CHEMISTRY

BOOKS - NAGEEN CHEMISTRY (ENGLISH)

STATES OF MATTER : GASES AND LIQUIDS

Example

1. The difference in the heights of mercury levels in an open end manometer connected to a gas chamber is found to be 175 mm. If the height of mercury level in the smaller limb is more as compared to that in the longer limb and the atmospheric pressure is 755 mm, what is the pressure of the gas ?

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2. The difference in the heights of mercury columns in a closed end manometer connected to a gas container is found to be 15 cm. What is the pressure of the gas in terms of Pa ?

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3. At a particular temperature, a certain quantity of gas occupies a volume of 74cm^3 at a pressure of 760 mm. If the pressure is decreased to 740 mm, what will be the volume of the gas at the same temperaute ?

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4. The volume of a certain amount of a gas at $25^\circ C$ and at 100 cm pressure is 80 mL. The gas is expanded to 140.5 mL keeping temperature constant. Calculate the pressure of the expanded gas.

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5. A weather balloon has a volume of 175 L when filled with hydrogen at a pressure of 1.000 atm. Calculate the volume of the balloon when it rises to a height of 2000 m, where atmospheric pressure is 0.8000 atm. Assume that temperature is constant.

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6. A sample of a gas occupies 650.0 cm at $100^{\circ}C$. At what temperature the gas will occupy a volume of $1050.0cm^3$ if the pressure is kept constant ?

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7. It is desired to reduce the volume of 1000 cm of a gas by $25\ \%$. To what temperature the gas be cooled if the initial temperature is $125^{\circ}C$ and the pressure remains constant ?

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8. A sample of helium has a volume of $500cm^3$ at 373 K. Calculate the temperature at which the volume will become $260cm^3$. Assume that the pressure is constant.

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9. A sample of gas occupies 12 L at $227^\circ C$ and at 1 atm pressure. The gas is cooled to - $73^\circ C$ at the same pressure. What would be the volume of the gas?

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10. A gas cylinder contains oxygen gas at $25^\circ C$ and 15.0 atm. If the temperature of the surroundings rises to $42^\circ C$, what would be the pressure of the gas in the cylinder ?

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11. Calculate the temperature at which 28 g of N_2 will occupy a volume of 10.0 litres at 2.46 atmospheres.

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12. A certain quantity of a gas measured 500 mL at a temperature of $15^\circ C$ and 750 mm Hg What pressure is required to compress this quantity of gas into a 400 mL vessel at a temperature of $50^\circ C$?

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13. Calculate the weight of methane in a 9.00 litres cylinder at 16 atm and $27^\circ C$.

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14. Oxygen is present in a 1 litre flask at a pressure of $7.6 \times 10^{-10} mm$ of Hg. Calculate the number of oxygen molecules in the flask at $0^\circ C$

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15. An open vessel at $27^\circ C$ is heated until three fifth of the air in it has been expelled! Assuming volume of vessel constant find the temperature to which the vessel has been heated

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16. A sample of nitrogen gas occupies a volume of 1 L at a pressure of 0.5 bar at $40^\circ C$. Calculate the pressure if the gas is compressed to $0.225 cm^3 \text{at} -6^\circ C$

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17. How many moles of oxygen are present in a $550 cm^3$ sample of a gas at a pressure of 1.5 atm and at a temperature of $27^\circ C$? (Given, R = 8.31 k Pa $dm^3 K^{-1} mol^{-1}$).

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18. Calculate the density of carbon dioxide at $27^{\circ}C$ and 5 atmosphere pressure.

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19. 7.00 g of a gas occupies a volume of 4.1 L at 300 K and 1 atm pressure. What is the molecular mass of the gas?

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20. A gas of molecular mass 71 g mol^{-1} is enclosed in a vessel at a temperature of $30^{\circ}C$. If the pressure exerted by the gas is 1065 mm of Hg, calculate the density of the gas.

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21. Calculate the weight of MnO_2 required to produce 1.50 L of chlorine at $27^\circ C$ and 1.50 atm pressure according to the following equation:

$MnO_2 + 4HCI \rightarrow MnCl_2 + 2H_2O + Cl_2$

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22. Ethane burns in oxygen to form CO_2 and H_2O according to the equation :

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

If 1250 cc of oxygen is burnt with 300 cc of ethane. Calculate :

the volume of unused O_2.

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23. Ethane burns in oxygen to form Carbon dioxide and Water vapours. Write the balanced equation.

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24. Compute the mass of potassium chlorate $(KClO_3)$ that should decompose to produce 8 g of oxygen as per the chemical equation , $2KClO_3 \rightarrow 2KCl + 3O_2(g)$

(R.A.M : K = 39, Cl = 35.5, $O = 16$.)

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25. 4 g of O_2 and 2g of H_2 are confined in a vessel of capacity 1 litre at $0^\circ C$. Calculate

the number of moles of each gas

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26. 4 g of O_2 and 2g of H_2 are confined in a vessel of capacity 1 litre at $0^\circ C$. Calculate

the partial pressure of each gas, and

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27. A container of 1 L capacity contains a mixture of 4 g of O_2 and 2 g H_2 at $0.^\circ C$. What will be the total pressure of the mixture ? (a) 50 . 42 atm (b) 25 . 21 atm (C) 15 . 2 atm (d) 12 . 5 atm

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28. At $27^\circ C$, a cylinder of 20 L capacity contains three gases He, O_2 and N_2. Their masses are 0.502 g, 0.250 g and 1.00 g respectively. If all these gases behave ideally, calculate the partial pressure of each gas as well as the total pressure.

