Ratna Sagar

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Education, Our Mission

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9

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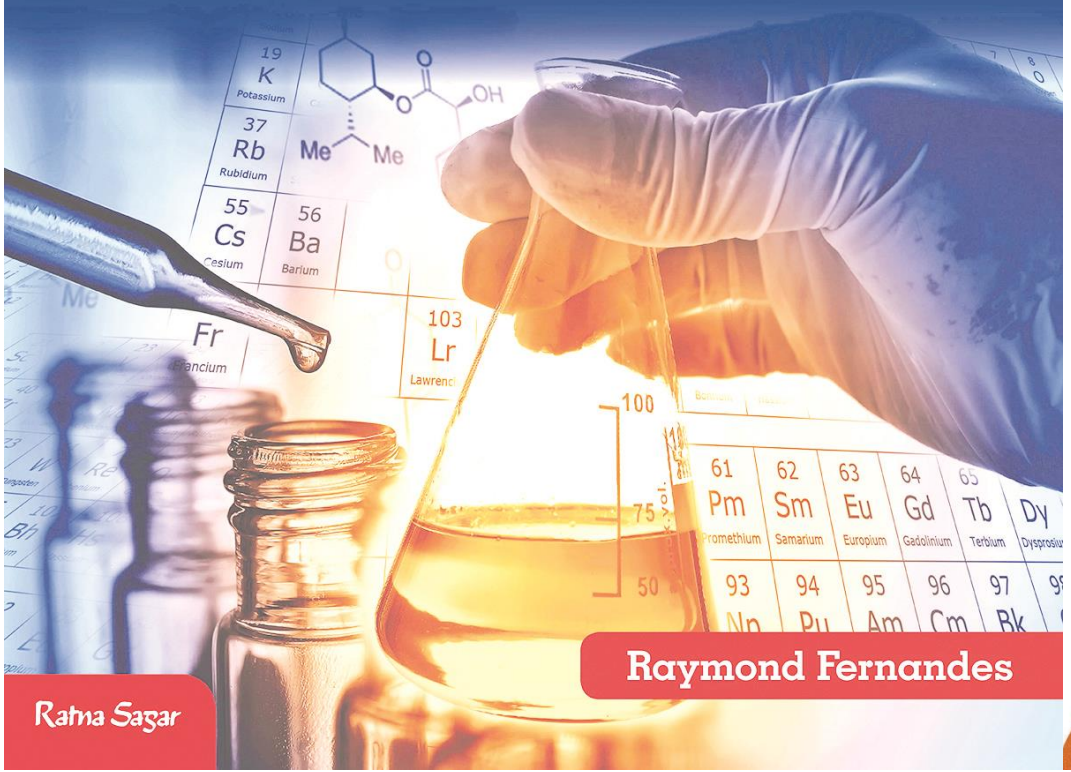
Living Science CHEMISTRY



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ICSE
Living Science
Chemistry

Class 9

Chapter 7 Study of Gas Laws

LEARNING OBJECTIVES

Kinetic Theory of Gases

- ❖Behaviour and characteristic properties of gases
- ❖The gas laws

Boyle's Law

- ❖Volume–pressure relationship
- ❖Graphical representation of Boyle's law

Charles' Law

- ❖Volume–temperature relationship
- ❖Mathematical expression of Charles' law
- ❖ Graphical representation of Charles' law

The Gas Equation

What is Kinetic Theory of Gases?

The general behaviour of gases, explained by varied gas laws compiled over the years came to be known as the **kinetic theory of gases**. This theory has been proved remarkable in explaining the behaviour and properties of gases.

What are the Main Postulates of Kinetic Theory of Gases?

1. Gases are made up of minute particles called molecules, atoms or ions.

2. The actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas.

3. The particles of a gas are in rapid motion in straight lines until they collide with each other or with the walls of the container. The pressure exerted by gases are the result of these collisions.

4. The particles of a gas are perfectly elastic. No energy is lost when the particles collide.

5. The average kinetic energy of the particles increases in direct proportion to the absolute temperature of the gas.

6. Intermolecular force of attraction between particles of a gas is negligible.

Behaviour and characteristic properties of gases

1. Gases have no definite shape or volume: Molecules in a gas are far apart and in random motion. This random motion causes the gas to expand and fill the closed container.

2. Gases exert pressure in all directions: Particles of a gas are in rapid motion in straight lines until they collide with each other or with the walls of the container. The pressure exerted by gases are the results of these collisions.

3. Gases are easily and highly compressible: The actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas

4. Gases are indefinitely expansible: The intermolecular force of attraction between particles of a gas is negligible.

5. Gases diffuse or disperse with no outside help: Gases are composed mostly of empty spaces. The particle of one gas can penetrate the empty spaces between the particles of another gas.

