Chapter Thirteen

KINETIC THEORY

MCQ I

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

(a) remains the same because 500m s^{-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 $\left(v^2_{rms} + (500)^2\right) / v^2_{rms}$ where v_{rms} was the original mean square velocity of the gas.

(d) will be different on the top wall and bottom wall of the vessel.

13.2 1 mole of an ideal gas is contained in a cubical volume *V*, ABCDEFGH at 300 K (Fig. 13.1). 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,

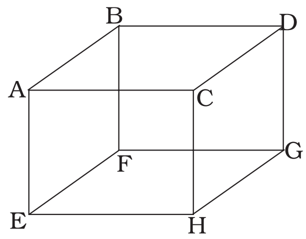

Fig. 13.1

(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.

13.3 Boyle's law is applicable for an

(a) adiabatic process.
(b) isothermal process.
(c) isobaric process.
(d) isochoric process.

13.4 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 (Fig. 13.2). If the temperature is increased,

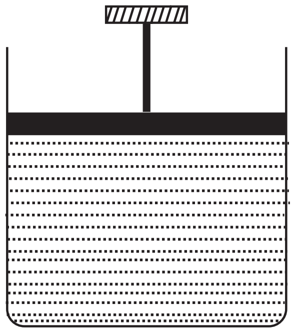

Fig. 13.2

(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*.

13.5 Volume versus temperature graphs for a given mass of an ideal gas are shown in Fig. 13.3 at two different values of constant pressure. What can be inferred about relation between P_1 & P_2?

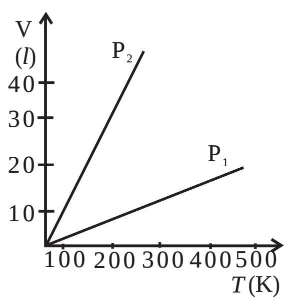

Fig.13.3

(a) $P_1 > P_2$
(b) $P_1 = P_2$
(c) $P_1 < P_2$
(d) data is insufficient.

13.6 1 mole of H_2 gas is contained in a 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.

13.7 A vessel of volume V contains a mixture of 1 mole of Hydrogen and 1 mole of 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 separately.
(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.

13.8 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 increaset to 1.05 V, the final pressure will be

(a) 1.1 p
(b) p
(c) less than p
(d) between p and 1.1.

MCQ II

13.9 ABCDEFGH is a hollow cube made of an insulator (Fig. 13.4). Face ABCD has positve charge on it. Inside the cube, we have ionized hydrogen.

The usual kinetic theory expression for pressure

(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.

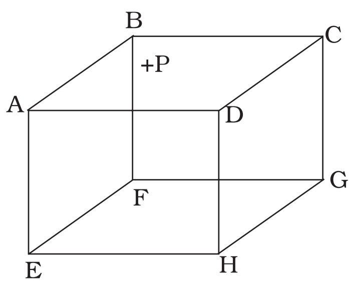

Fig. 13.4

13.10 Diatomic molecules like hydrogen have energies 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 wall 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.

13.11 In a diatomic molecule, the rotational energy at a given temperature

(a) obeys Maxwell's distribution.
(b) have the same value for all molecules.
(c) equals the translational kinetic energy for each molecule.
(d) is (2/3)rd the translational kinetic energy for each molecule.

