PHYSICS

BOOKS - PRADEEP PHYSICS (HINGLISH)

BEHAVIOUR OF PERFECT GAS & KINETIC THEORY

Sample Problem

1. One metre long tube, closed at both ends, is lying horizontally. A mercury column of length 0.1 m is filled in its middle and in rest two parts air is filled at atmospheric pressure. What will be the displancement of the mercury column when the tube is turned to vertical position ? Atmospheric pressure = 0.76 m of Hg.

2. The pressure of a gas filled in a closed vessel increase by 0.4% when temperature is increased by $1^\circ C$. Find the initial temperature of the gas.

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3. If masses of all molecules of a gas are halved and the speed doubled. Then the ratio of initial and final pressure is :

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4. What will be the root mean square speed of helium at $40^\circ C$, if mean square speed of oxygen molecule at $0^\circ C is 460 m/s$? Molecule weight of oxygen is $32g/\text{mole}$ and of helium is $4g/\text{mole}$.

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5. How many degrees of freedom are associated with 2 gram of helium at NTP ? Calculate the amount of heat energy required to raise the temp. Of this amount from $27^{\circ} C \rightarrow 127^{\circ} C$. Given Boltzmann constant $k_B = 1.38 \times 10^{-16}$ erg $\text{molecule}^{-1} K^{-1}$ and Avogadro's number $= 6.02 \times 10^{23}$.

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Curiosity Question

1. Order tends to disorder' comment on the statement. How do you justify it?

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2. What is the principal source of heating in many office bulidings in moderate climates?

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Solved Examples

1. Molar volume is the volume occupied by 1 mole of any (Ideal) gas at standard temperature and pressure (STP , $0^{\circ} C$, 1 atmospheric pressure). Show that it is 22.4 litres. Take $R = 8.31 J mol^{-1} K^{-1}$.

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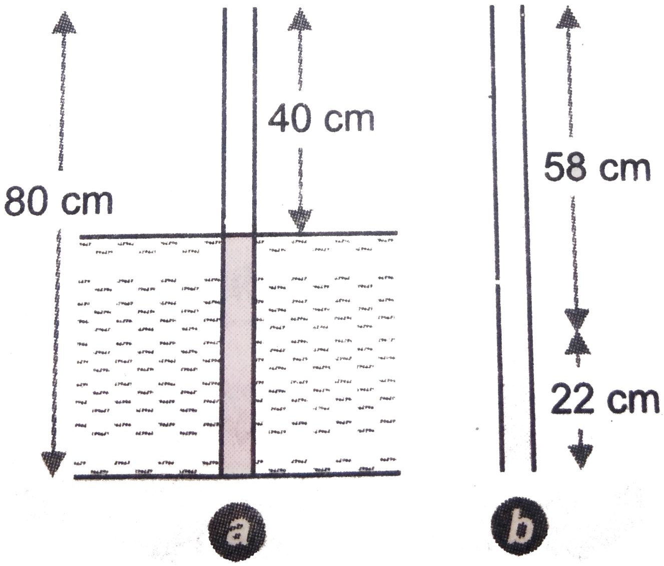
2. A narrow uniform glass tube 80 cm long and open at both ends is half immersed in mercurry. Then the top of the tube is closed and it is taken out of mercury. A column of mercury 22 cm long then remains in the tube. What is the atmospheric pressure?



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3. The density of water is $1000 kgm^{-3}$. The density of water vapour at $100^{\circ} C$ and 1 atmospheric pressure is $0.6 kgm^{-3}$. The volume of a molecule multiplied by the total number gives what is called, molecular volume. Estimate the ratio (or fraction) of the molecular volume to the total volume occupied by the water vapour under the above conditions of temperature and pressure.

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4. Estimate the volume of a water molecule using the data in the above questions. What is its approximate size?

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5. What is the average distance between atoms (interatomic distance) in water ? Use the data given in Examples 3 and 4.

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6. A gas at $27^{\circ} C$ in a cylinder has a volume of 4 litre and pressure $100 N m^{-2}$.

(i) Gas is first compressed at constant temperature so that the pressure is $150 N m^{-2}$. Calculate the change in volume.

(ii) It is then heated at constant volume so that temperature becomes $127^\circ C$. Calculate the new pressure.

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7. A closed container of volume $0.02m^3$contains a mixture of neon and argon gases, at a temperature of $27^\circ C$ and pressure of $1 \times 10^5 Nm^{-2}$. The total mass of the mixture is 28g. If the molar masses of neon and argon are 20 and $40gmol^{-1}$ respectively, find the masses of the individual gasses in the container assuming them to be ideal (Universal gas constant $R = 8.314J/mol - K$).

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8. A narrow uniform glass tube contains air enclosed by 15 cm long thread of mercury. When the tube is vertical with open end uppermost, the air column is 30 cm long. When the tube is inverted, the length of air column becomes 45 cm. Calculate the atmospheric pressure.

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9. A vessel contains two non-reactive gases neon (monoatomic) and oxygen (diatomic). The ratio of their partial pressures is 3:2. Estimate the ratio of

(i) number of molecules, and

(ii) mass density of neon and oxygen in the vessel.

Atomic mass of neon = 20.2 u, and molecular mass of oxygen = 32.0 u.

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10. Two soap bubbles of radii a and b coalesce to form a single bubble of radius c. If the external pressure is P, show that the surface tension T is given by $T = P\frac{c^3 - a^3 - b^3}{4(a^2 + b^2 - c^2)}$

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11. If the temperature of air is increased from $27^{\circ} \rightarrow 227^{\circ}$, in what ratio will the average kinetic energy of its molecules be increased?

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12. Calculate for hydrogen at 27°

(i) KE of one gram mole of the gas

(ii) KE of one gram of the gas

(iii) root mean square velocity of the molecule. Given, molecule wt. Of hydrogen = 2.

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13. A vessel is filled with a gas at a pressure of 76 cm of mercury at a certain temperature. The mass of the gas is increased by 50% by introducing more gas in the vessel at the same temperature. Find the resultant pressure of the gas.

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14. Calculate the number of molecules in $2 \times 10^{-6} m^3$ of a perfect gas at $27^\circ C$ and at a pressure of 0.01 mm of mercury. Mean KE of a molecules at $27^\circ C = 4 \times 10^{-11} J$ and $g = 9.8 m / s^2$.

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15. Two perfect gases at absolute temperature T_1 and T_2 are mixed. There is no loss of energy. The masses of the molecules are m_1 and m_2. The number of molecules in the gases are n_1 and n_2. The temperature of the mixture is

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16. Kinetic energy of oxygen molecule at $0^\circ C$ is $9.4 \times 10^{-21} J$. Calculate Avogadro's number, when $R = 8.31 J \text{mole}^{-1} K^{-1}$.

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17. Calculate (i) rms velocity and (ii) mean kinetic energy of one gram molecule of hydrogen at STP. Given density of hydrogen at STP is $0.09 kgm^{-3}$.

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18. A flask contains argon and chlorine in the ratio 2:1 by mass. The temperature of the mixture is 27°. Obtain the ratio of

(i) average kinetic energy per molecule, and

(ii) root mean square speed of the molecules of two gases.

Atomic mass of argon = 39.9 u, Molecular mass of chlorine = 70.9 u.

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19. Uranium has two isotopes of masses 235 and 238 units. If both are present in uranium hexa fluoride gas, which would have the larger average speed ? If atomic mass of fluorine is 19 units, estimate the percentage difference in speed at any temperature.

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20. (a) When a molecule (or an elastic ball) hits a (massive) wall, it rebounds with the same speed. When a ball hits a massive bat held firmly, the same thing happens However, when the bat is moving towards the ball, the ball rebounds with a different speed. Does the ball move faster or slower?

(b) When gas in a cylinder is compressed by pushing in a piston. Its temperature rises. Guess at an explanation of this in terms of kinetic theory using (a) above

(c) What happens when a compressed gas pushes a piston out and expands. What would you observe?

(d) Sachin Tendulkar uses a heavy cricket bat while playing. Does it help him in any way?

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21. A cylinder of fixed capacity 44.8 litre contains helium gas at standard temperature and pressure. What is the amount of heat needed to raise the temperature of the gas in the cylinder by $15.0^\circ C$? $[R = 8.31 Jmol^{-1}K(-1)]$

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22. About 0.014 kg nitrogen is enclosed in a vessel at temperature of $27^\circ C$ How much heat has to be transferred to the gas to double the rms speed of its molecules ? $(R = 2cal/molK)$

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23. Calculate the temperature at which the rms speed of nitrogen molecules will be equal to $8km/s$. Given molecuar weight of nitrogen = 28 and `R = 8.31 J//mole//K.

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24. A vessel A contains hydrogen and another vessel B whose volume is twice that of A contains same mass of hydrogen at same temperature. Compare

(i) average KE of hydrogen and oxygen molecule.

(ii) root mean square speeds of molecules

(iii) pressure of gases in A and B.

Molecular weight of hydrogen and oxygen are 2 and 32 respectively.

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25. Calculate the rms velocity of oxygen molecules at S.T.P. The molecular weight of oxygen is 32.

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26. If three gas molecules have velocity 0.5, 1 and $2km/s$ respectively, find the ratio of their root mean square speed and average speed.

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27. At what temperature is the root mean square velocity of gaseous hydrogen molecules is equal to that of oxygen molecules at $47^{\circ}C$?

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28. Calculate the temperature at which rms velocity of a gas is one third its value at $0^{\circ}C$, pressure remaining constant.

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29. Five molecules of a gas have speed $2, 4, 6, 8km/s$. Calculate average speed. Rms speed and most probable speed of these molecules.

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30. Calculate the temperature at which rms velocity of a gas is half its value at $0^{\circ}C$, pressure remaining constant

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31. Calculate the total number of degree of freedom for a mole of diatomic gas at STP.

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32. Calculate the number of degree of freedom in 15 c.c. Of nitrogen at N.T.P.?

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33. The specific heat of argon at constant value is $0.075 kcal kg^{-1} K^{-1}$. Calculate its atomic weight. $Take R = 2 cal mol^{-1} K^{-1}$.

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34. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. What is the molecular specific heat of mixture at constant volume? $R = 8.31 J mol^{-1} K^{-1}$.

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35. If one mole of a monatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of gamma for mixture is

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36. A gaseous mixture enclosed in a vessel consists of one gram mole of a gas A with $\gamma = \left(\frac{5}{3}\right)$ and some amount of gas B with $\gamma = \frac{7}{5}$ at a temperature T.

The gases A and B do not react with each other and are assumed to be ideal. Find the number of gram moles of the gas B if γ for the gaseous mixture is $\left(\frac{19}{13}\right)$.

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37. Calculate the mean free path and the collsion frequency of air molecules, if the number of molecules per $cm^3 is 3 \times 10^{19}$, the diameter of the molecule is $2 \times 10^{-8} cm$ and average molecule speed is $1 kms^{-1}$.

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38. Estimate the mean free path for a water molecule in water vapour at 373 K. Given diameter of water molecule $= 2\text{Å}$ and number density of water molecule (at NTP) $= 2.7 \times 10^{25} m^{-3}$. Compare it with interatomic distance for water $= 40\text{Å}$.

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39. Estimate the mean free path of a molecule of air at $27^\circ C$ and one atmospheric pressure. Given average radius of each air molecule is $2.0 \times 10^{-10} m$.

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40. How many collisions per second does each molecule of a gas make, when average speed of the molecule is $500 m/s$ and mean free path is

$2.66 \times 10^{-7} m$?

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41. Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be 3Å.

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42. One half mole each of nitrogen, oxygen and carbon dioxide are mixed in enclosure of volume 5 litres and temperature $27^{\circ} C$. Calculate the pressure exerted by the mixture. Given $R = 8.31 J mol^{-1} K^{-1}$.

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43. Find γ for a mixture of gases containing n_1 moles of a monoatomic gas and n_2 moles of a diatomic gas. Assuming diatomic molecules to be right.

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Conceptual Problems

1. Volume of vessel A is twice the volume of vessel B. Both are filled with the same gas. If gas in A is at twice the temerature and twice the pressure to the gas in B, what is the ratio of gas molecules in A and B ?

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2. Atoms are not point masses. What is the simplest evidence in nature ?

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3. In Brownian movement, what should be the typical size of suspended particles and why ?

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4. Under what conditions do the real gases obey more strictly the gas equation, PV = RT ? Explain.

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5. Two perfect gases at absolute temperature T_1 and T_2 are mixed. There is no loss of energy. The masses of the molecules are m_1 and m_2. The number of molecules in the gases are n_1 and n_2. The temperature of the mixture is

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6. A box contains equal number of molecules of hydrogen and oxygen. If there is a fine hole in the box, then which gas will leak rapidly ? Why ?