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29. 750 mL of nitrogen are collected over water at $25^\circ C$ and 740 mm pressure. If the aqueous tension at this temperature is 23.8 mm Hg, calculate the mass of the dry gas.

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30. The volume of a gas X and chlorine diffusing during the same time are 35 mL and 29 mL respectively. If molecular mass of chlorine is 71, calculate the molecular mass of gas X.

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31. A vessel with small opening contained equal volumes of oxygen and an unknown gas. Oxygen effused through the opening 1.8 times faster than the unknown gas. If the atomic mass of oxygen is 16, calculate the molecular mass of the unknown gas.

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32. A straight glass tube has two inlets X and Y at the two ends. The length of the tube is 200 cm. HCl gas through inlet X and NH_3 gas through inlet Y are allowed to enter the tube at the same time. White fumes first appear at a point Pinside the tube. Find the distance of P from X.

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33. Calculate the average kinetic energy of a hydrogen molecule at $27^\circ C$.

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34. Calculate the kinetic energy of 5 moles of O_2 at $0^\circ C$. $\left(R = 8.31 \times 10^7 \text{ ergs } K^{-1} mol^{-1}\right)$

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35. Calculate the average velocity of oxygen molecule at $27^\circ C$.

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36. Calculate the RMS velocity of hydrogen molecule at $0^\circ C$.

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37. Calculate the RMS velocity of chlorine molecules at $15^{\circ}C$ and 75 cm Hg pressure. (Given : density of $Hg = 13.596gcm$, $g = 980.6 \ \text{cm} \ s^{-2}$

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38. Calculate the most probable velocity of nitrogen molecules at $15^{\circ}C$.

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39. Two moles of ammonia occupy a volume of 5 L at $27^{\circ}C$ and 9.32 atm pressure. Calculate the compressibility factor of the gas.

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40. Calculate the pressure exerted by one mole of methane in a 450 mL container at $25^{\circ}C$ using van der Waals' equation. What pressure will be

predicted by ideal gas equation ?

(Given :

$a = 2.253 \text{ atm } L^2 mol^{-2}, b = 0.0428 L mol^{-2}, R = 0.0821 L \text{ atm } K^{-1} m$

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Review Exercises

1. Give a brief account of the important characteristics of gases.

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2. Explain the following:

Gases have no definite shape nor a definite volume of their own.

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3. Explain the following:

Gases can be compressed by applying pressure on them.

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4. Explain the following:

Gases can mix up freely with one another.

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5. Define the term pressure.

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6. What is the SI unit of pressure ? Define it.

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7. What do you understand by S.T.P. ?

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8. An LPG cylinder can withstand a pressure of 14.9 atmosphere. The pressure gauge of the cylinder indicates 12 atmosphere at $27^{\circ}C$. Because of a sudden fire in the building , the temperature rises. At what temperature will the cylinder explode ?

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9. A gas occupies 500 mL at $25^{\circ}C$ and 745 mm pressure. What would be its volume at S.T.P.?

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10. A gas occupies 3.00 L at $32^{\circ} C$ and 1 atm pressure. What volume will it occupy if the temperature is changed to $18^{\circ} C$, the pressure remaining unchanged?

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11. 7.00 g of a gas occupies a volume of 4.1 L at 300 K and 1 atm pressure. What is the molecular mass of the gas?

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12. A balloon blown up has a volume of 500 mL at $5^{\circ} C$. The balloon is distended to 7/8th of its maximum capacity.

Will it burst at $30^{\circ} C$?

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13. A balloon blown up has a volume of 500 mL at $5^{\circ}C$. The balloon is distended to 7/8th of its maximum capacity.

Calculate the minimum temperature above which it will burst.

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14. At a constant temperature, 250 mL of argon at 760 mm pressure and 600 mL of nitrogen at 500 mm pressure are put together in a one litre flask. Calculate the final pressure.

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15. H_2 gas produced by the reaction

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

is collected over water. If 0.3 g of Zn are consumed at $27^{\circ}C$ in the reaction, calculate the volume of hydrogen produced. (Given : Barometric reading = 750 mm, Aqueous tension at $27^{\circ}C$ = 25 mm, Atomic weight of Zn = 65.4).

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16. When 2g of a gas A is introduced into an evacuated flask kept at $25^\circ C$, the pressure is found to be one atmosphere. If 3 g of another gas B are then added to the same flask, the total pressure becomes 1.5 atm. Assuming ideal gas behaviour, calculate the ratio of molecular weights $M_A : M_B$.

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17. Calculate the density of SO_2 at $27^\circ C$ and 1.5 atm pressure.

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18. A gas at $0^\circ C$ and 1 atmospheric pressure occupies 2.5 litres. What change in temperature would be necessary if the pressure is to be adjusted to 1.5 atmospheres and the gas has been transferred to a 2.0 litre container?

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19. A balloon of 21 cm diameter is to be filled with hydrogen gas at S.T.P. from a cylinder containing hydrogen gas at 20 atm and 300 K. The capacity of the cylinder is 2.82 litres at S.T.P. How many balloons can be filled in ?

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20. What weight of AgCl would be precipitated if 10 mL of HCl gas measured at $12^{\circ} C$ and 750 mm pressure were passed into the excess of a solution of silver nitrate ?

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21. An open flask at $25^{\circ} C$ contains air. Calculate the temperature at which one fifth of air measured at $25^{\circ} C$ escapes.

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22. What time will be required for a sample of ethane (C_2H_6) to effuse through an orifice if a similar sample of butane (C_4H_{10}) required 2 minutes 23 seconds ?

