Chapter 2. Study of Gas Laws

Solution 1.

The state of matter in which inter-particle attraction is weak and inter-particle space is so large that the particles become completely free to move randomly in the entire available space, is known as gas.

Solution 2.

The main assumption of kinetic molecular theory of gases are as follows:

1. All gases are made up of a large number of extremely small particles called molecules.
2. There are large vacant spaces between the molecules of a gas so that actual volume of the molecules of a gas is negligible as compared to the total volume occupied by the gas.
3. The molecules of a gas are always in a state of constant random motion in straight lines in all possible direction.
4. There are negligible attractive forces between the molecules of a gas.
5. There is no effect of gravity on the motion of the molecules of a gas.
6. The average kinetic energy of the molecules of a gas is directly proportional to that of the Kelvin temperature of the gas.
7. The molecules are perfectly elastic so that there is no net loss of energy during molecular collisions.
8. The pressure of a gas is due to the bombardment of the molecules of a gas against the walls of a container.

Solution 3.

In a laboratory, when hydrogen sulphide gas is prepared, it can be smelt even at 50 meters away. This is due to the phenomenon called Diffusion.

Diffusion is a process of intermixing of two substances kept in contact.

The inter-particle or inter molecular spaces in a gas are very large. When hydrogen sulphide gas is produced, its particle collides with air particles. Due to the collisions of particles, they start moving in all possible directions. As a result of which the two gases mix with each other forming a homogeneous mixture of a gas. Thus, the released gas can be smelt to a long distance.

Solution 4.

Pressure and volume relationship of gases-
Experiment: Take a 10 ml syringe fitted with a piston. Raise the latter to the 10 ml mark and wrap an adhesive tape over its nozzle. Fit the wrapped nozzle tightly into a hole, bored half way through a rubber stopper.

Observation: On placing some weight on the piston (to put pressure), the piston moves downward and reduces the volume of air. Gradually, put more weight. The piston moves further downward and the volume of the air is further reduced.

Now remove the weights one by one. You will notice that, on decreasing the pressure, the piston moves upward as such the volume of the air increases.

Conclusion:

1. An increase in pressure at constant temperature causes a decrease in the volume of a gas; conversely, if the volume of a fixed mass of a gas at constant temperature is decreased, the pressure of the gas increases.
2. A decrease in pressure at constant temperature causes a increase in the volume of a gas; conversely, if the volume of a fixed mass of a gas at constant temperature is increased, the pressure of the gas decreases.

Pressure-volume relationship
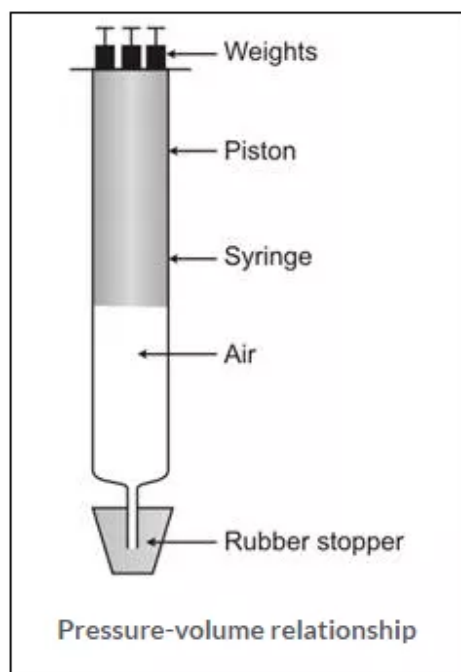
Solution 5.

The molecular motion is directly proportional to the temperature.
As temperature increases, molecular motion increases because the molecule possesses certain kinetic energy. And as the temperature decreases, molecular motion also decreases. Thus, when temperature is zero, molecular motion stops or ceases.

Solution 6.

The three variables for gas laws are:

1. Volume, V
2. Pressure, P
3. Temperature, T

These three are called as the **Standard variables**. S.I. unit of volume is cubic meter (m^3).
S.I. unit of pressure is Pascal (Pa).
S.I. unit of temperature is Kelvin (K) or degree Celsius (^{0}C).

Solution 7.

Boyle's law: At constant temperature, the volume of a definite mass of any gas is inversely proportional to the pressure of the gas.   Or
Temperature remaining constant, the product of the volume and pressure of the given mass of a dry gas is constant.

