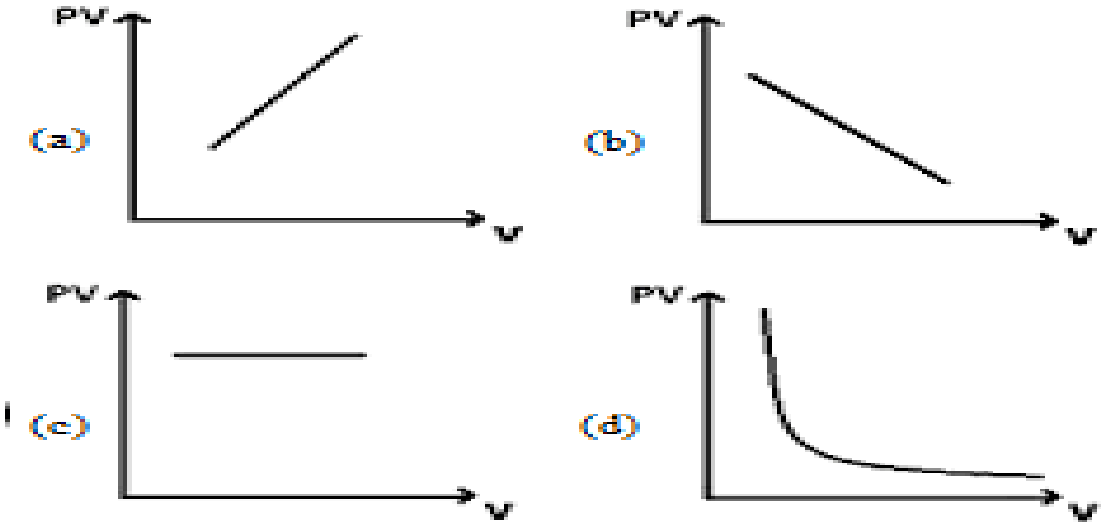
CLASS – 11

WORKSHEET- KINETIC THEORY

(1 mark questions)

1. The real gas behaves like an ideal gas if its
   (a) both pressure and temperature are high (b) both pressure and temperature are low
   (c) pressure is high and temperature is low (d) pressure is low and temperature is high

2. Which of the following graphs represent the behavior of an ideal gas?



3. Pressure of a gas at constant volume is proportional to
   (a) total internal energy of the gas (b) average kinetic energy of the molecules
   (c) average potential energy of the molecules (d) total energy of the gas

4. The temperatures of 2 mole of an ideal monatomic gas is raised to 15K at constant volume. The work done by the gas is
   (a) zero (b) 30J (c) 420J (d) 50J

5. Air pressure in a car tyre increases during driving. Explain.
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6. How is the volume of gas related to absolute zero temperature at constant pressure?
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7. Why is it not possible in increase the temperature of a gas while keeping its volume and pressure constant?

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8. Is Boyle's law perfectly obeyed at all temperatures and pressures?

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9. Plot a graph between (PV) and V for a given mass of a gas at fixed temperature.

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10. What is Avogadro's number? What is its value?

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11. Which one of the following is not an assumption of kinetic theory of gases?
(a) The volume occupied by the molecules of the gas is negligible.
(b) The force of attraction between the molecules is negligible
(c) The collision between the molecules are negligible
(d) All molecules have same speed

12. If three molecules have velocities 0.5 km s^{-1}, 1 km s^{-1} and 2 km s^{-1}, the ratio of the rms speed and average speed is
(a) 2.15 (b) 1.14 (c) 0.53 (d) 3.96

13. A vessel consists of three types of gas molecules A, B and C with mass $m_A > m_B > m_C$. Arrange the three types of gases in decreasing order of average KE.

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14. A container has equal number of molecules of hydrogen and carbon dioxide, If a fine hole is made in the container, then which of the two gases shall leak out rapidly?

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15. At what temperature is average speed of oxygen gas molecule is equal to rms velocity of the same gas at 27°C?

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16. In the kinetic theory of gases, why do we not take into account the changes in gravitational potential energy of the molecule?