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23. A discharge tube of 2 litre capacity containing hydrogen gas was evacuated till the pressure inside is 1×10^{-5} atm. If the tube is maintained at a temperature of $27^{\circ} C$, calculate the number of hydrogen molecules still present in the tube.

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24. Atomic and molecular sizes are typically of the order of a few Angstroms. Assuming that a N_2 molecules is spherical in shape with

radius $(r) = 2 \times 10^{-10}$ m, calculate

the volume of a single N_2 molecule,

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25. Atomic and molecular sizes are typically of the order of a few Angstroms. Assuming that a N_2 molecules is spherical in shape with radius $(r) = 2 \times 10^{-10}$ m, calculate

the percentage of empty space in one mole of N_2 gas at S.T.P.

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26. Calculate the average volume available to a molecule in a sample of oxygen gas at S.T.P. Also calculate the average distance between neighbouring molecules if a oxygen molecule is assumed to be spherical.

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27. Calculate the average, the RMS and the most probable velocities of nitrogen molecules at S.T.P.

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28. Calculate the average velocity of CO_2 molecule at S.T.P.

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29. Oxygen at 1 atm and $0^\circ C$ has a density of $1.4290 gL^{-1}$. Calculate the RMS velocity of oxygen molecules.

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30. 88 g of CO_2 are confined to a 6 L flask at $37^\circ C$. Calculate its pressure using van der Waals' equation. Given, $a = 4.17 \text{ atm } L^2 mol^{-2}, b = 0.038 L mol^{-1}$.

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31. Calculate the pressure exerted by 0.350 moles of carbon dioxide in 0.360 L container at $100^{\circ}C$. What pressure will be predicted by ideal gas equation? $(a = 3.59 \text{ atm } L^2mol^{-2}, b = 0.0427Lmol^{-1})$

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32. The pressure exerted by one mole of CO_2 at $0^{\circ}C$ in a volume of 0.05 L is 1386.15 atm. Calculate the compressibility factor of the gas.

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33. The values of the van der Waals' constant a for some gases are given below.

$H_2 = 0.245 \text{ atm } L^2mol^{-2}$

$O_2 = 1.360 \text{ atm } L^2mol^{-2}$

$CO_2 = 3.590 \text{ atm } L^2mol^{-2}$

$NH_3 = 4.170 \text{ atm } L^2 mol^{-2}$

Arrange these gases in the decreasing order of their liquefaction tendencies.

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34. Explain the exceptional behaviour of H_2 and He on Z-P plot.

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35. Explain giving reasons :

Which of the following is likely to cause more severe burns? (a) water at $100^\circ C$ (b) steam at $100^\circ C$.

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36. Explain giving reasons :

The rate of diffusion of liquids is less than that of gases.

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37. Why is the molar heat of vapourisation of water higher than that of alcohol?

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38. Arrange the following liquids in the decreasing order of the rate of evaporation : water, ethyl alcohol, benzene, .

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39. What is the effect of temperature on the viscosity of a liquid?

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40. What is the effect of temperature on the viscosity of a liquid?

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41. What is the effect of temperature on the Properties of liquids?

Viscosity

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42. What is the effect of temperature on surface tension?

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43. Explain, why :

tea or coffee is sipped from a saucer when it is quite hot?

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44. Why does a desert cooler cool better on a hot dry day?

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45. Explain, why :

oil rises up in the wick in an oil lamp?

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Very Short Answer Type Questions

1. Name the three physical states of matter.

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2. Can a substance exist in all the three states of matter? Give an example.

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3. What is the relation between mass and number of moles of a gas?

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4. Define the term volume of an object.

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5. Express one atm pressure in terms of the height of mercury column.

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6. What is the SI unit of pressure ? Define it.

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7. State the relation between atm, Nm, Pa, torr and bar.

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8. Name the apparatus used for the measurement of the pressure of a gas.

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9. What do you understand by S.T.P. ?

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10. What is the shape of the curve obtained on plotting P against PV at constant temperature for an ideal gas ?

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11. Which law is signified by the relation $\frac{V_1}{T_1} = \frac{V_2}{T_2}$?

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12. Name the scientist who introduced absolute scale of temperature.

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13. What is the general unit of gas constant R?

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14. What happens when a jar full of H_2 gas is placed inverted over a jar containing Cl_2 gas?

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15. State the following : Absolute temperature of a gas at $7^\circ C$.

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16. How are the different types of velocities of a gas molecules related with one another?

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17. Define compressibility factor of a gas.

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18. Is the excluded volume of a real gas equal to the actual E volume of the molecules of a gas ?

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19. State and explain the pressure-temperature law.

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20. The pressure of a real gas is less than the pressure of an ideal gas because of :

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Short Answer Type Question

1. Explain why does the mercury level in a barometer go down when atmospheric pressure decreases?

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2. Describe the working of an open end manometer.

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3. State Boyle.s Law.

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4. Which law is signified by the equation :

$$V_t = V_0\left(1 + \frac{t}{273}\right)$$

State the law in a different manner.

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5. Calculate the value of R in SI and C.G.S. systems for one mole of a gas.

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6. What is Dalton's law of partial pressure ? What do you understand by the partial pressure of a gas ?

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7. What do you understand by the term suface tension?

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8. What is the difference between diffusion and effusion ? Which law is applicable to the process of effusion ?

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9. State five important assumptions of the kinetic theory of matter.

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10. The average energy per molecule of a triatomic gas at room temperature T is

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11. What is the effect of increasing temperature on Maxwell's distribution of velocities in a gas?

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12. Define average, root mean square and most probable velocities of gas molecules. What is the relation between these velocities?

