Exercise - III (SUBJECTIVE PROBLEMS)

1. Find the average velocity of molecules of hydrogen gas in a container at temperature 300 K.

2. A cubical container having each side as ℓ is filled with a gas having N molecules in the container. Mass of each molecule is m. If we assume that at every instant half of the molecules are moving towards the positive x-axis and half of the molecules are moving towards the negative x-axis. Two walls of the container are perpendicular to the x-axis. Find the force acting on the two walls given ? Assume that all the molecules are moving with speed v_0.

3. A uniform tube closed at one end, contains a pallet of mercury 10 cm long. When the tube is kept vertically with the closed end upward, the length of the air column trapped is 20 cm. Find the length of the air column trapped when the tube is inverted so that the closed end goes down. Atmospheric pressure = 75 cm of mercury.

4. An ideal gas is trapped between a mercury column and the closed end of a narrow vertical tube of uniform base containing the column. The upper end of the tube is open to the atmosphere. The lengths of the mercury column and the trapped air column are 20 cm and 43 cm respectively. What will be the length of the air column when the tube is tied slowly in a vertical plane through an angle of 60° ? Assume the temperature to remain constant.

5. Find the temperature at which average speed of oxygen molecule be sufficient so as to escape from the earth? Escape velocity from the earth is 11.0 km/sec and the mass of one molecule of oxygen 5.34×10^{-26} kg (Boltzmann constant $k = 1.38 \times 10^{-23}$ joule/K) :

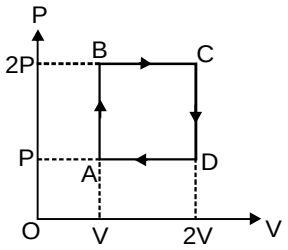
6. Find the average magnitude of linear momentum of a helium molecule in a sample of helium gas at 0°C Mass of helium molecule = 6.64×10^{-27} kg and Boltazmann constant = 1.38×10^{-23} J/K.

7. Find the ratio of the mean speed of hydrogen molecules to the mean speed of nitrogen molecules in a sample containing a mixture of the two gases.

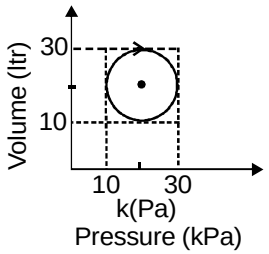
8. 0.040 g of He is kept in a closed container initially at 100.0ºC. The container is now heated. Neglecting the expansion of the container, calculate the temperature at which the internal energy is increased by 12 J.

9. Calculate the change in internal energy of a gas kept in a rigid container when 100 J of heat is supplied to it.

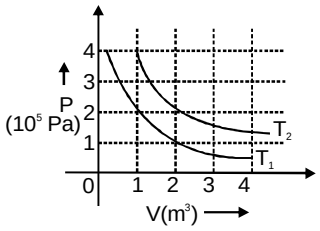
10. An ideal monoatomic gas is taken round the cycle ABCDA as shown in the P-V diagram. Find the work done by the gas during the cycle ?



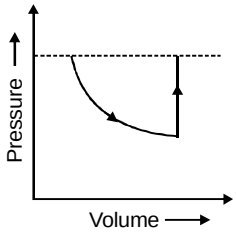
11. Find the work done by gas going through a cyclic process shown in figure ?



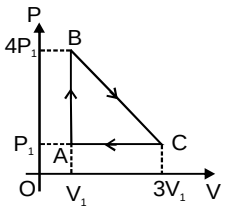
12. The following graph shows two isotherms for a fixed mass of an ideal gas. Find the ratio of r.m.s. speed of the moelcules at temperatures T_1 and T_2 ?



13. A sample of an ideal gas initially having internal energy U_1 is allowed to expand adiabatically performing work W. Heat Q is then supplied to it, keeping the volume constant at its new value, until the pressure rised to its original value. The internal energy is then U_2. (See Fig.) Find the increase in internal enery $(U_2 - U_1)$?



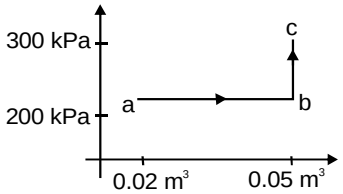
14. An ideal gas taken around the cycle ABCA shown in P – V diagram. Find the net work done by the gas during the cycle ?



15. A gas is enclosed in a cylindrical vessel fitted with a frictionless piston. The gas is slowly heated for some time. During the process, 10 J of heat is supplied and the piston is found to move out 10 cm. Find the increase in the internal energy of the gas. The area of cross-section of the cylinder = 4 cm^2 and the atmospheric pressure = 100 kPa.