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17. In terms of kinetic theory of gases, explain why the pressure of a gas in a container increases when a gas is heated?

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18. Derive Boyle's law using kinetic theory of gases.

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19. What would be the effect on the rms velocity of gas molecule if the temperature of the gas is increased by a factor of 4?

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20. In a monatomic gas, total degree of freedom are due to

(a) translational motion (b) rotational motion

(c) vibrational motion (d) oscillatory motion

21. The average translational kinetic energy of O_2 at a particular temperatures 0.768eV. The average translational kinetic energy of N_2 molecules in eV at the same temperature is

(a) 0.0015 (b) 0.0030 (c) 0.048 (d) 0.768

22. Name two factors on which the degree of freedom of gas depend.

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23. Define degree of freedom.

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24. The ratio of molar heat capacities of a diatomic gas at constant pressure to that at constant volume is

(a) 7/5 (b) 3/2 (c) 3/2 (d) 5/2

25. The average degree of freedom per molecule for a gas is 6. The gas performs 25J of work when it expands at constant pressure. What is the heat absorbed by the gas?

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26. Calculate the internal energy of 1g of oxygen gas at STP.

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27. Should the specific heat of monatomic gas be less than, equal to or greater than that of a diatomic gas at room temperature? Justify your answer.

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28. The mean free path of a gas varies with the density of gas according to the following relation:

(a) $\lambda \propto \rho$ (b) $\lambda \propto \sqrt{P}$ (c) $\lambda \propto 1/\rho$ (d) $\lambda \propto \rho^2$

29. The mean free path of the molecule of a gas having number density 0.167×10^{28} m^{-3} and molecular diameter 1Å is

(a) 1.51×10^{-6}m (b) 2.0×10^{-9}m (c) 1.34×10^{-8}m (d) 1.1×10^{-4}m

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

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32. What is mean free path of gases?

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33. How does mean free path depend on number density of the gas?

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34. What is the order of mean free path (λ) of the gas molecule?

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(2 marks Questions)

35. What is an ideal gas? Does such gas really exist?

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36. Why gases at high pressure and low temperature show large deviation from ideal gas behavior?

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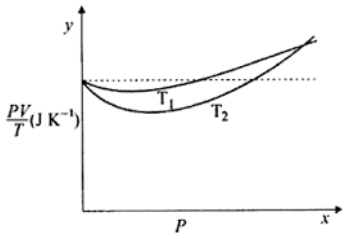
37. Figure shows plot of PV/T versus P for 1.00×10^{-3}kg of oxygen gas at two different temperatures.



(a) Which is true $T_1>T_2$ or $T_1<T_2$?
(b) What is the value of PV/T where the curves meet on the y-axis?

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38. Calculate the volume occupied by 3.2g of oxygen at 76cm of mercury at 27°C.

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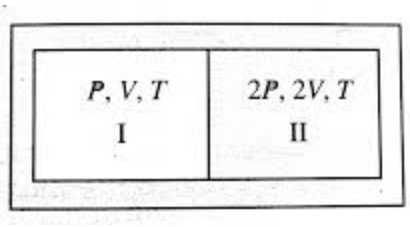
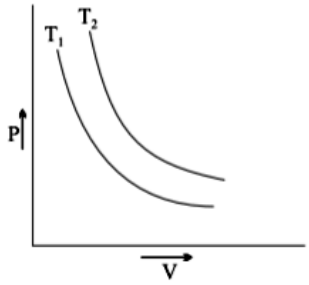
39. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments. What is the ratio of the number of molecules in compartments I and II?



40. Isothermal curves for a given mass of gas are shown at two different temperatures T_1 and T_2, State whether $T_1 > T_2$ or $T_2 > T_1$. Justify your answer.



41. State and prove Avogadro's law.

42. The root mean square (rms) speed of oxygen molecule at certain temperature T is V. If temperature is doubled, oxygen gas dissociates into atomic oxygen. What is the rms speed of atomic oxygen?

