Pakistan School
Kingdom of Bahrain


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PAKISTAN SCHOOL
المدرسة الباكستانية

Class: 10th

Subject: Chemistry

Review:

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

$2N_2 + O_2 \rightleftharpoons 2NO_2$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Topic

- Conditions for equilibrium
- Ways to recognize equilibrium

Objective

At the end of this lesson Students will be able to:

- State the necessary conditions for equilibrium constant and the ways that equilibrium can be recognized.
- Determine the units of equilibrium constants

Conditions for equilibrium

i) Concentration:

Concentration of none of the reactants or products is changed.

ii) Temperature:

Temperature of the system is kept constant.

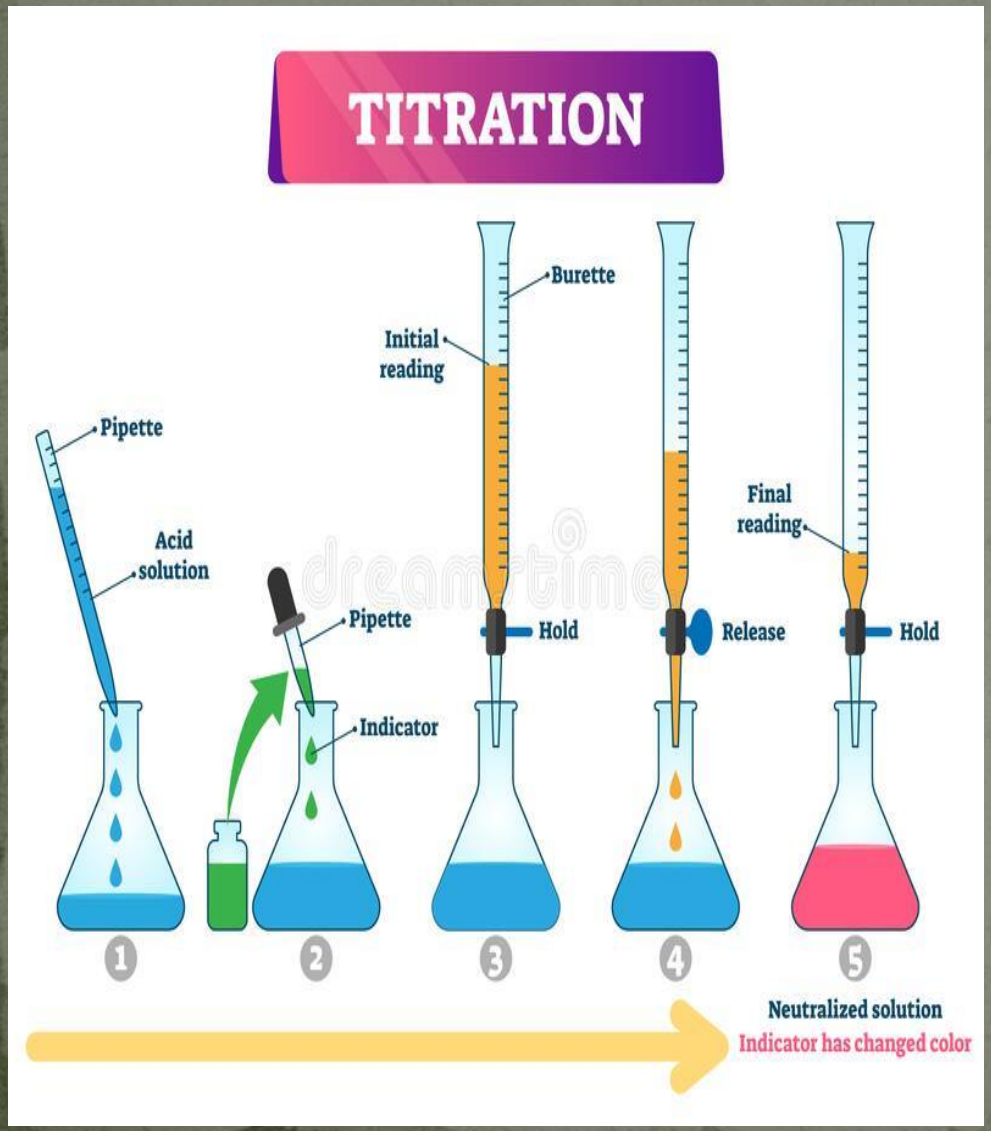
iii) Pressure or Volume:

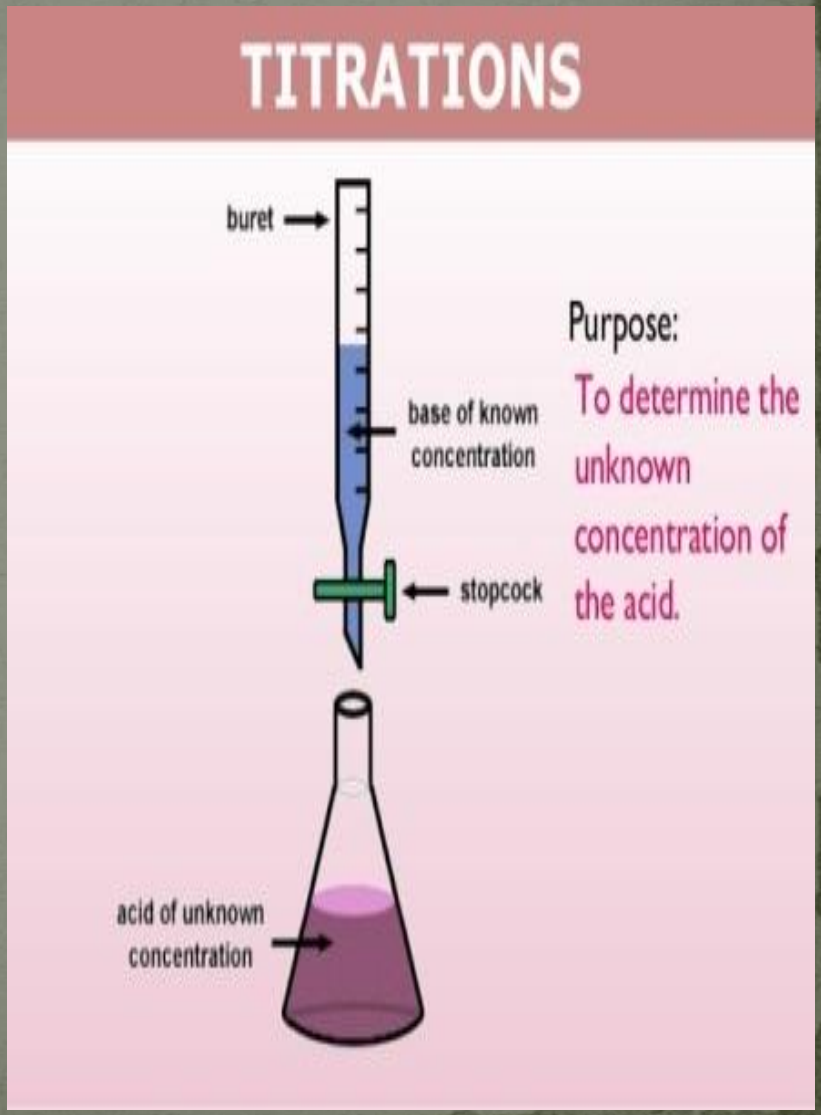
Pressure or volume of the system is kept constant.

Way to recognize Equilibrium

- **Equilibrium state of a chemical reaction can be determined by determining concentration of reactants and products at regular intervals. When constant concentration of products and reactants is observed, the reaction is at equilibrium. This can be done by both physical method as well as chemical methods such as titration, spectroscopy etc.**

Titration:


TITRATION
Burette
Initial reading
Pipette
Acid solution
Pipette
Indicator
Hold
Release
Final reading
Hold
1
2
3
4
5
Neutralized solution
Indicator has changed color


TITRATIONS
buret
base of known concentration
stopcock
acid of unknown concentration
Purpose:
To determine the unknown concentration of the acid.

Spectroscopy:

- **Spectroscopy** is used in physical and analytical **chemistry** because atoms and molecules have unique spectra. As a result, these spectra can be used to detect, identify and quantify information about the atoms and molecules

Catalyst

A catalyst is a substance which increases the rate of a chemical reaction. Catalysts reduce the time taken to reach equilibrium, but they have no effect on the position of equilibrium once this is reached.