16. Find the change in the internal energy of 2 kg of water as it is heated from 0°C to 4°C. The specific heat capacity of water is 4200 J/kg-K and its densities at 0°C and 4°C 999.9 kg/m^3 and 1000 kg/m^3 respectively. Atmospheric pressure = 10^5 Pa.

17. A substance is taken through the process abc as shown in figure. If the internal energy of the substance increases by 5000 J and a heat of 2625 cal is given to the system, calculate the value of J.



18. An ideal gas is taken through a process in which the pressure and the volume are changed according to the equation p = kV. Show that the molar heat capacity of the gas for the process is given by $C = C_v + R/2$.

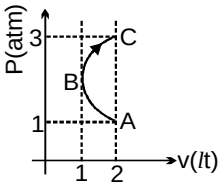
19. Two ideal gases have the same value of $C_p/C_v = \gamma$. What will be the value of this ratio for a mixture of the two gases in the ratio 1 : 2 ?

20. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. Find the ratio $\frac{C_p}{C_v}$ of the mixture ?

21. A gas at NTP is suddenly compressed to one-fourth of its original volume. If γ is supposed to be 3/2, then find final pressure ?

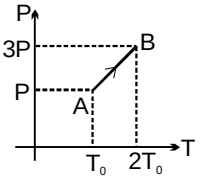
22. An ideal gas at pressure 2.5 × 10^5 Pa and temperature 300 K occupies 100 cc. It is adiabatically compressed to half its original volume. Calculate (a) the final pressure, (b) the final temperature and (c) the work done by the gas in the process. Take γ = 1.5.

23. In the P-V diagram shown in figure, ABC is a semicircle. Find the workdone in the process ABC.

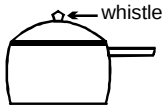


24. The average degrees of freedom per molecules for a gas is 6. The gas performs 25 J of work when it expands at constant pressure. Find the heat absorbed by the gas.

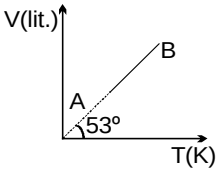
25. Pressure versus temperature graph of an ideal gas is shown. Density of gas at point A is ρ_0. Find the density of gas at B.



26. An empty pressure cooker of volume 10 litres contains air at atmospheric pressure 10^5 Pa and temperature of 27ºC. It contains a whistle which has area of 0.1 cm^2 and weight of 100 gm. What should be the temperature of air inside so that the whistle is just lifted up ?



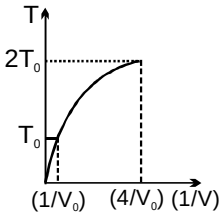
27. V-T curve for 2 moles of a gas is straight line as shown in the graph here. Find the pressure of gas at A.



28. Air at temperature of 400 K and atmospheric pressure is filled in a balloon of volume 1 m^3. If surrounding air is at temperature of 300 K, find the ratio of Buoyant force on balloon and weight of air inside

29. Ideal diatomic gas is taken through a process $\Delta Q = 2\Delta U$. Find the molar heat capacity for the process (where ΔQ is the heat supplied and ΔU is change in internal energy)

30. Figure shows a parabolic graph between T and 1/V for a mixture of a gas undergoing an adiabatic process. What is the ratio of V_{rms} and speed of sound in the mixtur



31. A piston divides a closed gas cylinder into two parts. Initially the piston is kept pressed such that one part has a pressure P and volume 5V and th other part has pressure 8P and volume V. The piston is now

left free. Find the new pressures and volumes for the adiabatic and isothermal processes. For this gas γ = 1.5.

32. A gas undergoes a process in which the pressure and volume are related by VP^n = constant. Find the buk modulus of the gas.

33. A standing wave of frequency 1000Hz in a column of methane at 27°C produces nodes which are 20.4 cm apart. Find the ratio of heat capacity of mathane at constant pressure to that at constant volume (Take gas constant, R = 8.31 $J.K^{-1}mol^{-1}$)

34. One mole of an ideal gas is compressed from 0.5 lit to 0.25 lit. During the compression, 23.04×10^2 J of work is done on the gas and heat is removed to keep the temperature of the gas constant all times. Find the temperature of the gas. (Take universal gas constant R = 8.31 J $mol^{-1}K^{-1}$)

35. The pressure of an ideal gas changes with volumes as P = aV where 'a' is a constant. One moles of this gas is expanded to 3 time its original volume V_0. Find
(i) the heat transferred in the process
(ii) the heat capacity of the gas.

36. 70 calorie of heat is required to raise the temperautre of 2 mole of an ideal gas at constant pressure from 40°C to 45°C. Find the amount of heat required to raise the temperature of the same through the same range at constant volume (R = 2 cal/mol-K)

37. Find the molecular mass of a gas if the specific heats of the gas are C_p = 0.2 cal/gm°C and C_v = 0.15 cal/gm°C . [Take R = 2 cal/mol°C]