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13. Which of the following expressions is true for an ideal gas ?

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14. What do the constants a and b signify in van der Waals' equation ?

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15. A gas is enclosed in a room. The temperature, pressure, density and the number of moles respectively are $t^{\circ}C, p$ atm, d g cm^{-3} and n moles.

What will be the pressure, temperature, density and number of moles in each compartment if the room is partitioned into four equal compartments ?

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What will be the pressure, temperature, density and number of moles in each compartment if the room is partitioned into four equal compartments ?

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18. Explain the following:

The tyre of an automobile is inflated to a lesser pressure in summer than in winter.

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19. Explain the following:

The size of a weather balloon becomes larger and larger as it ascends into higher altitudes.

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20. Why is air at sea level denser than air at mountains ?

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21. A real gas behaves like an ideal gas if its

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22. State and explain the pressure-temperature law.

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23. State Graham's law of diffusion.

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Essay Long Answer Type Questions

1. For a given mass of a gas what is the shape of (p) versus $\left(\frac{1}{V}\right)$ graph at constant temperature ?

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2. How charle's law can be represented graphically?

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3. For a gas deviation from ideal behaviour is maximum at :

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4. What is the significance of Kirchhoff's law ?

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5. State Graham's law of diffusion.

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6. State the postulates of kinetic theory of gases. Why are they called so?

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7. Deduce and explain Boyle's law and Charles' law on the basis of kinetic gas equation.

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8. Discuss the Maxwell's distribution of velocities in a gas. What is the effect of temperature on this distribution ?

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9. Assertion: The root mean square and most probable speeds of the molecules in a gas are the same.

Reason: The maxwell distribution for the speed of molecules in a gas is symmetrical.

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10. What do the constants a and b signify in van der Waals' equation ?

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Objective Multiple Choice Type Questions

1. At constant temperature, in a given mass of an ideal gas

A. the ratio of pressure and volume always remains constant

B. volume always remains constant

C. pressure always remains constant

D. the product of pressure and volume always remains constant.

Answer: D

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2. A gas is initially at 1 atm pressure. To compress it to 1/4 th of its initial volume, pressure to be applied is: 1 atm, 2 atm, 3 atm, 1/4 atm

A. 1 atm

B. 2 atm

C. 4 atm

D. 1/4 atm.

Answer: C

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3. One litre of a gas weighs 2 g at 300 K and 1 atm pressure. If the pressure is made 0.75 atm, at which of the following temperature will one litre of the same gas weigh 1 gram : 1) 450K 2) 600K 3) 800K 4)900K

A. 450 K

B. 600 K

C. 800 K

D. 900 K

Answer: A

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4. Pressure remaining constant, at what temperature the volume of a gas will be double of its volume at $0^\circ C$?

A. $100^\circ C$

B. $546^\circ C$

C. $273K$

D. $546K$

Answer: D

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5. A liquid is in equilibrium with its vapour at its boiling point. On the average, the molecules in the two phases have equal:

1)potential energy

2)total energy

3)kinetic energy

4)intermolecular forces.

A. potential energy

B. total energy

C. kinetic energy

D. intermolecular forces.

Answer: C

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6. Gases deviate from the ideal gas behaviour because their molecules

A. possess negligible volume

B. have forces of attraction between them

C. are polyatomic

D. are not attracted to one another.

Answer: B

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7. At $27^\circ C$, the ratio of RMS velocities of ozone to oxygen is

A. $\sqrt{3/5}$

B. $\sqrt{4/3}$

C. $\sqrt{2/3}$

D. 0.25.

Answer: C

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8. Helium atom is two times heavier than a hydrogen molecule. At 289 K, the average kinetic energy of a helium atom is

A. two times that of a hydrogen molecule

B. same as that of a hydrogen molecule

C. four times that of a hydrogen molecule

D. half that of a hydrogen molecule.

Answer: B

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9. Which of the following pairs will diffuse at the same rate through a porous plug ?

A. CO, NO_2

B. NO_2, CO_2

C. NH_3, PH_3

D. NO, C_2H_6

Answer: D

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10. 50 mL of hydrogen diffuses out through a small hole from a vessel in 20 minutes, time needed for 40 mL of oxygen to diffuse out is: 1) 12 min 2)64 min 3)8 min 4)32 min

A. 12 min

B. 64 min

C. 8 min

D. 32 min.

Answer: B

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11. The vapour density of a gas is 35.5. The volume occupied by 3.55 g of the gas at S.T.P is?

A. 1.12 litres

B. 11.2 litres

C. 22.4 litres

D. 44.8 litres.

Answer: A

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12. Which one of the following indicates the value of the gas constant R?

A. $1.987 \quad \text{cal} \quad deg^{-1}mol^{-1}$

B. $8.3 \quad \text{cal} \quad deg^{-1}mol^{-1}$

C. $0.0821 \quad \text{lit} \quad deg^{-1}mol^{-1}$

D. $1.987 \quad \text{J} \quad deg^{-1}mol^{-1}$

Answer: A

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13. A real gas behaves like an ideal gas if its

A. 5 atm and 200 K

B. 1 atm and 273 K

C. 0.5 atm and 500 K

D. 15 atm and 500 K.

Answer: C

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14. Which of the following statements regarding van der Waals' constants a and b is not correct?

A. The constant a is a measure of van der Waals' forces.

B. A gas with a lower value of a possesses a greater tendency to get liquefied.

C. b is a measure of effective size of molecules.

D .b is the excluded volume per mole.