Mathematical representation:

According to Boyle's Law,

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

$$V = K . \frac{1}{P}$$

$$= \frac{K}{P}$$

$$K = VP \text{ or } PV$$

Where K is the constant of proportionality if V' and P' are some other volume and pressure of the gas at the same temperature then,
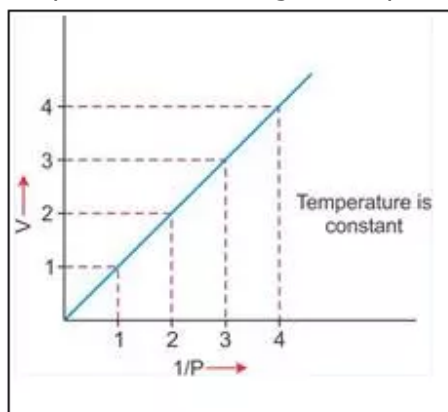
$$V' \propto \frac{1}{P'}$$

$$V' = K . \frac{1}{P'}$$
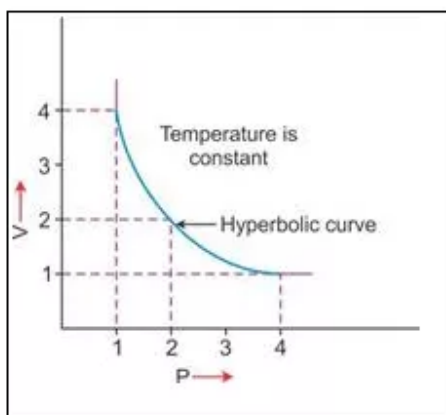
$$= \frac{K}{P'}$$

$$K = V'P' \text{ or } PV$$

Graphical representation of Boyle's Law:

1. V vs $\frac{1}{P}$: Variation in volume (V) plotted against (1/P) at a constant

temperature, a straight line passing through the origin is obtained.

2. V vs P : Variation in volume (V) plotted against pressure (P) at a constant temperature, a hyperbolic curve in the first quadrant is obtained.

3. PV vs P : Variation in PV plotted against pressure (P) at a constant temperature, a straight line parallel to X-axis is obtained.
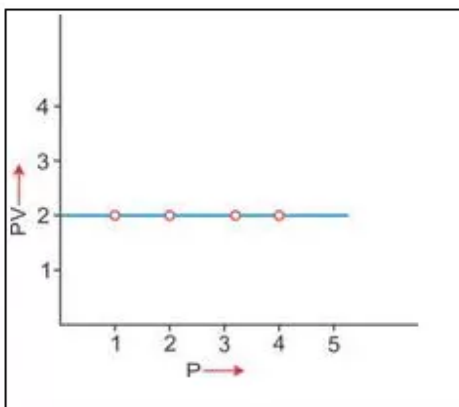
Significance of Boyles law:

According to Boyles law, on increasing pressure, volume decreases. The gas becomes denser. Thus, at constant temperature, the density of a gas is directly proportional to the pressure.

At higher altitude, atmospheric pressure is low so air is less dense. As a result, lesser oxygen is available for breathing. This is the reason that the mountaineers have to carry oxygen cylinders with them.

Solution 8.

Explanation of Boyle's Law on the basis of kinetic theory of matter.

According to kinetic theory of matter, the number of particles present in a given mass and the average kinetic energy is constant.

If the volume of given mass of a gas is reduced to half of its original volume. The same number of particles will have half space to move.

As a result, the number of molecules striking the unit area of the walls of the container at given time will get doubled of the **pressure will also get doubled.**

Alternatively, if the volume of a given mass of a gas is doubled at constant temperature, same number of molecules will have double space to move. Thus, number of molecule striking the unit area of the walls of container at a given time will become one half of original value. Thus, **pressure will also get reduced to half of original pressure.** Hence, it is seen that if pressure increases, volume of a gas decreases at constant temperature and this is **Boyle's law**.

Solution 9.

(a) Pressure will be doubled.
(b) Pressure remains the same.

Solution 10.

Charless Law

At constant pressure, the volume of a given mass of a dry gas increases or decreases by 1/273 of its original volume at 00C for each degree centigrade rise or fall in temperature.

$$V \propto T \text{ (At constant pressure)}$$

At temperature T_1 (K) and Volume V_1 (cm³)   At temperature T_2 (K), Volume is V_2 (cm³)

$$V_1 \propto T_1 \text{ or } \frac{V_1}{T_1} = K = \text{Constant} \qquad V_2 \propto T_2 \text{ or } \frac{V_2}{T_2} = K = \text{Constant}$$

$$\therefore \quad \frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{Constant}$$

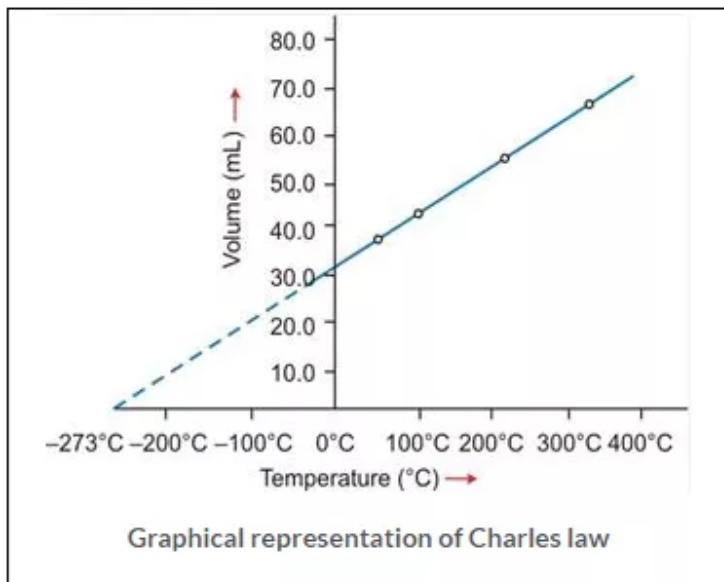For Temperature = Conversion from Celsius to Kelvin
1 K = ^{0}C + 273
For example,
20ºC = 20 + 273 = 293 K

Graphical representation of Charles law

T vs V: The relationship between the volume and the temperature of a gas can be plotted on a graph, A straight line is obtained.

