**Exercise :7**

**1. What do you understand by gas ?**

**Solution:**

Gas is a physical state of matter in which interparticle attraction is weak and interparticle space is so large. Because of this gas particles become completely free to move randomly in the entire available space.

2. **Give the assumptions of the kinetic molecular theory**

**Solution:**

i) Gases are made of tiny particles which move in all possible directions at all possible speeds. The size of molecules is small as compared to the volume of the occupied gas.

ii) There is no force of attraction between gas particles or between the particles and the walls of the container. So, the particles are free to move in the entire space available to them.

iii) The moving particles of gas collide with each other and with the walls of the container. Because of these collisions, gas molecules exert pressure. Gases exert the same pressure in all directions.

iv) There is large interparticle space between gas molecules, and this accounts for high compressibility of gases.

v) Volume of a gas increases with a decrease in pressure and increase in temperature.

vi) Gases have low density as they have large intermolecular spaces between their molecules.

vii) Gases have a natural tendency to mix with one and other because of large intermolecular spaces. So, two gases when mixed form a homogeneous gaseous mixture.

viii) The intermolecular space of a gas is reduced because of cooling. Molecules come closer resulting in liquefaction of the gas.

**3. During the practical in the lab when hydrogen sulphide gas having offensive odour is prepared for some test, we can smell the gas even 50 metres away. Explain phenomenon.**

**Solution:**

We can smell the gas even 50 meters away because of the diffusion of gas molecules allow thorough mixing of the gas.

**4. What is diffusion ? Give an example to illustrate**

**Solution:**

Diffusion is a process of mixing of two substanecs kept in contact. Diffusion is due to molecular motion.

If a jar of chlorine is opened in a large room, the odorous gas mixes with air and spreads to every part of the room. Although chlorine is heavier than air, it does not remain at the floor level but spreads throughout the room.

**5. How is molecular motion related with temperature.**

**Solution:**

Molecular motion is directly proportional to temperature. Hence it affects kinetic energy of the molecule.

**6. State (i) the three variables for gas laws ii) S.I units of these variables.**

**Solution:**
i) Three variables for gas laws: Volume (V), Pressure (P), Temperature (T)

ii) SI units of these variables:
Volume: Cubic metre ($m^3$)
Pressure: Pascal (Pa)
Temperature: Kelvin (K)



**7. (a) State Boyle's Law.**
**(b) Give its**
**(i) mathematical expression,**
**(ii) graphical representation and**
**(iii) significance.**

**Solution:**

a) Boyle's law states that the volume of a given mass of a dry gas is inversely proportional to its pressure at a constant temperature.

b)
i. 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

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

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

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

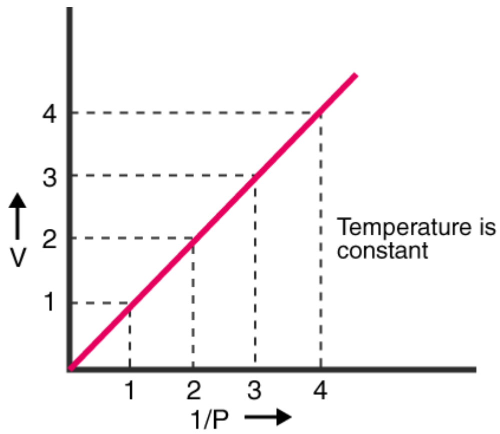
$$K = V'P' \text{ or } PV$$



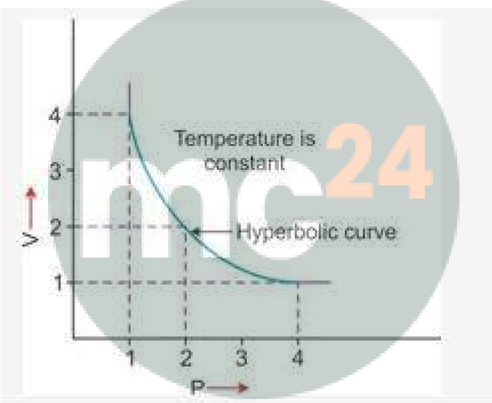
i. Graphical representation of Boyle's Law:

$$V \text{ vs } \frac{1}{P}$$

1 : Variation in volume (V) plotted against (1/P) at a constant temperature: A straight line passing through the origin is obtained.

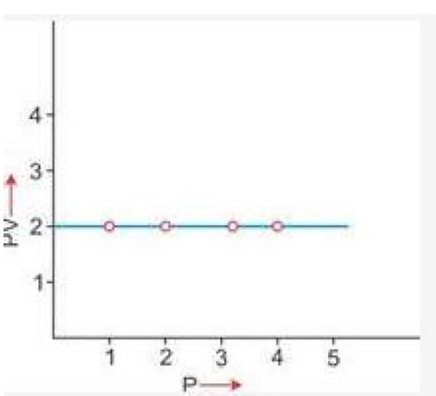



2. V vs P: Variation in volume (V) plotted against pressure (P) at a constant temperature: A hyperbolic curve in the first quadrant is obtained.






3. PV vs P: Variation in PV plotted against pressure (P) at a constant temperature: A straight line parallel to the X-axis is obtained.



Significance of Boyle's Law

On increasing pressure. volume decreases. The gas becomes denser. Thus at a constant temperature, the density of a gas is directly proportional to its pressure.

Atmospheric pressure is low at high altitudes, so air is less dense. Hence, a lesser quantity of oxygen is available for breathing. This is the reason why mountaineers have to carry oxygen cylinders with them.