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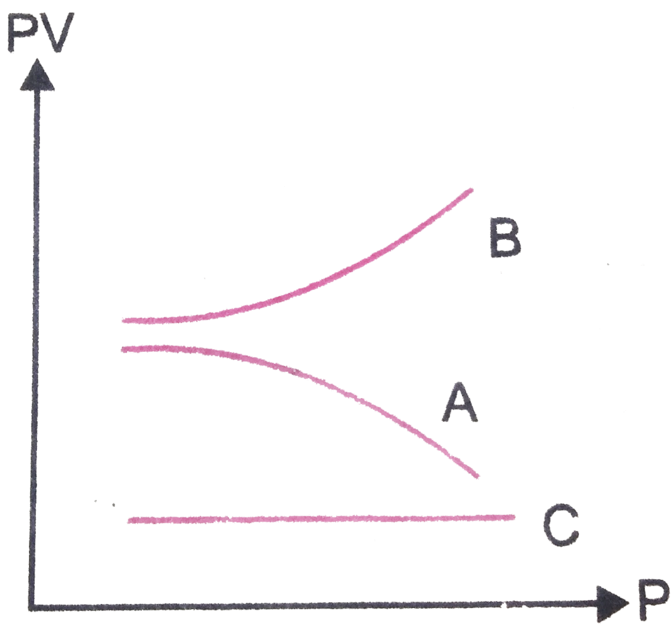
7. The graphs in Fig shown the variation of the product PV with respect to the pressure (P) of given masses of three gases, A, B and C. The temperature is kept constant. State with proper arguments which of these gases is ideal.



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8. Two different gases at the same temperature have equal root mean square velocities.

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9. Distinguish between average speed and rms speed. If three molecules have speed u_1, u_2, u_3 what will be their average speed and rms speed.

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10. A gas is filled in a cylinder fitted with a piston at a definite temperature and pressure. Explain on the basis of kinetic theory, the pressure of the gas increases by raising its temperature.

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11. A gas is filled in a cylinder fitted with a piston at a definite temperature and pressure. Explain on the basis of kinetic theory why on pulling the piston out, the pressure of decreases.

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12. On reducing the volume of the gas at constant temperature, the pressure of the gas increases. Explain on kinetic theory.

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13. Explain the phenomenon of evaporation on the basis of kinetic theory.

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14. Why cooling is caused by evaporation?

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15. The rms speed of oxygen molecules at a certain temperature T is v. If the temperature is doubled and oxygen gas dissociates into atomic oxygen, then the rms speed

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16. A vessel of volume 4 litres contains a mixture of 8 grams of O_2, 14 grams of N_2 and 32 grams of $SO_2 at 27^\circ C$. Find the pressure exerted by the mixture. Given, $R = 8.3 J mol_{-1} K_{-1}$.

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17. Why temperature less than OK is not possible ?

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18. The ratio of vapour densities of two gases at the same temperature is 8:9. Compare the rms velocities of their molecules.

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19. How can the number of molecular collisions per unit time in a gas be increased ?

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20. On which factors does the average KE of gas molecules depend : nature of gas, its temperature , its volume?

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21. What happens when a compressed gas pushes a piston out and expands ?

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22. Though the velocity of air molecules is nearly $0.5 km/s$, yet the smell of scent spreads at a much slower rate. Why ?

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23. There are N molecules of a gas in a containter. If this number is increased to 2N, what will be (i) pressure (ii) total energy (iii) rms speed of the gas ?

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Very Short Answer Questions

1. For a given mass of a gas at a fixed temperature, what is the nature of graph between pressure P and volume V?

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2. What does universal gas constant R signify?

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3. What is the nature of graph of PV versus P for a given mass of a gas at constant temperature?

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4. At a constant temperature, what is the relation between pressure P and density ρ of gas?

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5. A gas enclosed in a vessel has pressure P, volume V and absolute temperature T, write the formula for number of molecule N of the gas.

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6. What is the value of gas constant in cgs system for 1 gram or helium ?

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7. Obtain the dimensional formula for R used in the ideal gas equation, PV = RT.

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8. What is meant by Boltzmann constant Calculate its value in SI units.

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9. The pressure of a gas at $-173^{\circ}C$ is 1 atmosphere. Keeping the volume constant, to what temperature should the gas be heated so that its pressure becomes 2 atmosphere?

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10. Given samples of 1 c.c. of hydrogen and 1 c.c. of oxygen, both at N.T.P. which sample has a larger number of molecules?

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11. What is the correct value of $0^{\circ}C$ on the Kelvin scale?

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12. Can the temperature of a gas increased keeping its pressure and volume constant ?

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13. Two identical cylinders at same temp. Contains hydrogen at 2.5 atm. And oxygen at 1.5 atmosphere. If both the gases were filled in one of the cylinders, what will be the pressure?

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14. The ratio of rms velocities of two gases at the same temperature is $1:\sqrt{2}$. Compare the vapour densities of the gases.

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15. A vessel is filled with a mixture of two different gases. State with reason (i) will the mean K.E. Per molecule of both the gases be equal ? (ii) Will the root mean square velocities of the molecules be equal (iii) will the pressure be equal ?

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16. The velocities of three molecules are 3v, 4v and 5v. Calculate their root mean square velocity.

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17. Helium gas is filled in a closed vessel whose coefficient of thermal expansion is negligible. When it is heated from 300 K to 600 K, then find the average kinetic energy of helium atoms.

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18. Oxygen and hydrogen are at the same temperature T. What is the ratio of kinetic energies of oxygen molecule and hydrogen molecule when oxygen is 16 times heavier than hydrogen ?

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19. The absolute temperature of the gas is increased 3 times. What will be the increases in root mean square velocity of the gas molecules?

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20. If the forces of attraction between the molecules of a gas suddently disappear, will there be any change in pressure inside a gas container ?

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21. Two different gases A and B are enclosed in two vessels at pressure P_1 and P_2 respectively. If temperature of both the gases is the same, what will be the ratio of average $KE/\text{molecule}$ of the two gases ?

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22. Who proposed a model for a gas for the kinetic theory of gases?

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23. How is the average KE of a gas molecule related to the temperature of the gas ?

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24. The absolute temperature of a gas is made 4 time its initial value. What will be the change in rms velocity of its molecules ?

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25. What is the ratio of rms velocity of the molecules of an ideal gas at 240 k and 60 K ?

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26. A mixture of helium and hydrogen gases is filled in a vessel at $30^\circ C$. Compare the rms velocities of molecules of the two gases. Atomic weights of hydrogen and helium are 1 and 4 respectively.

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27. A cylinder contains He at 2 atmosphere pressure and hydrogen at 1.5 atmosphere pressure. What is the pressure of the mixture of gases in the cylinder ?

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28. Name the factors on which degrees of freedom of a gas molecule depend.

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29. The ratio of the specific heats $\frac{C_P}{C_v} = \gamma$ in terms of degrees of freedom is given by

A. $1 + \frac{n}{3}$

B. $1 + \frac{2}{n}$

C. $1 + \frac{n}{2}$

D. $1 + \frac{1}{n}$

Answer: B

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30. Calculate the number of atom in 39.4 g gold. Molar mass of gold is $197g\text{mole}^{-1}$

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31. The volume of a given mass of a gas at $27^{\circ} C$, 1 atm is 100 cc. What will be its volume at $327^{\circ} C$?

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32. The molecules of a given mass of gas have root mean square speeds of $100ms^{-1}at27^{\circ} C$ and 1.00 atmospheric pressure. What will be the root mean square speeds of the molecules of the gas at $127^{\circ} C$ and 2.0 atmospheric pressure?

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33. Two molecules of gas have speeds of $9 \times 10^6 ms^{-1}$ and $1 \times 10^6 ms^{-1}$ respectively. What is the root mean square speed of these molecules?

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34. A gas mixture consists of 2.0 moles of oxygen and 4.0 moles of neon at temperature T. Neglecting all vibrational modes, calculate the total internal energy of the system. (Oxygen has two rotational modes.)

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35. Calculate the ratio of the mean free paths of the molecules of two gases having molecular diameters $1A$ and $2A$. The gases may be considered under identical conditions of temperature, pressure and volume.

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Short Answer Questions

1. What are the two main characteristics of an ideal gas ?

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2. For an ideal gas, interval energy can only be translational K.E. Why ?

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3. What is the average velocity of the molecules of an ideal gas ?

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4. On driving the scooter for a long time, the air pressure in the tyres slightly increases. Why ?

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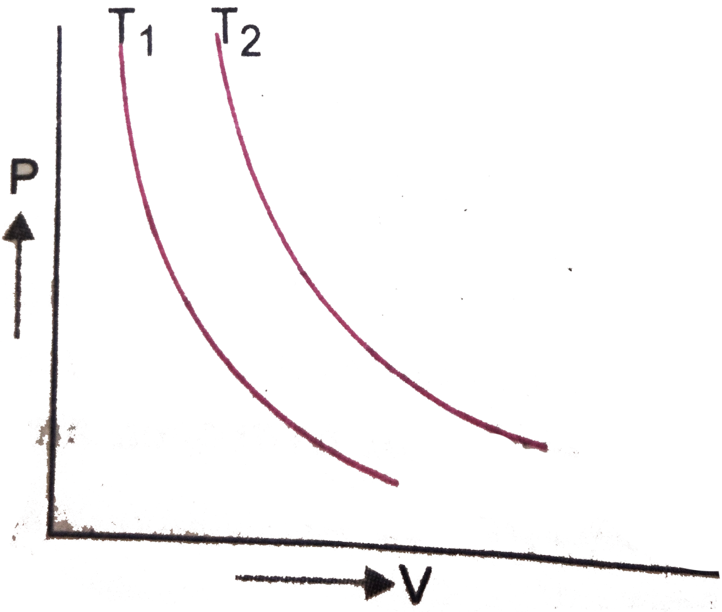
5. Isothermal curves for a given mass of gas are shown at two different temperture T_1 and T_2 in Fig. State whether $T_1 > T_2$ or $T_2 > T_1$. Justify your answer.



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6. Explain the rise of temperature on heating on the basis of kinetic theory.

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7. The pressure of a given mass of a gas is halved at constant temperature. What will be the volume of the gas in comparison to its initial volume? Explain on the basis of kinetic theory.

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8. Two gases A and B each at temperature T. Pressure P and volume V, are mixed. If the mixture be at the same temperature T and its volume also be V, then what should be its pressure ? Explain.

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9. Two vessels of the same volume and filled with the same gas at the same temperature. If the pressure of the gas in these vessel be in the ratio 1:2, then state : (i) the ratio of the rms speeds of the molecules, (ii) the ratio of the number of molecules.

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10. The volume of vessel A is twice the volume of another vessel B and both of them are filled with the same gas. If the gas in A is at twice the temperature and twice the pressure in comparison to the gas in B, what is the ratio of number of gas molecule in A and B ?

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11. On which of the following factors does the average kinetic energy of gas molecules depends ? (i) Nature of the gas, (ii) absolute temperature, (iii) volume, what will be its value at the absolute zero ?

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12. A gas in a vessel is at the pressure P_0. If the masses of all the molecules be made half and their speeds be made double, then find the resultant pressure.

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13. The absolute temperatue of a gas is made four times. How many times will its total kinetic energy, root mean square velocity of its molecules and pressure become ?

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14. If a molecule of krypton is 2.25 times heavier than a molecule of hydrogen, what would be the ratio of their root mean square velocities in a mixture of equal masses of the two gases ?

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15. Two gases each at temperature T, volume V and pressure P are mixed such that temperature of mixture is T and volume is V. What will be the pressure of the mixture ?

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16. Cooking gas cylinders are kept in a lorry moving with uniform speed. Will there be any effect on temperature of the gas ?

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17. Kinetic energy of translation of molecules of a gas having volume V and pressure P is 100 J. If same volume V of gas were at pressure 2 P, what would be the KE of translation ?

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18. Under what condition of pressure and temperature, a gas can be assumed as an ideal gas? Explain .

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19. What is an ideal gas ? Explain its main characteristics.

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20. Using the law of equipartition of energy , detemine the values of C_p, C_V and γ for monoatomic gas.

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21. Obtain the relation between degrees of freedom of a gas and ratio of two principal specific heats of the gas.

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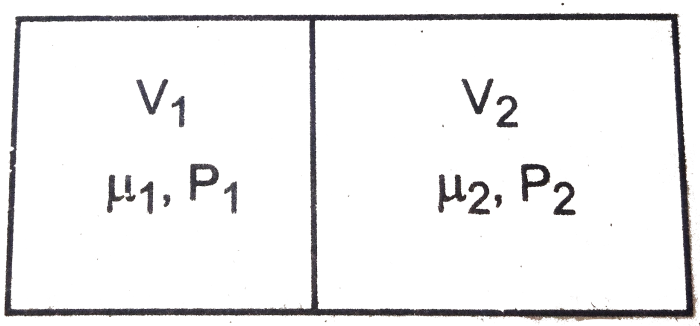
22. The container shown in Fig. 9(EP).6 has two chambers, separated by a partition, of volumes $V_1 = 2.0 litre$ and $V_2 = 3.0 litre$. The chambers contains $\mu_1 = 4.0$ and $\mu_2 = 5.0$moles of a gas at pressures $p_1 = 1.00 atm$ and $p_2 = 2.00 atm$. calculate the pressure after the partition is removed and the mixture attains equilibrium.



