



NCERT Solutions for 11th Class Chemistry: Chapter 5-States of Matter



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NCERT Solutions for 11th Class Chemistry: Chapter 5-States of Matter

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Question 1. What will be the minimum pressure required to compress 500 dm³ of air at 1 bar to 200 dm³ at 30°C?

Answer: $P_1 = 1 \text{ bar}, P_2 = ?$ $V_1 = 500 \text{ dm}^3, V_2 = 200 \text{ dm}^3$

As temperature remains constant at 30°C,

$$P_1 V_1 = P_2 V_2$$

$$1 \text{ bar} \times 500 \text{ dm}^3 = P_2 \times 200 \text{ dm}^3 \text{ or } P_2 = 500/200 \text{ bar} = 2.5 \text{ bar}$$

Question 2. A vessel of 120 mL capacity contains a certain amount of gas at 35°C and 1.2 bar pressure. The gas is transferred to another vessel of volume 180 mL at 35°C. What would be its pressure?

Answer: $V_1 = 120 \text{ mL}, P_1 = 1.2 \text{ bar},$

$V_2 = 180 \text{ mL}, P_2 = ?$

As temperature remains constant, $P_1 V_1 = P_2 V_2$

$$(1.2 \text{ bar}) (120 \text{ mL}) = P_2 (180 \text{ mL})$$

Question 3. Using the equation of state $PV = nRT$, show that at a given temperature, density of a gas is proportional to the gas pressure P .

Answer: According to ideal gas equation

$$PV = nRT \text{ or } PV = nRT/V$$

$$n = \frac{\text{Constant Mass of gas}}{\text{Molar mass of gas}}$$

$$P = \frac{mRT}{MV}$$

$$P = \frac{\rho RT}{M}$$

$$P \propto \rho \text{ at constant temperature}$$

$$\left[\because \rho (\text{density}) = \frac{m}{V} \right]$$

Question 4. At 0°C, the density of a gaseous oxide at 2 bar is same as that of dinitrogen at 5 bar. What is the molecular mass of the oxide?

Answer: Using the expression, $d = MP/RT$, at the same temperature and for same density,

$$M_1 P_1 = M_2 P_2 \text{ (as } R \text{ is constant)}$$

(Gaseous oxide) (N_2)

or

$$M_1 \times 2 = 28 \times 5 \text{ (Molecular mass of } N_2 = 28 \text{ u)}$$

$$\text{or } M_1 = 70 \text{ u}$$

Question 5. Pressure of 1 g of an ideal gas A at 27°C is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at same temperature, the pressure becomes 3 bar. Find the relationship between their molecular masses.

Answer: Suppose molecular masses of A and B are M_A and M_B respectively. Then their number of moles will be

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$$n_A = \frac{1}{M_A}, \quad n_B = \frac{2}{M_B}$$

$$P_A = 2 \text{ bar}, \quad P_A + P_B = 3 \text{ bar}, \quad \text{i.e., } P_B = 1 \text{ bar}$$

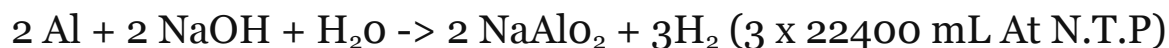
Applying the relation $PV = nRT$

$$P_A V = n_A RT, \quad P_B V = n_B RT \quad \therefore \quad \frac{P_A}{P_B} = \frac{n_A}{n_B} = \frac{1/M_A}{2/M_B} = \frac{M_B}{2M_A}$$

$$\text{or} \quad \frac{M_B}{M_A} = 2 \times \frac{P_A}{P_B} = 2 \times \frac{2}{1} = 4 \quad \text{or} \quad M_B = 4 M_A$$

Question 6. The drain cleaner, Drainex contains small bits of aluminium which react with caustic soda to produce dihydrogen. What volume of dihydrogen at 20 °C and one bar will be released when 0.15g of aluminium reacts?

Answer: The chemical equation for the reaction is



$$2 \times 27 = 54 \text{ g.}$$

54 g of Al at N.T.P release

H₂ gas = 3 x 22400 0.15 g of Al at N.T.P release

$$\begin{aligned} \text{H}_2 \text{ gas} &= \frac{3 \times 22400 \times 0.15}{54} \\ &= 186.7 \text{ mL} \end{aligned}$$

N.T.P condition.	$V_1 = 186.7 \text{ mL}$	$V_2 = ?$
	$P_1 = 1.013 \text{ bar}$	$P_2 = 1 \text{ bar}$
	$T_1 = 0 + 273 = 273 \text{ K}$	$T_2 = 20 + 273$
		$= 293 \text{ K}$

According to Gas equation

$$\begin{aligned} \frac{P_1 V_1}{T_1} &= \frac{P_2 V_2}{T_2} \quad \text{or} \quad V_2 = \frac{P_1 V_1 T_2}{P_2 T_1} \\ V_2 &= \frac{1.013 \text{ bar} \times 186.7 \text{ mL} \times 293 \text{ K}}{1 \text{ bar} \times 273 \text{ K}} \\ &= 203 \text{ mL} \end{aligned}$$

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Question 7. What will be the pressure exerted by a mixture of 3.2g of methane and 4.4g of carbon dioxide contained in a 9 dm³ flask at 27 °C?