- **Why should we always add acid to water when diluting it?**

The addition of water to the concentrated sulphuric acid produces a vigorous reaction, which often causes acid droplets to spew in all direction. Always add the acid to water when diluting it.

Determine the units of equilibrium constants:

i) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

$$K_c = \frac{[SO3]2}{[SO2]2\,[O2]}$$

$$K_c = \frac{[\,mol.dm{-}3]2}{[mol.dm{-}3\,]2\,[mol.dm{-}3\,]}$$

$K_c = mol^{-1}.dm^3$

ii) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$$K_c = \frac{[\,NH3\,]2}{[N2]\,[H2]3}$$

$$K_c = \frac{[\,mol.dm{-}3]2}{[mol.dm{-}3\,]\,[mol.dm{-}3\,]3}$$

$K_c = mol^{-2}.dm^6$

iii) $2N_2 + O_2 \rightleftharpoons 2NO_2$

$$K_c = \frac{[\,NO2\,]2}{[N2]2\,[O2]}$$

$$K_c = \frac{[\,mol.dm{-}3]2}{[mol.dm{-}3\,]2\,[mol.dm{-}3\,]}$$

$K_c = mol^{-1}.dm^3$

Importance of equilibrium constant for a chemical reaction:

i) Determine the equilibrium concentration of equilibrium mixture knowing the initial concentration of reactants.

ii) Predict the direction of a chemical reaction.

iii) Predict the extent of a chemical reaction.

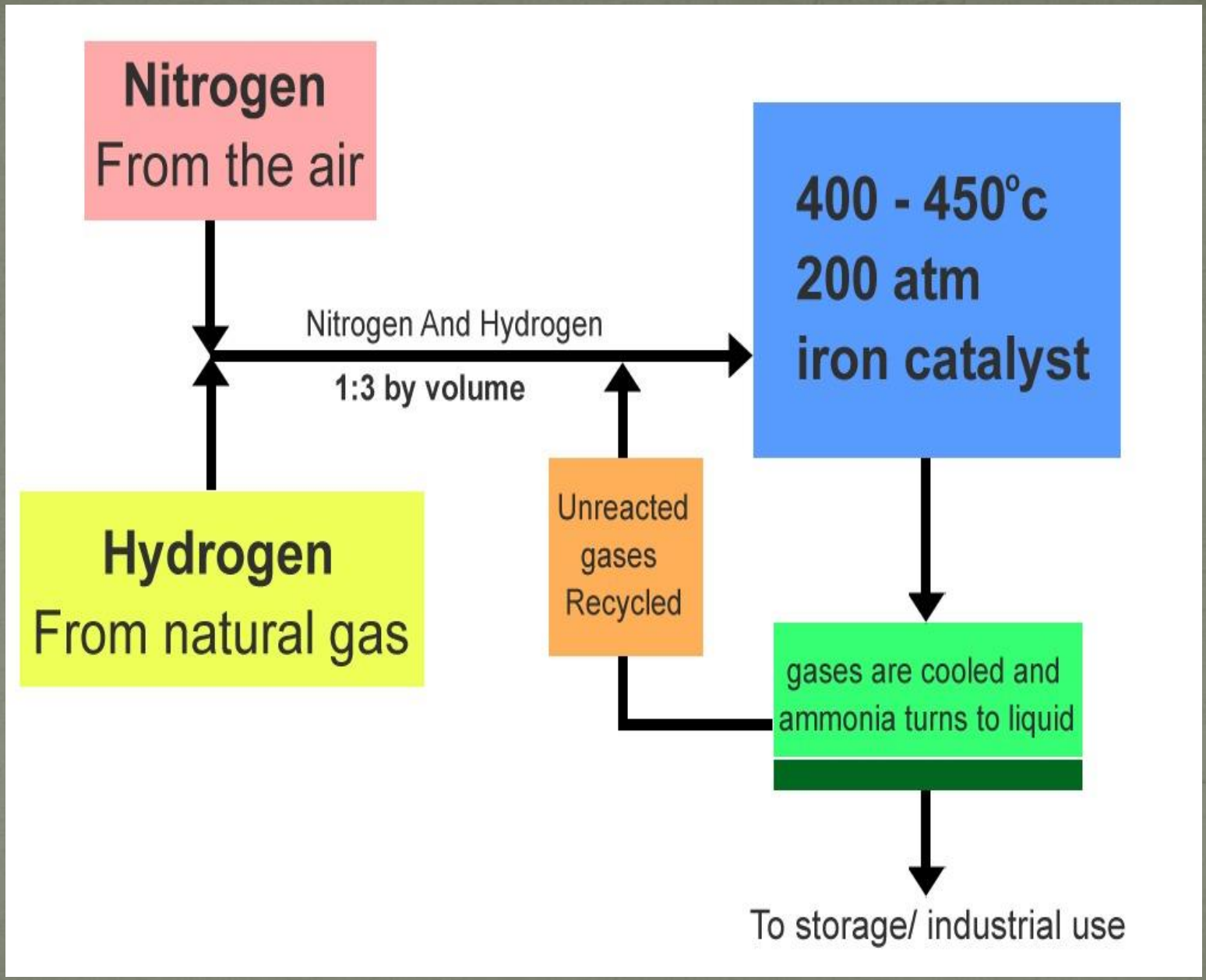
iv) Predict the effect of change in conditions of a chemical reaction on the equilibrium state.