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23. A gas mixture consists of molecules of type A, B and C with masses $m_A > m_B > m_C$. Rank the three types of molecules in decreasing order of (a) average K.E., (b) rms speeds

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24. We have 0.5 g of hydrogen gas in a cubic chamber of size 3 cm kept at NTP. The gas in the chamber is compressed keeping the temperature constant till a final pressure of 100 atm. Is one justified in assuming the ideal gas law in the final state ? (Hydrogen molecules can be consider as spheres of radius 1Å).

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25. When air is pumped into a cycle tyre, the volume and pressure of the air in the tyre, both are increased.

What about Boyle's law in this case?

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26. A ballon has 5.0 g mole of helium at $7^{\circ}C$ Calculate

(a) the number of atoms of helium in the balloon,

(b) the total internal energy of the system.

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27. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

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28. An insulated container containing monoatomic gas of molar mass s is moving with a velocity v_0. If the container is suddenly stopped, find the change in temperature.

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Long Answer Questions

1. Explain (i) Boyle's law (ii) Charle's law. Why are they not applicable to real gases in all states ?

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2. State and explain (i) Gay lussac's law and (ii) Gas equation. Distinguish clearly between R and r for a gas.

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3. State the postions of Kinetic Theory of gases. Explain the pressure exerted by an ideal gas.

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4. v49_newFlow

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5. From Kinetic Theory of gases, explain kinetic interpretation of temperature and absolute zero.

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6. From Kinetic Theory of gases, explain the various gas laws.

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7. Define most probable speed, average speed and root mean square speed of a gas. How are they related to each other ?

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8. What is mean free path? Derive an expression for mean free path.

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9. Explain what is meant by Brownian Motion ?

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10. Explain why

(a) there is no atmosphere on moon

(b) there is fall in temperature with altitude

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11. Ten small planes are flying at a speed of $150km/h$ in total darkness in an air space that is $20 \times 20 \times 1.5km^3$ in volume. You are in one of the planes, flying at random within this space with no way of knowing where the other planes are, On the average about how long a time will elapse between near collision with your plane. Assume for this rough computation that a safety region around the plane can be approximately by a sphere of radius 10 m.

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12. A box of $1.00m^3$ is filled with nitrogen at 1.50 atm at 300 k. The box has a hole of an area 0.010 mm^2. How much time is required for the pressure to reduce by 0.10 atm, if the pressure outside is 1 atm.

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13. Consider a rectangular block of wood moving with a velocity v_0 in a gas at temperature T and mass density p. Assume the velocity is along x-axis and the are of cross-section of the block perpendicular to v_0 is A. show that the drag force on the block is $4rAv_0\sqrt{\frac{kT}{m}}$ where,m is the mass of the gas molecule.

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Advance Problem For Competitions

1. An electric bulb of volume $250cm^3$ was sealed off during manufacture at a pressure of 10^{-3} mm of Hg at $27^\circ C$. Find the number of molecules in the bulb. Given, Boltzmann constant $= 1.38 \times 10^{-16} \text{erg molecule}^{-1} \hat{} (\circ) C^{-1}$.

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2. An open glass tube is immersed in mercury in such a way that a lenth of 8cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46cm. What will be length of the air column above mercury in the tube now?

(Atmosphere pressure =76cm of Hg)

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3. A closed container of volume $0.02m^3$ contains a mixture of neon and argon gases, at a temperature of $27^\circ C$ and pressure of $1 \times 10^5 Nm^{-2}$. The total mass of the mixture is 28g. If the molar masses of neon and argon are $20 \text{ and } 40gmol^{-1}$ respectively, find the masses of the individual gasses in the container assuming them to be ideal (Universal gas constant $R = 8.314J/mol - K$).

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4. A column of mercury of 10cm length is contained in the middle of a narrow horizontal 1m long tube which is closed at both the ends. Both the halves of the tube contain air at a pressure of 76 cm of mercury. By what distance will the column of mercury be displaced if the tube is held vertically?

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5. An assembly of smoke particle in air at NTP is under consideration. If the mass of each particles is $5 \times 10^{-17} kg$. Then the rms speed is (Given: $k = 1.38 \times 19^{-23} JK^{-1}$)

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6. When 1 mole of monoatomic gas is mixed with 2 moles of diatomic gas, then find C_P, C_v, f and γ for the mixture of gases.

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7. At what temperature , will the rms speed of oxygen molecules be sufficient for escaping from the earth ? $Takenm = 2.76 \times 10^{-26} kg, k = 1.38 \times 10^{-23} J/K$ and $v_e = 11.2 km/s$.

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8. A vessel contains 1 mole of O_2 gas (relative molar mass 32) at a temperature T. The pressure of the gas is P. An identical vessel containing one mole of He gas (relative molar mass 4) at temperature 2T has a pressure of

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9. The molecules of a given mass of gas have a rms velocity of $200m/\sec at 127^\circ C$ and $1.0 \times 10^5 N/m^2$ pressure. When the temperature is $127^\circ C$ and pressure is $0.5 \times 10^5 N/m^2$ the rms velocity in $m/\sec$ will be

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10. A vessel contains $28 g of N_2$ and $32 g of O_2$ at temperature T = 1800 K and pressure 2 atm. What would be the pressure when N_2 dissociates 30% and O_2 dissociates 50% and temperature remains constant ?

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Ncert Questions

1. Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be 3Å.

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2. Molar volume is the volume occupied by 1 mole of any (Ideal) gas at standard temperature and pressure (STP , $0^{\circ} C$, 1 atmospheric pressure). Show that it is 22.4 litres. Take $R = 8.31 J mol^{-1} K^{-1}$.

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3. Fig shows of PV/T versus P for $1.00 \times 10^{-3} kg$ of oxygen gas at two different temperatures.

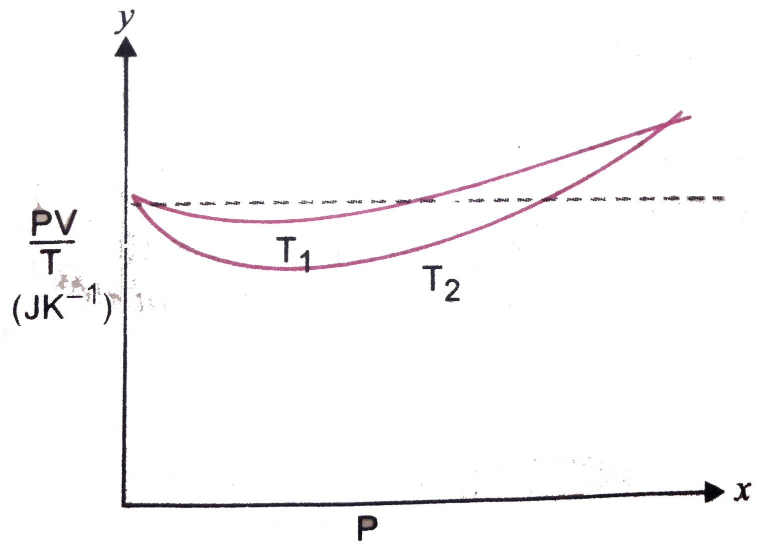
(a) What does the dotted plot signify ?

(b) Which is true : $T_1 < T_2$ or $T_2 < T_1$?

(c) What is the value of PV/T where the curves meet on the Y-axis ?

(d) If we obtained similar plot for $1.00 \times 10^{-3} kg$ of hydrogen, would we get the same value of PV/T at the point where the curves meet on the y-axis ? If not, what mass of hydrogen yield the same value of PV/T (for low pressure high temperature region of the plot) ?

(Molecular mass of $H = 2.02u$, of $O = 32.0u$, $R = 8.31 J mol^{-1} K^{-1}$



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4. An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15 atm. And a temperature of $27^{\circ} C$. After some oxygen is withdrawn from the cylinder, the gauge pressure drops to 11 atm. And its temperature drops to $17^{\circ} C$. Estimate the mass of oxygen taken out of the cylinder. $\left(R = 8.1 J \text{mole}^{-1} K^{-1}\right.$, molecular mass of $O_2 = 32u)$.

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5. An air bubble of volume $1.0 cm^3$ rises from the bottom of a take 40 m deep at a temperature of $12^{\circ} C$. To what volume does it grow when it reaches the surface, which is at a temperature of $35^{\circ} C$. ? Given $1 atm = 1.01 \times 10^5 Pa$.

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6. Estimate the total number of air molecules (inclusive of oxygen, nitrogen, water vapour and other constituents) in a room of capacity $25.0m^3$ at a temperature of $27^\circ C$. And 1 atm pressure. (Boltzmann constant $= 1.38 \times 10^{-23} JK^{-1}$).

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7. Estimate the average thermal energy of a helium atom at (i) room temperature $(27^\circ C)$ (ii) the temperature on the surface of the sun (6000K), (iii) the temperature of 10 million kelvin (the typical core temperature in the case of a car)

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8. Three vessel of equal capacity have gases at the same temperature and pressure. The first vessel contains neon (monoatomic), the second contains chlorine (diatomic), and the third contains uranium hexafluoride (polyatomic). Do the vessels contains equal number of respectice molecules ? Is the root mean square speed of molecules the same in the three cases ? If not, which case is v_{rms} the largest?

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9. At what temperature is the root mean square speed of an atom in an argon gas cylinder equal to the r.m.s. speed of a helium gas atom at $-20^{\circ}C$? (Atomic mass of Ar = 39.9 u, of He = 4.0 u).

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10. Estimate the mean free path and collision frequency of a nitrogen molecule in a cylinder containing nitrogen at 2 atm. And temperature 17°. Take the radius of a nitrogen molecule to be roughly 1.0Å. Compare the collision time with the time molecule moves freely between two successive collisions. (Molecular mass of nitrogen = 28.0 u).

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11. A metre long narrow bore held horizontally (and close at one end) contains a 76 cm long mercury thread, which traps a 15 cm column of air. What happens if the tube is held vertically with the open end at the bottom?

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12. From a certain apparatus, the diffusion rate of hydrogen has an average value of $28.7 cm^3 s^{-1}$. The diffusion of another gas under the same condition is measured to have an average rate of $7.2 cm^3 s^{-1}$. Identify the gas.

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13. A gas in equilibrium has uniform density and pressure throughout its volume. This is strictly true only if there are no external influences. A gas column under gravity, for example, does not have uniform density (and pressure). As you might expect, its density decreases with height. the precise dependence is given by the so called law of atmosphere' : $n_2 = n_1 \exp[-mg(h_2 - h_1)/k_B T]$ where, $n_1 . n_2$ refer to number density at height h_1 and h_2 respectively. use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid columns:

$n_2 = n_1$ exp $\left[-mgN_A(roh - roh')(h_2 - h_1)/(rohRT)\right]$

where, roh is the density of the suspended particle, and roh' that of surrounding medium. $[N_A$ is Avogadro's number, and R is the universal gas constant$]$.

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Higher Order Thinking Skills Questions

1. Calculate the mean free path of nitogen at $27^{\circ} C$ when pressure is 1.0 atm. Given, diameter of nitogen molecule = $1.5 Å$, $k = 1.38 \times 10^{-23} J K^{-1}$. If the average speed of nitrogen molecules is $675 m s^{-1}$, find the time taken by the molecule between two successive collsions and the frequency of collisions.

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2. There is a soap bubble of radius $2.4 \times 10^{-4} m$ in air cylinder at a pressure of $10^{5} N / m^{2}$. The air in the cylinder is compressed isothermal untill the radius of the bubble is halved. Calculate teh new pressure of air in the cylinder. Surface tension of soap solution is $0.08 N m^{-1}$.

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3. A gas has molar heat capacity $C = 37.55 J \text{mole}^{-1} K^{-1}$, in the process PT = constant, find the number of degree of freedom of the molecules of the gas.

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4. A moles of a monoatomic ideal gas are at pressure $3 \times 10^5 Nm^{-2}$ and temperature 100K (state A, say). Is is head heated isobarically to temperature 400K (state B, say). Next it undergoes isothermal expansion to pressure $1 \times 10^5 Nm^{-2}$ (state C). It is then cooled isobarically to 100 K (state D). Finally, it is compressed isothermal to returm to its initial state A. Draw P-T : P-V and V-T diagrams for the whole process.

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5. A vessel of volume , $V = 5.0$ litre contains $1.4g$ of nitrogen at a temperature $T = 1800K$. Find the pressure of the gas if 30% of its molecules are dissociated into atoms into atmos at this temperature.

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6. $(1/2)$ mole of helium is contained in a container at STP how much heat energy is needed to double the pressure of the gas, keeping the volume constant? Heat capacity of gas is $3Jg^{-1}K^{-1}$.

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7. 8g of oxygen, 14 g of nitrogen and 22 g carbon dioxide are mixed in an encloser of volume 10 litre and temperature $27^{\circ}C$. Calculate the pressure exerted by the mixture , $R = 8.3J\text{mole}^{-1}K^{-1}$, Molecular weight of oxygen , nitrogen and carbon 32 , 28 and 44 respectively.