Answer:

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$$p = \frac{n}{V} RT = \frac{m}{M} \frac{RT}{V}$$

$$p_{\text{CH}_4} = \left(\frac{3.2}{16} \text{ mol} \right) \frac{0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1} \times 300 \text{ K}}{9 \text{ dm}^3} = 0.55 \text{ atm}$$

$$p_{\text{CO}_2} = \left(\frac{4.4}{44} \text{ mol} \right) \frac{0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1} \times 300 \text{ K}}{9 \text{ dm}^3} = 0.27 \text{ atm}$$

$$p_{\text{total}} = 0.55 + 0.27 = 0.82 \text{ atm}$$

In terms of SI units, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$, $V = 9 \times 10^{-3} \text{ m}^3$

$$P = 5.543 \times 10^4 \text{ Pa} + 2.771 \times 10^4 \text{ Pa} = 8.314 \times 10^4 \text{ Pa.}$$

Question 8. What will be the pressure of the gas mixture when 0.5 L of H_2 at 0.8 bar and 2.0 L of dioxygen at 0.7 bar are introduced in all vessel at 27°C ?

Answer: Calculation of partial pressure of H_2 in 1L vessel $P_1 = 0.8 \text{ bar}$,

$$P_2 = ? \quad V_1 = 0.5 \text{ L}, \quad V_2 = 1.0 \text{ L}$$

As temperature remains constant, $P_1 V_1 = P_2 V_2$

$$(0.8 \text{ bar})(0.5 \text{ L}) = P_2 (1.0 \text{ L}) \text{ or } P_2 = 0.40 \text{ bar, i.e., } P_{\text{H}_2} = 0.40 \text{ bar}$$

Calculation of partial pressure of O_2 in 1 L vessel

$$P_1' V_1 = P_2' V_2'$$

$$(0.7 \text{ bar})(2.0 \text{ L}) = P_2' (1\text{L}) \text{ or } P_2' = 1.4 \text{ bar, i.e., } P_{\text{O}_2} = 1.4 \text{ bar}$$

$$\text{Total pressure} = P_{\text{H}_2} + P_{\text{O}_2} = 0.4 \text{ bar} + 1.4 \text{ bar} = 1.8 \text{ bar}$$

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Question 9. Density of a gas is found to be 5.46 g/dm³ at 27 °C and at 2 bar pressure. What will be its density at STP?

Answer:

$d = \frac{MP}{RT}$. For the same gas at different temperatures and pressures, $\frac{d_1}{d_2} = \frac{P_1}{P_2} \times \frac{T_2}{T_1}$.

Here, $d_1 = 5.46 \text{ g dm}^{-3}$, $T_1 = 27^\circ\text{C} = 300 \text{ K}$, $P_1 = 2 \text{ bar}$.
At STP, $d_2 = ?$, $T_2 = 0^\circ\text{C} = 273 \text{ K}$, $P_2 = 1 \text{ bar}$

$$\therefore \frac{5.46 \text{ g dm}^{-3}}{d_2} = \frac{2 \text{ bar}}{300 \text{ K}} \times \frac{273 \text{ K}}{1 \text{ bar}} \text{ or } d_2 = 3 \text{ g dm}^{-3}$$

Question 10. 34.05 mL of phosphorus vapour weighs 0.0625 g at 546°C and 1.0 bar pressure. What is the molar mass of phosphorus?

Answer:

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Step I. Calculation of volume at 0°C and 1 bar pressure

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \text{ i.e., } \frac{1 \times 34.05}{546 + 273} = \frac{1 \times V_2}{273} \text{ or } V_2 = 11.35 \text{ mL}$$

11.35 mL of vapour at 0°C and 1 bar pressure weigh = 0.0625 g

∴ 22700 mL of vapour at 0°C and 1 bar pressure will weigh

$$= \frac{0.0625}{11.35} \times 22700 = 125 \text{ g}$$

∴ Molar mass = **125 g mol⁻¹**

Alternatively, using

$$R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$$

$$PV = nRT, \text{ i.e., } n = \frac{PV}{RT} = \frac{1.0 \text{ bar} \times (34.05 \times 10^{-3} \text{ dm}^3)}{0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ Mol}^{-1} \times 819 \text{ K}}$$
$$= 5 \times 10^{-4} \text{ mol}$$

$$\therefore \text{Mass of 1 mole} = \frac{0.0625}{5 \times 10^{-4}} \text{ g} = 125 \text{ g}$$

∴ Molar mass = **125 g mol⁻¹**

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Question 11. A student forgot to add the reaction mixture to the round bottomed flask at 27 °C but instead, he/she placed the flask on the flame. After a lapse of time, he realized his mistake, and using a pyrometer, he found the temperature of the flask was 477 °C. What fraction of air would have been expelled out?

