

Study of Gas Laws

Exercise

Question 1.(1988)

"When stating the volume of a gas the pressure and temperature should also be given". Why ?

Answer:

Volume of a gas under goes significant change if its pressure or temperature is slightly changed.

Question 1.(1989)

Define or state : Boyle's Law

Answer:

Boyle's Law : "Temperature remaining constant the volume of a given mass of dry gas is inversely proportional to its pressure."

$$V \propto \frac{1}{P} = T = \text{Constant}$$

Question 2.(1989)

Express Kelvin Zero in °C

Answer:

Kelvin zero or absolute zero = — 273°C.

Question 1.(1992)

A fixed volume of a gas occupies 760cm³ at 27° C and 70cm of Hg. What will be its vol. at s.t.p. [637 cm³]

Answer:

$$P_1 = 70 \text{ cm of Hg}$$

$$V_1 = 760 \text{ cm}^3$$

$$T_1 = 27^\circ\text{C} = (27 + 273) \text{ K}$$

$$P_2 = 76 \text{ cm of Hg}$$

$$V_2 = ?$$

$$T_2 = 273 \text{ K}$$

$$\text{Using the gas equation, } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{70 \times 760}{300} = \frac{76 \times V_2}{273}$$

$$\therefore V_2 = \frac{70 \times 760 \times 273}{300 \times 76} = 637 \text{ cm}^3$$

Question 1.(1993)**State :** Boyle's Law**Answer:****Boyle's Law :** "Temperature remaining constant the volume of a given mass of dry gas is inversely proportional to its pressure."

$$V \propto \frac{1}{P} = T = \text{Constant}$$

Question 1.(1995)

At 0°C and 760 mm Hg pressure, a gas occupies a volume of 100 cm³. The Kelvin temperature (Absolute temperature) of the gas is increased by one-fifth while the pressure is increased one and a half times. Calculate the final volume of the gas. [80 cc.]

Answer:**Initial conditions**

$$P_1 = 760$$

$$V_1 = 100$$

$$T_1 = 0 + 273 = 273 \text{ K}$$

Final conditions

$$P_2 = 760 \times \frac{3}{2} = (380 \times 3)$$

$$V_2 = ?$$

$$T_2 = 273 \times \frac{1}{5} + 273$$

$$= 273 \times \frac{6}{5}$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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

$$V_2 = \frac{760 \times 100}{273 \times 380 \times 3} \times \frac{273 \times 6}{5} = 80 \text{ c.c}$$

Question 1.(1996)

The pressure on one mole of gas at s.t.p. is doubled and the temperature is raised to 546 K. What is the final volume of the gas ? [one mole of a gas occupies a volume of 22.4 litres at stp.] [22.4 ltrs.]

Answer:

One mole of gas occupies a volume of 22.4 lit. at s.t.p.

$$\therefore V_1 = 22.4 \text{ lit.}$$

$$V_2 = ?$$

$$P_1 = 1 \text{ atm.}$$

$$P_2 = 2 \text{ atm.}$$

$$T_1 = 273 \text{ K}$$

$$T_2 = 546 \text{ K}$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{1 \times 22.4 \times 546}{273 \times 2} = 22.4 \text{ lits.}$$

Question 1.(1997)

Is it possible to change the temperature and pressure of a fixed mass of gas without changing its volume. Explain your answer.

Answer:

No, it is not possible as change of any one of the parameters (pressure or temperature) has significant effect on volume.

Additional Questions

Question 1.

What volume will a gas occupy at 740 mm pressure which at 1480 mm occupies 500 cc ?
[Temperature being constant] [1000 cc]

Answer:

$$P_1 V_1 = P_2 V_2$$
$$1480 \times 500 = 740 V_2$$

$$\therefore V_2 = \frac{1480 \times 500}{740} = 1000 \text{ c.c}$$

Question 2.

The volume of a given mass of a gas at 27°C is 100 cc. To what temperature should it be heated at the same pressure so that it will occupy a volume of 150 cc ? [177°C]

Answer:

$$V_1 = 100 \text{ cc}$$

$$T_1 = 27 + 273 = 300 \text{ K}$$

$$V_2 = 150 \text{ cc}$$

$$T_2 = ?$$

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

$$\therefore T_2 = \frac{150 \times 300}{100} = 450 \text{ K}$$

$$\therefore T_2 = 450 - 273 = 177^\circ\text{C}$$

Question 3.