Graphical representation of Charles law

Significance of Charles' Law: Since the volume of a given mass of gas is directly proportional to its temperature, hence the density decreases with temperature. This is the reason that:

(a) Hot air is filled in the balloons used for meteorological purposes. (b) Cable wires contract in winters and expand in summers.

Solution 11.

Explanation Of Charles' Law on the basis of kinetic theory of matter is as follows:

According to kinetic theory of matter, the average kinetic energy of the gas molecules is directly proportional to the absolute temperature. Thus, when the temperature of a gas is increased, the molecules would move faster and the molecules will strike the unit area of the walls of the container more frequently and vigorously. If the pressure is kept constant, the volume increases proportionately. Hence, at constant pressure, the volume of a given mass of a gas is directly proportional to the temperature (**Charles' law**).

Solution 12.

Absolute zero

The temperature - 273ºC is called absolute zero.

$$V = V_0 \left(\frac{273 + t}{273} \right)$$

$$\text{Volume at } -273°C = V_0 \left(\frac{273 - 273}{273} \right) = 0$$

Absolute or Kelvin scale of temperature

The temperature scale with its zero at – 273ºC and each degree equal to one degree on the Celsius scale is called Kelvin or the absolute scale of temperature.

Conversion of temperature from Celsius scale to Kelvin scale and vice versa

The value on the Celsius scale can be converted into Kelvin scale by adding 273 to it.
For example,
20ºC = 20 + 273 = 293 K

Solution 13.

(a) The behaviour of gases shows that it is not possible to have temperature below 273.15C. This act has led to the formulation of another scale known as Kelvin scale. The real advantage of the Kelvin scale is that it makes the application and the use of gas laws simple. Even more significantly, all values on the Kelvin scale are positive.

(b) The boiling point of water on the Kelvin scale is 373 K.
Now, K = C + 273 and C = K – 273
Kelvin scale can be converted to degree Celsius by subtracting 273 from it. So, boiling point of water on centigrade sale is : 373 K – 273 = **100C**

Solution 14.

(a) **Standard or Normal Temperature and Pressure (S.T.P. or N.T.P.)**

The pressure of the atmosphere which is equal to 76 cm or 760 mm of mercury is referred to as S.T.P. or N.T.P. The full form for S.T.P. is Standard Temperature and Pressure or Normal Standard temperature and pressure denotes 0ºC or 273K.

Value: The standard values chosen are 0ºC or 273 K for temperature and 1 atmospheric unit (atm) or 760 mm of mercury for pressure.

The standard values chosen are 0°C or 273 K for temperature and 1 atmospheric unit (atm) or 760 mm of mercury for pressure.

Standard temperature = 0°C = 273 K

Standard pressure = 760 mm Hg

= 76 cm of Hg

= 1 atmospheric pressure (atm)

(b) Because the volume of a given mass of dry enclosed gas depends upon the pressure of the gas and temperature of the gas in Kelvin so to express the volume of the gases we compare these to S.T.P.

Solution 15.

(a) (i) C = °C (ii) K = 273K

(b) (i) 1 atm (ii) 760 mm Hg (iii) 76 cm Hg. (iv) 1, torr = 133.32 Pascal

Solution 16.

Temperature on Kelvin scale (K) = 273 + Temperature on Celsius scale

Or K = 273 + °C

(i) 273C in Kelvin

t °C = t K – 273

273°C = t K – 273

T K = 273 + 273 = 546 K

273°C = 546 K

(ii) 293 K in °C

t °C = 293 – 273

t °C = 20°C

293 K = 20°C

Solution 17.

(a) Charles's Law

(b) Boyles Law

Solution 18.

(a) The real advantage of the Kelvin scale is that it makes the application and use of gas laws simple. Even more significantly, all values on the scale are positive. Thus, removing the problem of negative (-) values on the Celsius scale.

(b) The mass of a gas per unit volume is very small due to the large intermolecular spaces between the molecules. Therefore, gases have low density. Whereas in solids and liquids, the mass is higher and intermolecular spaces are negligible.

(c) At a given temperature, the number of molecules of a gas striking against the walls of the container per unit time per unit area is the same. Thus, gases exert the same pressure in all directions.

(d) Since the volume of a gas changes remarkably with change in temperature and pressure, it becomes necessary to choose standard value of temperature pressure.