A. The constant a is a measure of van der Waals' forces.

B. A gas with a lower value of a possesses a greater tendency to get liquefied.

C. b is a measure of effective size of molecules.

D. b is the excluded volume per mole.

Answer: B

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15. 8.2 L of an ideal gas weights 9.0 g at 300 K and 1 atm pressure. The molecular mass of the gas is

A. 54

B. 27

C. 13.5

D. 81

Answer: B

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16. Which of the Maxwell distribution curves (obtained at different temperatures) shown in the following figure corresponds to the highest

temperature of the gas ?

A. A. A

B. B. B

C. C. C

D. D. D

Answer: D

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17. Is the excluded volume of a real gas equal to the actual E volume of the molecules of a gas ?

A. equal to the actual volume of the gas molecule

B. twice the actual volume of the gas molecule

C. four times the volume of the gas molecule

D. has no relation with the actual volume of the gas molecule.

Answer: C

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18. The values of van der Waals' constant 'a' for O_2, N_2, NH_3 and CH_4 are $1.360, 1.390, 4.170$ and $2.253 L^2$ atm mol respectively. The most easily liquefiable gas among these is

A. N_2

B. NH_3

C. O_2

D. CH_4.

Answer: B

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19. A closed vessel contains equal number of oxygen and hydrogen molecules at a total pressure of 740 mm. If oxygen is removed from the system, the pressure: 1)becomes half of 740 mm 2)becomes $\frac{1}{3}$ rd of 740 mm 3)becomes double of 740 mm 4)remains unchanged.

A. becomes half of 740 mm

B. becomes $\frac{1}{3}$ rd of 740 mm

C. becomes double of 740 mm

D. remains unchanged.

Answer: A

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20. At what temperature will the total kinetic energy of 0.5 moles of He be the same as the total kinetic energy of 0.6 moles of neon at 300K?

A. 300 K

B. 360 K

C. 400 K

D. 250 K

Answer: B

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21. The densities of two gases are in the ratio of 1:16. The ratio of their rates of diffusion is

A. $16:1$

B. $4:1$

C. $1:4$

D. $1:16$

Answer: B

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22. 2g of H_2 and 17g of NH_3 are placed in a 8.21 litre flask at $27^\circ C$. The total pressure of the gas mixture is?

A. 4 atm

B. 5 atm

C. 6 atm

D. 3 atm.

Answer: C

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23. For a given mass of a gas, if pressure is reduced to half and temperature is doubled, then volume V will become

A. $4V$

B. $2V^2$

C. $\frac{V}{4}$

D. $8V$.

Answer: A

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24. The ratio between the root mean square velocity of H_2 at 50 K and that of O_2 at 800 K is:

A. 4

B. 2

C. 1

D. $\frac{1}{4}$.

Answer: C

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25. X mL of H_2 gas effuses through a hole in a container in 5 seconds. The time taken for the effusion of the same volume of the gas specified below under identical condition is:

A. 10 seconds : He

B. 20 seconds : 02

C. 25 seconds : CO

D. 55 seconds : 02.

Answer: B

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26. According to Graham's law, at a given temperature the ratio of diffusion $\frac{r_A}{r_B}$ of gases A and B is given by

(where P and M are pressures and molecular weights of gases A and B respectively)

A. $\left(\frac{P_A}{P_B}\right)\left(\frac{M_A}{M_B}\right)^{1/2}$

B. $\left(\frac{M_A}{M_B}\right)\left(\frac{P_A}{P_B}\right)^{1/2}$

C. $\left(\frac{P_A}{P_B}\right)\left(\frac{M_B}{M_A}\right)^{1/2}$

D. $\left(\frac{M_A}{M_B}\right)\left(\frac{P_B}{P_A}\right)^{1/2}$

Answer: C

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27. A real gas behaves like an ideal gas if its

A. low temperature and low pressure

B. low temperature and high pressure

C. high temperature and low pressure

D. high temperature and high pressure.

Answer: C

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28. The RMS velocity of hydrogen is $\sqrt{7}$ times the RMS velocity of nitrogen. If T is the temperature of the gas

A. $T(H_2) = T(N_2)$

B. $T(H_2) > T(N_2)$

C. $T.\ (H_2) < T(N_2)$

D. $T(H_2) = \sqrt{7}T(N_2).$

Answer: C

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29. Which of the following does not constitute 0.1g mole ?

A. 6.022×10^{22} molecules of benzene

B. $0.14g$ of N_2 gas

C. 2.24 litre of CO_2 at S.T.P.

D. 0.40 g of He gas

Answer: B

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30. For an ideal gas , number of moles per litre in terms of its pressure , temperature and gas constant is

A. $\frac{PT}{R}$

B. PRT

C. $\frac{P}{RT}$

D. $\frac{RT}{P}$.

Answer: C

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31. Based on kinetic theory of gases following laws can be proved

A. Boyle's law

B. Charles' law

C. Avogadro's law

D. all of the above.

Answer: D

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32. According to the kinetic theory of gases, in an ideal gas, between two successive collisions, a gas molecule travels

A. in a circular path

B. in a wavy path

C. in a straight line path

D. with an accelerated velocity.

Answer: C

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33. As the temperature is raised from $20^\circ C$ to $40^\circ C$, the average kinetic energy of neon atoms changes by a factor of which of the following?

A. $\frac{1}{2}$

B. $\sqrt{\frac{313}{293}}$

C. $\frac{313}{293}$

D. 2

Answer: C

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34. In van der Waals' equation of state, the constant 'b' is a measure of

A. intermolecular repulsion

B. intermolecular attraction

C. volume occupied by the molecules

D. intermolecular collisions per unit volume.

Answer: C

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35. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas?