A fixed mass of a gas has a volume of 750 cc at -23°C and 800 mm pressure. Calculate the pressure for which its volume will be 720 cc. The temperature being -3°C . [900mm]

Answer:

$$V_1 = 750\text{cc}$$

$$T_1 = -23 + 273 = 250\text{K}$$

$$P_1 = 800 \text{ mm}$$

$$V_2 = 720\text{cc}$$

$$T_2 = -3 + 273 = 270\text{K}$$

$$P_2 = ?$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$P_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{800 \times 750 \times 270}{250 \times 720}$$

$$P_2 = 900 \text{ mm}$$

Question 4.

What temperature would be necessary to double the volume of a gas initially at s.t.p. if the pressure is decreased by 50% ? [0°C]

Answer:

$$P_1 = 1 \text{ atm}$$

$$V_1 = x \text{ cc}$$

$$T_1 = 273 \text{ K}$$

$$P_2 = 1 \times \frac{50}{100} = \frac{1}{2} \text{ atm.}$$

$$V_2 = 2x \text{ cc}$$

$$T_2 = ?$$

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

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

$$T_2 = \frac{1}{2} \times \frac{2x \times 273}{1 \times x} = 273 \text{ K}$$

$$T_1 = 273 - 273 = 0^\circ \text{C}$$

Question 5.

A gas cylinder having a capacity of 20 litres contains a gas at 100 atmos. How many flasks of 200 cm³ capacity can be filled from it at 1 atmos. pressure if the temperature remains constant ?
[10,000]

Answer:

$$V_1 = 20 \text{ lits.} = 20,000 \text{ cc}$$

$$P_1 = 100 \text{ atm.}$$

At constant temperature

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{100 \times 20000}{1} = 2000000 \text{ cc}$$

\therefore Number of flasks of capacity 200cc

$$n \times 200 = 2000000$$

$$n = \frac{2000000}{200} = 10000 \text{ flasks}$$

Question 6.

A certain mass of gas occupied 850 ml at a pressure of 760 mm of Hg. On increasing the pressure

it was found that the volume of the gas was 75% of its initial value. Assuming constant temperature, find the final pressure of the gas? [1013.33 mm of Hg]

Answer:

$$V_1 = 850 \text{ ml}$$

$$V_2 = 850 \times \frac{75}{100} = \frac{850 \times 3}{4} \text{ ml}$$

$$P_1 = 760 \text{ mm of Hg}$$

$$P_2 = ?$$

$$\text{At constant temperature } P_1 V_1 = P_2 V_2$$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{760 \times 850 \times 4}{850 \times 3}$$

$$P_2 = \frac{3040}{3} = 1013.33 \text{ mm of Hg}$$

Question 7.

It is required to reduce the volume of a gas by 20% by compressing it at a constant pressure. To do so, the gas has to be cooled. If the gas attains a final temperature of 157°C, find the initial temperature of the gas ? [264.5°C]

Answer:

Initial conditions

Final conditions

$$V_1 = x \text{ cc (suppose)}$$

$$V_2 = \frac{80}{100}x = \frac{4}{5}x \text{ cc}$$

$$T_1 = ?$$

$$T_2 = 157 + 273 = 430\text{K}$$

$$\text{At constant pressure } \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\therefore T_1 = \frac{V_1 T_2}{V_2} = \frac{x \times 430}{\frac{4}{5}x} = \frac{430 \times 5}{4}$$

$$T_1 = 537.5\text{K} = 537.5 - 273 = 264.5^\circ\text{C}$$

Question 8.

At a given temperature the pressure of a gas reduces to 75% of its initial value and the volume increases by 40% of its initial value. Find this temperature if the initial temperature was -10°C . [3.15°C]

Answer:

$$P_1 = 1 \text{ atm.}$$

$$P_2 = \frac{75}{100} \times 1 = \frac{3}{4} \text{ atm.}$$

$$V_1 = x \text{ cc (suppose)}$$

$$V_2 = \frac{140}{100}x = \frac{7}{5}x$$

$$T_1 = -10 + 273 = 263\text{K}$$

$$T_2 = ?$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\therefore T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{3}{4} \times \frac{7x}{5} \times \frac{263}{1 \times x} = \frac{5523}{20}$$

$$T_2 = \frac{552.3}{2} = 276.15\text{K} = 276.15 - 273$$

$$\therefore T_2 = 3.15^\circ\text{C}$$

Study Of Gas Laws – Unit Test Paper 7

Q.1. Name or state the following :

Question 1.