**8. Explain Boyle's law on the basis of kinetic theory of matter.**

**Solution:**

The kinetic theory states that the number of molecules present in a given mass and the average possessed by the particles is constant.

If the volume of a given mass of dry gas is reduced to half its original volume, the same number of particles will have half the space to move. As a result, the number of molecules striking at a unit area of the walls of the container at a given time will get doubled. Conversely, if the volume of a given mass of a gas is doubled at a constant temperature, the same number of molecules will have double the space to move about. Consequently, the number of molecules striking at a unit area of the walls of the container at a given time will become one half of the original value. Thus, the pressure of the gas will be reduced to half of its original pressure. Hence it is observed that if pressure increases, the volume of a given mass of gas decreases at a constant temperature.

**9 The molecular theory states that the pressure exerted by a gas in closed vessel results from the gas molecules striking' against the walls of the vessel. How will the pressure change if :**

**(a) the temperature is doubled keeping the volume constant**
**(b) the volume is made half of its original value keeping the temperature constant?**

**Solution:**

a) Pressure will double.
b) Pressure remains the same.

**10.**

**(a) State Charles law**
**(b) Give its**
**(i) Graphical representation,**
**(ii) mathematical expression and**
**(iii) Significance.**

**Solution:**

a)

Charles law states that At constant pressure, the volume of a given mass of a dry gas increases or decreases by 1/273rd of its original volume at 0°C for each degree centigrade rise or falls in temperature.

$V \propto T$ (at constant pressure)

At temperature $T_1$ (K) and volume $V_1$ ($cm^3$):

$$V_1 \propto T_1 \text{ or } \frac{V_1}{T_1} = K = \text{Constant} \quad ...(i)$$

At temperature $T_2$ (K) and volume $V_2$ ($cm^3$):

$$V_2 \propto T_2 \text{ or } \frac{V_2}{T_2} = K = \text{Constant} \quad ....(ii)$$

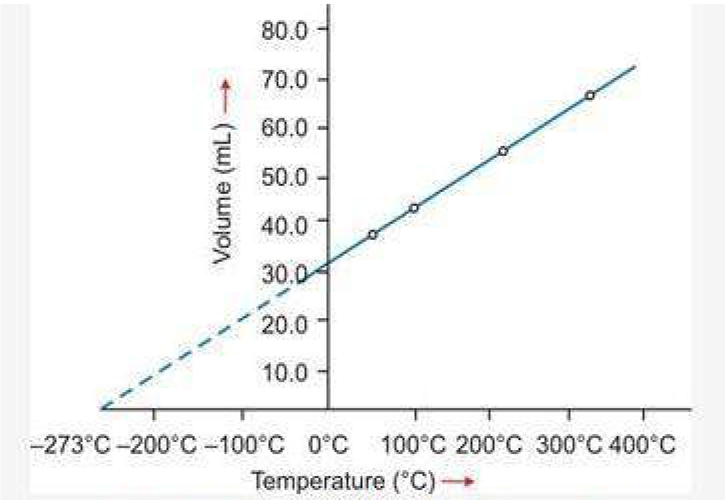
From (i) and (ii),

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

For Temperature = Conversion from Celsius to Kelvin
1 K = °C + 273
Example:
20°C = 20 + 273 = 293 K

b)

i) Graphical representation of Charles's 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's law**

ii)

$V \alpha T$

Since V and T vary directly, we can equate them by making use of a constant k.

$VT = constant = k$

The value of k depends on the pressure of the gas, the amount of the gas and also on the unit of the volume.

$VT = k$ ——— (I)

Let V1 and T1 be the initial volume and temperature of an ideal gas. We can write the equation I as:

$V_1T_1 = k$ ——— (II)

Let's change the temperature of the gas to T2. Consequently, its volume changes to V2. So we can write,

$V_2T_2 = k$ ——— (III)

Equating equations (II) and (III),

$V_1T_1 = V_2T_2 = k$

Hence, we can generalize the formula and write it as:

$(V_1)(T_1) = (V_2)(T_2)$

Or

$V_1T_2 = V_2T_1$

iii)

**Significance of Charles's Law:** The volume of a given mass of a gas is directly proportional to its temperature; hence, the density decreases with temperature. This is the reason that
(a) Hot air is filled in balloons used for meteorological purposes. (b) Cable wires contract in winters and expand in summers.

**11. Explain Charles's law on the basis of the kinetic theory of matter.**

**Solution:**

According to the kinetic theory of matter, the average kinetic energy of 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's law).

**12. Define absolute zero and absolute scale of temperature. Write the relationship between °C and K.**

**Solution:**

Absolute zero is – 273 °C. The value on the Celsius scale can be converted to the Kelvin scale by adding 273 to it. Example: 20°C = 20 + 273 = 293 K .

**13. (a) What is the need for the Kelvin scale of temperature?**
**(b) What is the boiling point of water on the Kelvin scale? Convert it into a centigrade scale.**

**Solution:**

The behavior of gases cannot be express in temperature below 273.15°C. Hence there was need of Kelvin scale to express behaviour.

Boiling point of water on the Kelvin scale is 373 K.

In Centigare 372-273= 100 °C

**14. (a) Define S.T.P.**
**(b) Why is it necessary to compare gases at S.T.P.?**

**Solution:**

The temperature of 0°C or 273 K, the pressure of 76mm Hg or 1 atm is considered as standard temperature and pressure.