13.12 Which of the following diagrams (Fig. 13.5) depicts ideal gas behaviour?

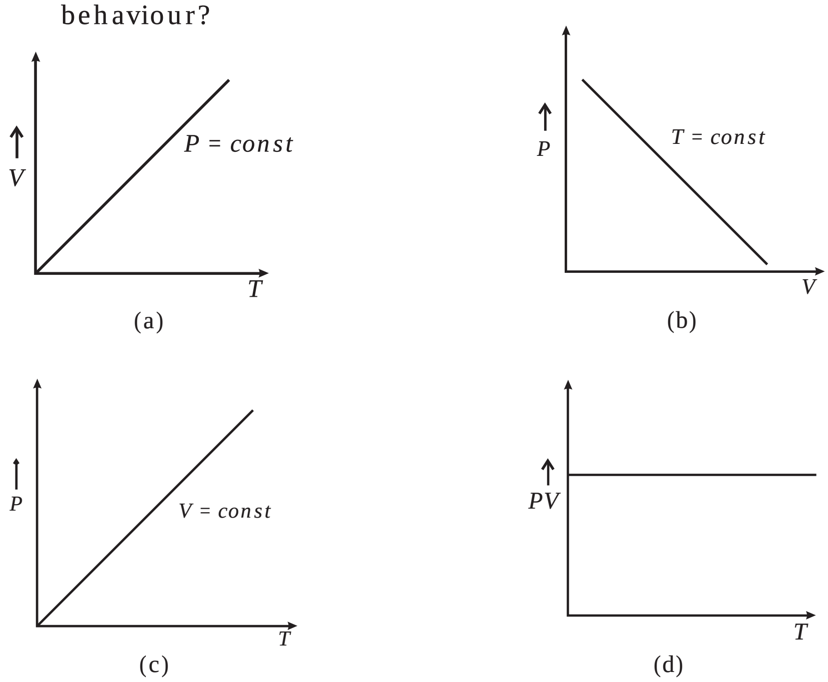

Fig. 13.5

13.13 When an ideal gas is compressed adiabatically, its temperature rises: the molecules on the average have more kinetic energy than before. The kinetic energy increases,

(a) because of collisions with moving parts of the wall only.
(b) because of collisions with the entire wall.

(c) because the molecules gets accelerated in their motion inside the volume.

(d) because of redistribution of energy amongst the molecules.

VSA

13.14 Calculate the number of atoms in 39.4 g gold. Molar mass of gold is 197g mole^{-1}.

13.15 The volume of a given mass of a gas at 27°C, 1 atm is 100 cc. What will be its volume at 327°C?

13.16 The molecules of a given mass of a gas have root mean square speeds of 100 m s^{-1} at $27°\text{C}$ and 1.00 atmospheric pressure. What will be the root mean square speeds of the molecules of the gas at 127°C and 2.0 atmospheric pressure?

13.17 Two molecules of a gas have speeds of $9 \times 10^6 \text{ m s}^{-1}$ and $1 \times 10^6 \text{ m s}^{-1}$, respectively. What is the root mean square speed of these molecules.

13.18 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.)

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

SA

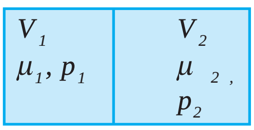

Fig 13.6

13.20 The container shown in Fig. 13.6 has two chambers, separated by a partition, of volumes V_1 = 2.0 litre and V_2= 3.0 litre. The chambers contain $\mu_1 = 4.0$ 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.

13.21 A gas mixture consists of molecules of types 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.

13.22 We have 0.5 g of hydrogen gas in a cubic chamber of size 3cm 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 1 $\overset{o}{A}$).

13.23 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?

13.24 A ballon has 5.0 g mole of helium at 7°C. Calculate

(a) the number of atoms of helium in the balloon,
(b) the total internal energy of the system.

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

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

LA

13.27 Explain why

(a) there is no atmosphere on moon.
(b) there is fall in temperature with altitude.

13.28 Consider an ideal gas with following distribution of speeds.

Speed (m/s)	% of molecules
200	10
400	20
600	40
800	20
1000	10

(i) Calculate V_{rms} and hence T. ($m = 3.0 \times 10^{-26}$ kg)

(ii) If all the molecules with speed 1000 m/s escape from the system, calculate new V_{rms} and hence T.

13.29 Ten small planes are flying at a speed of 150 km/h in total darkness in an air space that is $20 \times 20 \times 1.5\ km^3$ 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 saftey region around the plane can be approximated by a sphere of radius 10m.

13.30 A box of $1.00 m^3$ is filled with nitrogen at 1.50 atm at 300K. 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.

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