The law which states that pressure remaining constant the volume of a given mass of dry gas is directly proportional to its absolute [Kelvin] temperature.

Answer:

Charle's Law.

Question 2.

The law which studies the relationship between pressure of a gas and the volume occupied by it at constant temperature.

Answer:

Boyle's Law.

Question 3.

An equation used in chemical calculations which gives a simultaneous effect of changes of temperature and pressure on the volume of a given mass of dry gas

Answer:

Gas equation.

Question 4.

The standard pressure of a gas in cm. of mercury corresponding to one atmospheric pressure.

Answer:

76 cm.

Question 5.

The absolute temperature value corresponding to 35°C.

Answer:

$$35 + 273 = 308\text{K}$$

Q.2. Give reasons for the following :**Question 1.**

Gases unlike solids and liquids exert pressure in all directions.

Answer:

Impact of gas molecules with high velocity causes pressure to be exerted on the walls.

Question 2.

Gases have lower densities compared to solids or liquids.

Answer:

Gases have low densities as the inter-molecular distance between the molecules of gases is very large.

$$\text{Pressure on the wall} = \frac{\text{Force exerted on the wall}}{\text{Total area of the container wall}}$$

Question 3.

Temperature remaining constant the product of the vol. & the press, of a given mass of dry gas is a constant.

Answer:

$$\text{According to Boyle's Law } V \propto \frac{1}{p}$$

$$V = K \cdot \frac{1}{p}$$

$$\therefore P \times V = K = \text{a constant}$$

\therefore Product of volume and pressure of a given mass of dry gas is constant. [at constant temperature]

Question 4.

All temperatures on the Kelvin scale are in positive figures.

Answer:

All temperatures on the Kelvin scale are in positive figures.

The temperature $-273^{\circ}\text{C} = 0\text{K}$ [Absolute zero or zero Kelvin]

Hence it may be negative or positive on Celsius scale, it is always positive on Kelvin as $0^{\circ}\text{C} = 0 + 273 = 273\text{K}$

$30^{\circ}\text{C} = 30 + 273 = 303\text{K}$

$-70^{\circ}\text{C} = -70 + 273 = 203\text{K}$

$-273^{\circ}\text{C} = -273 + 273 = 0\text{K}$

Question 5.

Volumes of gases are converted into s.t.p. conditions and then compared.

Answer:

Volumes of gases are converted into s.t.p. conditions and then compared as

volumes of gases change with temperature and pressure – hence a standard value of temperature and pressure is chosen to which gas volumes are referred.

Q.3. Calculate the following :**Question 1.**

Calculate the temperature to which a gas must be heated, so that the volume triples without any change in pressure. The gas is originally at 57°C and having a volume 150 cc.

Answer:

$$V_1 = 150\text{cc}$$

$$V_2 = 3 \times 150\text{cc}$$

$$T_1 = (57 + 273) = 330\text{K}$$

$$T_2 = ?$$

$$\text{At constant pressure } \frac{V_1}{T_1} = \frac{V_2}{T_2} \therefore T_2 = \frac{V_2 T_1}{V_1}$$

$$T_2 = \frac{(3 \times 150) \times 330}{150} = 990\text{K} = 990 - 273 = 717^{\circ}\text{C}$$

Question 2.

A gas 'X' at -33°C is heated to 127°C at constant pressure. Calculate the percentage increase in the volume of the gas.

Answer:

$$\text{Let } V_1 = x \text{ cc}$$

$$T_1 = -33 + 273$$

$$= 240\text{K}$$

$$V_2 = ?$$

$$T_2 = 127 + 273 = 400\text{K}$$

$$\text{At constant pressure } \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\therefore V_2 = \frac{V_1 T_2}{T_1} = \frac{x \times 400}{240} = \frac{5x}{3} \text{ cc}$$

$$\text{Increase in volume} = \frac{5x}{3} - x = \frac{2}{3}x \text{ cc}$$

$$\therefore \% \text{ increase} = \frac{\frac{2x}{3}}{x} \times 100 = \frac{200}{3} = 66\frac{2}{3} \%$$

Question 3.

Calculate the volume of a gas 'A' at s.t.p., if at 37°C and 775 mm of mercury pressure, it occupies a volume of $9\frac{1}{2}$ litres.