It is necessary to compare gases at STP because the volume of a gas changes remarkably with a change in temperature.

**15. Write the value of**

**a) Standard temperature in**
**i) °C ii) K**

**b) Standard pressure in**
**i) atm ii) mmHg iii) cm Hg iv) torr**

**Solution:**

Standard temperature  i) 0°C ii)273 K
b) Standard pressure i) 1 atmospheric pressure (atm)  ii) 760 mmHg iii) 76 cm of Hg iv) 101325760 pascals

**16. What is the relationship between the Celsius and the Kelvin scales of temperature?**

**Solution:**

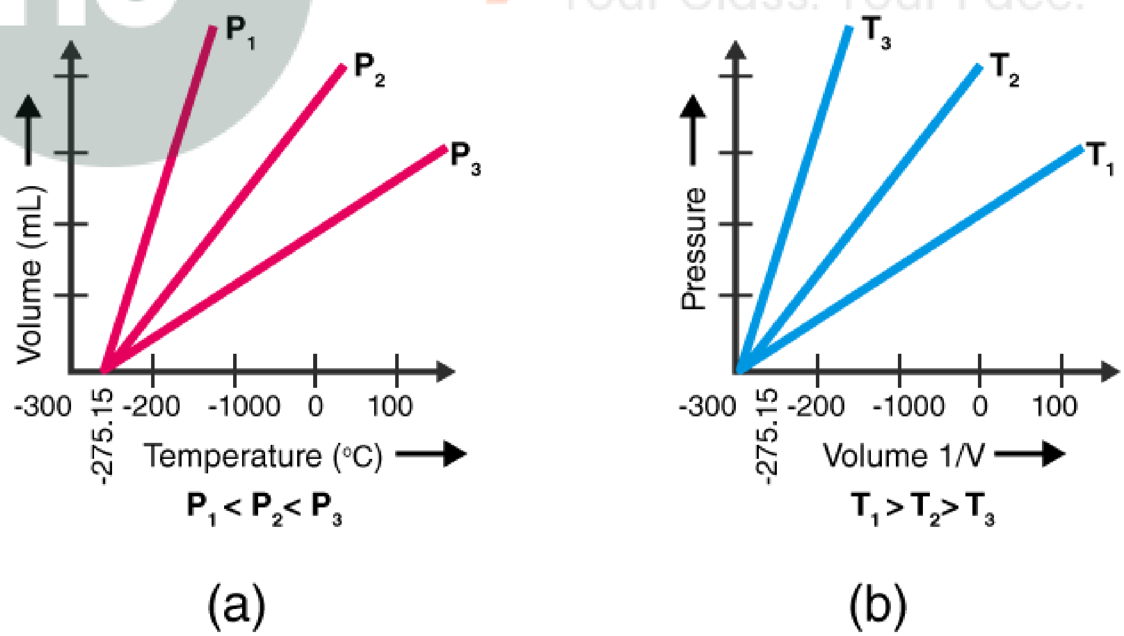
Temperature on the Kelvin scale (K)
= 273 + temperature on the Celsius scale
Or K = 273 + °C

(i)273°C  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



**17. State the laws which are represented by the following graphs.**



**Solution:**

a) Charles's law
b) Boyle's law

**18. Give reasons for the following**

- **a) All temperatures in the absolute (Kelvin) scale are in positive figures.**
- **b) Gases have lower density compared to that of solids or liquids.**
- **c) Gases exert pressure in all directions.**
- **d) It is necessary to specify the pressure and temperature of gas while stating its volume.**
- **e) Inflating balloon seems to violate Boyle’s law.**
- **f) Mountaineers carry oxygen cylinders with them.**
- **g) Gas fills completely the vessel in which it is kept.**

**Solution:**

a) The behaviour of gases cannot be express in temperature below 273.15°C. Hence Kelvin scale is expressed in positive figures.

b) Gases have lower density compared to that of solids or liquids because the mass of a gas per unit volume is small due to large intermolecular spaces between the molecules.

c) At a given temperature, the number of molecules of 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) It is necessary to specify the pressure and temperature of gas while stating its volume because the volume of a gas changes remarkably with a change in temperature and pressure, it becomes necessary to choose a standard value of temperature pressure.

e) 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 it will decrease violating Boyle’s law.

f) Atmospheric pressure is low at high altitudes. The volume of air increases and 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.

f) Mountaineers carry oxygen cylinders with them because in high altitudes atmospheric pressure is low which makes air less dense. This makes the volume of Oxygen for breathing very less.

g) Gas fills completely the vessel in which it is kept because interparticle attraction is weak and interparticle space is large in gases which makes particles completely free to move randomly in the entire available space.