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8. A nitrogen molecules at teh surface of earth happens to have the rms speed for that gas at 0°. If it were to go straight up without colliding with other molecules, how high would it rise? Mass of nitrogen molecules, $m = 4.65 \times 10^{26}lg, k = 1.38 \times 10^{-23}J\text{molecule}^{-1}K^{-1}$.

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9. A vessel is filled with a gas at a pressure of 76 cm of mercury at a certain temperature. The mass of the gas is increased by 50% by introducing more gas in the vessel at the same temperature. Find the resultant pressure of the gas.

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Value Based Questions

1. An ideal gas or a perfect gas is that which strictly obeys the gas laws (such as Boyle's Law, Charle's Law etc.) Two essential characteristics of an ideal gas are :

(i) size of molecule of an ideal gas is zero.

(ii) There is no force of attraction or reputation amongst the moleculess of an ideal gas.

In view of this, no real gas is perfect.

Read the above passage and answer the following questions :

(i) Under what conditions do same real gases behave as nearly perfect gases ?

What does this concept imply in day to day life ?

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2. According to kinetic theory, every gas consists of a very large number of molecules, which are in a state of incessant random motion. They move in all directions with different speeds and obey Newton's law of motion. The molecules do not exert any force of attraction or repulsion on one another except during collision.

Read the above passage and answer the following questions :

(i)What is the cause of pressure exerted by the gas ?

(ii) What values of life do you learn from the kinetic theory ?

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3. As in known, the pressure exerted by a gas is due to continuous bombardment of gas molecules against the walls of the container. The expression for pressure is $P = \frac{1}{3}(roh)C^2$, where (roh) is density of the gas and C is root mean square velocity of the gas molecules.

Read the above passage and answer the following questions :

(i) What is the root mean square velocity of hydrogen molecules at STP? Given density of hydrogen at STP is $0.09kg/m^3$.

How is this concept related in day to day life ?

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4. According to kinetic theory of gases, absolute temperature of a gas is directly proportional to the average kinetic energy of translation per molecules to the gas. Zeroth law of thermodynamics established that temperature is the obly physical quantity that determines whether a given system is in thermal equilibrium with another system. heat flows from a system at higher temperatures to another system at lower temperature till their temperatures becomes equal. temperature corresponds to level in case of liquids, pressure in case of gases potential in case of electricity.

Read the above passage and answer the following questions :

(i) The absolute temperature of a gas is increased three times. what will be the increase in rms velocity of gas molecules ?

What values of life do you learn this concept of temperature ?

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5. Accordig to Law of equipartition of energy, for any dynamical system in thermal equilibrium, the total energy in distributed equality amongst all the degrees of freedom. The energy associated with each molecule per degree of freedom is $\frac{1}{2}k_BT$ where k_B is Boltzmann constant and T is temperature of the system. the law emphasises that in thermal equilibrium, at temperature T, each more of energy : translation, rotational and vibrational, contribute an average energy equal $\frac{1}{2}k_B \cdot T$

Read the above passage and answer the following questions :

(i) What is the internal energy of one gram mole of a polyatomic gas having an degree of freedom ?

(ii) What value of life do you learn from this law ?

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6. Avogadro's number N_A is

A. 6.02×10^{-23}

B. 6.02×10^{23}

C. 8.31×10^{23}

D. none of these

Answer: B

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7. Number of molecules in V litre of a gas at NTP is

A. $\frac{N_A}{22.4} \times V$

B. $\frac{22.4}{N_A} \times V$

C. $\frac{N_A \times 22.4}{V}$

D. $N_A \times V \times 22.4$

Answer: A

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8. All curves for real gases approach the ideal gas behaviour at

A. low pressure only

B. high temperatures only

C. low pressures and high temperatures

D. high pressures and low temperatures

Answer: C

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9. If typical size of a gas molecule is 2Å, average distance between the molecules is

A. 1Å

B. 2Å

C. $< 20\text{Å}$

D. $\geq 20\text{Å}$

Answer: D

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10. In an ideal gas without preferred direction of motion of molecules,

A. $v_x = v_y = v_z$

B. $v_x^2 = v_y^2 = v_z^2$

C. $\overline{v_x^2} = \overline{v_y^2} = \overline{v_z^2}$

D. none of these

Answer: C

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11. The mean kinetic energy per unit volume of gas (E) is related to average pressure P, exerted by the gas is

A. $E = \frac{2}{3}P$

B. $E = \frac{3}{2}P$

C. E = P

D. $E = \frac{5}{4}P$

Answer: B

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12. Average K.E. Of translation of a molecule of gas varies with temperature T of gas is

A. $\propto T$

B. $\propto T^{-1}$

C. $\propto T^{0}$

D. $\propto T^{2}$

Answer: A

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13. The correct formula for rates of diffusion of two gases is

A. $\frac{r_1}{r_2} = \frac{c_1}{c_2} = \sqrt{\frac{\rho_1}{\rho_2}}$

B. $\frac{r_1}{r_2} = \frac{c_2}{c_1} = \sqrt{\frac{\rho_2}{\rho_1}}$

C. $\frac{r_1}{r_2} = \frac{c_1}{c_2} = \sqrt{\frac{\rho_2}{\rho_1}}$

D. none of these

Answer: C

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14. Most probable speed, c_{mp}, average speed, c_{av} and root mean square speed c_{rms} of gas molecules are related as

A. $\sqrt{3}: \sqrt{2}: \sqrt{8/\pi}$

B. $2: \sqrt{3}: \sqrt{8/\pi}$

C. $\sqrt{2}: \sqrt{3}: \sqrt{8/\pi}$

D. $\sqrt{2}: \sqrt{\frac{8}{\pi}}: \sqrt{3}$

Answer: D

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15. The number of degrees of freedom associated with 2 grams of helium at NTP is

A. 9.03×10^{23}

B. 6.01×10^{23}

C. 9.03×10^{26}

D. 9.03×10^{-26}

Answer: A

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Fill In The Blanks

1. An ideal gas or a perfect gas is that ....the such as ....

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2. According to Avogadro's hypothesis, ...of all gases ....would contain..................

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3. Avogadro's number is ....

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4. Actual weight of one atom of an element = ...

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5. number of molecules in given mass m of substance = ...

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6. Pressure exerted by a gas is due to ....against.............................

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7. Average straight distance covered between two successive collision of molecules is called....................

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8. The pressure exerted by an ideal gas is numerically equal to .... of......................per unit volume of the gas

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9. Root Mean Square velocity of molecules of a gas varies................as the ....of absolute temp. of the gas.

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10. The ratio of most probable speed, average speed and rms speed of gas molecules is..................................

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Problems For Practice

1. Using the ideal gas equation, determine the value of gas constant R. Given that one gram mole of a gas at S.T.P occupies a volume of 22.4 litres

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2. Air is filled in a bottle and it is corked at $35^{\circ} C$. If the cork can come out at 3 atmospheric pressure, then upto what temperature should the bottle be heated to remove the cork ?

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3. When a gas filled in a closed vessel is heated through $2^{\circ} C$, its pressure increases by 0.4%. What is the initial temperature of gas ?

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4. A vessel of volume , $V = 5.0$ litre contains $1.4g$ of nitrogen at a temperature $T = 1800K$. Find the pressure of the gas if 30% of its molecules are dissociated into atoms at this temperature.

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5. A litre of dry air weighs 1.293 gram at S.T.P Find the temperature at which a litre of air will weigh one gram when the pressure is 72 cm. of mercury.

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6. As an air bubble rises from the bottom of a lake to the surface, its volume is doubled. Find the depth of the lake. Take atmospheric pressure = 76 cm of Hg.

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7. A $3000cm^3$ tank contains oxygen at $20^\circ C$ and the gauge pressure is $2.5 \times 10^6 Pa$. Find the mass of the oxygen in the tank. Take 1 atm $= 10^5 Pa$.

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8. A balloon partially filled with helium has a volume of $30m^3$, at the earth's surface, where pressure is $76cm$ of (Hg) and temperature is $27^\circ C$ What will be the increase in volume of gas if balloon rises to a height, where pressure is $7.6cm$ of Hg and temperature is $-54^\circ C$?

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9. An empty barometric tube 1 m long is lowered vertically (mouth downwards) into a tank of water. What will be the depth above the water level in the tube, when the water has risen 20 cm inside the tube ? Take atmospheric pressure as 10.4 m column of water.

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10. One litre of hydrogen under standard conditions weighs 0.0896 g. find the value of gas constant (R) for one mole of the gas.

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11. A perfect gas in a cylinder provided with frictionless piston is at $37^\circ C$. The gas is cooled at constant pressure so that its volume becomes $(4/5)th$ of its initial volume. Find the resulting temperature.

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12. A litre of dry air weighs 1.293 gram at S.T.P Find the temperature at which a litre of air will weigh one gram when the pressure is 72 cm. of mercury.

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13. Calculate the KE per molecule and also rms velocity of a gas at $127^\circ C$. Given $k = 1.38 \times 10^{-23} J\text{molecule}^{-1} K^{-1}$ and mass of each molecule $= 6.4 \times 10^{-27} kg$.

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14. At what temperature will the average velocity of oxygen molecules be sufficient to escape from the earth. Given mass of oxygen molecule $= 5.34 \times 10^{-26} kg$. Boltzmann constant,

$k = 1.38 \times 10^{-23} J\text{molecule}^{-1} K^{-1}$. Escape velocity of earth $= 11.0 kms^{-1}$.

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15. A vessel A contains hydrogen and another vessel B whose volume is twice that of A contains same mass of oxygen at same temperature. Compare

(i) average KE of hydrogen and oxygen molecule.

(ii) root mean square speeds of molecules

(iii) pressure of gases in A and B.

Molecular weight of hydrogen and oxygen are 2 and 32 respectively.

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16. Calculate the rms velocity of molecules of a gas of density $1.5 glitre^{-1}$ at a pressure of $2 \times 10^6 N / m^2$.

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17. Estimate the average thermal energy of a helium atom at (i) room temperature $(27^{\circ} C)$. Boltzmann constant $= 1.38 \times 10^{-23} JK^{-1}$

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18. Given that mass of an atom of helium gas is $6.68 \times 10^{-27} kg.$ Calculate Avogadro's number. Molecular weight of He = 4.

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19. At what temperature, pressure remaining unchanged, will the rms velocity of hydrogen be doubled its value at NTP ?

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20. Calculate the temperature at which root mean square velocity of SO_2 molecules is the same as that of O_2 molecules at $127^\circ C$. Molecular weights. Of O_2 and SO_2 are 32 and 64 respectively.

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21. If root mean sqauare velocity of the molecules of hydrogen at NTP is $1.84 kms^{-1}$, calculate the rms velocity of oxygen molecules at NTP. Molecular weights of hydrogen and oxygen are 2 and 32 respectively.

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22. If Avogadro's number is 6.06×10^{23} per gram mole, what is the mass of a molecule of hydrogen in SI units ? Calculate Boltzmann's constant if $R = 8.31 J mol^{-1} K^{-1}$.

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23. Calculate kinetic energy of a gram molecule of oxygen at $127^{\circ} C$. Value of Boltzmann constant $= 1.381 \times 10^{-23} JK^{-1}$. Avogardro's number $= 6.022 \times 10^{23}$ per gm-mole.

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24. Calculate the kinetic energy of one gram mole of gas at NTP. Density of gas $= 0.178 kgm^{-3}$ at NTP. Its molecular weight = 4. Density of mercury $= 13.6 \times 10^{3} kgm^{-3}$.

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25. If three gas molecules have velocity 0.5, 1 and $2 km / s$ respectively, find the ratio of their root mean square speed and average speed.

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26. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

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27. Calculate the temperature at which the average K.E. of a molecule of a gas will be the same as that of an electron accelerated through 1 volt. Boltzmann constant $= 1.4 \times 10^{-23} J\text{molecule}^{-1} K^{-1}$, charge of an electron $= 1.6 \times 10^{-19} C$.

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28. Caculate molecular K.E. of 1 g of helium at NTP. What will be its energy at $100^\circ C$?

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29. The kinetic energy of a molecule of hydrogen at $0^{\circ} is 5.64 \times 10^{-21} J$. Calculate Avogadro's number. Take $R = 8.31 \times J\text{mole}^{-1} K^{-1}$

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30. Show that the rms velocity of O_2 molecule is $\sqrt{2}$ times that of SO_2. Atomic weight of sulphur is 32 and atomic weight of oxygen is 16.

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31. Estimate the temperature at which the oxygen molecules will have the same rms velocity as hydrogen molecules at $150^{\circ} C$. Molecular weight of oxygen is 32 and that of hydrogen is 2.

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32. The density of carbon dioxide gas at $0^\circ C$ and at pressure $1.0 \times 10^5 Nm^{-2} is 1.98 kgm^{-3}$. Find the rms velocity of its molecules at $0^\circ C$ and also at $30^\circ C$, assuming pressure to be constant.