A. The area under the distribution curve remains the same as under the lower temperature.

B. The distribution becomes broader.

C. The fraction of the molecules with the most probable speed increases.

D. The most probable speed increases.

Answer: C

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36. Equal mass of methane and oxygen are mixed in an empty container at 25° C. The fraction of the total pressure exerted by oxygen is:

A. $\frac{2}{3}$

B. $\frac{1}{3} \times \frac{273}{298}$

C. $\frac{1}{3}$

D. $\frac{1}{2}$.

Answer: C

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37. The compressibility factor for a real gas at high pressure is :

A. $1 + \frac{RT}{Pb}$

B. 1

C. $1 + \frac{Pb}{RT}$

D. $1 - \frac{Pb}{RT}$.

Answer: C

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38. a and b are van der Waals' constants for gases. Chlorine is more easily liquefied than ethane because

A. a and b for $Cl_2 > a$ and b for C_2H_6

B. a and b for $Cl_2 < a$ and b for C_2H_6

C. a for $Cl_2 < a$ for C_2H_6 but b for $Cl_2 >$ b for C_2H_6

D. a for $Cl_2 > a$ for C_2H_6 but b for $Cl_2 <$ b for C_2H_6.

Answer: D

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39. The molecular velocity of any gas is

A. inversely proportional to the square root of temperature

B. inversely proportional to absolute temperature

C. directly proportional to square of temperature

D. directly proportional to square root of temperature.

Answer: D

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40. When r, p and M represent rate of diffusion, pressure and molecular mass, respectively, then the ratio of the rates of diffusion $(r_A r_B)$ of two gases A and B, is given by?

A. $(P_A / P_B)^{1/2} \left(\frac{M_A}{M_B} \right)$

B. $(P_A / P_B)(M_B / M_A)^{1/2}$

C. $(P_A / P_B)^{1/2}\left(\frac{M_B}{M_A}\right)$

D. $(P_A / P_B)(M_A / M_B)^{1/2}$

Answer: B

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41. A gaseous mixture was prepared by taking equal moles of CO and N_2. If the total pressure of the mixture was found 1 atmosphere, the partial pressure of the nitrogen (N_2) in the mixture is

A. 0.8 atm

B. 0.9 atm

C. 1 atm

D. 0.5 atm.

Answer: D

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42. By what factor does the average velocity of a gaseous molecule increase when the temperature (in Kelvin) is doubled ?

A. 2.8

B. 4.0

C. 1.4

D. 2.0

Answer: C

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43. Equal masses of H_2, O_2, and methane have been taken in a container of volume V at temperature $27^\circ C$ in identical conditions. The ratio of the volumes of gases $H_2 : O_2 : CH_4$ would be

A. $8:16:1$

B. $16:8:1$

C. $16:1:2$

D. $8:1:2$.

Answer: C

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44. If Z is a compressibility factor, van der Waals equation at low pressure can be written as:

A. $Z = 1 + \frac{RT}{pb}$

B. $Z = 1 - \frac{a}{VRT}$

C. $Z = 1 - \frac{pb}{RT}$

D. $Z = 1 + \frac{pb}{RT}$.

Answer: B

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45. For gaseous state, if most probable speed is denoated by C^*, average speed by C and mean square speed by $\overline{C}$, then for a large number of molecules the ratios of these speeds are:

A. $C^* : \overline{C} : C = 1.225 : 1.128 : 1$

B. $C^* : \overline{C} : C = 1.228 : 1.125 : 1$

C. $C^* : \overline{C} : C = 1.228 : 1.125$

D. $C^* : \overline{C} : C = 1.225 : 1.128$

Answer: C

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46. Given van der Waals' constant for NH_3, H_2, O_2 and CO_2 are respectively $4.17, 0.244, 1.36$ and 3.59, which one of the following gases is most easily liquefied?

A. NH_3

B. H_2

C. O_2

D. CO_2

Answer: A

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47. The correction factor 'a' to the ideal gas equation corresponds to

A. density of the gas molecules

B. volume of the gas molecules

C. electric field present between the gas molecules

D. forces of attraction between the gas molecules.

Answer: D

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48. A gas at 350 K and 15 bar has molar volume 20 percent smaller than that for an ideal gas under the same conditions. The correct option above the gas and its compressibility factor (Z) is :

A. $Z < 1$ and attractive forces are dominant

B. $Z < 1$ and repulsive forces are dominant

C. $Z > 1$ and attractive forces are dominant

D. $Z > 1$ and repulsive forces are dominant.

Answer: A

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49. Consider the van der Waals' constants, a and b, for the following gases:

gas	Ar	Ne	Kr	Xe
$a/\left(atm \ \ \mathrm{dm}^6 mol^{-2}\right)$	1.3	0.2	5.1	4.1
$b/\left(10^{-2} dm^3 mol^{-1}\right)$	3.2	1.7	1.0	5.0

Which gas is expected to have the highest critical temperature?

A. Xe

B. Ne

C. Kr

D. Ar.

Answer: C

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True Or False Type Question

1. The mass of a gas does not depend upon its temperature or pressure.

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2. The column of mercury in a barometer is 76mm of Hg. Calculate the atmospheric pressure if the density of mercury = 13600kgm −3 . (Take g=10ms −2)

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3. The SI unit of pressure is pascal and one pascal is equal to 1 Nm^{-2}

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4. The density of a gas depends up on its molar mass, pressure and temperature

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5. Temperature on Kelvin scale = Temperature on Celsius scale + 273.15.

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6. The partial pressure exerted by the water vapors is called ___

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7. Two gases can mix up together even against gravity.