6. Gases have relatively low density: The actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas.

Gas laws

Physical behaviour of a gas can be defined by three variables namely, pressure (*P*), temperature (*T*) and volume (*V*). The specific relationship between the three variables are called **gas laws**. A gas whose behaviour follows the law exactly is called an **ideal gas**.

Boyle's Law

Volume–pressure relationship

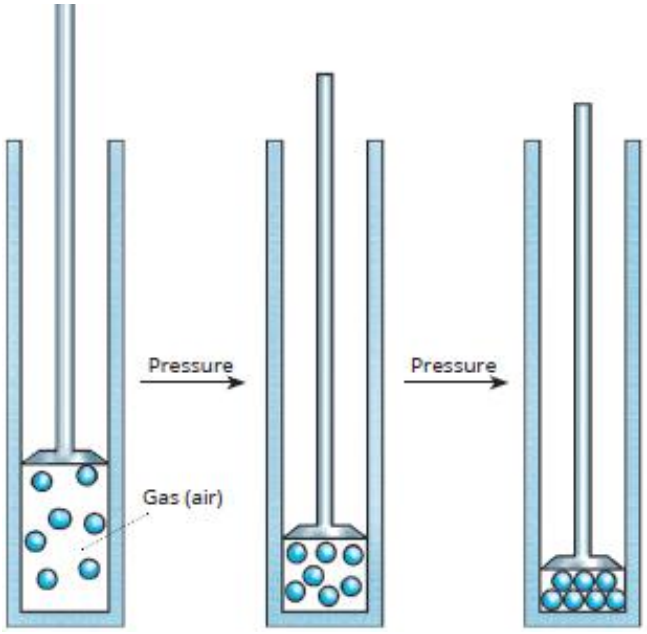
The temperature remaining constant, the volume of a given mass of gas is inversely proportional to the pressure applied to it.

According to Boyle's law,

$$P \propto 1/V \text{ (temperature remaining constant)}$$

or, $PV = k$ (a constant)

The value of k depends on the nature and mass of the gas.



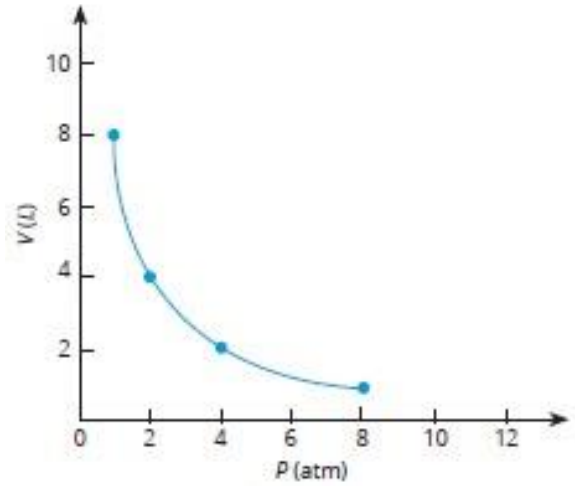
Increase in pressure brings the molecules close together

Now, let the volumes occupied by the same amount of gas be V_1 and V_2 at pressures P_1 and P_2 respectively, at constant temperature. Then

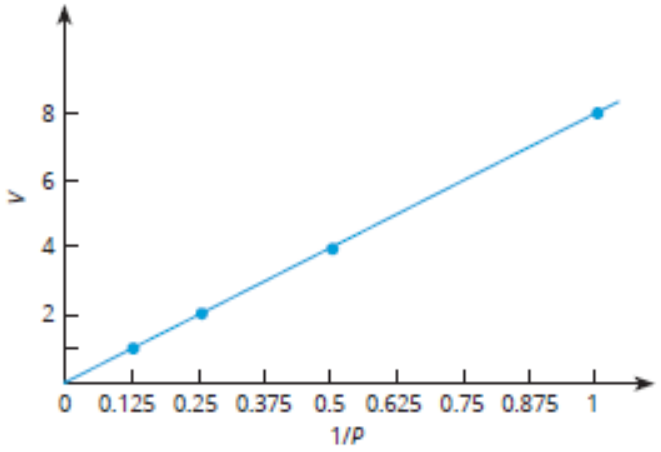
$$P_1V_1 = P_2V_2$$

Graphical representation of Boyle's law

When volume is plotted against pressure and temperature is constant, we get a curve which is called **isotherm**. From the graph, it is clear that, at high pressure, the volume of the gas is small and as the pressure decreases, volume increases.



Variation of volume with pressure at constant temperature



Graph of volume against inverse of pressure at constant temperature

When volume is plotted against reciprocal of pressure, a straight line passing through the origin is obtained. This indicates that 1/*P* is directly proportional to *V*, and therefore, *P* is inversely proportional to *V*.