(e) According to Boyle's Law, the volume of a given mass of a day gas is inversely proportional to its pressure at constant temperature.

According to Boyle's Law,

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

When a balloon is inflated, the pressure inside the balloon decreases and according to Boyle's Law, the volume of the gas should increase. But this does not happen. On inflation of a balloon along with reduction of pressure of air inside balloon, the volume of air also decreases. And this violates Boyle's law.

(f) Atmospheric pressure is very low at high altitudes, volume of air increases thus air becomes less dense. Because volume is inversely proportional to density. Hence, lesser volume of oxygen is available for breathing. Thus, mountaineers have to carry oxygen cylinders with them.

(g) In gas as inter-particle attraction is weak and inter-particle space is so large that the particles become completely free to move randomly in the entire available space and takes the shape of the vessel in which it is kept.

Solution 19.

The temperature scale with its zero at -273⁰C and where each degree is equal to degree on the Celsius scale is called the absolute scale of temperature.

The temperature -273⁰C is called the absolute zero. Theoretically, this is the lowest temperature that can never be reached. At this temperature all molecular motion ceases.

The temperature – 273⁰C is called absolute zero.

$$V = V_0 \left(\frac{273 + t}{273} \right)$$

$$\text{Volume at } -273°C = V_0 \left(\frac{273 - 273}{273} \right) = 0$$

Solution 20.

Gases like nitrogen, hydrogen are collected over water as shown in the figure. When the gas is collected over water. The gas is moist and contains water vapour. The total pressure exerted by this moist gas is equal to the sum of the partial pressures of the dry gas and the pressure exerted by water vapour: The partial pressure of water vapour is also known as Aqueous tension.

Collection of gas over water
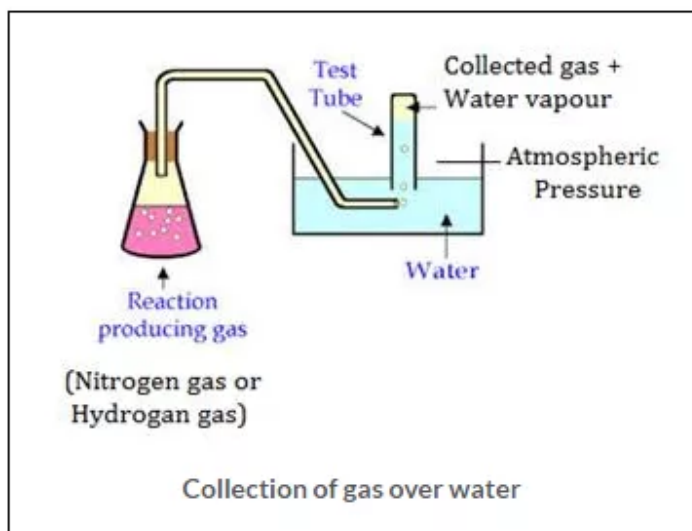
$P_{total} = P_{gas} + P_{water\ vapour}$

$P_{gas} = P_{total} - P_{water\ vapour}$

Actual Pressure of gas = Total pressure – Aqueous tension

Solution 21.

(a) The volume of gas is zero.

(b) The absolute temperature is 7 + 273 = 280 K

(c) The gas equation is-

$$\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$$

(d) Ice point = 0 + 273 = 273 K

(e) Standard Temperature is taken as 273 K or °C

Standard pressure is taken as 1 atmosphere (atm) or 760 mm Hg.

Solution 22.

(a) (iii) Straight line paralled to X- axis.

(b) (ii) 27C = 27 + 273 = 300 K

(c) (iv) Charles

(d) (ii) 1/2 times

Solution 23.

Column A	Column B
(a) Cm^3	Volume
(b) Kelvin	Temperature
(c) Torr.	Pressure
(d) Boyles law	$PV = P_1 V_1$
(e) Charles's law	$\dfrac{V}{T} = \dfrac{V_1}{T_1}$

Solution 24.

(a) Volume of a gas is directly proportional to the pressure at constant temperature.
(b) Volume of a fixed mass of a gas is inversely proportional to the temperature, the pressure remaining constant.
(c) -273C is equal to zero Kelvin.
(d) Standard temperature is 0°C
(e) The boiling point of water is -373 K.

Solution 25.

(a) Absolute temperature
(b) Absolute zero
(c) Volume
(d) 273

Numericals

Solution 1.

Given: $V = 800$ cm^3 $P = 650$ m $P_1 = ?$

V_1 = reduced volume = 40% of 800

$$= 800 \times \frac{40}{100} = 320$$

Net $V_1 = 800 - 320 = 480$ cm^3

$T = T_1$

Using gas equation, we get,

$$\frac{PV}{T} = \frac{P_1 V_1}{T_1}$$

$$\frac{800 \times 650}{T} = \frac{P_1 \times 480}{T}$$

Since, $T = T1$

$$\therefore P_1 = \frac{800 \times 650}{480}$$

= 1083.33 mm of Hg.

