University of Science & Technology

Faculty of Engineering - First year - Batch 31

General Chemistry

Lecture 3

States of Matter – 1

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Matter can exist in different states

— as a solid, a liquid or a gas.

Solid:

- In solids, particles are tightly packed together.
- The gaps between the particles are tiny and hence it is hard to compress.
- Solid has a fixed shape and volume ,cannot flow.
- Kinetic energy of the particles is low.

Liquid:

- **In a liquid state of matter, particles are less tightly packed as compared to solids.**
- **Liquids flow and can be poured.**
- **Liquids have fixed volume but no fixed shape ~ taking the shape of the container in which they are kept.**
- **Less dense than solids.**
- **Medium kinetic energy.**

Gaseous State:

- **In gases, particles are far apart from each other. They flow and completely fill the container.**
- **Gases have neither a fixed volume nor a fixed shape.**
- **The gaseous state has the highest compressibility as compared to solids and liquids.**

- **The rate of diffusion is higher than solids and liquids.**
- **The kinetic energy of particles is higher than in solids and liquids.**
- **The intermolecular forces of attraction are weak. These weak forces allow rapid, independent movement of the molecules.**

- **Gases are capable of infinite expansion.**
- **Gases have much lower densities than liquids and solids.**

Substances that exist as Gases:

* **Elements that exist as gases at 25˚C and 1 atm are H_2, N_2, O_2, F_2, Cl_2 and Noble gases.**
* **Ionic compounds do not exist as gases at 25˚C and 1 atm.**
* **Molecular compounds(covalent compounds) are more varied.**

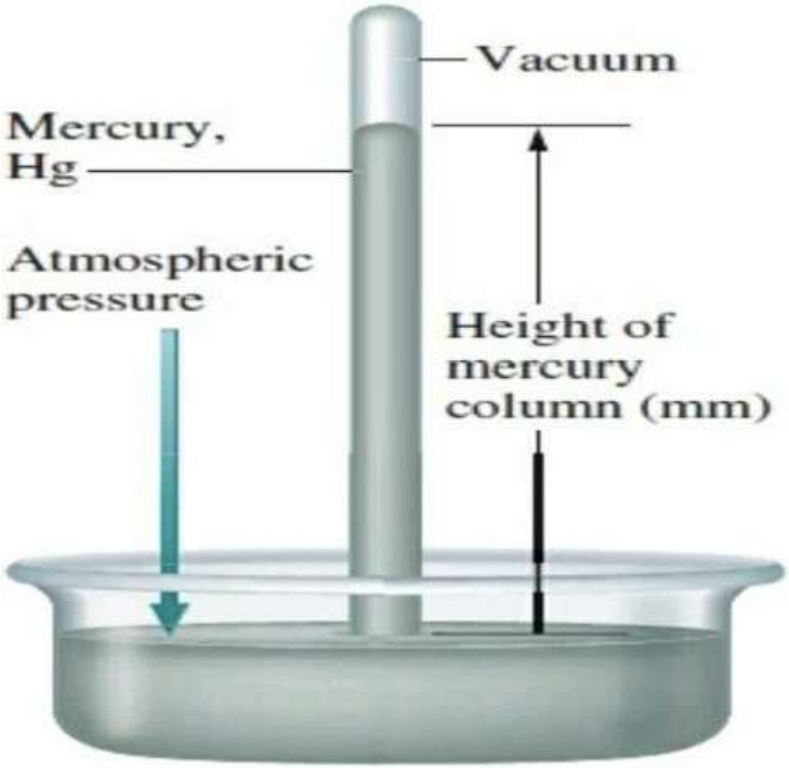
Gas Pressure and its measurement:

- **Gases exert pressure on any surface with which they come in contact, because gas molecules are constantly in motion.**
- **Pressure is one of the most readily measurable properties of a gas. Pressure = Force / Area**