Charles' Law

The volume of a fixed mass of a gas increases or decreases by 1/273 of its volume at 0 ° C for each degree rise or fall of temperature, provided pressure remains the same.

Charles' law can also be stated as, at constant pressure, the volume of a fixed mass of a gas is directly proportional to its absolute (Kelvin) temperature.

Mathematical expression of Charles' law

Let the volumes of a fixed mass of a gas at 0 ° C and t ° C are V_0 and V respectively, then

$$V = (V_0 + V_0/273) \times t$$

$$= V_0 (1 + t / 273) = V_0 \frac{(273 + t)}{273}$$

$$= V_0(T/T_0) = V/T = V_0/ T_0$$

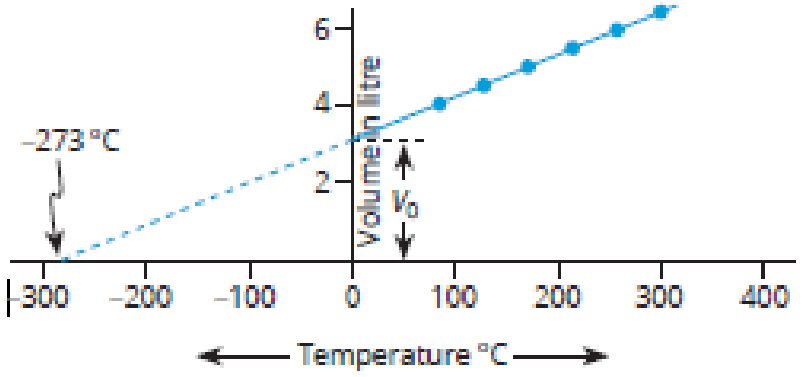
$$V/T = \text{Constant}$$

Graphical representation of Charles' law

When the volume of a certain mass of a gas is plotted against the corresponding temperature at constant pressure, a straight line graph is obtained.

The curve obtained by plotting volume (V) vs temperature (T) at any given pressure is called **isobar**.

On heating the gas, the kinetic energy of molecules increases. This means the molecules will move faster. Hence the gas will expand provided pressure remains constant.



Volume vs Temperature (° C) graph

The Gas Equation

Boyle's law and Charles' law can be combined to form one single relation. The equation is called **gas equation**. According to the Boyle's law,

$$V \propto 1/P \text{ at constant temperature}$$

According to the Charles' law,

$$V \propto T \quad \text{at constant pressure}$$

Then, combining the two laws, we have

$$V \propto T/P$$

$$V = k\,T/P \ (k \text{ is gas constant})$$

or $$PV/T = k$$

Thus, if the volume of a fixed mass of a gas changes from V_1 to V_2, its pressure from P_1 to P_2 and temperature from T_1 to T_2, we have

$$P_1V_1/T_1 = P_2V_2/T_2$$

The above mathematical relation is called gas equation.

SUMMARY..

1. Main postulates of Kinetic theory of gases

- Gases are made up of minute particles called molecules, atoms or ions.
- The actual volume occupied by the particles is only a small fraction of the entire space occupied by the gas.
- The particles of a gas are in rapid motion in straight lines until they collide with each other or with the walls of the container. The pressures produced by gases are the results of these collisions.
- The particles of a gas are perfectly elastic. No energy is lost by their collisions.
- The average kinetic energy of the molecules of a gas increases or decreases in direct proportion to the absolute temperature of the gas.
- Gas particles exert no attractive or repulsive force on one another. The effect of gravity on the motion of molecules is negligible.

2. General behaviour of gases

- Gases have no definite shape or volume.
- Gases exert pressure in all directions.
- Gases are easily and highly compressible.
- Gases are indefinitely expansible.
- Gases diffuse or disperse with no outside help.
- Gases have relatively low density.

3. Boyle's law

The temperature remaining constant, the volume of a given mass of gas is inversely proportional to the pressure applied to it.

$$V \propto 1/P \text{ or } \quad PV = k \text{ (a constant)}$$

4. Charles' law

The pressure remaining constant, the volume of a given mass of gas is directly proportional to its absolute temperature.

$$V \propto T \text{ or } VT = k \text{ (constant)}$$

5. Gas equation

Boyle's law and Charles' law can be combined to form one single relation. The equation is called gas equation.

$$V \propto T/P \text{ or } V = k\,T/P \text{ (k is gas constant)}$$

or $$PV/T = k$$

6. The S.T.P. conditions are 1 atm or 76 cm of Hg (or 760 mm of Hg) as standard pressure and 0 ° C or 273 K as standard temperature.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