Le Chatelier's Principle

Pages 138 - 144

Pre-Lab = Page 143, 40%

No post lab questions, lab = 60%

Lab Objectives

- To study the effects of concentration and temperature on the position of equilibrium in a chemical system

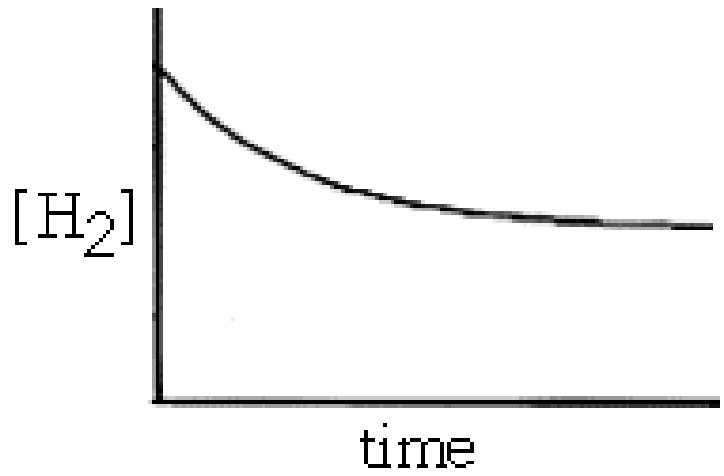
Equilibrium

- At chemical equilibrium in a reversible reaction the ratio of the rate of the forward reaction to the rate of the reverse reaction is a constant for that reaction

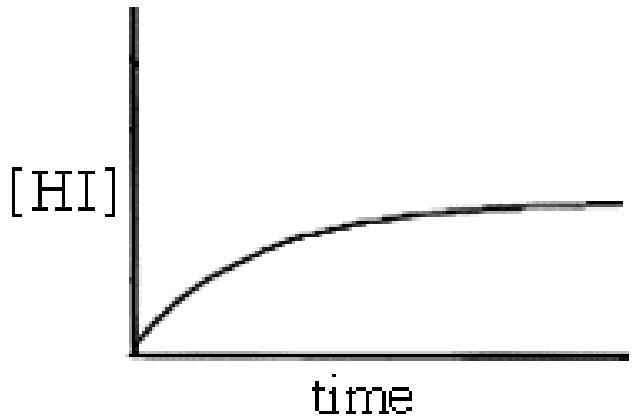
$$A + B \leftrightarrow C + D$$

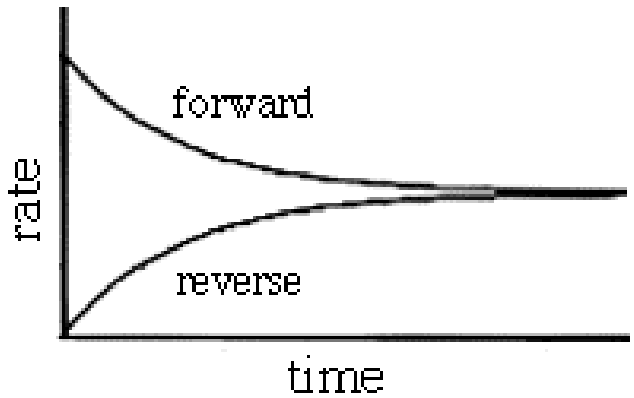
- Consider the reaction of hydrogen gas with iodine vapor to form hydrogen iodide
- The forward reaction $H_2 + I_2 \rightarrow 2\ HI$
- The reverse reaction is $2\ HI \rightarrow H_2 + I_2$
- For convenience these two reactions are usually written together with a special arrow between them

$$H_2 + I_2 \Leftrightarrow 2\ HI$$


[H2]
time


[I2]
time


[HI]
time


forward
rate
reverse
time

- When a chemical system is in equilibrium a number of items are true:

- The rates of the forward and reverse reactions are equal.

- The concentrations of all the substances involved stop changing. This happens because they are being formed at the same rate that they are being consumed.

- There will be both reactants and products present but the concentrations of them will not necessarily be equal. The fact that the forward and reverse reaction rates are the same does not mean the concentrations of the reactants and products are the same.

- The system is a dynamic one. The reaction rates are equal, and the concentrations of the substances involved are not changing but there is still an inter-conversion of reactant and product.

Equilibrium Affects

- The condition of **chemical equilibrium** is attained when the concentrations of the reactants and products are no longer changing.
- Once a reaction has reached equilibrium, the rate of reaction is constant provided the temperature remains constant.
- If any one of the concentrations should change, the concentrations of all other species must change in order to maintain the same value of the equilibrium constant. This idea is stated in **Le Chatelier's Principle.**

Le Chatelier's Principle.

- If a stress is applied to a system at chemical equilibrium, the equilibrium will shift in such a manner as to counteract the effects of that stress.

What factors affect equilibrium?

- concentration of a species
- a change in temperature
- change in pressure

Experimental Outline

In this experiment you will be shown a series of equilibrium systems and asked to apply certain "stresses" to the systems. For each system, record:

Your observations

This means a color change, a precipitate formed or some like statement. For example, "the red solution turned green". Do not use this part to state what chemical change occurred.

What you think happened chemically

State what chemical reaction occurred or species was formed that resulted in your observation. For example, "by adding chloride ion to the solution it shifted the equilibrium to the left which caused more $CoCl_4^{-2}$ ion to be formed. Since this ion is blue, the solution became more blue."