**19. How did Charles's law lead to the concept of absolute scale of temperature ?**

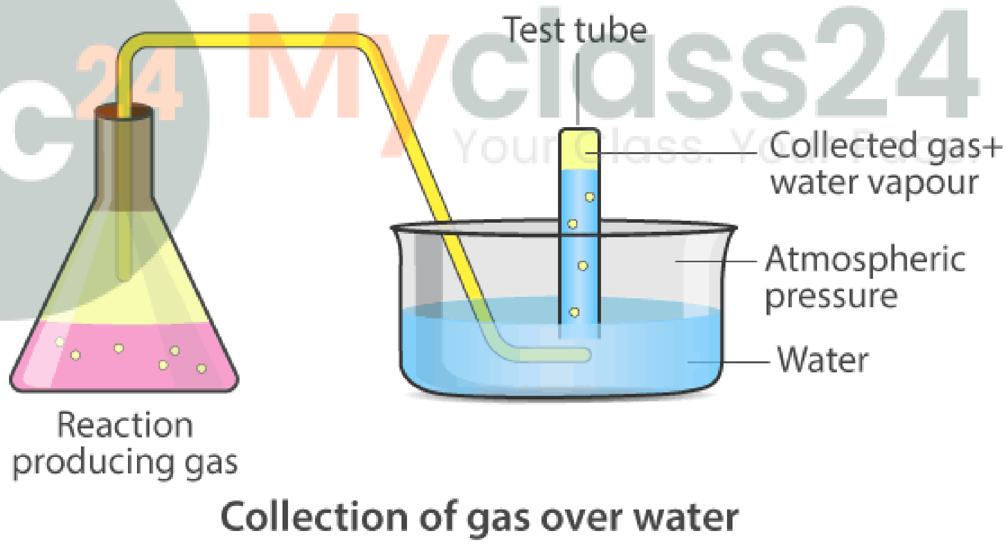
**Solution:**

Initially, Charles conducted some experiments to plot the variation of volume of a gas with the temperature, to study the relation between them when the other factors were kept constant ( pressure, no of moles etc). While doing so, he plot a graph between V and T, with volume in SI units and Temperature in Celsius. This turned out to be a straight line with a positive slope, but it cut the x axis at a point in the negative axis. This implied that in Celsius scale, zero volume could only be attained at that low temperature which turned out to be approximately -273 Celsius. Hence, a new scale was adopted called Kelvin scale with - 273 C being the 0 of the Kelvin scale. This marked the absolute temperature which is the lowest temperature

**20. What is meant by aqueous tension ? How is the pressure exerted by a gas corrected to account for aqueous tension ?**

**Solution:**

When the gas is collected over water, it is moist and contains water vapour. The tptal pressure exerted by moist gas is equal to the sum of the partial pressure of the dry gas and the pressure exerted by water vapour. Partial pressure of water vapour is called as aqueous tension.






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

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

Actual pressure of gas = Total pressure - Aqueous tension

**21. State the following (a) Volume of a gas at 0 Kelvin.**
**(b) Absolute temperature of a gas at 7°C.**
**(c) Gas equation.**
**(d) Ice point in absolute temperature.**
**(e) S.T.P. conditions**

**Solution:**

a) Volume of gas is zero.
b) Absolute temperature is 7 + 273 = 280 K.
c) The gas equation is

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

d) Ice point = 0 + 273 = 273 K
e) Standard temperature is 273 K or O°C.
Standard pressure is 1 atmosphere (atm) or 760 mmHg.

**22. Choose the correct answer (a) The graph of PV vs P for a gas is**
**(i) parabolic**
**(ii) hyperbolic**
**(iii) a straight line parallel to X-axis**
**(iv) a straight line passing through origin**

**(b) The absolute temperature value that corresponds t 27°C is**
**(i) 200K**
**(ii) 300K**
**(iii) 400K**
**(iv)246K**

**c) Volume-Temperature relationship is given by**
**(i) Boyle**
**(ii) Gay Lussac**
**(iii) Dalton**
**(iv) Charles**

**(d) If the pressure is doubled for a fixed mass of gas, its volume will become**
**(i) 4 times**
**(ii) 1/2 times**
**(iii) 2 times**
**(iv) No change**

**Solution:**

a) (iii) Straight line parallel to the X-axis.
b) (ii) 27°C = 27 + 273 = 300 K
c) (iv) Charles
d) (ii) 1/2 times

**23. Match the following**

| **Column A** | **Column B** |
|---|---|
| **a) $Cm^3$** | **i) Pressure** |
| **b) Kelvin** | |
| **c) Torr** | **iii) Volume** |
| **d) Boyle's law** | **iv) $\frac{v}{t} = \frac{v1}{t1}$** |
| **e) Charles law** | **v) $\frac{pv}{t} = \frac{p1v1}{t1}$** |
| | **vi)temperature** |

**Solution:**

| Column A | Column B |
|---|---|
| a) $Cm^3$ | iii) Volume |
| b) Kelvin | vi)temperature |
| c) Torr | i) Pressure |
| d) Boyle's law | ii) $PV= P_1V_1$ |
| e) Charles law | iv) $\frac{v}{t} == \frac{v1}{t1}$ |
| | |

**24. Correct the following statements.**
**(a) Volume of a gas is inversely proportional to its pressure at constant temperature.**
**(b) Volume of a fixed mass of a gas is directly proportional to its temperature, pressure remaining constant.**
**(c) 0°C is equal to zero Kelvin.**
**(d) Standard temperature is 25°C.**
**(e) Boiling point of water is 273 K.**

**Solution:**

a) Volume of a given mass of a dry gas is directly proportional to its absolute temperature , if the pressure is kept constant.
b) Volume of a fixed mass of a gas is inversely proportional to its temperature, pressure remaining constant.
c) 0°C is equal to 273 Kelvin
d) Standard temperature is 0°C or 273 K.
e) Boiling point of water is 373 K.

**25, Fill in the blanks**
**(a) The average kinetic energy of the molecules of is proportional to the ………….**
**(b) The temperature on the Kelvin scale at which molecular motion completely ceases is called ……….**
**(c) If temperature is reduced to half, …….would, also reduce to half.**
**(d) The melting point of ice is................Kelvin.**

**Solution:**

(a) The average kinetic energy of the molecules of is proportional to the **Absolute temperature.**

(b) The temperature on the Kelvin scale at which molecular motion completely ceases is called **Absolute zero**

(c) If temperature is reduced to half **volume**would, also reduce to half.