Answer:

Original conditions

$$T_1 = 37 + 273 = 310\text{K}$$

$$P_1 = 775 \text{ mm}$$

$$V_1 = 9\frac{1}{2} \text{ litres}$$

Final conditions

$$T_2 = 273\text{K}$$

$$P_2 = 760 \text{ mm}$$

$$V_2 = ?$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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

$$V_2 = \frac{775 \times 19 \times 273}{310 \times 2 \times 760} = 17\frac{1}{16} \text{ litres}$$

Question 4.

Calculate the temperature at which a gas 'A' at 20°C having a volume, of 500 cc. will occupy a volume of 250 cc.

Answer:

Initial conditions

$$T_1 = 20 + 273 = 293\text{K}$$

$$V_1 = 500 \text{ c.c}$$

Final conditions

$$T_2 = ?$$

$$V_2 = 250 \text{ cc}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \therefore T_2 = \frac{T_1 V_2}{V_1} = \frac{293 \times 250}{500}$$

$$T_2 = 146.5\text{K} = 146.5 - 273 = -126.5^\circ\text{C}$$

Question 5.

A gas 'X' is collected over water at 17°C and 750 mm. pressure. If the volume of the gas collected is 50 cc., calculate the volume of the dry gas at s.t.p. [at 17°C the vapour pressure is 14 mm.]

Answer:

Initial conditions

$$T_1 = 17 + 273 = 290\text{K}$$

$$P_1 = 750 \text{ mm} - 14 \text{ mm}$$

$$V_1 = 50 \text{ cc}$$

Final conditions

$$T_2 = 273\text{K}$$

$$P_2 = 760 \text{ mm}$$

$$V_2 = ?$$

$$\text{Using gas equation } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\therefore V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{736 \times 50 \times 273}{290 \times 760} = 45.58$$

$$\Rightarrow 45.6 \text{ cc}$$

Q.4. Assuming temperature remaining constant calculate the pressure of the gas in each of the following :

Question 1.

The pressure of a gas having volume 1000 cc. originally occupying 1500 cc. at 720 mm. pressure.

Answer:

$$P_1 = 720 \text{ mm}$$

$$V_1 = 1500 \text{ cc}$$

$$P_2 = ?$$

$$V_2 = 1000 \text{ cc}$$

$$\text{At constant temperature } P_1 V_1 = P_2 V_2$$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{720 \times 1500}{1000} = 1080 \text{ mm}$$

Question 2.

The pressure of a gas having volume 100 lits. originally occupying 75 dm³ at 700 mm. pressure.

Answer:

$$P_1 = 700 \text{ mm}$$

$$V_1 = 75 \text{ dm}^3$$

$$P_2 = ?$$

$$V_2 = 100 \text{ lits But } 1 \text{ dm}^3 = 1 \text{ litre}$$

$$\therefore V_2 = 100 \text{ dm}^3$$

$$\text{At constant temperature } P_1 V_1 = P_2 V_2$$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{700 \times 75}{100} = 525 \text{ mm}$$

Question 3.

The pressure of a gas having volume 380 lits. originally occupying 800 cm³ at 76 cm. pressure.

Answer:

$$V_1 = 800 \text{ cm}^3$$

$$P_1 = 76 \text{ cm}$$

$$V_2 = 380 \text{ lit.} = 380 \times 1000 \text{ cm}^3$$

$$P_2 = ?$$

$$\text{At constant temperature } P_1 V_1 = P_2 V_2$$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{76 \times 800}{380 \times 1000} = 0.16 \text{ cm of Hg}$$

Question 4.

The pressure of a gas having volume 1800 ml. originally occupying 300 ml. at 6 atms. pressure.

Answer:

$$V_1 = 300 \text{ ml}$$

$$P_1 = 6 \text{ atm.}$$

$$V_2 = 1800 \text{ ml}$$

$$P_2 = ?$$

At constant temperature $P_1 V_1 = P_2 V_2$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{6 \times 300}{1800} = 1 \text{ atm.}$$

Question 5.

The pressure of a gas having volume 1500 cm^3 originally occupying 750 cc. at 5 ats. pressure.

Answer:

$$V_1 = 750 \text{ cc}$$

$$P_1 = 5 \text{ atm.}$$

$$V_2 = 1500 \text{ cc}$$

$$P_2 = ?$$

At constant temperature $P_1 V_1 = P_2 V_2$

$$\therefore P_2 = \frac{P_1 V_1}{V_2} = \frac{5 \times 750}{1500} = \frac{5}{2} = 2.5 \text{ atm.}$$

Q.5. Calculate the following :

Question 1.