Haber Process:

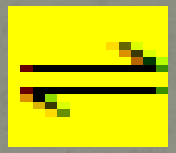
Ammonia is produced by the reaction of nitrogen with hydrogen at 450° C, 200 atm pressures and in the presence of a catalyst.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

This is known as Haber process .This is reversible process and produces only 33% NH_3 at equilibrium. The high pressure is used to favor the formation of ammonia. Then, cooling the equilibrium mixture gives 98% ammonia.


Nitrogen
From the air
Nitrogen And Hydrogen
1:3 by volume
400 - 450°c
200 atm
iron catalyst
Hydrogen
From natural gas
Unreacted
gases
Recycled
gases are cooled and
ammonia turns to liquid
To storage/ industrial use

Contact Process:

- **Sulphuric acid is produced on the large scale by the contact process. In this process sulphur is converted into sulphur dioxide.**
- **$S + O_2$  SO_2**

- **Sulphur dioxide is purified and further oxidized at 450° C and 200 atm pressure in the presence of Pt or V_2O_5 as catalyst.**

- $2SO_2 + O_2 \rightleftharpoons 2SO_3$

- This reaction is reversible reaction .Here again by the application of principles of chemical equilibrium, maximum amount of SO_2 is converted into SO_3.Sulphur trioxide is than converted into 100% pure sulphuric acid.

Le Chatellier's principle:

- It says that" if you impose a change in concentration, temperature or pressure on a chemical system at equilibrium, the system responds in a way that opposes the change.
- With the application of this principle, components of air i.e. N_2 and O_2 can be used successfully in producing important chemicals, so inadequate amount of products are formed under normal conditions.

Le Chatelier's Principle

- When a system is in equilibrium and a stress is added to the system, the system will shift in order to alleviate itself of the stress in order to return to equilibrium

- Stresses:
  1. concentration changes
  2. temperature changes
  3. pressure changes

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \qquad (V_2O_5, \text{ at } 450^0\,C \text{ and } 200 \text{ atm})$$

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad (Fe, \text{ at } 450^0\,C, 200 \text{ atm})$$

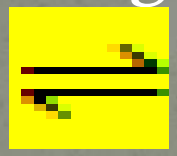
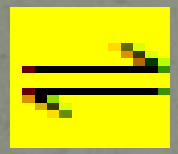
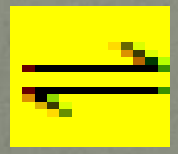
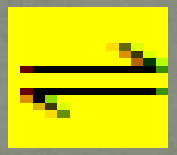
As such these reactions are uneconomical; However, Le Chatellier's principle has made it possible to get maximum amounts of products.

Plenary

- Equilibrium state of a chemical reaction can be determined by determining concentration of reactants and products at regular intervals. (T/F)
- Why should we always add acid to water when diluting it?
- Define Catalyst?
- Sulphuric acid is produced on the large scale by the ___ process(Haber/ contact)

Home wrok

Determine the units of equilibrium constants for the following reactions.

- $COCl_2$  $CO + Cl_2$
- $H_2 + I_2$  $2HI$
- $2H_2 + O_2$  $2H_2O$
- $N_2 + 2O_2$  $2NO_2$


STAY
home
STAY
safe

ALLAH HAFIZZ