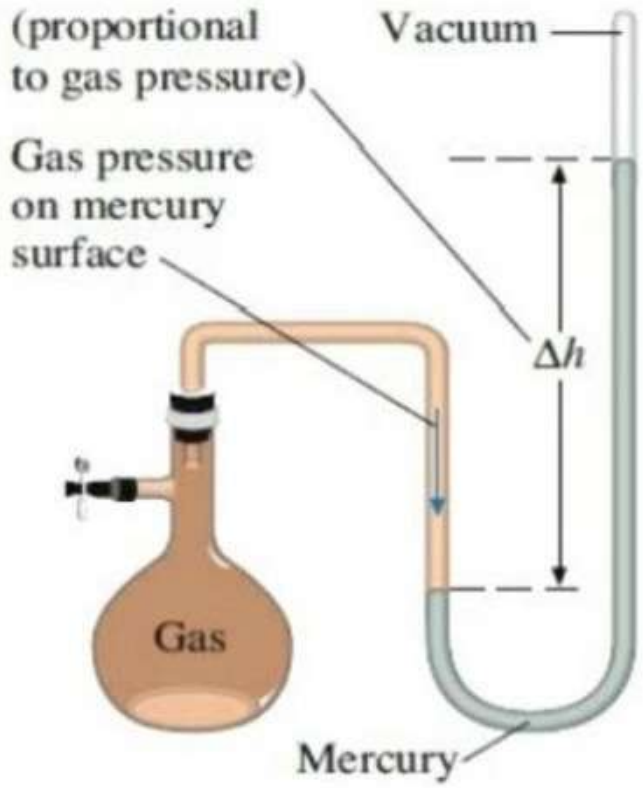
- **The SI unit of pressure is the pascal (pa).**

$$1 \text{ pa} = 1 \text{ N/m}^2.$$

- **A barometer is a device for measuring the pressure of the atmosphere.**



A manometer is a device that measures the pressure of a gas or liquid in a vessel.



The unit millimeters of mercury (mmHg), also called the torr is a unit of pressure equal to that exerted by a column of mercury 1mm high at 0.00˚C.

The standard atmospheric pressure (1atm) is equal to the pressure that supports a column of mercury exactly 760 mmHg.

$$\textbf{1 atm = 760 mmHg = 760 torr = } 1.01325 \times 10^{5} \textbf{pa}$$

Gas Laws:

The behavior of gases is summarized by the gas laws:

Boyle's law:

At constant temperature, the volume of a sample of gas is inversely proportional to the applied pressure.