Solution 2.

Let, $V_1 = x$ $V_2 = ?$

$P_1 = 1$ atm. $P_2 = 2$ atm.

T_1 $T_2 = 3 T_1$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{1 \times x}{T_1} = \frac{2 \times V_2}{3 T_1}$$

$$V_2 = \frac{3 T_1 \ x}{T_1 \times 2}$$

$V_2 = 1\frac{1}{2}$ times original volume V_1

Solution 3.

P = 100   V = 20
P1 = 1   V = ?

T = T₁

Using equation,

$$\frac{PV}{T} = \frac{P_1 V_1}{T_1}$$

$$\frac{100 \times 20}{T}$$

$$\frac{1 \times V_1}{T}$$

∴ V_1 = 2000 lit. = 2m³   (Since, 1000 lit. = 1m³)

Volume of one flask = 200 cm³   = $\frac{200}{100 \times 100 \times 100}$ m³

∴   Number of flasks = $\frac{2 \times 1000000}{200}$

= 10000

Number of flasks = 10000

Solution 4.

V = 20 lit. P = 29 atm

P 1 = 1.25 atm V₁ =?

t = t₁

Using gas equation,

∵ $\frac{PV}{t} = \frac{P_1 V_1}{t_1}$ $\frac{29 \times 20}{t} = \frac{1.25 \times V_1}{t}$

∴ $V_1 = \frac{29 \times 20}{1.25}$
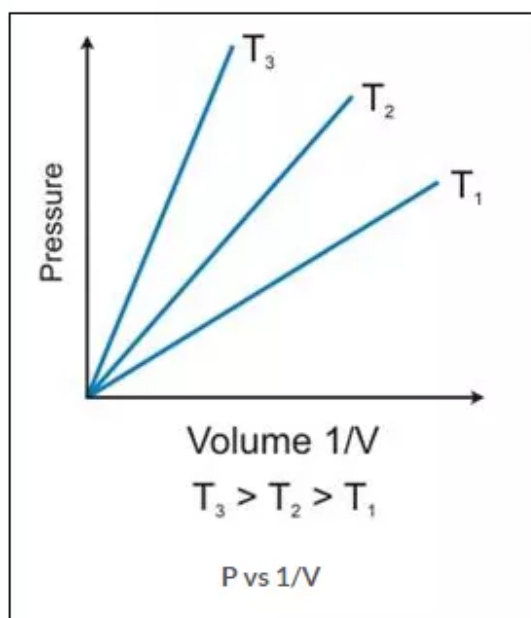
V_1 = 464 liters

Solution 5.
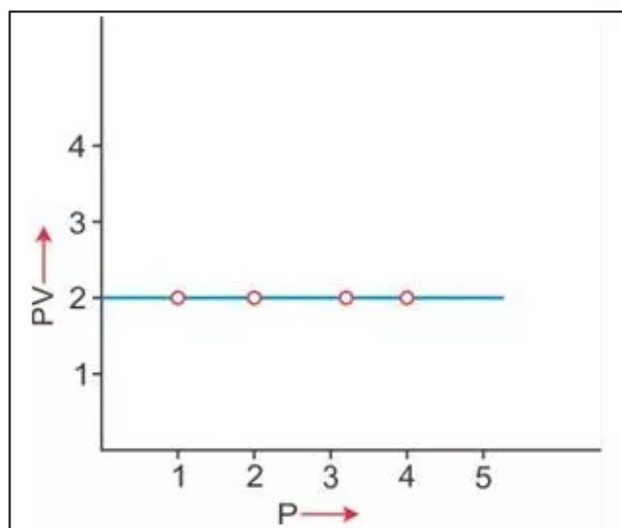
(a)
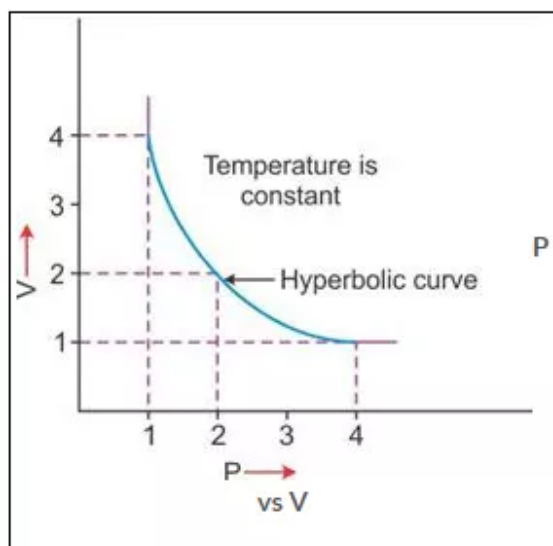
(b)

(c)

PV vs P

At .9 atmosphere volume = 24.9 liters

At 1 atmosphere volume = $\dfrac{24.9}{9}$

= 27.67 atm.

Solution 6.

