PHYSICS – CLASS XI

Chapter 12 : Kinetic Theory

PRACTICE PAPER (Chapter-wise Test)

Time : 1½ Hours **Max. Marks : 35**

General Instructions

(a) All questions are compulsory.

(b) There are 17 questions in total. Section A: Q. 1 to 8 carry 1 mark each. Section B: Q. 9 to 12 carry 2 marks each. Section C: Q. 13 to 15 carry 3 marks each. Section D: Q. 16 and 17 carry 5 marks each.

(c) There is no overall choice. An internal choice is given in one 2-mark question (Q. 11), one 3-mark question (Q. 14) and both 5-mark questions (Q. 16, Q. 17). Attempt only one of the given choices.

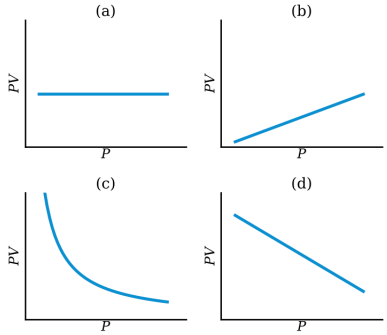
(d) Use of calculators is not permitted. Take $R = 8.3\ \text{J mol}^{-1}\ \text{K}^{-1}$, Boltzmann constant $k_B = 1.38 \times 10^{-23}\ \text{J K}^{-1}$ and $T\ (\text{K}) = t\ (°\text{C}) + 273$ unless a different value is given in the question. Treat all gases as ideal.

(e) Figures are schematic and not drawn to scale. Write the unit with every numerical answer.

SECTION A

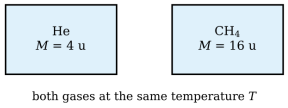
Questions 1 to 8 carry 1 mark each.

1. Which of the graphs (a) to (d) correctly shows the variation of PV with pressure P for a fixed mass of an ideal gas at constant temperature? **(1)**



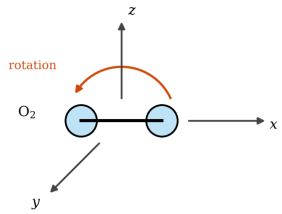
(a) graph (a)
(b) graph (b)
(c) graph (c)
(d) graph (d)

2. Two flasks contain helium and methane at the same temperature (figure). The ratio of the rms speed of helium molecules to that of methane molecules is **(1)**



(a) 1 : 2
(b) 2 : 1
(c) 4 : 1
(d) 1 : 1

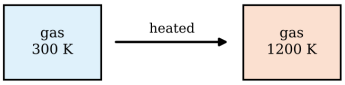
3. A rigid diatomic molecule such as O_2 (figure) can move along x, y, z and can rotate about the two axes perpendicular to its own axis. The total number of degrees of freedom is **(1)**



(a) 3
(b) 5
(c) 6
(d) 7

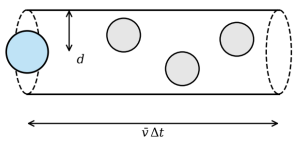
4. **Assertion (A):** At the same temperature, helium and oxygen molecules have the same average translational kinetic energy per molecule. **(1)**
Reason (R): The average translational kinetic energy per molecule of an ideal gas is $(3/2)k_BT$, which depends only on the temperature.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

5. A gas is heated from 300 K to 1200 K (figure). By what factor does the rms speed of its molecules change? **(1)**



6. When gas A alone occupies a vessel at a given temperature, its pressure is 3×10^5 Pa; when gas B alone occupies the same vessel at the same temperature, its pressure is 2×10^5 Pa. Find the pressure when both gases are present together in the vessel. **(1)**

7. A molecule of diameter d moves with average speed $\bar{v}$ among other molecules (figure). Write the expression for the volume swept out by it in time Δt within which any other molecule will collide with it. **(1)**

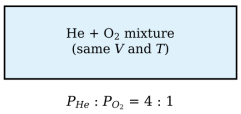


8. A gas is at a pressure of 1.38×10^5 Pa and a temperature of 100 K. Find the number of molecules per unit volume. **(1)**

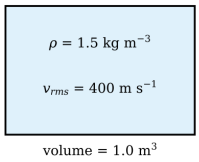
SECTION B

Questions 9 to 12 carry 2 marks each.

9. A vessel contains a mixture of helium (atomic mass 4 u) and oxygen (molecular mass 32 u). The ratio of their partial pressures is 4 : 1 (figure). Find the ratio of (i) the number of helium molecules to the number of oxygen molecules and (ii) the mass density of helium to that of oxygen in the vessel. **(2)**



10. A gas of density 1.5 kg m^{-3} has an rms speed of 400 m s^{-1} (figure). Using $P = (1/3)\rho v^2_{\text{rms}}$, find (i) the pressure of the gas and (ii) the total translational kinetic energy of the gas in 1.0 m^3. **(2)**

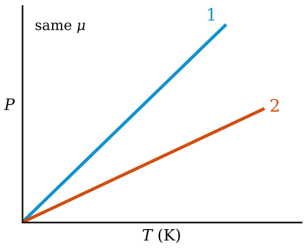


11. Using $P = (1/3)nm\bar{v}^2$ and the ideal gas relation $P = nk_BT$, show that the average translational kinetic energy of a molecule is $(3/2)k_BT$. **(2)**

OR

State the law of equipartition of energy. Hence write the average total energy of a rigid diatomic molecule at temperature T.