(d) The melting point of ice is **273** Kelvin.

**Numerical Problems**

**1. What will be the minimum pressure required to compress 500 dm$^3$ of air at 1 bar to 200 dm$^3$ temperature remaining constant.**

**Soln:**

$V_1$ = 500 dm$^3$
$P_1$ = 1 bar
$T_1$ = 273 K
$V_2$ = 200 dm$^3$
$T_2$ = 273 K
$P_2$= ?

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{500x1}{273} = \frac{P2 \times 200}{273}$$

$$P2 = \frac{500}{200}$$
$$= 2.5 \text{ bar}$$

**2. 2 litres of agas is enclosed in a vessel at a pressure of 760 mm Hg. If temperature remains constant, calculate the pressure when volume changes to 40 dm$^3$.**

**Soln:**

V = 2 litres
P = 760 mm
$V_1$ = 4000 m$^3$ [1 dm$^3$ = 4 litres]
$P_1$= ?

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{760 \times 2}{T} = \frac{P1 \times 4}{T1}$$

$P1 = \frac{760}{2} = 380mm$

**3. At constant temperature, the effect of change of pressure on volume of a gas was as given below:**

| **Pressure in atmospheres** | **Volume in litres** |
|---|---|
| **0.20** | **112** |
| **0.25** | **89.6** |
| **0.40** | **56** |
| **0.80** | **28** |
| **1.0** | **22.4** |

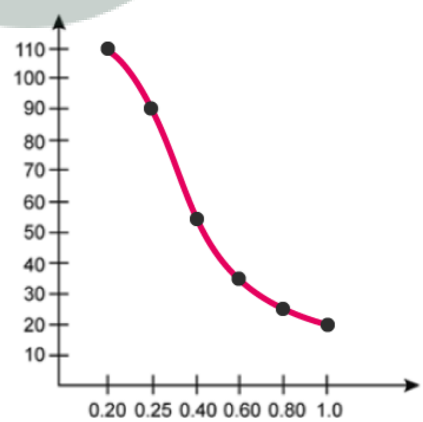
**(a) Plot the following graphs**
**1. P vs V 2. P vs 1/V 3. PV vs P**

**b) Assuming that the pressure values given above are correct, find the correct measurement of the volume at 0.60 atmospheric pressure.**

**Soln:**

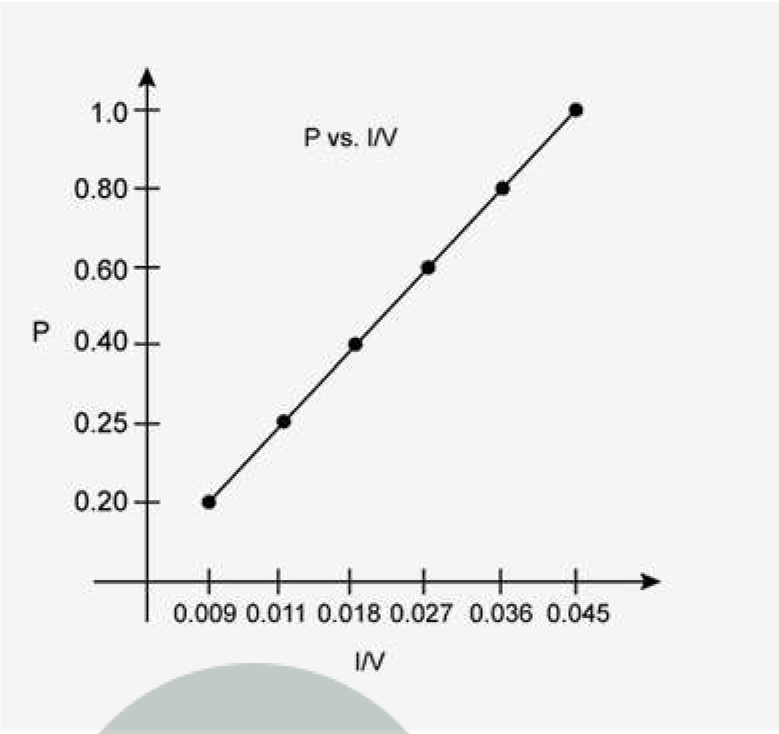
| P/atm | $V/dm^3$ | 1/V | PV |
|---|---|---|---|
| 0.2 | 112 | 0.009 | 22.4 |
| 0.25 | 89.2 | 0.011 | 22.4 |
| 0.4 | 56.25 | 0.018 | 22.4 |
| 0.6 | 37.4 | 0.027 | 22.4 |
| 0.8 | 28.1 | 0.036 | 22.4 |
| 1 | 22.4 | 0.045 | 22.4 |






P vs. V

At constant temperature, P is inversely proportional to V. Thus, the plot of V versus P will be a rectangular hyperbola.




According to Boyle's law, the product of pressure and volume is constant at a constant temperature. The graph of PV versus P is constant, which indicates that the given gas obeys Boyle's law.