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8. The rate of diffusion of a gas is proportional to:

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9. Effusion is a particular case of diffusion.

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10. Molecular collisions are perfectly elastic.

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11. At absolute zero, the molecules of a gas come at perfect rest.

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12. Kinetic energy of electron in nth orbit is given by

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13. The RMS velocity of the molecules of a gas is greater than the most probable velocity at the same temperature.

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14. The value of compressibility factor for an ideal gas is equal to 1.

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15. The constant a in van der Waals' equation can be regarded as a measure of intermolecular forces in a real gas.

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Fill In The Blanks Type Questions

1. The pressure of a gas is due to ..... exerted by its molecules per ..... of the walls of the container.

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2. The region above mercury in a barometer consists of .....

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3. At constant pressure, the volume of a given mass of a gas ..... by 1/273 of its volume at ..... for each one degree rise in temperature.

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4. At S.T.P., 22.4 L of a gas contain ..... molecules.

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5. When pressure is expressed in dynes and volume in cm^3 the value of R is ..... .

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6. The ..... of a gas is a measure of the average kinetic energy of its molecules.

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7. The Boltzmann constant k is given by k = ...

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8. The units of constant b used in van der Waals' equation are ..... .

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9. Solids possess a ..... range order while liquids possess a ..... range order.

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10. The compressibility of a liquid is much ..... as compared to that of a gas.

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Assertion Reason Type Questions

1. Assertion (A) Three states of matter are the result of balance between intermolecular forces and thermal energy of the molecules.

Reason (R) Intermolecular forces tend to keep the molecules together but thermal energy of molecules tends to keep tham apart.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: a

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2. Assertion : Solids possess a rigid structure whereas liquids possess a non-rigid structure.

Reason : In solids, the intermolecular distances are much smaller than those in liquids.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: b

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3. Assertion : At constant pressure, the volume of a given mass of a gas is inversely proportional to its absolute temperature.

Reason : At absolute zero, the volume of a gas reduces to zero.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: d

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4. Gases deviate from the ideal gas behaviour because their molecules

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: c

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5. Assertion : The drop of a liquid is always spherical or nearly spherical.

Reason : Water is not a viscous liquid.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: b

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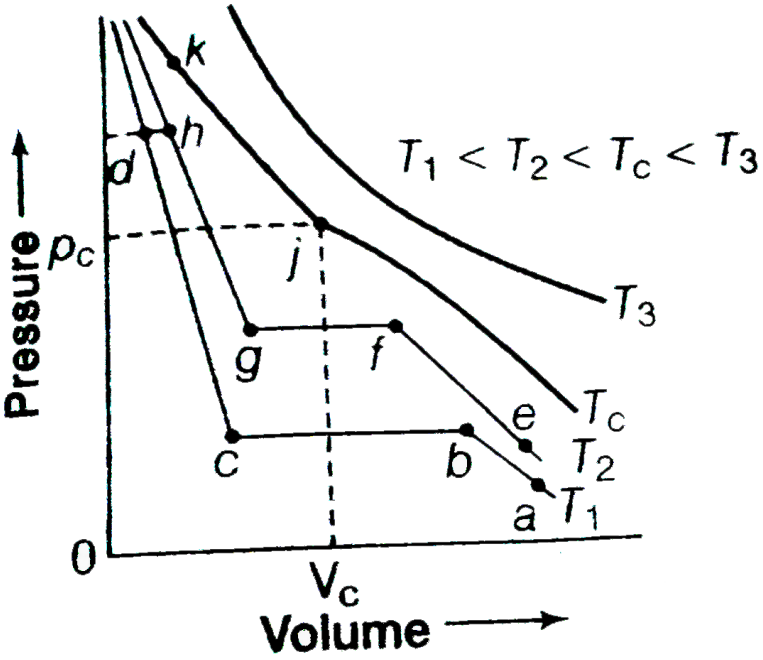
Numerical Problems

1. Isotherms of carbon dioxide at various temperatures are repersented in figure. Answer the following questions based on this figures.



(i) In which state will CO_2 exist between the points a and b at temperature T_1 ?

(ii) At what point will CO_2 start liquefyinh when temperature is T_1 ?

(iii) At what point will CO_2 be completely liquefued when temperature is T_2 ?

(iv) Will condensation take place when the temperature is T_3 ?

(v) What portion of the isotherm at T_1 represent liquid and gaseous CO_2 at equilibrium ?

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2. The volume of an air bubblebecomes three times as it rises from the bootom of a lake to its surface. Assuming temperature to be constant and atmospheric pressure to be 75 cm of Hg and the density of water to be $1/10$ of the density of the mercury, the depth of the lake is

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3. At S.T.P. a mixture of 280 mL of CH_4 and $140\ \text{mL}$ of H_2 is completely burnt. Calculate the required volume of oxygen and weight of water formed, assuming that whole of the steam condenses to water.

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4. Calculate the pressure exerted by 0.250 moles of carbon dioxide in 0.275 litres at $100^\circ C$ and compare this value with that expected for an ideal gas.

(Given : $a = 3.59L^2\ \text{atm}\ \ mol^{-2}, b = 0.0427Lmol^{-1}$)

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5. Calculate the relative rates of diffusion of $^{235}UF_6$ and $^{238}UF_6$ in gaseous form (F= 19).

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6. An iron cylinder contains helium at a pressure of 250 k Pa at 300 K. The cylinder can withstand a pressure of 1×10^6 Pa. The room in which cylinder is placed catches fire. Predict the temperature (in K) at which the cylinder will blow up before it melts or not (m.p.t. of the cylinder =1800K)..