Answer:

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Suppose volume of vessel = $V \text{ cm}^3$
i.e., volume of air in the flask at $27^\circ\text{C} = V \text{ cm}^3$.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}, \text{ i.e., } \frac{V}{300} = \frac{V_2}{750} \text{ or } V_2 = 2.5 V$$

$$\therefore \text{Volume expelled} = 2.5 V - V = 1.5 V$$

$$\therefore \text{Fraction of air expelled} = \frac{1.5 V}{2.5 V} = \frac{3}{5}$$

Question 12. Calculate the temperature of 4.0 moles of a gas occupying 5 dm^3 at 3.32 bar ($R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$)

Answer:

$$PV = nRT \text{ or } T = \frac{PV}{nR} = \frac{3.32 \text{ bar} \times 5 \text{ dm}^3}{4.0 \text{ mol} \times 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}} = 50\text{K}$$

Question 13. Calculate the total number of electrons present in 1.4 g of dinitrogen gas.

Answer: Molecular mass of $\text{N}_2 = 28\text{g}$

28 g of N_2 has No. of molecules = 6.022×10^{23} 1.4 g of

N_2 has No. of molecules = $6.022 \times 10^{23} \times 1.4 \text{ g} / 28 \text{ g}$

= 3.011×10^{22} molecules.

Atomic No. of Nitrogen (N) = 7

1 molecule of N_2 has electrons = $7 \times 2 = 14$

3.011×10^{22} molecules of N_2 have electrons

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$$= 14 \times 3.011 \times 10^{22}$$

$$= 4.215 \times 10^{23} \text{ electrons.}$$

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Question 14. How much time would it take to distribute one Avogadro number of wheat grains if 10^{10} grains are distributed each second ?

Answer:

$$\begin{aligned} \text{Time taken to distribute } 10^{10} \text{ grains} &= 1 \text{ s} \\ \text{Time taken to distribute} &= 6.022 \times 10^{23} \text{ grains} \\ &= \frac{1 \text{ s} \times 6.022 \times 10^{23} \text{ grains}}{10^{10} \text{ grains}} \\ &= \frac{6.022 \times 10^{13}}{60 \times 60 \times 24 \times 365} = 1.9 \times 10^6 \text{ yr.} \end{aligned}$$

Question 15. Calculate the total pressure in a mixture of 8g of oxygen and 4g of hydrogen confined in a vessel of 1 dm^3 at 27°C . $R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$.

Answer:

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$$\text{Molar mass of O}_2 = 32 \text{ g mol}^{-1} \quad \therefore \quad 8 \text{ g O}_2 = \frac{8}{32} \text{ mol} = 0.25 \text{ mol}$$

$$\text{Molar mass of H}_2 = 2 \text{ g mol}^{-1} \quad \therefore \quad 4 \text{ g H}_2 = \frac{4}{2} = 2 \text{ mol}$$

$$\therefore \text{ Total number of moles } (n) = 2 + 0.25 = 2.25$$

$$V = 1 \text{ dm}^3, \quad T = 27^\circ\text{C} = 300 \text{ K}, \quad R = 0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$$
$$PV = nRT$$

or

$$P = \frac{nRT}{V} = \frac{(2.25 \text{ mol}) (0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}) (300 \text{ K})}{1 \text{ dm}^3}$$
$$= 56.025 \text{ bar}$$

Question 16. Pay load is defined as the difference between the mass of the displaced air and the mass of the balloon. Calculate the pay load when a balloon of radius 10 m, mass 100 kg is filled with helium at 1.66 bar at 27°C (Density of air = 1.2 kg m⁻³ and R = 0.083 bar dm³ K⁻¹ mol⁻¹).