V = 3 liters t = 0°C = 0 + 273 = 273 K

V_1 = ?

T_1 = -20°C = -20° + 273 = 253 K

P = P_1

Using gas equation,

$$\dfrac{PV}{T} = \dfrac{P_1V_1}{T_1}$$

$$\dfrac{3 \times P}{273} = \dfrac{V_1 \times P}{253} \quad \left[\because P = P_1\right]$$

$$\therefore V_1 = \dfrac{3 \times 253}{273}$$

= 2.78 liters

$\therefore V_1$ = 2.78 liters

Solution 7.

(a)

V = 2 liters P =760 mm

V_1 = 4 Dm^3 = 4 X I0m X 10m X 10m = 4000 m^3 [since, 1 Dm^3 = 1000 m^3]

= 4 lit. [Since, I lit = 1000 m^3]

P_1 = ?

t = t_1

Using gas equation,

$$\frac{PV}{t} = \frac{P_1 V_1}{t_1}$$

$$\frac{2 \times 760}{t} = \frac{P_1 \times 4}{t_1} \quad [\because t = t_1]$$

$$P_1 = \frac{2 \times 760}{4} = \frac{760}{2} = 380$$

P_1 = 380 mm.

Solution 8.

V = 500 cm^3

Normal temperature, t = 0°C = 0 + 273 K

V_1 = Reduced volume + 20% of 500 cm^3

$$= \frac{20 \times 500}{100} = 100 \text{ cm}^3$$

Net, V_1 = 500 - 100 = 400 cm^3

T_1 = ?

P = P_1

Using gas equation, we get,

$$\frac{PV}{t} = \frac{P_1 V_1}{t_1}$$

$$\frac{P \times 500}{273} = \frac{P \times 400}{t_1}$$

$$t_1 = \frac{273 \times 4}{5} = 218.4 \text{ K}$$

$$\therefore \quad t_1 = 218.4 - 273$$

= - 52.60^{O}C

Solution 9.

$V = 30$ cm^3

$t = 15$C $= 15 + 273 = 288$ K P $= 740$ mm

At S.T.P.

$V_1 = ?$

$t_1 = 0$C $= 273$ K $P_1 = 760$ mm

Using gas equation, $\dfrac{PV}{t} = \dfrac{P_1V_1}{t_1}$

$$\dfrac{30 \times 740}{288} = \dfrac{760 \times V_1}{273}$$

$\therefore \quad V_1 = \dfrac{30 \times 740 \times 273}{288 \times 760} = 27.68 = 27.7$ cm^3

$\therefore \quad V_1 = 27.7$ cm^3

Solution 10.

$P = 770$ mm V $= 88$ cm^3 $P_1 = 880$ mm $V_1 = ?$

$t = t_1$

Using gas equation,

$$\dfrac{PV}{t} = \dfrac{P_1V_1}{t_1}$$

Or $770 \times 88 = V_1 \times 880$

$\therefore V_1 = 77$ cm^3

$\therefore$ Volume diminished $= 88 - 77 = 11$ cm^3

Solution 11.

Pressure of dry hydrogen P = 750 - 14 = 736 mrn V = 50 cm^3

t = 17C = 17 + 273 = 290 K

P_1 = 760 mm

V = ?

T_1 = 0°C = 273 K

Using gas equation,

$$\frac{PV}{t} = \frac{P_1V_1}{t_1}$$

$$\frac{736 \times 50}{290} = \frac{760 \times V_1}{273}$$

$$\therefore V_1 = \frac{736 \times 50 \times 273}{290 \times 760}$$

= 45.85 cm^3

Let us say (By rounding up),

= 45.6 cm^3

$\therefore V_1$ = 45.6 cm^3

Solution 12.

t = C = 273 K P = 760 mm

V = 100 cm^3

$t_1 = 273 \times \dfrac{1}{5} = 54.6$ (Increased) $= 273 + 54.6 = 327.6$ K

$P_1 = 1\dfrac{1}{2} \times 760 = 760 \times \dfrac{3}{2}$

$\quad = 1140$ mm

$V_1 = ?$

Using gas equation,

$$\dfrac{PV}{t} = \dfrac{P_1V_1}{t_1} = \dfrac{760 \times 100}{273} = \dfrac{1140 \times V_1}{327.6}$$

$\therefore \quad V_1 = \dfrac{760 \times 100 \times 327.6}{273 \times 1140} = 80$ cm^3

$\therefore \quad V_1 = 80$ cm^3

Solution 13.