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33. The rms velocity of hydrogen at S.T.P is $(\mu) ms^{-1}$. If the gas is heated at constant pressure till its volume is three fold, what will be its final temperature and rms velocity ?

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34. Calculate the rms speed of smoke particles of mass $5 \times 10^{-17} kg$ in their Brownian motion in air at NTP. Given $k_B = 1.38 \times 10^{-23} J/K$

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35. Calculate the temperature at which the rms velocity of hydrogen will be equal to $8km/s. TakeR = 8.31J\text{mole}^{-1}K^{-1}$

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36. The molar gas volume at S.T.P is 22.4 litre and Avogadro's number is 6.023×10^{23}. Calculate (i) number of gas molecules per unit volume (ii) radius of gas molecule when mean free path is $1.1 \times 10^{-8}m$.

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37. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. Find γ for the mixture.

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38. Calculate the total number of degree of freedom possessed by 10 c.c. of hydrogen gas at N.T.P

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39. How many degrees of freedom are associated with 2 gram of helium at NTP ? Calculate the amount of heat energy required to raise the temp. Of this amount from $27^\circ C \rightarrow 127^\circ C$. Given Boltzmann constant $k_B = 1.38 \times 10^{-23}$ erg molecule$^{-1} K^{-1}$ and Avogadro's number $= 6.02 \times 10^{23}$.

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40. Calculate the internal energy of 1 gram of oxygen at NTP.

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41. Calculate the mean free path of gas molecules, if number of molecules per $cm^3 is 3 \times 10^{19}$ and diameter of each "molecule" is 2Å.

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42. The diameter of a gas molecule is $2.4 \times 10^{-10} m$. Calculate the mean free path at NTP. Given Boltzmann constant $k = 1.38 \times 10^{-23} Jmo \leq \underline{ce}^{-1} K^{-1}$.

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43. At standard temperature and pressure, the mean free path of He gas is 300 mm.

(a) Determine the effective diameter of He atom

(b) the number of atoms per cubic metre.

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44. You are given the following group of particles n_1 represents the number of molecules with speed ve_1

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45. Calculate the number of molecules is 2 c.c of the perfect gas at $27^{\circ}C$ at a pressure of 10 cm. of mercury. Mean kinetic energy of each molecule at $27^{\circ}C = 7 \times 10^{-4} erg$ and acceleration due to gravity $= 980 cms^{-2}$.

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46. At what temperature the root mean square velocity is equal to escape velocity from the surface of earth for hydrogen and for oxygen ? Given radius of earth $= 6.4 \times 10^6 m, g = 9.8 ms^{-2}$. Boltzmann constant $= 1.38 \times 10^{-23} J\text{molecule}^{-1}$.

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47. A closed container of volume $0.02m^3$ contains a mixture of neon and argon gases, at a temperature of $27^\circ C$ and pressure of $1 \times 10^5 Nm^{-2}$. The total mass of the mixture is 28g. If the molar masses of neon and argon are 20 and $40gmol^{-1}$ respectively, find the masses of the individual gasses in the container assuming them to be ideal (Universal gas constant $R = 8.314J/mol - K$).

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Multiple Choice Questions I

1. A cubic vessel (with face horizontal + vetical) contains an ideal gas at NTP. The vessel is being carried by a rocket which is moving at a speed of $500ms^{-1}$ in vertical direction. The pressure of the gas inside the vessel as observed by us on the ground.

A. Remains the same because $500ms^{-1}$ is very much smaller than v_{rms} of the gas.

B. remains the same because motion of the vessel as a whole does not affect the relative motion of the gas molecules and the walls.

C. will increase by a factor equal to $[v)(rms)^2 + (500)^2[/v_{rms}^2$ where v_{rms} was the original nean square velocity of the gas.

D. will be different on the top wall and bottom wall of the vessel.

Answer: B

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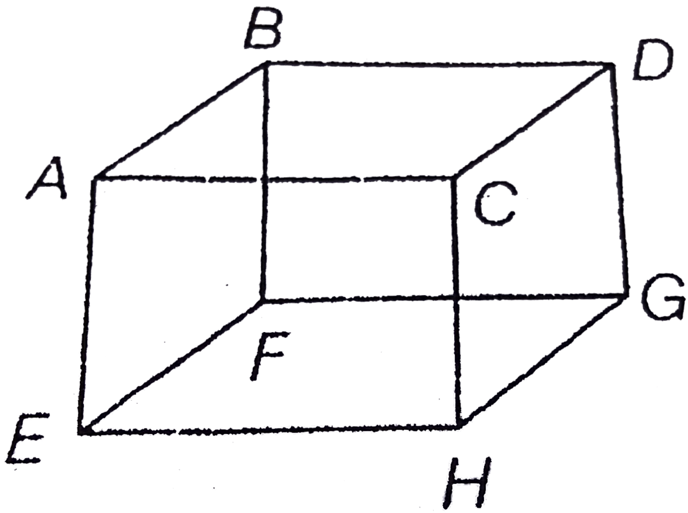
2. Mole of an ideal gas is contained in a cubical volume V, ABCDEFGH at 300 K (figure). One face of the cube (EFGH) is made up of a material which totally absorbs any gas molecule incident on it .At any given time.



A. The pressure on $EFGH$ would be zero.

B. the pressure on all the faces will the equal

C. the pressure of $EFGH$ would be double the pressure on ABCD.

D. The pressure on $EFGH$ would be half that on $ABCD$.

Answer: D

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3. Boyle's law is applicable for an

A. adiabatic process

B. isothermal process

C. isobaric process

D. isochoric process.

Answer: B

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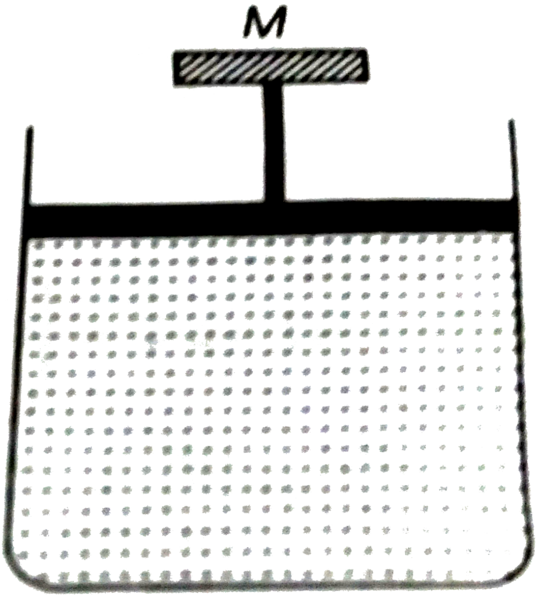
4. A cylinder containing an ideal gas is in vertical position and has a piston of mass M that is able to move up or down without friction (figure). If the temperature is increased



A. both p and V of the gas will change.

B. only p will increase according to Charle's law

C. V will change but not p.

D. p will change but not V.

Answer: C

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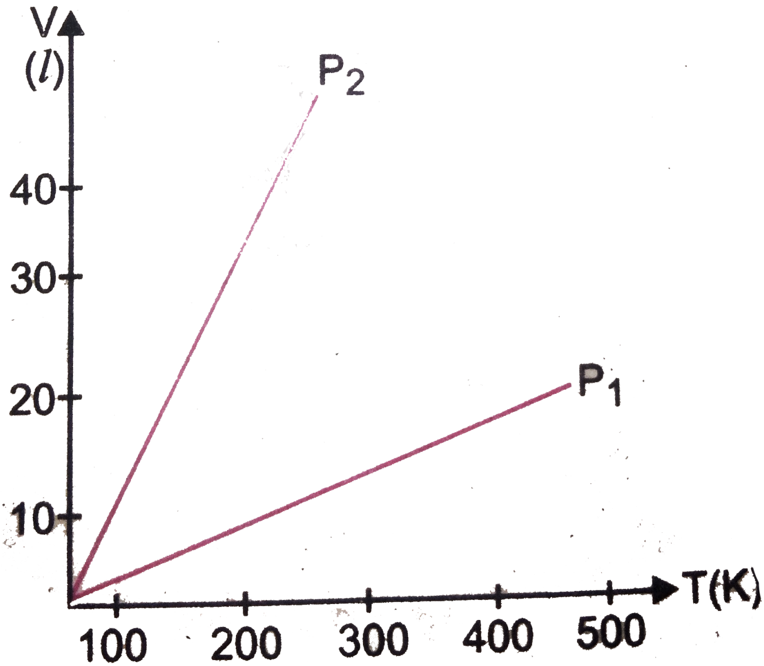
5. Volume versus temperature graphs for a given mass of an ideal gas are shown in Fig. at two different values of constant pressure. What can be inferred about relation between P_1 and P_2?



A. $P_1 > P_2$

B. $P_1 = P_2$

C. $P_1 < P_2$

D. data is insufficient.

Answer: A

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6. 1 mole of H_2 gas is contained in box of volume $V = 1.00 m^3 at T = 300 K$. The gas is heated to a temperature of T = 3000 K and the gas gets converted to a gas of hydrogen atoms. The final pressure would be (considering all gases to be ideal)

A. same as the pressure initially.

B. 2 times the pressure initially.

C. 10 times the pressure initially

D. 20 times the pressure initially

Answer: D

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7. A vessel of volume V contains a mixture of 1 mole of hydrogen and 1 mole oxygen (both considered as ideal). Let $f_1(v)dv$, denote the fraction of molecules with speed between v and (v+ dv) with $f_2(v)dv$, similarly for oxygen . Then ,

A. $f_1(v) + f_2(v) = f(v)$ obeys the Maxwell's distribution law.

B. $f_1(v), f_2(v)$ will obey the maxwell's distribution law seperately.

C. Neither $f_1(v)$, nor $f_2(v)$ will obey the Maxwell's distribution law.

D. $f_2(v)$ and $f_1(v)$ will be the same.

Answer: B

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8. An inflated rubber balloon contains one mole of an ideal gas has a pressure p, volume V and temperature T. if the temperature rises to 1.1 T, and the volume is increased to 1.05 V, the final pressure will be

A. $1.1p$

B. p

C. less than p

D. between p and $1.1p$

Answer: D

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9. Diatomic molecules like hydrogen haven energy due to both translational as well as rotational motion. From the equation in kinetic theory $PV = \frac{2}{3}E$, E is

A. the total energy per unit volume.

B. only the translational part of energy because rotational energy is very small compared to the translational energy.

C. only the translational part of the energy because during collisions with the walls, pressure relates to change in linear momentum.

D. The translational part of the energy because rotational energies of molecules can be of either sign and its average over all the molecules is zero.

Answer: C

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10. In a diatomic molecule, the rotational energy at given temperature

A. obeys Maxwell's distribution

B. have the same values for all molecules.

C. equals the translational kinetic energy for each molecules.

D. is $(2/3)rd$ the translational kinetic energy for each molecules.

Answer: A::D

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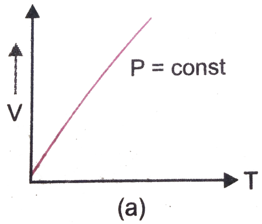
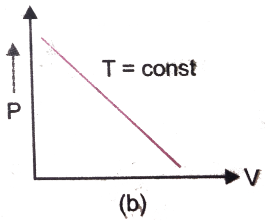
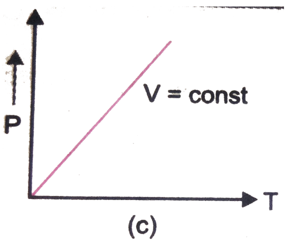
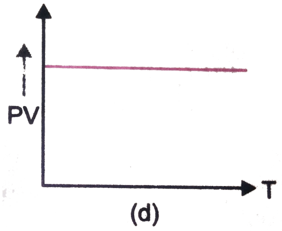
11. Which of the following diagrams, Fig. depicts ideal gas behaviour ?

A. 

B. 

C. 

D. 

Answer: A::C

Watch Video Solution

12. When an ideal gas is compressed adiabatically, is temperature rises the molecule have more kinetic energy than before. The kinetic energy increases,

A. becaise of collisions with moving parts of the wall only.

B. because of collision with the entire wall.

C. because the molecules gets accelerated in their motion inside the volume.

D. because of redistribution of energy amongest the molecules.

Answer: A

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13. A gas at 300 K has pressure $4 \times 10^{-10} N/m^2$. IF $k = 1.38 \times 10^{-23} J/K$, the number of $\text{molecule}/cm^3$ is of the order of

A. 10^5

B. 10

C. 10^7

D. 10^{11}

Answer: A

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14. 16 gram of oxygen, 14 gram of nitrogen and 11 gram of carbon dioxide are mixed in an enclosure of volume 5 L and temperature

`27^(@)C. The pressure exerted by the mixture is

A. $9 \times 10^5 N/m^2$

B. $5 \times 10^5 N/m^2$

C. $6.2 \times 10^5 N/m^2$

D. $4 \times 10^5 N/m^2$

Answer: C

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15. A gas is found to obey the law $P^2V = cons\tan t$. The initial temperature and volume are T_0 and V_0. If the gas expands to a volume $3V_0$, its final temperature becomes

A. $\frac{T_0}{3}$

B. $\frac{T_0}{\sqrt{3}}$

C. $3T_0$

D. $\sqrt{3}T_0$

Answer: D

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16. The specific heat of the mixture of two gases at constant volume is $\frac{13}{6}R$. The ratio of the number of moles of the first gas to the second gas is 1:2.