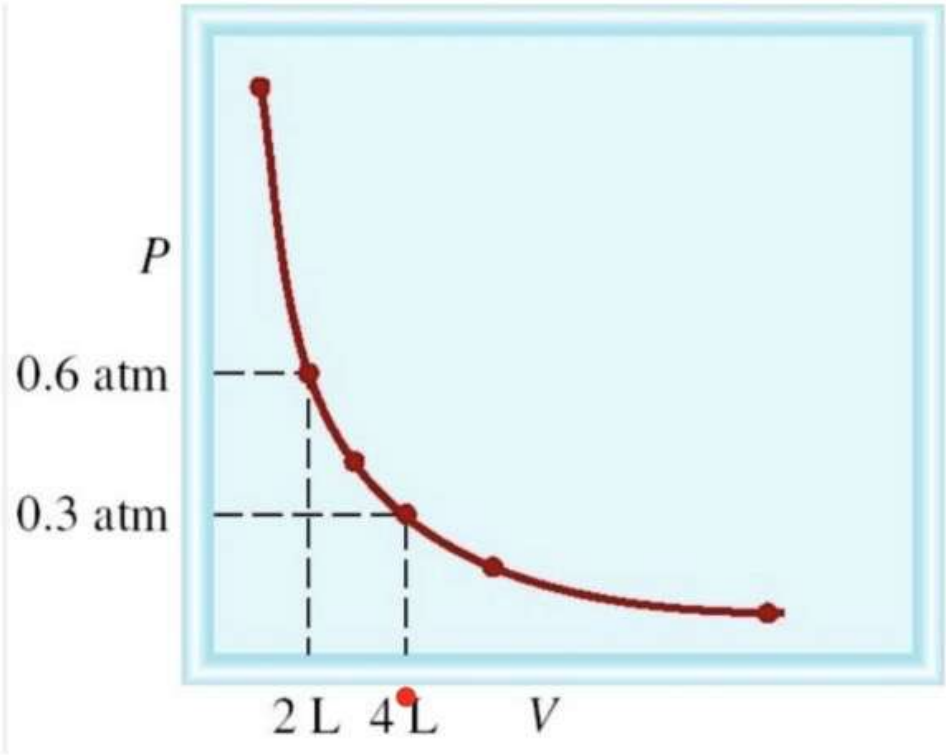
$$V \propto \frac{1}{P}$$

V = volume

P = pressure **α = proportional to**

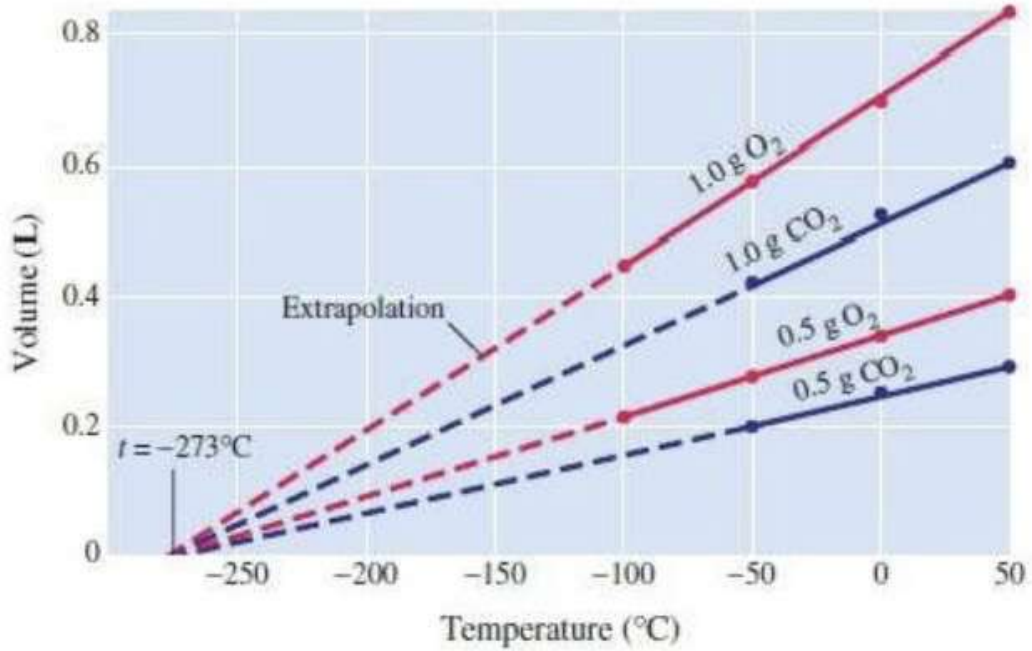
PV = constant (at fixed temperature(

⋆**If the pressure is doubled, the volume is halved.**



Charles's law:

At constant pressure, the volume of a sample of a gas is directly proportional to the absolute temperature.



Linear relationship of gas volume and temperature at constant pressure

$V \propto T$, $V = kT$

$\frac{V}{T} = k$ (for a given amount of gas at a fixed pressure)

Doubling the absolute temperature of a gas doubles its volume.

Avogadro's law:

The volume of a gas at constant temperature and pressure is directly proportional to the number of molecules of the gas.

V α number of moles(n) V = constant X n

Or $V_1 / n_1 = V_2 / n_2$

example: + N_2(g(⟶ $2NH_3$ (g(

$3H_2$ (g(+ 1 ⟶ 2molecul

3 molecules ⟶ es 2

molecules + 1 mole ⟶ moles

3 moles + 1 volume 2

3 volumes volumes

Boyle's law, Charles's law and Avogadro's law are special cases of one equation, the ideal gas equation:

$$PV = n R T \longrightarrow (1)$$

P = the pressure of a gas.
V = its volume.
n = the number of moles of gas.
T = its temperature on the Kelvin scales.
R = proportionality constant called the gas constant.

Standard temperature and pressure, STP:

- **Standard temperature is 0˚C or 273.15 K;**
- **Standard pressure is 760 mmHg (torr) or 1 atm.**
- **The volume of one mole of ideal gas at STP equals 22.414 L.**

R = 0.082057 atm. L/mol K.

R = 8.314 KPa. L/mol K

R = 62.36 mmHg. L. mol^{-1}. K^{-1}

Example 1:

Calculate the volume occupied by 0.54 mol of N_2 at 15˚C & 0.967 atm (R= 0.08206 L.atm/mol K).

Solution:

PV = n RT, n = 0.54mol; P = 0.967atm; T= 15 +273 = 288K

$$V = \frac{nRT}{P} = \frac{0{,}54 \times 0.08206 \times 288}{0.967} = 13\text{L}$$

Quiz

1. The state of matter in which particles are tightly packed together and has a fixed shape and volume is…….

2. The state of matter with the lowest density among solid, gas and liquid is……

3. The volume of a gas is……proportional with the applied pressure.

4. The standard pressure is equal to …….. mmHg or ….. atm.

5. Calculate the volume in liters occupied by 2.12 mol of NO at 76˚C & 6.54 atm(R= 0.08206 L.atm/mol K).