The temp, at which 500 cc. of a gas 'X' at temp. 293K occupies half it's original volume [pressure constant].

Answer:

$$V_1 = 500 \text{ cc}$$

$$T_1 = 293\text{K}$$

At constant pressure

$$V_2 = \frac{500}{2} = 250 \text{ cc}$$

$$T_2 = ?$$

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

$$\therefore T_2 = \frac{T_1 V_2}{V_1} = \frac{293 \times 250}{500} = 146.5\text{K}$$

$$= 146.5 - 273 = -126.5^\circ\text{C}$$

Question 2.

The volume at s.t.p. occupied by a gas 'Y' originally occupying 760 cc. at 300K and 70 cm. press, of Hg.

Answer:

$$P_1 = 70 \text{ cm}$$

$$V_1 = 760 \text{ cc}$$

$$T_1 = 300\text{K}$$

$$P_2 = 76 \text{ cm}$$

$$V_2 = ?$$

$$T_2 = 273\text{K}$$

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

$$\therefore V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{70 \times 760 \times 273}{300 \times 76} = 637$$

$$\therefore V_2 = 637 \text{ c.c}$$

Question 3.

The volume at s.t.p. occupied by a gas 'Z' originally occupying 1.57 dm³ at 310.5K and 75 cm. press. of Hg.

Answer:

Initial conditions

$$V_1 = 1.57 \text{ dm}^3$$

$$P_1 = 75 \text{ cm}$$

$$T_1 = 310.5\text{K}$$

Final conditions

$$V_2 = ?$$

$$P_2 = 76 \text{ cm}$$

$$T_2 = 273\text{K}$$

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

$$\therefore V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{75 \times 1.57 \times 273}{310.5 \times 76} = 1.36 \text{ dm}^3$$

Question 4.

The volume at s.t.p. occupied by a gas 'Q' originally occupying 153.7 cm³ at 287K and 750 mm. pressure [vapour pressure of gas 'Q' at 287K is 12 mm of Hg.]

Answer:

Initial conditions

$$V_1 = 153.7 \text{ cm}^3$$

$$P_1 = 750 \text{ mm} - 12 = 738 \text{ mm}$$

$$T_1 = 287\text{K}$$

Final conditions

$$V_2 = ?$$

$$P_2 = 760 \text{ mm}$$

$$T_2 = 273\text{K}$$

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

$$\therefore V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{738 \times 153.7 \times 273}{287 \times 760} = 141.707 \text{ cm}^3$$

Question 5.

The temperature to which a gas 'P' has to be heated to triple its volume, if the gas originally occupied 150 cm^3 at 330K [pressure remaining constant].

Answer:

$$T_1 = 330\text{K}$$

$$V_1 = 150 \text{ cm}^3$$

$$T_2 = ?$$

$$V_2 = 3 \times 150 = 450 \text{ cm}^3$$

At constant pressure $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$$\therefore T_2 = \frac{T_1 V_2}{V_1} = \frac{330 \times 450}{150} = 990\text{K}$$

$$\Rightarrow T_2 = 990 - 273 = 717^\circ\text{C}$$

Q.6. Fill in the blanks with the correct word, from the words in bracket :

Question 1.

If the temperature of a fixed mass of a gas is kept constant and the pressure is increased, the volume correspondingly ____ [increases / decreases]

Answer:

If the temperature of a fixed mass of a gas is kept constant and the pressure is increased, the volume correspondingly **decreases**.

Question 2.

If the pressure of a fixed mass of a gas is kept constant and the temperature is increased, the volume correspondingly ____ [increases / decreases]

Answer:

If the pressure of a fixed mass of a gas is kept constant and the temperature is increased, the volume correspondingly **increases**.

Question 3.

1 dm³ of a gas is equal to ____ [1 litre / 100ml. / 100 cc.]

Answer:

1 dm³ of a gas is equal to **1 litre**.

Question 4.

All the temperature on the kelvin scale are in ____ figures [negative positive]

Answer:

All the temperature on the kelvin scale are in **positive** figures.

Question 5.

At -273°C the volume of a gas is theoretically ____ [272 cc. / 0 cc. / 274 cc.]

Answer:

At -273°C the volume of a gas is theoretically **0 cc**.