The correct measurements of the volume are given below:

| **P/atm** | **V/dm$^3$** |
|---|---|
| 0.2 | 112 |
| 0.25 | 89.6 |
| 0.4 | 56 |
| 0.6 | 37.33 |
| 0.8 | 28 |
| 1 | 22.4 |

**4. 800 cm3 of gas is collected at 654 mm pressure. At what pressure would the volume of the gas reduce by 40% of its original volume, temperature remaining constant.**

**Soln:**

V = 800 $cm^3$
P = 650 m
$P_1$= ?
$V_1$ = reduced volume = 40% of 800

$= \frac{80 \times 40}{100}$
= 320

Net $V_1$ = 800 - 320 = 480 $cm^3$
$T = T_1$
Using the gas equation,

$\frac{PV}{T} = \frac{P1V1}{T1}$

$= \frac{800x\ 650}{T}$

$= \frac{P1 \times 480}{T1}$

Since T = T1

$= \frac{800x\ 650}{480}$

= 1083.33 mm of Hg.

**5. A cylinder of 20 litres capacity contains a gas at atmospheric pressure. How many flasks of 200 $cm^3$ capacity can be filled from it at 1 atmosphere pressure, temperature remaining constant ?**

**Soln:**

P= 100 atm
V= 20 ltrs
P1 = 1atm
V1= ?
T= $T_1$

Using equation

$\frac{PV}{T} = \frac{P1V1}{T1}$

$\frac{100 \times 20}{T} = \frac{1 \times V1}{T}$

V1= 2000 ltrs = $2m^3$ ( 100 lit = $1m^3$)

Volume of one falsk = $\frac{200}{100x100x100}$

Number of flasks = $\frac{2 \times 1000000}{200}$ = 10000

**6. A steel cylinder of internal volume 20 litres is filled with hydrogen at 29 atmospheric pressure. If hydrogen is used to fill a balloon at 1.25 atmospheric pressure at the same temperature, what volume will the gas occupy?**

**Soln:**

V = 20 litre
P = 29 atm
$P_1$ = 1.25 atm
$V_1$ =?
T = $T_1$

By gas equation $\frac{PV}{T} = \frac{P1V1}{T1}$

$= \frac{29 \times 20}{T}$

$= \frac{1.25 \times V_1}{T}$

$V_1$ = 464 litres

**7. 561 dm³ of a gas at S.T.P. is filled in a 748 dm³ Container. If temperature is constant, calculate the percentage change in pressure required.**

**Soln:**

Initial volume = $V_1$ = 561 $dm^3$
Final volume = $V_2$ = 748 $dm^3$
Difference in volume = 748 - 561 = 187 $dm^3$
As the temperature is constant,
Decrease in pressure percentage = $\frac{187}{748} \times 100$
= 25%

**8. 88 $cm^3$ of nitrogen is at a pressure of 770 mm of mercury. If the pressure is raised to 880 mm Hg, find by how much the volume will diminish, temperature remains Constant.**

**Soln:**

V = 88 $cm^3$
P = 770 mm
$P_1$ = 880 mm
$V_1$= ?
T = $T_1$

Using Gas equation

$\frac{PV}{T} = \frac{P1V1}{T1}$

$= \frac{770 \times 88}{T}$

$= \frac{880 \times V1}{T}$

$V_1 = 77\ cm^3$

Diminished volume = 88-77

= $11 cm^3$

**9. A gas at 240 K is heated to l27°C. Find the Percentage change in the volume of the gas (pressure remaining constant).**

**Soln :**

Let volume = 100 ml
T = 240 K
Volume increased = x ml
New volume = 100 + x ml
$T_1$ = 400 K

Using the gas equation

$\frac{PV}{T} = \frac{P1V1}{T1}$

$\frac{P \times 100}{240}$

$\frac{P \times (100 + x)}{400}$

$1000 = \frac{6(100 + x)}{400}$

1000= 600 + 6x

6x = 400

$X = \frac{400}{6}$

= 66.6

Percentage increased = 66.6 %

**10. Certain amount of a gas occupies a volume of 0.4 litre at 17º c. To what temperature should it be heated so that its volume gets (a) doubled (b) reduced to half, pressure remaining constant?**

**Soln:**

a)

$V_1 = 0.4$ L
$V_2 = 0.4 \times 2$L
$T_1 = 17°C\ (17 + 273) = 290$ K
$T_2 = ?$

$\frac{V1}{T1} = \frac{V2}{T2}$

$\frac{0.4}{290} = \frac{0.8}{T2}$

T2 = 290 x 2

T2 = 580- 273

T2 = 307º c

b) $V_1 = 0.4$ L
$V_2 = 0.2$ L
$T_1 = 17°C\ (17 + 273) = 290$ K
$T_2 = ?$

$\frac{V1}{T1} = \frac{V2}{T2}$

$\frac{0.4}{290} = \frac{0.2}{T2}$

$T2 = \frac{290 \times 0.2}{0.4}$

T2= 145 K

T2= 145- 273 = - 128º c

**11• A given mass of a gas occupies 143 $cm^3$ at 27°C and 700 mm Hg pressure. What will be its volume at 300 K and 180 mm Hg pressure?**

**Soln:**

V = 3 litres
$P = P_1$
$V_1 = ?$
T = 0°C = 0 + 273 = 273 K
$T_1$ = -20°C = -20°C + 273 = 253 K

Gas equation states that

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{P \times 3}{273} = \frac{P1 \times V1}{253}$$

$$V1 = \frac{3 \times 253}{273} = 2.78 \text{ litres}$$

**12. A gas occupies 500 cm3 at normal temperature. At what temperature will the volume of the gas be reduced by 20% of its original volume, pressure being constant?**