The respective gases may be

A. O_2, H_2

B. He, Ne

C. N_2, He

D. He, N_2

Answer: D

Watch Video Solution

17. The equation of state for 5 g of oxygen at a pressure P and temperature T, when occupying a volume V, will be

A. $PV = \frac{5}{2}RT$

B. $PV = \frac{5}{16}RT$

C. $PV = \frac{5}{32}RT$

D. $PV = 5RT$

Answer: C

Watch Video Solution

18. A certain amount of gas is sealed in a glass flask at 1 atmosphere pressure and $20^{\circ}C$. The flask can withstand upto a pressure of 2 atmosphere. Find the temperature to which gas can be heated so that the flask does not break.

A. $513^{\circ} C$

B. $413^{\circ} C$

C. $313^{\circ} C$

D. $213^{\circ} C$

Answer: C

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19. The temperature of an open room of volume $30m^3$ increases from $17^{\circ} C \rightarrow 27^{\circ} C$ due to sunshine. The atmospheric pressure in the room remains $1 \times 10^5 Pa$. If n_i and n_f are the number of molecules in the room before and after heating then n_f and n_i will be

A. 2.5×10^{25}

B. -2.5×10^{25}

C. -1.61×10^{23}

D. 1.38×10^{23}

Answer: B

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20. When a gas filled in a closed vessel is heated through $1^\circ C$, its pressure increases by 0.4%. What is the initial temperature of gas ?

A. $250^\circ C$

B. $25^\circ C$

C. $250^\circ K$

D. $25^\circ K$

Answer: C

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21. Temperature ramaining constant, the pressure of gas is decreased by 20%. The percentage change in volume is

A. increased by 20%

B. decrease by 20%

C. increased by 25%

D. decreased by 25%

Answer: C

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22. At $10^{\circ}C$, the value of the density of a fixed mass of an ideal gas divided by its pressure is x. at $110^{\circ}C$, this ratio is

A. x

B. $\frac{383}{283}x$

C. $\frac{10}{110}x$

D. $\frac{283}{383}x$

Answer: D

Watch Video Solution

23. An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains ideal gas at pressure P_1 and temperature T_1.The other chamber has volume V_2 and contains ideal gas at pressure P_2 and temperature T_2. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be

A. $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_2+P_2V_2T_1}$

B. $\frac{P_1V_1(T_1+P_2V_2T_2)}{P_1V_1+P_2V_2}$

C. $\frac{P_1V_1(T_2+P_2V_2T_1)}{P_1V_1+P_2V_2}$

D. $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_1+P_2V_2T_2}$

Answer: A

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24. One litre of oxygen at a pressure of 1 atm and two litres of nitrogen at a pressure of 0.5 atm are introduced into a vessel of volume 1 litre. If there is no change in temperature, the final pressure of the mixture of gas (in atm) is

A. 1.5

B. 2.5

C. 2

D. 4

Answer: C

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25. A container with insulating walls is divided into two equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure P and temperature T, whereas the other part is completely evacuated . If the valve is suddenly opened, the pressure and temperature of the gas will be

A. $\frac{P}{2}, T$

B. $\frac{P}{2}, \frac{T}{2}$

C. P, T

D. $P, \frac{T}{2}$

Answer: A

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26. If gas molecules undergo inelastic collision with the walls of container when temperature of gas is same as that of walls of container, then

(a) the temperature of the gas will decrease

the pressure of the gas will increase

(c) neither the temperature nor the pressure will change.

(d) the temperature of the gas will increase

A. the temperature of the gas will decrease

B. the pressure of the gas will increase

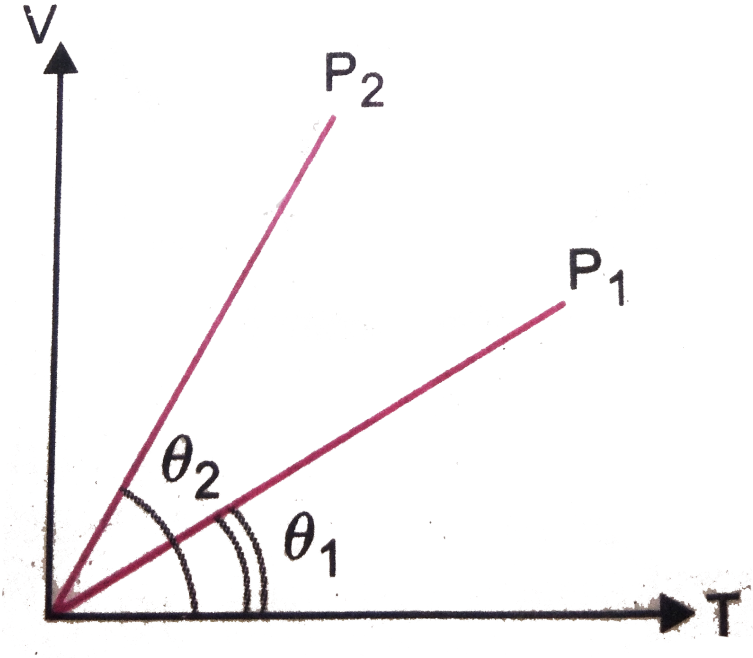
C. neither the temperature nor the pressure will change

D. the temperature of the gas will increase

Answer: C

Watch Video Solution

27. In the given (V-T) diagram, what is the relation between pressure P_1 and P_2 ?



A. Cannot be predicted

B. $P_2 = P_1$

C. $P_2 > P_1$

D. $P_2 < P_1$

Answer: D

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28. An open glass tube is immersed in mercury in such a way that a lenth of 8cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46cm. What will be length of the air column above mercury in the tube now?

(Atmosphere pressure =76cm of Hg)

A. 38 cm

B. 6 cm

C. 16 cm

D. 22 cm

Answer: C

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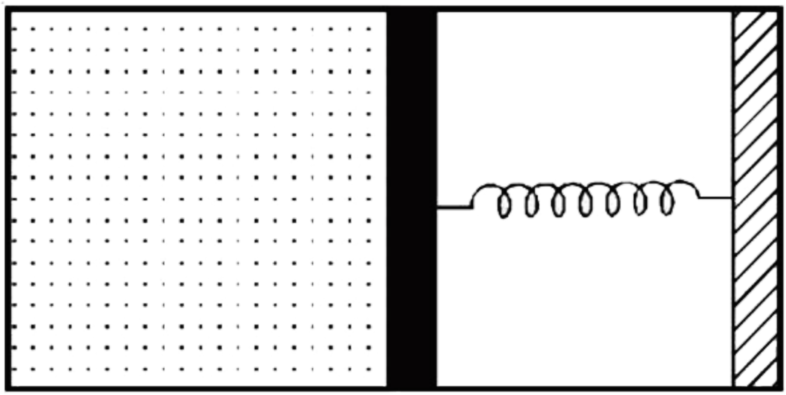
29. An ideal monoatomic gas is confined in a horizontal cylinder by a spring loaded piston (as shown in the figure). Initially the gas is at temperature T_1, pressure P_1 and volume $V_1$and the spring is in its relaxed state. The gas is then heated very slowly to temperature T_2 ,pressure $P_2$and volume V_2. During this process the piston moves out by a distance x. Ignoring the friction between the piston and the cylinder, the correct statement (s) is (are)



A. If $V_2 = 2V_1$ and $T_2 = 3T_1$, then the energy stored in the string is $\frac{1}{4}P_1V_1$

B. If V_2 and $2V_1$ and $T_2 = 3T_1$, then the charge in iternal energy is $3P_1V_1$.

C. If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the work done by the gas is

$\frac{7}{3}P_1V_1$

D. If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the heat supplied to the gas is

$\frac{17}{6}P_1V_1$.

Answer: B

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30. The rms speed of oxygen molecules at a certain temperature is v. If the temperature is doubled and the oxygen gas dissociates into atomic oxygen, the rms speed would be

A. v

B. $3v$

C. $2v$

D. $2\sqrt{2}v$

Answer: C

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31. Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increase as V^q, where V is the volume of the gas. The value of q is : $\left(\gamma = \frac{C_p}{C_v}\right)$

A. $\frac{3(\gamma) + 5}{6}$

B. $\frac{3(\gamma) - 5}{6}$

C. $\frac{(\gamma) + 1}{2}$

D. $\frac{(\gamma) - 5}{2}$

Answer: C

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32. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

A. 4 RT

B. 15 RT

C. 9 RT

D. 11 RT

Answer: D

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33. The ratio of the specific heats $\frac{C_P}{C_v} = \gamma$ in terms of degrees of freedom is given by

A. $\frac{1 + (n)}{3}$

B. $\frac{1 + (2)}{n}$

C. $\frac{1+(n)}{2}$

D. $\frac{1+(1)}{n}$

Answer: B

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34. The molar specific heat of a gas as given from the kinetic theory is $\frac{5}{2}R$. If it is not specified whether it is C_p or C_v one could conclude that the molecules of the gas

A. are definitely monoatomic

B. are definitely rigid diatomic

C. are definitely non-rigid diatomic

D. can be monoatomic or rigid diatomic

Answer: D

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35. Two vessel separately contains two ideal gases A and B at the same temperature, the pressure of A being twice that of B. under such conditions, the density of A is found to be 1.5 times the density of B. the ratio of molecular weight of A and B is

A. $1/2$

B. $2/3$

C. $3/4$

D. 2

Answer: C

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36. A gas is filled in a container at pressure P_0. If the mass of molecules is halved and their rms speed is doubled, then the resultant pressure would be

A. $2P_0$

B. $4P_0$

C. $\frac{P_0}{4}$

D. $\frac{P_0}{2}$

Answer: A

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37. In a mixture of gases, the average number of degrees of freedom per molecule is 6. the rms speed of the molecules of the gas is C. the velocity of sound in the gas is

A. C

B. $\frac{2C}{3}$

C. $\frac{3C}{4}$

D. $\frac{2C}{\sqrt{3}}$

Answer: B

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38. Three moles of oxygen ar mixed with two moles of helium. What will be the ratio of specific heats at constant pressure and constant volume for the mixture ?

A. 6.7

B. 1.5

C. 4

D. none of the above

Answer: B

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39. Four cylinders contain equal number of moles of argon, hydrogen, nitrogen and carbon dioxide at the same temperature. The energy is minimum in

A. argon

B. carbon dioxide

C. nitrogen

D. hydrogen

Answer: A

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40. Oxygen and hydrogen gas are at same temperature and pressure. And the oxygen molecule has 16 times the mass of hydrogen molecule. Then the ratio of their rms speed is

A. 2

B. $1/4$

C. 4

D. 16

Answer: B

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41. The average translational energy and the rms speed of molecules in a sample of oxygen gas at $300K$ are $6.21 \times 10^{-21} J$ and $484 m/s$, respectively. The corresponding values at $600K$ are nearly (assuming ideal gas behaviour)

A. $12.42 \times 10^{-21} J, 968 ms^{-1}$

B. $8.78 \times 10^{-21} J, 684 ms^{-1}$

C. $6.21 \times 10^{-21} J, 968 ms^{-1}$

D. $12.42 \times 10^{-21} J, 684 ms^{-1}$

Answer: D

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42. The K.E. of one mole of an ideal gas is

A. 0.5 R

B. 0.1 R

C. 1.5 R

D. 2.5 R

Answer: D

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43. At what temperature is the rms velocity of a hydrogen molecule equal to that of an oxygen molecule at $47^\circ C$?