Concentration Changes - Example

$$H_2 + I_2 \leftrightarrow 2\ HI$$

- If we add some hydrogen to the system at equilibrium, the system will shift to the right in an attempt to remove the extra hydrogen.
- The new equilibrium concentration of hydrogen will be higher than it was in the original equilibrium.
- To remove the hydrogen from the system it will react with iodine, so the new equilibrium concentration of iodine will be lower than it was in the original equilibrium.
- When hydrogen and iodine react they form hydrogen iodide, so the concentration of hydrogen iodide will be higher than it was in the original equilibrium conditions.

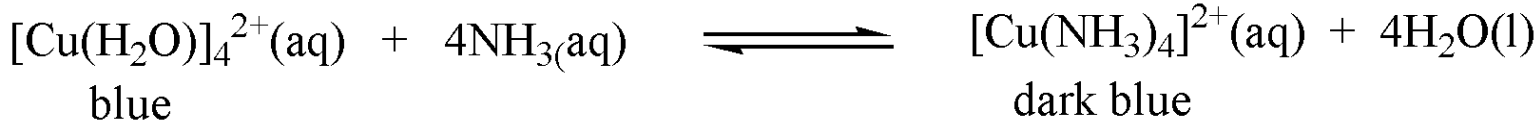
$H_2 + I_2 \leftrightarrow 2\ HI$

Applied Stress	Direction of Shift	Effect on $[H_2]$	Effect on $[I_2]$	Effect on [HI]
H_2 added	Right HI formation	Increase	Decrease	Increase

$H_2 + I_2 \leftrightarrow 2\ HI$

Applied Stress	Direction of Shift	Effect on $[H_2]$	Effect on $[I_2]$	Effect on [HI]
H_2 removed	Left	Decrease	Increase	Decrease

Experimental Procedure



- Addition of ammonia causes displacement of the water ions for ammonia.

- After addition of NH_3 and formation of the copper ammonia complex, HCl is added.

Addition of HCl

- The HCl reacts with the ammonia and shifts the equilibrium.
- Note your observations.
- Repeat the same experiment with $NiCl_2$.

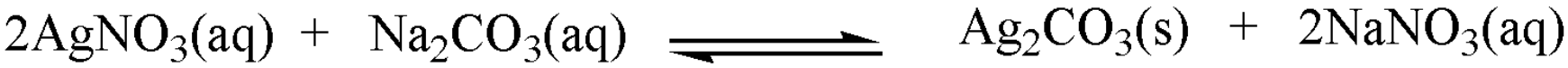
Change in Concentration

Pink Blue

$$Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \leftrightarrow CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)\backslash}$$

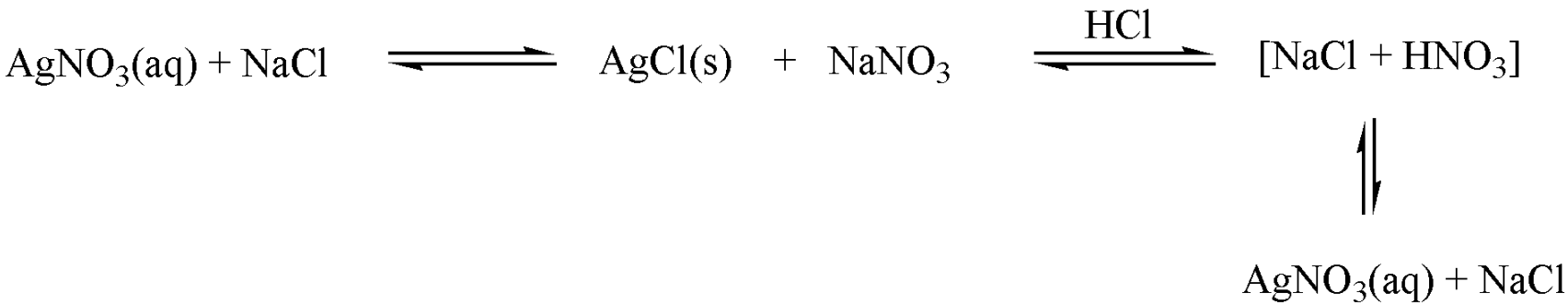
- With this system, it is easy to observe the shifts in equilibrium because the cobalt compounds involved have two distinct colors.
- When a stress is applied to this system, the direction in which the equilibrium was shifted may be readily observed.

Equilibrium of sparingly soluble salts

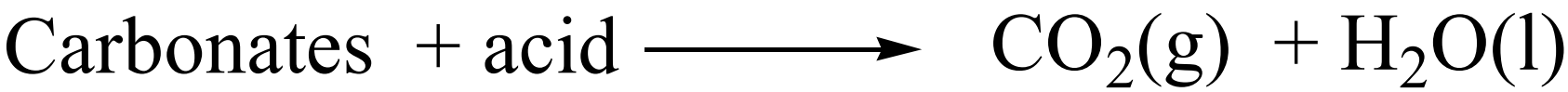


- Silver carbonate, chloride and iodide have limited solubility in water.
- Addition of a solution of these ions causes precipitation of the silver salt.

Addition of HCl to silver salt



Addition of acid to carbonate



This causes removal of the carbonate ions from the system and shifts the equilibrium.

Effect of temperature

Place ~ 1 mL of a $CoCl_2$ solution in a test tube and place the tube in the boiling water.

$CoCl_2$ is blue.

Observe the color of the reaction and comment on whether the reaction is exothermic or endothermic.

Caution

- Silver salts stain your skin!
- Ammonia has an irritating odor.
- Wear gloves at all times.
- Clean benches thoroughly after experiment.
- Take care with acids.