**Soln:**

$V = 500\ cm^3$

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

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

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

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

$T_1 = ?$

$P = P_1$

From gas equation

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{P \times 500}{273} = \frac{P \times 400}{T1}$$

$$T1 = \frac{273 \times 4}{5}$$

= 218.4

= 218.4 – 273

= 52.60° c

**13• Calculate the final volume of a gas 'X', if the original pressure of the gas, at S.T.P. is doubled and its temperature is increased three times.**

**Soln:**

$V_1 = X$
$P_1 = 1$ atm
$V_2 = ?$
$T_2 = 3\ T_1$
$P_2 = 2$ atm

$$\frac{P1V1}{T1} = \frac{P2\ V2}{T2}$$

$$\frac{1 \times X}{T1} = \frac{2 \times V2}{3 \times T1}$$

$$V2 = \frac{3 \times T1 \times X}{T1 \times 2}$$

$$= 1\tfrac{1}{2} V1$$

**14• A sample of carbon dioxide occupies 30 cm3 at 15°C and 740 mm pressure. Find its volume at S.T.P.**

**Soln:**

$V = 30\ cm^3$
$P = 740$ mm
$T = 288$ K
$P_1 = 760$ mm
$V_1 = ?$
$T_1 = 273$ K

By gas equation

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{740 \times 30}{288} = \frac{750 \times V1}{273}$$

$V1 = 27.7\ cm^3$

**15. What temperature would be necessary to double the volume of a gas,initially at S.T.P.,if the pressure is decreased to 50%.**

**Soln:**

V = 50 $cm^3$
P = 750 - 14 = 736 mm
T = 290 K
$P_1$ = 760 mm
$V_1$= ?
$T_1$ = 273 K

Using gas equation

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{736}{290} = \frac{760 \times V1}{273}$$

V1= 45.6 $cm^3$

**16. At $0^oc$ and 760 mm Hg pressure,a gas occupies a volume of 100 cm3. Kelvin temperature of the gas is increased by one-fifth and the pressure is increased one and a half times.Calculate the final volume of the gas.**



**Soln:**

V = 100 $cm^3$
P = 760 mm
T = 273 K
$V_1$= ?

$$T1 = \frac{273 \times 1}{5} = 54.6$$

= 273+ 54.6 = 327.6 K

P1 = $1\frac{1}{2}$ x 760

$$= \frac{760 \times 3}{2}$$

= 1140 mm

V1 = ?

From gas equation

$\frac{PV}{T} = \frac{P1V1}{T1}$

$= \frac{760 \times 100}{273}$

$= \frac{1140 \times V1}{327.6}$

V1 = 80 $cm^3$

**17. It is found,on heating a gas,its volume increases by 50% and pressure decreases to 60% of its original value.If the original temperature was-15'C,find the temperature to which it was heated?**

**Soln:**

Let the original volume (V) = 1 and
the original pressure (P) = 1 and
the temperature given (T) = -15°C = -15 + 273 = 258 K
$V_1$ or new volume after heating = original volume + 50% of original volume

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

Here P1 is the decreased pressure

P1 = 60%

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

= 0.6

T1 = ?

$\frac{PV}{T} = \frac{P1V1}{T1}$

$\frac{1 \times 1}{258} = \frac{3}{2} \times \frac{0.6}{T1}$

T 1= 232.2

T1 = 232.2- 273

= - 40.8°c

**18. A certain mass of a gas occupies 2 litres at 27°C and 100 pascal.Find the temperature when volume and pressure become half of their initial values.**

**Soln:**

V = 2 litres
P = 100 Pa
T = 300 K
T1 = ?

$P1 = \frac{1}{2} \times 100 = 50$ Pa

$V1 = \frac{1}{2} \times 2$

V1 = 1 litre

From Gas equation

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{100 \times 2}{300} = \frac{50 \times 1}{T1}$$

T1 = 75 K

T1 = 75-273

= - 198°c



**19. 2500 cm3 of hydrogen is taken at S.T.P.The pressure of this gas is further increased by two and a half times (temperature remaining Constant). What volume will hydrogen occupy now?**

**Soln:**

$V_1 = 2500\ cm^3$
$P_1$ = 1 atm = 760 mm
$T_1$ = 273 K
$V_2$= ?
$T_2$ = 273 K

$P2 = \frac{760 \times 5}{2} + 760$

= 1900 + 760 = 2660 mm

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$= \frac{760 \times 2500}{273} = \frac{2660 \times V2}{273}$

$V2 = \frac{5000}{7} = 714.29\ cm^3$

**20. Taking the volume of hydrogen as calculated in Q.19, what change must be made in Kelvin( absolute) temperature to return the volume to 2500 cm$^3$ ( pressure remaining constant)**

**Soln:**

$V_1 = 714.29\ cm^3$
$P_1 = P_2 = P$
$T_1 = 273\ K$
$V_2 = 2500\ cm^3$
$T_2 = ?$

$\frac{P1V1}{T1} = \frac{P2V2}{T2}$

$\frac{P \times 714.29}{273} = \frac{P \times 2500}{T2}$

$T2 = 273 \times 3.5$

$= 955.5$



**21. A given amount of gas A is confined in a chamber of constant volume. When the chamber is immersed in a bath of melting ice, the pressure of the gas is 100 cm Hg.**
**(a) What is the temperature, when the pressure is 10 cm Hg**
**(b) What will be the pressure, when the chamber is brought to 100°C?**