43. From the expression for pressure of a gas on the basis of kinetic theory find an expression for rms speed of a gas molecule.

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44. Write any four fundamental postulates of the kinetic theory of an ideal gas.

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45. A balloon has 5g of helium at 7°C. Calculate: (a) the number of atoms of helium in the balloon (b) the total internal energy of the system.

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46. Calculate the molecular kinetic energy and translation of a mole of hydrogen atom at NTP. Given R = 8.31 J/mol/K.

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47. Derive Avogadro's law using kinetic theory of gases.

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48. Calculate the number of degrees of freedom of molecules of hydrogen in $1cm^3$ of hydrogen gas at NTP.

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49. State the law of equipartition of energy.

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50. Equal masses of helium and oxygen gases are given equal quantities of heat. Which gas will undergo a greater temperature rise?

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51. Calculate specific heat of water using law of equiproportion of energy.

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52. The molar specific heats of an ideal gas at constant pressure and volume are denoted by C_P and C_V respectively. If $\gamma = C_p/C_V$ and R is the universal gas constant, then find C_V.

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53. A cylinder of fixed capacity 44.78 litres 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°C? ($R = 8.31 J\ mol^{-1}\ K^{-1}$).

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54. What is mean free path of a gas molecule? On which factors dies the mean free path depend?

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

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56. 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 conditions is measured to have an average rate of 7.2 cm^3 s^{-1}. Identify the gas.

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(3 marks Questions)

57. Explain how does the behavior of real gas differ from that of an ideal gas.

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58. Two monatomic gases A and B occupying the same volume V are at same temperature T and pressure P. If they are mixed, the resultant mixture has volume V and temperature T. Calculate the pressure of the mixture.

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59. An air bubble of volume 1.0cm^3 rises from the bottom of the lake 40m deep at a temperature 12°C. To what volume does it grow when it reaches the surface which is at a temperature of 35°C?

60. We have 0.5g 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 100atm. Is one justified in assuming the ideal gas law, in the final state (Hydrogen molecules can be considered as spheres of radius 1Å).

61. A vessel is filled with gas at a pressure of 76cm 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 out the resultant pressure of the gas.

62. Show that the average kinetic energy of a gas molecule is directly proportional to the temperature of the gas. Hence give the kinetic interpretation of temperature.

63. (a) Using the kinetic theory expression for pressure, show that the average translational kinetic energy per gram molecules equal (3/2)RT.
(b) At what temperature would the rms velocity of gas become n times its value at 0°C, pressure remaining constant.

64. A vessel A contains hydrogen and another vessel B whose volume is twice of A contains same mass of oxygen at the same temperature. Compare (a) average kinetic energies of hydrogen and oxygen molecules and (b) pressures of gases in A and B. Molecular weights of hydrogen and oxygen are 2 and 32 respectively.

65. There are N molecules of a gas in a container. If the number of molecules is increased to 2N then what will be (a) pressure of the gas (b) rms speed of the gas?

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

67. Show that the average kinetic energy of a gas molecule is directly proportional to absolute temperature of the gas.

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

69. Give a formula for mean free path of the molecule of a gas. Briefly explain how its value is affected by (i) change in temperature and (ii) change in pressure.

70. Estimate the fraction of the molecular volume to the actual volume occupied by oxygen gas at STP. Take the radius of an oxygen molecule to be roughly 3Å. [Ans. 3×10^{3}]

71. Molar volume is the volume occupied by 1 mole of any (ideal) gas at standard temperature and pressure (0°C, 1 atmospheric pressure). Show that it is 22.4 litres.

[Ans. 22.4 litres]

72. An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15atm and a temperature of 27°C. After some oxygen is withdrawn from the cylinder, the gauge pressure drops to 11 atm and its temperature drops to 17°C. Estimate the mass of oxygen taken out of the cylinder. R = 8.3 J mol^{-1} K^{-1}, molecular weight of oxygen = 32.