Answer:

Radius of the balloon = 10 m

$$\therefore \text{Volume of the balloon} = \frac{4}{3} \pi r^3 = \frac{4}{3} \times \frac{22}{7} \times (10 \text{ m})^3 = 4190.5 \text{ m}^3$$

Volume of He filled at 1.66 bar and 27 °C = 4190.5 m³

Calculation of mass of He

$$PV = nRT = \frac{w}{M} RT$$

$$\text{or } w = \frac{MPV}{RT} = \frac{(4 \times 10^{-3} \text{ kg mol}^{-1}) (1.66 \text{ bar}) (4190.5 \times 10^3 \text{ dm}^3)}{(0.083 \text{ bar dm}^3 \text{ K}^{-1} \text{ mol}^{-1}) (300 \text{ K})}$$
$$= 1117.5 \text{ kg}$$

Total mass of the balloon alongwith He = 100 + 1117.5 = 1217.5 kg

Maximum mass of the air that can be displaced by balloon to go up = Volume × Density
= 4190.5 m³ × 1.2 kg m⁻³ = 5028.6 kg

$$\therefore \text{Pay load} = 5028.6 - 1217.5 \text{ kg} = 3811.1 \text{ kg}$$

Question 17. Calculate the volume occupied by 8.8 g of CO₂ at 31.1 °C and 1 bar pressure. R = 0.083 bar LK⁻¹ mol⁻¹

Answer:

$$\begin{aligned} \text{No. of moles of CO}_2 (n) &= \frac{\text{Mass of CO}_2}{\text{Molar mass}} \\ &= \frac{8.8 \text{ g}}{44 \text{ g mol}^{-1}} = 0.2 \text{ mol} \end{aligned}$$

Pressure of CO₂ (P) = 1 bar

R = 0.083 bar LK⁻¹ mol⁻¹

Temperature (T) = 273 + 31.1

= 304.1 K

Since from gas eq. $PV = nRT$

$$\begin{aligned} V &= \frac{nRT}{P} = \frac{0.2 \times 0.083 \times 304.1}{1 \text{ bar}} \\ &= 5.048 \text{ L} \end{aligned}$$

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Question 18. 2.9 g of a gas at 95°C occupied the same volume as 0.184 g of hydrogen at 17°C at the same pressure. What is the molar mass of the gas ?

Answer:

$$\begin{aligned} \text{As } P_1 &= P_2 \text{ and } V_1 = V_2 \\ \therefore P_1 V_1 &= P_2 V_2, \text{ i.e., } n_1 R T_1 = n_2 R T_2 \quad \therefore n_1 T_1 = n_2 T_2 \\ \text{or } \frac{w_1}{M_1} T_1 &= \frac{w_2}{M_2} T_2 \\ \frac{2.9}{M_x} \times (95 + 273) &= \frac{0.184}{2} \times (17 + 273) \quad \text{or } M_x = \frac{2.9 \times 368 \times 2}{0.184 \times 290} = 40 \text{ g mol}^{-1} \end{aligned}$$

Question 19. A mixture of dihydrogen and dioxygen at one bar pressure contains 20% by weight of dihydrogen. Calculate the partial pressure of dihydrogen.

Answer: As the mixture H_2 and O_2 contains 20% by weight of dihydrogen, therefore, if $\text{H}_2 = 20\text{g}$, then $\text{O}_2 = 80\text{g}$

$$\begin{aligned} n_{\text{H}_2} &= \frac{20}{2} = 10 \text{ moles, } n_{\text{O}_2} = \frac{80}{32} = 2.5 \text{ moles} \\ p_{\text{H}_2} &= \frac{n_{\text{H}_2}}{n_{\text{H}_2} + n_{\text{O}_2}} \times P_{\text{total}} = \frac{10}{10 + 2.5} \times 1 \text{ bar} = 0.8 \text{ bar} \end{aligned}$$

Question 20. What would be the SI unit for the quantity PV^2T^2/n ?

Answer:

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$$\frac{(\text{Nm}^{-2})(\text{m}^3)^2(\text{K})^2}{\text{mol}} = \text{Nm}^4 \text{K}^2 \text{mol}^{-1}$$

Question 21. In terms of Charles' law explain why -273°C is the lowest possible temperature.

Answer: At -273°C , volume of the gas becomes equal to zero, i.e., the gas ceases to exist.

Question 22. Critical temperature for CO_2 and CH_4 are 31.1°C and -81.9°C respectively. Which of these has stronger intermolecular forces and why?

Answer: Higher the critical temperature, more easily the gas can be liquefied, i.e., greater are the intermolecular forces of attraction. Hence, CO_2 has stronger intermolecular forces than CH_4 .

Question 23. Explain the physical significance of vander Waals parameters.

Answer: 'a' is a measure of the magnitude of the intermolecular forces of attraction, while b is a measure of the effective size of the gas molecules.

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Organise pre-service and in-service training of teachers; develop and disseminate innovative educational techniques and practices; collaborate and network with state educational departments, universities, NGOs and other educational institutions; act as a clearing house for ideas and information in matters related to school education; and act as a nodal agency for achieving the goals of Universalisation of Elementary Education. In addition to research, development, training, extension, publication and dissemination activities, NCERT is an implementation agency for bilateral cultural exchange programmes with other countries in the field of school education. Its headquarters are located at Sri Aurobindo Marg in New Delhi. [Visit the Official NCERT website](#) to learn more.

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