A. 80 K

B. $-73K$

C. 3 K

D. 20 K

Answer: D

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44. The molar specific heat at constant pressure of an ideal gas is $(7/2R)$. The ratio of specific heat at constant pressure to that at constant volume is

A. $9/7$

B. $7/5$

C. $5/7$

D. $8/7$

Answer: B

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45. Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while Box contains one mole of helium at temperature $\left(\frac{7}{3}\right)T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gasses reach a common final temperature (ignore the heat capacity of boxes). Then, the final temperature of the gasses, T_f in terms of T_0 is

A. $T_f = \frac{7}{3}T_0$

B. $T_f = \frac{3}{2}T_0$

C. $T_f = \frac{5}{2}T_0$

D. $T_f = \frac{3}{7}T_0$

Answer: B

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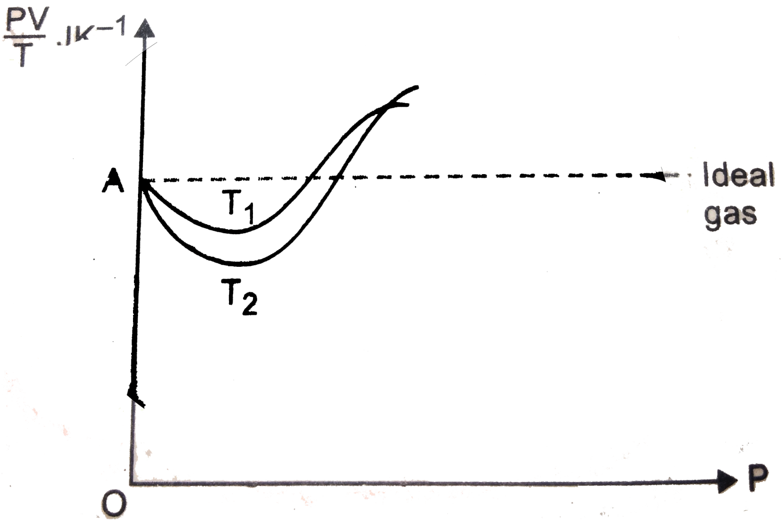
46. Given is the graph between $\frac{PV}{T}$ and P for 1 gm of oxygen gas at two different temperatures T_1 and T_2 Fig. Given, density of oxygen $= 1.427 kgm^{-3}$. The value of $(PV)/(T)$ at the point A and the relation between T_1 and T_2 are respectively :



A. $0.256 JK^{-1}$ and $T_1 < T(2)$

B. $8.314 mol^{-1} K^{-1}$ and $T_1 > T(2)$

C. $0.256 JK^{-1}$ and $T_1 > T(2)$

D. $4.28 JK^{-1}$ and $T_1 < T(2)$

Answer: C

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47. The root mean square velocity of hydrogen molecules at 300 K is $1930 ms^{-1}$. The rms velocity of oxygen molecules at 1200 K will be

A. $965 ms^{-1}$

B. $765 ms^{-1}$

C. $1065 ms^{-1}$

D. $865 ms^{-1}$

Answer: A

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48. Two moles of oxygen are mixed with eight moles of helium. The effective specific heat of the mixture at constant volume is

A. 1.3 R

B. 1.4 R

C. 1.7 R

D. 1.9 R

Answer: C

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49. 1 mole of monoatomic and one mole of diatomic gas are mixed together. The value of C_v is

A. 2 R

B. $(3/2)R$

C. R

D. $R/2$

Answer: A

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50. One kg of a diatomic gas is at pressure of $8 \times 10^4 N/m^2$. The density of the gas is $4kg/m^3$. What is the energy of the gas due to its thermal motion?

A. $5 \times 10^4 J$

B. $6 \times 10^4 J$

C. $7 \times 10^4 J$

D. $3 \times 10^4 J$

Answer: A

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51. 10 moles of an ideal monoatomic gas at $10^{\circ}C$ are mixed with 20 moles of another monoatomic gas at $20^{\circ}C$. Then the temp. of the mixture is

A. $15.5^{\circ}C$

B. $15^{\circ}C$

C. $16^{\circ}C$

D. $16.6^{\circ}C$

Answer: D

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52. Find the temperature at which oxygen molecules would have the same rms speed as of hydrogen molecules at $300K$.

A. 600 K

B. 2400 K

C. 1200 K

D. 4800 K

Answer: D

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53. Mean free path of a gas molecule is

A. inversely proportional to number of molecules per unit volume

B. Inversely proportional to diameter of molecule

C. directly proportional to square root of absolute temperature

D. directly proportional to molecular mass

Answer: A

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54. A mixture of 2 moles of helium gas $((a \rightarrow micmass) = 4a.m.u)$ and 1 mole of argon gas $((a \rightarrow micmass) = 40a.m.u)$ is kept at 300K in a container. The ratio of the rms speeds $\left(\frac{v_{rms}(helium)}{(v_{rms}(argon))}\right)$ is

A. 0.32

B. 0.45

C. 2.24

D. 3.16

Answer: D

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55. The molar specific heats of an ideal gas at constant pressure and volume are denotes by C_P and C_v respectively. If $\gamma = \frac{C_P}{C_v}$ and R is the universal gas constant, then C_v is equal to

A. γR

B. $\frac{1+\gamma}{1-\gamma}$

C. $\frac{R}{\gamma-1}$

D. $\frac{\gamma-1}{R}$

Answer: C

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56. The mean free path of molecules of a gas (radius r) is inversely proportional to

A. r^3

B. r^2

C. r

D. $\sqrt{r}$

Answer: B

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57. The root mean square velocity of hydrogen molecule at $27^\circ C is (v_H$ and that of oxygen at $402^\circ C is (v_0$, then

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58. The molecules of a given mass of a gas have rms velocity of $200 m / s at 27^\circ C$ and $1.0 \times 10^5 N / m_2$ pressure. When the temperature and pressure of the gas are respectively $127^\circ C$ and $0.05 \times 10^5 N m^{-2}$, the rms velocity of its molecules in $m s^{-1}$ is

A. $\frac{400}{\sqrt{3}}$

B. $\frac{100\sqrt{2}}{3}$

C. $\frac{100}{3}$

D. $100\sqrt{2}$

Answer: A

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59. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

A. 4 RT

B. 15 RT

C. 9 RT

D. 11 RT

Answer: D

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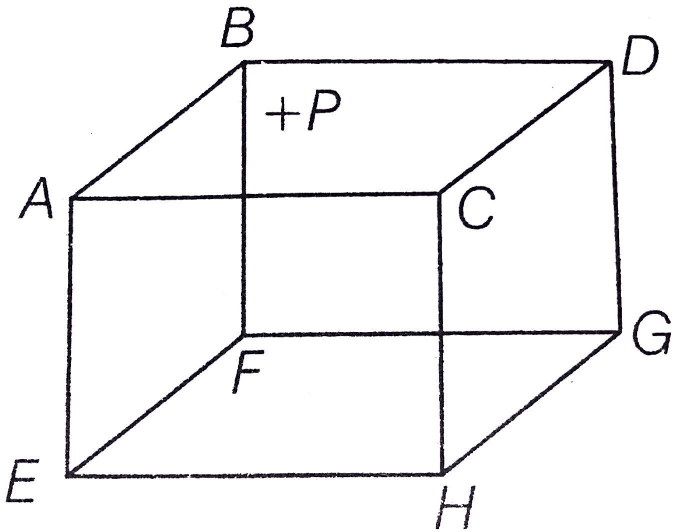
Multiple Choice Questions Ii

1. ABCDEFGH is a hollow cube made of an insulator (figure) face ABCD has positive charge on it. Inside the cube, we have ionised hydrogen.



A. will be valid

B. will not be valid since the ions would experience forces other than due to collisions with the walls.

C. will not be valid since collisions with walls would not be elastic.

D. will not be valid because isotropy is lost.

Answer: B::D

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2. A container of fixed volume has a mixture of a one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gasses are ideal, the correct statement (s) is (are)

A. The average energy per mole of the gas mixture is 2 RT

B. The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{\frac{6}{5}}$

C. The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/2$

D. The ratio of the rms speed of helium atoms to that of hydrogen molecule is $1/\sqrt{2}$

Answer: A::B::D

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3. Which of the following quantities is the same for all ideal gases at the same temperature?

A. The kinetic energy of 1 mole

B. The kinetic energy is 1 g

C. The number of molecules in 1 mole

D. The number of molecule in 1 g

Answer: A::C

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4. The rms speed of the perfect gas molecules is doubled if.

A. pressure is doubled at constant volume

B. pressure is made four times at constant volume

C. volume is made four times at constant pressure

D. volume is increased by about 42% at constant pressure

Answer: B::C

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5. At ordinary temperatures, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperatures, they may also have vibrational energy. As a result of this, at higher temperatures, molar specific heat capacity at constant volume, C_V is

A. $> 5/2R$ for a diatomic gas

B. $> 3/2R$ for a monoatomic gas

C. $< 5/2R$ for a diatomic gas

D. $= 3/2R$ for a monoatomic gas

Answer: A

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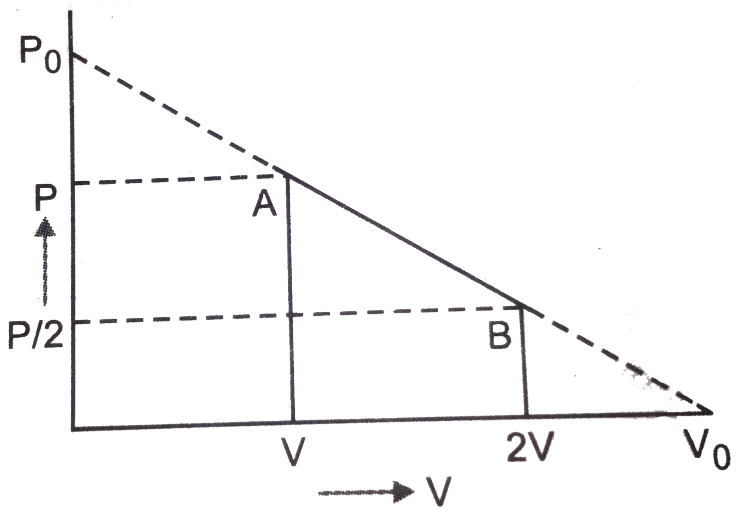
6. An ideal gas is taken from the state A (P, V) to the state B $(P/2, 2V)$ along a st. line path as shown in Fig. Select the correct statement from the following:



A. work done by the gas in going from A to B exceed the work done in going from A to D under isothermal conditions,

B. in the T - V diagram, part AB would become a parabola

C. in the T - V diagram, part AB would become a hyperbola

D. in going from A to D the Temp. Of gas first increases to a max value and then decreases

Answer: A::B::D

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7. Let $\bar{v}$, v_{rms} and v_p respectively denote the mean speed. Root mean square speed, and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then

A. $(v)_P < \overrightarrow{v} < (v)_{rms}$

B. no molecule can have a speed greater than $\sqrt{2}(v)_{rms}$

C. no molecule can have speed less than $(v)_P / (\sqrt{2})$

D. the average kinetic energy of a molecule is $\frac{3}{4}m(v)^2 \_ (P)$

Answer: A::D

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8. Which of the following processes are reversible ?

A. Diffusion

B. Change of state

C. Electrolysis

D. Heat conduction

Answer: B::C

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Multiple Choice Questions Iii

1. The pressure exerted by an ideal gas is $P=\frac{1}{3}\frac{M}{V}C^2$, where the symbols have their usual meaning. Using standard gas equation, PV =

RT, we find that $C^2 = \frac{3RT}{M}$ or $C^2 \infty T$. Average kinetic energy of translation of one mole of gas $= \frac{1}{2}MC^2 = \frac{3RT}{2}$ with the help of the passage given above, choose the most appropriate alternative for each of the following quetions :

Average thermal energy of a helium atom at room temperature $(27^\circ C)$ is Given, Boltzmann constant $k = 1.38 \times 10^{-23} JK^{-1}$:

A. $2.61 \times 10^{21} J$

B. $6.21 \times 10^{21} J$

C. $6.21 \times 10^{-21} J$

D. $6.21 \times 10^{-23} J$

Answer: C

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2. The pressure exerted by an ideal gas is $P = \frac{1}{3}\frac{M}{V}C^2$, where the symbols have their usual meaning. Using standard gas equation, PV =

RT, we find that $C^2 = \frac{3RT}{M}$ or $C^2 \infty T$. Average kinetic energy of translation of one mole of gas $= \frac{1}{2}MC^2 = \frac{3RT}{2}$ with the help of the passage given above, choose the most appropriate alternative for each of the following quetions :

Average thermal energy of one mole of helium at this temperature is (Given gas constant for 1 gram mole $= 8.31 J \text{mole}^{-1} K^{-1}$.

A. $3.74 \times 10^3 J$

B. $3.74 \times 10^{-3} J$

C. $3.47 \times 10^6 J$

D. $3.47 \times 10^{-6} J$

Answer: A

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3. The pressure exerted by an ideal gas is $P = \frac{1}{3}\frac{M}{V}C^2$, where the symbols have their usual meaning. Using standard gas equation, PV =

RT, we find that $C^2 = \frac{3RT}{M}$ or $C^2 \infty T$. Average kinetic energy of translation of one mole of gas $= \frac{1}{2}MC^2 = \frac{3RT}{2}$ with the help of the passage given above, choose the most appropriate alternative for each of the following quetions :

Average thermal energy of a helium atom at 600 K would be

A. $6.21 \times 10^{-21} J$

B. $1.24 \times 10^{-20} J$

C. $1.24 \times 10^{-21} J$

D. $1.24 \times 10^{21} J$

Answer: B

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4. The pressure exerted by an ideal gas is $P = \frac{1}{3}\frac{M}{V}C^2$, where the symbols have their usual meaning. Using standard gas equation, PV = RT, we find that $C^2 = \frac{3RT}{M}$ or $C^2 \infty T$. Average kinetic energy of translation of one mole of gas $= \frac{1}{2}MC^2 = \frac{3RT}{2}$ with the help of the passage given above, choose the most appropriate alternative for each of the following quetions :

At what temperature, pressure remaining unchanged, will the rms velocity of hydrogen be double its value at NTP ?