**Soln:**

a) $V_1 = V_2 = V$
$P_1 = 100\ cmHg$
$T_1 = 273\ K$
$P_2 = 10\ cmHg$
$T_2 = ?$

$\frac{P1V1}{T1} = \frac{P2V2}{T2}$

$\frac{100 \times V}{273} = \frac{10 \times V}{T2}$

b) $V_1 = V_2 = V$
$P_1 = 100\ cmHg$
$P_2 = ?$
$T_1 = 273\ K$
$T_2 = 373\ K$

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{100 \times V}{273} = \frac{P2 \times V}{373}$$

P2 = 136.63 cm of Hg

**22. A gas is to be filled from a tank of capacity 10,000 litres into cylinders each having capacity of 10 litres. The condition of the gas in the tank is as follows**
**(a) pressure inside the tank is 800 mm of Hg.**
**(b) temperature inside the tank is —3°C.**

**When the cylinder is filled, the pressure gauge reads 400 mm of Hg and the temperature is 270 K. Find the number of cylinders required to fill the gas.**

**Soln:**

Capacity of the cylinder V = 10000 litres
P = 800 mm
T = -3°C = -3 + 273 = 270 K
$P_1$ = 400 mmHg
$T_1$ = 0°C = 0 + 273 = 273 K
$V_1$= ?

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{800 \times 1000}{270} = \frac{400 \times V1}{273}$$

V1 = 20222 .2 litres

$$\text{Number of cylinders} = \frac{V1}{\text{Volume of cylinder}}$$

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

= 2022 cylinders

**23. Calculate the volume occupied by 2 g of hydrogen at 27°C and 4 atmosphere pressure, if at S.T.P. it occupies 22.4 litres.**

**Soln:**

$V_1$ = 22.4 litres
$P_1$ = 1 atm
$T_1$ = 273 K
$V_2$ =?
$T_2$ = 300 K
$P_2$ = 4 atm

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{1 \times 22.4}{273} = \frac{4 \times V2}{300}$$

V2 = 6.15 liters

**24. 50 cm3 of hydrogen is collected over water at 17°C and 750 mm Hg pressure. Calculate the volume of dry gas at S.T.P. The water vapour pressure at 17°C is 14 mm Hg.**

**Soln:**

$V_1$ = V1
$P_1$ = 760 atm
$T_1$ = 273 K
$V_2$ = $2V_1$
$T_2$ =?

$$P2 = \frac{50}{100} \times 760 = 380$$

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{760 \times V1}{273} = \frac{380 \times 2V1}{T2}$$

T2 = 273 K

**25. Which will have greater volume when the following gases are compared at S.T.P**
**a) 1.2 l N2 at 25°c and 748 mm Hg**
**b) 1:25 l O2 at S.T.P**

**Soln:**

a)

V = 1.2 litres
P = 748 mmHg
T = 298 K
$P_1$ = 760 mmHg
$T_1$ = 273 K
$V_1$= ?

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{748 \times 1.2}{298} = \frac{760 \times V1}{273}$$

V1 = 1.081 litres

b)
V = 1.25 litres
P = 760 mmHg
T = 273 K
$P_1$ = 760 mmHg
$T_1$ = 273 K
$V_1$= ?

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{760 \times 1.25}{273} = \frac{760 \times V1}{273}$$

V1= 1.25 litres

**26. Calculate the volume of dry air at S.T.P. that occupies 28 $cm^3$ at 14°C and 750 mm Hg pressure when saturated with water vapour. The vapour pressure of water at 14°C is 12 mm Hg.**

**Soln:**

Pressure due to dry air,
P = 750 - 12 = 738 mm
V = 28 $cm^3$
T = 14°C = 14 + 273 = 287 K
$P_1$ = 760 mmHg
$V_1$= ?
$T_1$ = 0°C = 273 K
Using gas equation,

$$\frac{PV}{T} = \frac{P1V1}{T1}$$

$$\frac{750 \times 28}{287} = \frac{760 \times V1}{273}$$

V1= 25.9 $cm^3$

**27. L.P.G. cylinder can withstand a pressure of 14.9 atmosphere. The pressure gauge of the cylinder indicates 12 atmosphere at 27°C. Due to a sudden fire in the building the temperature rises. At what temperature will the cylinder explode.**



**Soln:**

P = 14.9 atm
V = 28 $cm^3$
T = ?
$P_1$ = 12 atm
V = $V_1$
$T_1$ = 300 K
Using gas equation,

By gas equation

$$\frac{PV}{T} = \frac{P1V1}{T1}$$
$$\frac{14.9 \times 28}{T} = \frac{12 \times V}{300}$$

T = 372.5 K

T = 372.5 – 273 = 99.5°c

**28. 22.4 litres of a gas weighs 70 g at S.T.P. Calculate the eight of the gas if it occupies a volume of 20 litres at 27ºC and 700 mm Hg of pressure.**

**Soln:**

**Step 1**

$V_1$ = 20 litres
$P_1$ = 700 mm
$T_1$ = 300 K
$V_2$= ?
$T_2$ = 273 K
$P_2$ = 760 mm

By gas equation

$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

$$\frac{700 \times 20}{300} = \frac{760 \times V2}{273}$$

$$V2 = \frac{791 \times 7}{76} = \frac{637}{38} = 16.76$$

**Step 2**

22.4 litres of the gas at STP weighs = 70 g
16.76 litres of the gas has weight at STP =

$$\frac{70 \times 16.76}{22.4} = 52.38$$