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7. A 4: 1 molar mixture of He and CH4 is contained in a vessel at 20 bar pressure. Due to a hole in the vessel, the gas mixture leaks out. What is the composition of the mixture effusing out initially?

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8. What will be the density of carbon dioxide at $100^{\circ} C$ and 800 mm Hg pressure ?

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9. A gas occupies 300.0 mL at $27^{\circ} C$ and 730 mm pressure. What would be its volume at standard temperature and pressure (S.T.P.) ?

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10. A certain quantity of a gas occupies 300 mL when collected over water at $25^{\circ} C$ and 745 mm pressure. It occupied 182.6 mL in dry state at S.T.P. Find the vapour pressure of water at $25^{\circ} C$.

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11. A gas bulb of 1 litre capacity contains 2.0×10^{21} molecules of nitrogen exerting a pressure of $7.57 \times 10^{3} Nm^{-2}$. Calculate the root mean square speed and the temperature of gas molecules. If the ratio of most probable speed to the root mean square speed is 0.82, calculate the most probable speed for the molecules at this temperature.

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12. In a Victor Meyer's determination, 0.23 g of a volatile substance displaced air which measured 112 mL at S.T.P. Calculate the vapour density and molecular weight of the substance (1 litre of H_2 at S.T.P. weighs 0.09 g).

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13. At room temperature, ammonia gas at 1 atm pressure and hydrogen chloride gas at P atm pressure are allowed to effuse through identical pin holes from opposite ends of a glass tube of one metre length and of

uniform cross section. Ammonium chloride is first formed at a distance of 60 cm from the end through which HCl gas is sent in. What is the value of P?

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14. An open vessel contains air at $27^\circ C$. To what temperature should the vessel be heated so that the number of molecules in the vessel decreases by 25% ? (Neglect the expansion of the container).

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15. Calculate the average kinetic energy in joules of the molecules in 8.0 g of methane at $27^\circ C$.

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16. 3 moles of a gas are present in a vessel at a temperature of $27^\circ C$. What will be the value of R, the gas constant, in terms of the kinetic energy of the molecules of the gas ?

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17. $1470 cm^3$ of a gas is collected over water at 303 K and 74.4 cm of Hg. If the gas weighs 1.98 g and vapour pressure of water at $30^\circ C$ is 3.2 cm of Hg, calculate the molecular weight of the gas.

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18. A certain gas occupies 0.418 litres at $27^\circ C$ and 740 mm Hg.

What is the volume at S.T.P. ?

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19. A certain gas occupies 0.418 litres at $27^{\circ} C$ and 740 mm Hg.

If the same gas weighs 3.00 g, what is its molecular weight?

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20. A certain gas occupies 0.418 litres at $27^{\circ} C$ and 740 mm of Hg.

If we increase the weight of the gas to 7.5 g in the same vessel and the temperature is changed to 280 K, what would be its pressure ?

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Ncert Text Book Exercises With Hints And Solutions

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

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

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3. Using the equation of state pV=nRT, show that at a given temperature density of a gas is proportional to gas pressure p.

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4. At $0^{\circ} C$, the density of a certain oxide of a gas at 2 bar is same as that of dinitrogen at 5 bar. What is the molecular mass of the oxide?

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5. Pressure of 1 g of an ideal gas A at $27^{\circ} C$ 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 a relationship between their molecular masses.

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6. The drain cleaner Drainex contains small bits of aluminium which react with caustic soda to produce hydrogen What volume of hydrogen at $20^{\circ} C$ aand one bar will be released when $0.15g$ of aluminium reacts ? .

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7. What will be the pressure exerted by a mixture of 3.2 g of methane and 4.4 g of carbon dioxide contained in a 9 dm^3 flask at $27^{\circ} C$?

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8. What will be the pressure of the gaseous 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 a 1L vessel at

$27^{\circ} C$?

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9. Density of a gas is found to be $5.46 g / dm_3$ at $27^{\circ} C$ at 2 bar pressure. What will be its density at STP?

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10. 34 . 05 mL of phosphorus vapours weigh 0.0625 g at $546.^{\circ} C$ and 0.1 bar pressure . What is the molart mass of phosphorus ?

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11. A student forgot to add the reaction mixture to the round bottomed flask at $27^{\circ} C$ 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 $477^{\circ}C$. What fraction of air would have been expelled out?

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

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13. calculte the total number of electrons present 1.4 g of dinitrogen gas.

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

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

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16. Pay load is defined as the difference between the mass of displaced air and the mass of the balloon Calculate the pay-load when a balloon of radius $10m$ mass $100kg$ is filled with helium at 1.66 bar at $27^\circ C$ (Density of air $= 1.2kgm^{-3}$ and $R = 0.083$ bar dm 3 $K^{-1} mol^{-1}$) .

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17. Calculate the volume occupied by 8.8 g of CO_2 at $31.1^\circ C$ and 1 bar pressure. R= 0.083 bar L $K^{-1} mol^{-1}$.

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18. 2.9 g of a gas at $95^{\circ}C$ occupied the same volume as 0.184 g of dihydrogen at $17^{\circ}C$, at the same pressure. What is the molar mass of the gas?

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19. A mixture of dihydrogen and dioxygen at one bar pressure contains 20% by weight of dihydrogen . What would be the partial pressure of dihydrogen in bar ?

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

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21. In terms of Charles' law explain why $-273^{\circ}C$ is the lowest possible temperature?

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22. Critical temperature for carbon dioxide and methane are $31.1^{\circ}C$ and $-81.9^{\circ}C$ respectively. Which of these has stronger intermolecular forces and why?

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23. Explain the physical significance of van der Waals parameters.

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