A. 819 K

B. $819^\circ C$

C. 1000 K

D. $1000^\circ C$

Answer: B

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5. The pressure exerted by an ideal gas is $P = \frac{1}{3}\frac{M}{V}C^2$, where the symbols have their usual meaning. Using standard gas equation, PV = RT, we find that $C^2 = \frac{3RT}{M}$ or $C^2 \infty T$. Average kinetic energy of translation of one mole of gas $= \frac{1}{2}MC^2 = \frac{3RT}{2}$ with the help of the passage given above, choose the most appropriate alternative for each of the following quetions :

At waht temperature, pressure remaining unchanged, will the rms velocity of a gas be half its value at $0^\circ C$?

A. 204.75 K

B. $204.75^\circ C$

C. $-204.75K$

D. $-204.75^\circ C$

Answer: D

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6. If C_1, C_2, C_3......are random speed of gas molecules, then average speed $C_{av} = \frac{C_1 + C_2 + C_3 + ...C_n}{n}$ and root mean square speed of gas molecules, $C_{rms} = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + ...C_n^2}{n}} = C$. Further ,

$C_2 \propto T$ or $C \propto \sqrt{T}$ at $0k, C = 0$, ie., molecular motion stops. With the help of the passage given above , choose the most appropriate alternative for each of the following question:

If three molecules have velocities $0.5, 1$ and $2km/s$, the ratio of rms speed and average speed is

A. 0.134

B. 1.34

C. 1.134

D. 13.4

Answer: C

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7. If C_1, C_2, C_3......are random speed of gas molecules, then average speed $C_{av} = \dfrac{C_1 + C_2 + C_3 + \ldots C_n}{n}$ and root mean square speed of gas molecules, $C_{rms} = \sqrt{\dfrac{C_1^2 + C_2^2 + C_3^2 + \ldots C_n^2}{n}} = C$. Further ,

$C_2 \propto T$ or $C \propto \sqrt{T}$ at $0k, C = 0$, ie., molecular motion stops. With the help of the passage given above , choose the most appropriate alternative for each of the following question:

Temperature of a certain mass of a gas is doubled. the rms speed of its molecules becomes n times. where n is

A. $\sqrt{2}$

B. 2

C. $\frac{1}{\sqrt{2}}$

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

Answer: A

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8. If C_1, C_2, C_3......are random speed of gas molecules, then average speed $C_{av} = \frac{C_1 + C_2 + C_3 + \dots C_n}{n}$ and root mean square speed of gas molecules, $C_{rms} = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + \dots C_n^2}{n}} = C$. Further ,

$C_2 \propto T$ or $C \propto \sqrt{T}$ at $0k, C = 0$, ie., molecular motion stops. With the help of the passage given above , choose the most appropriate alternative for each of the following question:

KE per molecule of the gas in the above question becomes x times, where x is

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

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

C. 4

D. 2

Answer: D

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9. If C_1, C_2, C_3......are random speed of gas molecules, then average speed $C_{av} = \frac{C_1 + C_2 + C_3 + \dots C_n}{n}$ and root mean square speed of gas molecules, $C_{rms} = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + \dots C_n^2}{n}} = C$. Further ,

$C_2 \propto T$ or $C \propto \sqrt{T}$ at $0k$, $C = 0$, ie., molecular motion stops. With the help of the passage given above , choose the most appropriate alternative for each of the following question:

$K.E.$ per gram mole of hydrogen at $100^{\circ}C$ (given $R = 8.31 J \text{mole}^{-1} K^{-1}$) is

A. 4946 J

B. 4649 J

C. 4496 J

D. 4699 J

Answer: B

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10. If C_1, C_2, C_3......are random speed of gas molecules, then average speed $C_{av} = \dfrac{C_1 + C_2 + C_3 + ...C_n}{n}$ and root mean square speed of gas molecules, $C_{rms} = \sqrt{\dfrac{C_1^2 + C_2^2 + C_3^2 + ...C_n^2}{n}} = C$. Further ,

$C_2 \propto T$ or $C \propto \sqrt{T}$ at $0k, C = 0$, ie., molecular motion stops. With the help of the passage given above , choose the most appropriate alternative for each of the following question:

At what temperature, pressure remaining constant will the rms speed of a gas molecules increase by $10\,\%$ is the rms speed at NTP?

A. 57.3 K

B. $57.3^\circ C$

C. 557.3 K

D. $-57.3^\circ C$

Answer: B

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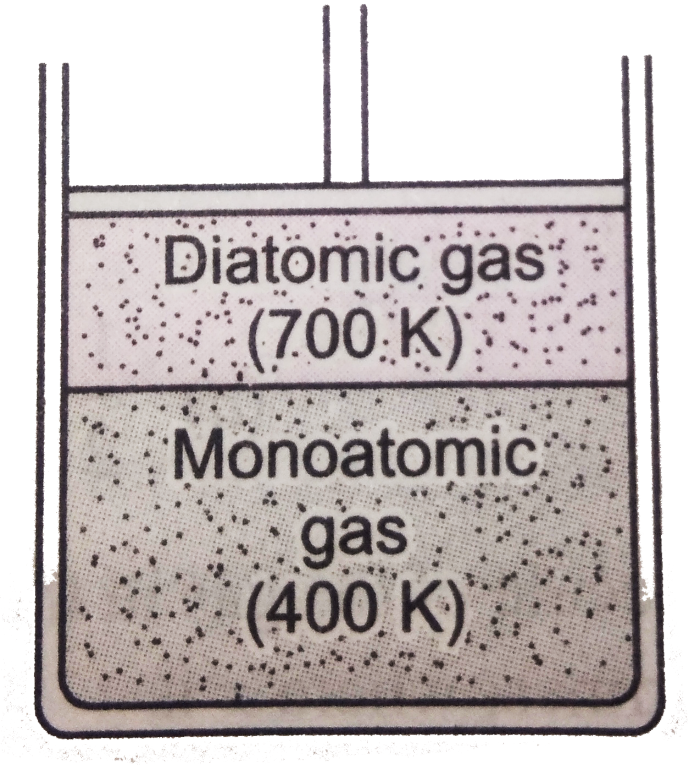
11. In Fig., a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. the lower compartment of the container is filled with 2 moles of an ideal monoatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. the heat capacities per mole of an ideal monoatomic gas are $C_v = \frac{3}{2}R$ and $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_{ve} = \frac{5}{2}R$ and $C_P = \frac{7}{2}R$.

Consider the partition to be rigidly fixed so that it does not move. when equilibrium is achieved, the final temperature of the gases will be



A. 550 K

B. 525 K

C. 512.5 K

D. 490 K

Answer: C

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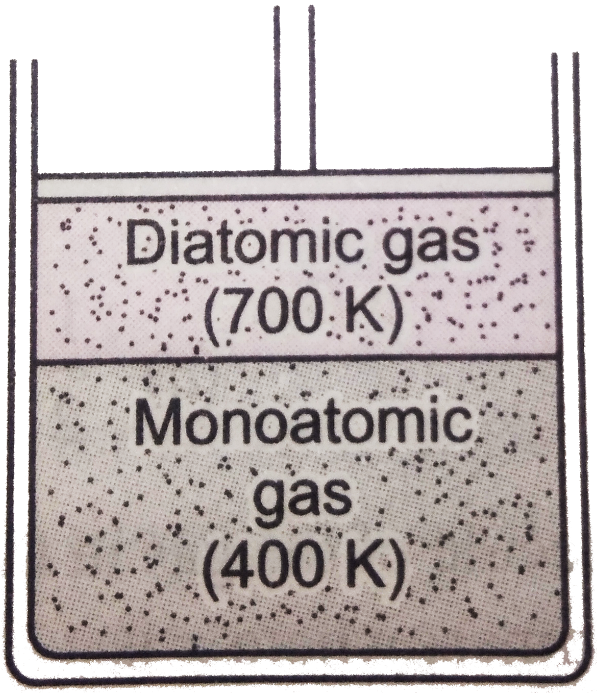
12. In Fig., a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. the lower compartment of the container is filled with 2 moles of an ideal monoatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. the heat capacities per mole of an ideal monoatomic gas are $C_v = \frac{3}{2}R$ and $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_{ve} = \frac{5}{2}R$ and $C_P = \frac{7}{2}R$.

Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. the total work done by the gases till the time they achieve equilibrium will be



A. 250 R

B. 200 R

C. 100 R

D. $-100R$

Answer: D

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Integer Type Questions

1. At $27^{\circ}C$, a certain mass of gas exerts a pressure of 6 cm of Hg column. What will be the pressure (in cm of Hg) exerted when it is heated to $127^{\circ}C$ at constant volume ?

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2. From the relation PV = RT, calculate the value of the constant R for one gram mole of an ideal gas (in cal/K)

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3. Two gases A and B, having the same temp. T, same pressure P and same volume V are mixed. If mixture occupies a volume V and has temp.

T, the pressure of the mixture will be x P, where x = ?

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4. The rms velocity of molecules of a gas at $-73^\circ C$ and 1 atmospheric pressure is $100m/s$. The temp. of the gas is increased to $527^\circ C$ and pressure is doubled. The rms velocity becomes K times. What is the value of K ?

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5. A surface is hit elastically and normally by n balls per second, each of mass m moving with velocity u. if each ball is made to hit the same surface with velocity 2 u, the force on the surface would become K times. What is the value of K ?

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6. A cylinder has a mixture of hydrogen and oxygen gases in the ratio 1:3. the ratio of mean kinetic energies of the two gases is :

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7. The speeds of 4 molecules of a gas in arbitary units are 2, 3, 4 and 5. what is the ratio of rms speed and mean speed of the gas molecules.

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8. The density of water is $10^3 kg/m^3$. Estimate the size $(\text{in} \text{Å})$ of a water molecule.

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9. A vessel contains two non-reactive gases oxygen (diatomic) and hydrogen (diatomic). The ratio of their partial pressure is 4:1. estimate the ratio of their number of molecules.

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Assertion Reason Type Questions

1. Assetion : Equal masses of helium and oxygen gases are given equal quantities of heat. The rise in temperature of helium is greater thant that in case of oxygen.

Reason : The molecular mass of oxygen is more than molecular mass of helium.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: B

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2. Assertion : For monoatomic gas, $R/C_v = 0.67.$

Reason : For a monoatomic gas $C_v = \frac{3}{2}R.$

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: A

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3. Assertion : The ratio C_P / C_v for a diatomic gas is more than that for a monoatomic gas.

Reason : The moleculess of a monoatomic gas have more degrees of freedom than those of a diatomic gas.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: D

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4. Assertion : The ratio C_P/C_v is more for helium gas than for hydrogen gas.

Reason : Atomic mass of helium is more than that of hydrogen.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expatination of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: B

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5. Assertion : The root mean square velocity of molecules of a gas having Maxwellian distribution of velocities is higher than their most probable velocity, at any temperature.

Reason : A very small no. of molecules of a gas which possess very large velocities increase root mean square velocity, without affecting most probable velocity.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expatination of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: A

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6. Assetion : Specific heat of a gas at constant pressure is greater than its specific heat at constant volume.

This is because at constant pressure, some heat is spent in expansion of the gas.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: A

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7. Assertion : Internal energy of an ideal gas does not depend upon volume of the gas.

Reason : This is because internal energy of ideal gas depends only on temperature of gas.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expatination of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: B

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8. Assertion : The rms velocity and most probable speeds of the molecules in a gas are same.

The Maxwell distribution curve for the speed of the molecules in a gas is symmetrical.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: D

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9. Assertion : The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and volume.

Reason : The molecules of gas collide with each other and the velocities of the molecules chane due to the collision.

A. If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and reason are true but Reason is not a correct expatination of the Assertion.

C. If Assertion is true but the Reason is false.

D. If Both, Assertion and reason are false.

Answer: B

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10. Statement-1 : $C_P - C(v) = R$ is true for monoatomic gases only.

Statement-2 : The relation applies equally to all gases.

A. Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

B. Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: D

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11. Statement-1 : One mole of any substance at any temperature, pressure or volume always contains 6.02×10^{23} molecules.

Statement-2 : This is the value of Avogadro's number

A. Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

B. Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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12. Statement-1 : Average K.E./molecule/ degree of freedom is same for all gases, provided they are at the same temperature.

Statement-2 : Average K.E./ molecule/ degree of freedom $\frac{1}{2}k_BT$, which depends only on temperature.

A. Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

B. Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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13. Statement-1 : For a gas $R/C_v = 0.4$. The gas must be diatomic.

Statement-2 : For diatomic gases, $C_v = \frac{5}{2}R$.

A. Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

B. Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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14. Statement-1 : Mean free path of molecules of a gas decreases with increases in number density of the molecules.

Statement-2 : More the molecules per unit volume, more are the chances of molecular collision. Therefore, mean free path decreases.

A. Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

B. Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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