[Ans. 0.141 kg]

73. An air bubble of volume 1.0 cm^3 rises from the bottom of a lake 40m deep at a temperature of 12°C. To what volume dies it grow, when it reaches the surface, which is at a temperature of 35°C? Given 1 atm = 1.01×10^5 Pa [Ans. 5.275×10^{-6} m^3]

74. Estimate the total number of molecules inclusive of oxygen, nitrogen, water vapour and other constituents in a room of capacity 25.0 m^3 at a temperature of 27°C and 1 atmospheric pressure. [Ans. 6.117×10^{26}]

75. Estimate the average energy of a helium atom at (i) room temperature (27°C) (ii) the temperature on the surface of the sun (6000K) and (iii) the temperature of 10^7 K
[Ans. (i) 6.21×10^{-21} J (ii) 1.242×10^{-19} J (iii) 2.07×10^{-16} J]

76. Three vessels 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). (i) Do the vessel contain equal number of respective molecules? (ii) Is the root mean squared speed of molecules same in the three cases? If not, in which case v_{rms} the largest?

77. At what temperature is the root mean square speed of an atom in an argon gas cylinder equal to the rms speed of a helium gas at – 20°C? Atomic mass of argon = 39.9u and that of helium = 4.0 u. [Ans. 2523.7 K]

78. Estimate the mean free path and collision frequency of a nitrogen molecule in a cylinder containing nitrogen at 2.0atm and temperature 17°C. Take the radius of a nitrogen molecule to be roughly 1.0Å. Compare the collision time with the time the molecule moves freely between two successive collisions (molecular mass of N_2 = 28.0u).

[Ans. 500]

79. Given below are densities of some solids and liquids. Give rough estimates of the size of their atoms:

Substance	Atomic mass (u)	Density (10^3 kg m^{-3})
Carbon (diamond)	12.01	2.22
Gold	197.00	19.32
Nitrogen (liquid)	14.01	1.00

Lithium	6.94	0.53
Fluorine (liquid)	19.00	1.14

(5 marks Questions)

80. Show that the pressure exerted by an ideal gas is $p = \frac{1}{3}\rho\overline{v^2}$ where ρ is the density and v is the root mean square velocity.

81. Derive an expression for pressure of a gas in a container. Using it, relate KE with pressure.

82. Using the law of equipartition of energy determine the values of C_p, C_V and γ for (a) monatomic (b) diatomic (c) triatomic gases.

83. What is meant by mean free path of a gas molecule? Derive expression for it. On which factors does the mean free path depends?

84. Figure shows plot of PV/T versus P for 1.00×10^{-3} kg of oxygen gas at two different temperature.

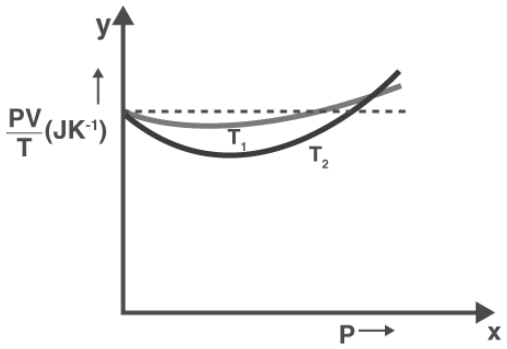
85. A gas is in equilibrium has uniform density and pressure throughout its volume. This is strictly true only if there are no external influences. A gas column under gravity, for example, dies not have uniform density (and pressure). As you might expect, its density decreases with height. The precise dependence is given by the so called law of atmospheres.

$$n_2 = n_1 \exp[=mg(h_2 - h_1)/k_B T]$$

where n_2, n_1 refer to number density at heights h_2 and h_1 respectively. Use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid column.

$$n_2 = n_1 \exp[-mgN_A(\rho - \rho')(h_2 - h_1)/rRT]$$

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



(a) What is the dotted plot signify?

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

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

(d) If we obtained similar plots for 1.00×10^{-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 yields the same output of PV/T (for low pressure high temperature region of the plot)? [Molecular mass of H_2 = 2.02u, of O_2 = 32.0u, R = 8.31 J mol^{-1} K^{-1}]