Let original volume (V) = 1 and original pressure (P) = 1 and temp given (t) = - 15C = - 15 + 273 = 258 K

V_1 or New volume after heating = original volume + 50% of original volume

$$= 1 + 1 \times \frac{50}{100} = 1 + \frac{1}{2} = \frac{3}{2}$$

P_1 or decreased Pressure = 60%

$$= 1 \times \frac{60}{100} = 6$$

t_1 = To be calculated.

$$\because \quad \frac{PV}{t} = \frac{P_1 V_1}{t_1} \Rightarrow \frac{1 \times 1}{258} = \frac{3}{2} \times \frac{6}{t_1}$$

$$\therefore \quad t_1 = \frac{3 \times 6 \times 258}{1 \times 1 \times 2} = \frac{3 \times 6 \times 258}{2 \times 10} = 232.2$$

$t_1 \times 10 = 9 \times 258 = 2322$

$t_1 + 232.2$

$\therefore t_1 = 232.2 - 273 = $ **-40.8ºC.**

Solution 14.

V = 2 lit.

P = 100 pascal t = 27C = 273 + 27 = 7300 K

$$P_1 = \frac{1}{2} \text{ of } 100 = \frac{1}{2} \times 100 = 50 \text{ Pascal}$$

$$V_1 = \frac{1}{2} \text{ of } V = \frac{1}{2} \times 2 = 1 \text{ lit.}$$

$$t_1 = ?$$

Using gas equation,

$$\frac{PV}{t} = \frac{P_1V_1}{t_1} \Rightarrow \frac{2 \times 100}{300} = \frac{50 \times 1}{t_1}$$

$$\therefore t_1 = \frac{50 \times 300}{2 \times 100}$$

$$\therefore t_1 = 25 \times 3 = 75 \text{ K}$$

$$\therefore t_1 = 75 - 273$$

$$\therefore t_1 = -198^{O}C$$

Solution 15.

(Initial Conditions)	(Final Conditions)
$P_1 = 1 \text{ atm} = 760 \text{ mm}$	$P_2 = 760 \times \frac{5}{2} + 760 = 2660 \text{ mm}$
$V_1 = 2500 \text{ cm}^3$	$V_2 = ?$
$T_1 = 273 + 0 = 273 \text{ K}$	$T_2 = 273 \text{ K}$

Applying general gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \frac{760 \times 2500}{273} = \frac{2600 \times V_2}{273}$$

$$V_2 = \frac{760 \times 2500}{273} \times \frac{273}{2660} = \frac{5000}{7} \text{ cc} = 714\frac{2}{7} \text{ cc}$$

$$= 5000/7 \text{ cm}^3$$

Solution 16.

(Initial Conditions)	(Final Conditions)

$P_1 = P \text{ mm} = 760 \text{ mm}$

$P_2 = 760 \times \dfrac{5}{2} + 760 = 2660 \text{ mm}$

$V_1 = 5000/7 \text{ cc}$

$V_2 = 2500 \text{ cc}$

$T_1 = 273 \text{ K}$

$T_2 = ?$

Applying general gas equation,

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = \frac{P \times 5000}{273 \times 7} = \frac{P \times 2500}{T_2}$$

$$T_2 = \frac{P \times 25000 \times 273 \times 7}{P \times 5000} = \frac{7}{2} \times 273K = 3.5 \text{ Times}$$

Solution 17.

(a)

Initial Condition Final Condition

$V_1 = V_{cc}$ $V_2 = V_{cc}$

$P_1 = 100$ cm of Hg $P_2 = 10$ cm of Hg

$T_1 = 0 \, C = 273 K$ $T_2 = ?$

Applying general gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{100 \times v}{273} = \frac{10 \times v}{T_2}$$

$$T_2 = \frac{273 \times 10}{100}$$

$T_2 = 27.3 \, K$

(b) **Initial Conditions Final Conditions**

$V_1 = V_{cc}$ $V_2 = V_{cc}$

$P_1 = 100$ cm of Hg $P_2 = ?$

$T_1 = 0 + 273 = 273 K$ $T_2 = 273 + 100 = 373 \, K$

Applying general gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{100 \times V}{273} = \frac{P_2 \times V}{373}$$

$$P_2 = \frac{373 \times 100}{273}$$

$P_2 = 136.63$ cm of Hg

Solution 18.

Capacity of the cylinder V = 10000 lit.

P = 800 mm

t = -3C = -3 + 273 = 270 K P_1 = 400 mm of Hg

t_1 = 0C = 0 + 273 = 273 K

V_1 = ?

Using gas equation,

$$\frac{PV}{t} = \frac{P_1V_1}{t_1}$$

$\therefore$ $\frac{800 \ X \ 10000}{270} = \frac{400 \ X \ V_1}{273}$

$\therefore$ $V_1 = \frac{800 \ X \ 10000 \ X \ 273}{270 \ X \ 400}$

= 20222.2 lit.

Number of Cylinders = $\frac{V_1}{\text{Volume of one cylinder}}$

= $\frac{20222.2}{10}$ = 2022.22

= 2022 Cylinders

Solution 19.

Volume of 1 mole of gas at STP = 22.4 lit.

$V_1 = 22.4$ liters $V_2 = ?$

$T_1 = 273$ K $T_2 = 27 + 273 = 300$ K

$P_1 = 1$ atm $P_2 = 4$ atm

Using gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\therefore V_2 = \frac{P_1V_1T_1}{T_1P_2}$$

$$= \frac{1 \times 22.4 \times 300}{273 \times 4}$$

$$= \frac{560}{91}$$

$V_2 = 6.15$ Liters

Solution 20.

