Le Chatelier (cont.)

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\ NO_{(g)}$$

c) Find the equilibrium partial pressures when $K_p = 0.0025$

| | $P_{N_2}$ | $P_{O_2}$ | $P_{NO}$ |
|---|---|---|---|
| **I**nitial | | | |
| **C**hange | | | |
| **E**quilibrium | | | |

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\ NO_{(g)}$$

## Ex) *Q* and Le Chatelier (cont.)

c) Equilibrium partial pressures when $K_p = 0.0025$