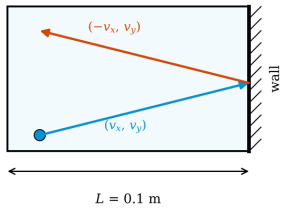
12. The graph shows the variation of pressure with absolute temperature for the same amount of an ideal gas kept in two rigid containers of volumes V_1 and V_2 (figure). (i) Which volume is larger? (ii) Give a reason for your answer. **(2)**



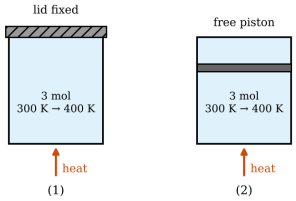
SECTION C

Questions 13 to 15 carry 3 marks each.

13. A molecule of mass 5×10^{-26} kg moves inside a cubical box of side $L = 0.1$ m and collides elastically with a wall perpendicular to the x-axis (figure). Its x-component of velocity is $v_x = 400$ m s^{-1}. Find (i) the change in momentum of the molecule in one collision, (ii) the time between two successive collisions of the molecule with this wall and (iii) the average force exerted on the wall by this molecule. **(3)**

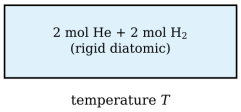


14. 3 mol of a rigid diatomic gas are heated from 300 K to 400 K, first in a cylinder with a fixed lid (1) and then in a cylinder with a free piston at constant pressure (2) (figure). Find (i) the heat required in (1), (ii) the heat required in (2) and (iii) the work done by the gas in (2). Take $C_v = 5R/2$ and $C_p = 7R/2$. **(3)**

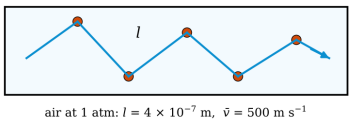


OR

A vessel contains 2 mol of helium and 2 mol of hydrogen (rigid diatomic) at temperature T (figure). Find (i) the total internal energy of the mixture, (ii) the molar specific heat at constant volume of the mixture and (iii) the ratio of specific heats γ of the mixture.



15. Air molecules at 1 atm have a mean free path $l = 4 \times 10^{-7}$ m and an average speed $\bar{v} = 500$ m s^{-1} (figure). Find (i) the average time between two successive collisions, (ii) the collision frequency and (iii) the mean free path when the pressure is reduced to 1/1000 of its value at the same temperature. **(3)**



SECTION D

Questions 16 and 17 carry 5 marks each.

16. A cylinder of fixed volume V contains 12 mol of oxygen at an (absolute) pressure of 10 atm and temperature 300 K. After some gas is withdrawn, the pressure falls to 6 atm and the temperature to 270 K (figure). **(5)**

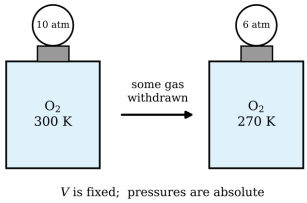
(a) Write the ideal gas equation in terms of the number of moles μ. (1)

(b) Show that for a fixed volume, $\mu \propto P/T$. (1)

(c) Find the ratio of the final to the initial number of moles. (1)

(d) Find the number of moles withdrawn. (1)

(e) Find the mass of oxygen withdrawn (molar mass of O_2 = 32 g mol^{-1}). (1)



V is fixed; pressures are absolute

OR

The figure shows a plot of PV/T against P for 0.32 kg of oxygen at two temperatures T_1 and T_2. The dotted line is a horizontal line.

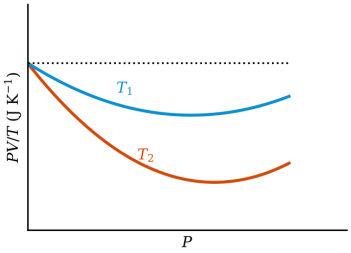
(a) What does the dotted line represent? (1)

(b) Which is true: $T_1 > T_2$ or $T_1 < T_2$? (1)

(c) Find the value of PV/T at the point where the curves meet the y-axis (molar mass of O_2 = 32 g mol^{-1}). (1)

(d) Would 0.32 kg of hydrogen give the same value at that point? (1)

(e) What mass of hydrogen (molar mass 2 g mol^{-1}) gives the same value? (1)



17. Carbon monoxide molecules at moderately high temperature can rotate and also vibrate along the bond (figure). Each vibrational mode has kinetic and potential energy terms. Treat the molecule as a rigid rotator plus one vibrational mode. **(5)**

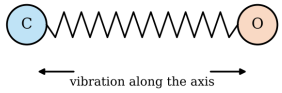
(a) How many quadratic energy terms does the molecule have in all (translational, rotational and vibrational)? (1)

(b) Find the average energy per molecule at temperature T. (1)

(c) Find the internal energy of one mole of the gas. (1)

(d) Find C_v and C_p. (1)

(e) Find the ratio $\gamma = C_p/C_v$. (1)



OR

A mixture of hydrogen (molar mass 2 g mol^{-1}) and oxygen (molar mass 32 g mol^{-1}) is separated by a porous wall (figure). Hydrogen passes through the pores faster.

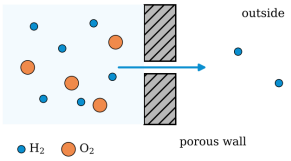
(a) Why does the lighter gas pass through faster at the same temperature? (1)

(b) Find the ratio of the rms speeds of H_2 and O_2 at the same temperature. (1)

(c) Find the ratio of their average translational kinetic energies per molecule. (1)

(d) Which gas is in excess in the gas that first appears outside the wall? (1)

(e) H_2 is at 100 K. At what temperature will O_2 have the same rms speed? (1)



— END OF QUESTION PAPER —