Applying equation,

$$\frac{PV}{t} = \frac{P_1V_1}{t_1}$$

$P_1 = 760$ mm $P_2 = 50\%$ of $P_1 = 50 \times 760 = 380$ mm

$V_1 = V_1$ $V_2 = 2V_1$

$t_1 = 273$ K $t_2 = ?$

$$\therefore \frac{760 \times V_1}{273} = \frac{380 \times 2 V_1}{t_2}$$

$$\therefore t_2 = \frac{380 \times 2V_1}{760 \times V_1}$$

$\therefore t_2 = 273$ K

Solution 21.

(a) P = 748 mm Hg V = 1.2l

T = 25C = 25 + 273 K = 298 K

P_1 = 760 mm of Hg

V_1 = ?

T_1 = 273 K

Applying general gas equation,

$$\frac{P\,V}{T} = \frac{P_1 V_1}{T_1}$$

$$\therefore \quad \frac{748 \times 1.2}{298} = \frac{760 \times V_1}{273}$$

$$\therefore V_1 = \frac{748 \times 1.2 \times 273}{298}$$

= 1.081 liters

(b)

P = 760 mm Hg P_1 = 760 mm Hg V = 1.25l V_1 = ?

T = 273 K T_1 = 273 K

Applying general gas equation,

$$\frac{P\,V}{T} = \frac{P_1 V_1}{T_1}$$

$$\therefore \quad \frac{760 \times 1.25}{273} = \frac{760 \times V_1}{273}$$

$$\therefore V_1 = \frac{760 \times 1.25 \times 273}{760 \times 273}$$

= 1.25 l

1.25 l O_2 at S.T.P. will have greater volume than 1.2 l N_2 at 25^OC and 748 mm Hg, when the 2 gases are compared at S.T.P.

Solution 22.

P_1 = 1 bar P_2 = ?
V_1 = 500 dm3 V_2 = 200 dm3
T_1 = 273 K T_2 = 273 + 30 = 303 K

Using gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_2 = \frac{P_1V_1T_2}{T_1V_2}$$

$$= \frac{1 \times 500 \times 303}{273 \times 200} = \frac{5 \times 101}{91} = \frac{505}{91}$$

$$\therefore P_2 = 2.77 \text{ bar}$$

Solution 23.

(i) $V_1 = 0.4 L$ $V_2 = 0.4 \times 2 L$

$T_1 = 17^O C$ $(17 + 273) = 290 K$ $T_2 = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{0.4}{290} = \frac{0.8}{T_2}$$

$$\therefore T_2 = \frac{290 \times 0.8}{0.4}$$

$= 290 \times 2 = 580$

$= 580 - 273 = \mathbf{307\ K}$

(ii) $V_1 = 0.4 L$ $V_2 = 0.2 L$

$T_1 = 17^O C$ $(17 + 273) = 290 K$ $T_2 = ?$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{0.4}{290} = \frac{0.2}{T_2}$$

$$\therefore T_2 = \frac{290 \times 0.2}{0.4}$$

$= 145 K$

$= 145 - 273 = -\mathbf{128^O C}$

Solution 24.

Pressure due to dry air,

P = 750 - 12 = 738 mm

V = 28 cm3

t = 14C = 14 + 273 = 287 K

P_1 = 760 mm of Hg

V_1 = ?

t_1 = 0^OC = 273 K

Using gas equation,

$$\frac{PV}{t} = \frac{P_1V_1}{t_1}$$

$$\frac{738 \times 28}{287} = \frac{V_1 \times 760}{273}$$

$$\therefore V1 = \frac{738 \times 28 \times 273}{287 \times 760}$$

$$= 25.86 \text{ cm}^3$$
$$= 25.9 \text{ cm}^3$$
$$\therefore V_1 = 25.9 \text{ cm}^3$$

Solution 25.

Step 1: To convert the volume of the gas to S.T.P.

Initial conditions Final Conditions

P_1 = 760 mm P_2 = 760 mm

V_1 = 20 L V_2 = ?

T_1 = 273 + 27 = 300 K T_2 = 273 K

Applying general gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{700 \times 20}{300} = \frac{760 \times V_2}{273}$$

$$\therefore V_2 = \frac{273}{760} \times \frac{700 \times 20}{300}$$

$$= \frac{91 \times 14}{76} = \frac{91 \times 7}{38} = \frac{637}{38} c$$

Step 2: To calculate weight of the gas.

22.4 liters of the gas weighs at S.T.P. $= \frac{70}{22.4} \times \frac{637}{38}$

$$= \frac{700}{224} \times \frac{637}{38} \times \frac{100}{32} \times \frac{637}{38}$$

$$= \frac{25}{8} \times \frac{637}{38}$$

$$= 52.38 \text{ g.}$$