Chapter 12

Kinetic Theory of Gases

1. One kg of diatomic gas is at a pressure of 8×10^4 N/m^2. The density of the gas is 4 kg/m^3. What is the energy of the gas due to its thermal motion? **[AIEEE-2009]**

   (1) 5×10^4 J (2) 6×10^4 J

   (3) 7×10^4 J (4) 3×10^4 J

2. An open glass tube is immersed in mercury in such a way that a length of 8 cm 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 46 cm. What will be length of the air column above mercury in the tube now?

   (Atmospheric pressure = 76 cm of Hg) **[JEE (Main)-2014]**

   (1) 16 cm (2) 22 cm

   (3) 38 cm (4) 6 cm

3. Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as V^q, where V is the volume of the gas. The value of q is

   $\left(\gamma = \dfrac{C_P}{C_V}\right)$ **[JEE (Main)-2015]**

   (1) $\dfrac{3\gamma+5}{6}$ (2) $\dfrac{3\gamma-5}{6}$

   (3) $\dfrac{\gamma+1}{2}$ (4) $\dfrac{\gamma-1}{2}$

4. The temperature of an open room of volume 30 m^3 increases from 17°C to 27°C due to the sunshine. The atmospheric pressure in the room remains 1×10^5 Pa. If n_i and n_f are the number of molecules in the room before and after heating, then $n_f - n_i$ will be **[JEE (Main)-2017]**

   (1) -1.61×10^{23}

   (2) 1.38×10^{23}

   (3) 2.5×10^{25}

   (4) -2.5×10^{25}

5. The mass of a hydrogen molecule is 3.32×10^{-27} kg. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area 2 cm^2 at an angle of 45° to the normal, and rebound elastically with a speed of 10^3 m/s, then the pressure on the wall is nearly **[JEE (Main)-2018]**

   (1) 2.35×10^3 N/m^2 (2) 4.70×10^3 N/m^2

   (3) 2.35×10^2 N/m^2 (4) 4.70×10^2 N/m^2

6. A mixture of 2 moles of helium gas (atomic mass = 4 u), and 1 mole of argon gas (atomic mass = 40 u) is kept at 300 K in a container. The ratio of their rms speeds $\left[\dfrac{V_{rms}(\text{helium})}{V_{rms}(\text{argon})}\right]$, is close to

   [JEE (Main)-2019]

   (1) 2.24 (2) 0.45

   (3) 3.16 (4) 0.32

7. A 15 g mass of nitrogen gas is enclosed in a vessel at a temperature 27°C. Amount of heat transferred to the gas, so that rms velocity of molecules is doubled, is about **[JEE (Main)-2019]**

   [Take R = 83 J/K mole]

   (1) 3 kJ (2) 14 kJ

   (3) 10 kJ (4) 0.9 kJ

8. Two kg of a monoatomic gas is at a pressure of 4×10^4 N/m^2. The density of the gas is 8 kg/m^3. What is the order of energy of the gas due to its thermal motion ? **[JEE (Main)-2019]**

   (1) 10^3 J (2) 10^5 J

   (3) 10^4 J (4) 10^6 J

9. A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Considering only translational and rotational modes, the total internal energy of the system is

   [JEE (Main)-2019]

   (1) 4 RT (2) 12 RT

   (3) 15 RT (4) 20 RT

10. An ideal gas occupies a volume of 2 m^3 at a pressure of 3×10^6 Pa. The energy of the gas is **[JEE (Main)-2019]**

(1) 10^8 J (2) 9×10^6 J

(3) 6×10^4 J (4) 3×10^2 J

11. An ideal gas is enclosed in a cylinder at pressure of 2 atm and temperature, 300 K. The mean time between two successive collisions is 6×10^{-8} s. If the pressure is doubled and temperature is increased to 500 K, the mean time between two successive collisions will be close to **[JEE (Main)-2019]**

(1) 2×10^{-7} s (2) 3×10^{-6} s

(3) 0.5×10^{-8} s (4) 4×10^{-8} s

12. If 10^{22} gas molecules each of mass 10^{-26} kg collide with a surface (perpendicular to it) elastically per second over an area 1 m^2 with a speed 10^4 m/s, the pressure exerted by the gas molecules will be **[JEE (Main)-2019]**

(1) 1 N/m^2 (2) 2 N/m^2

(3) 3 N/m^2 (4) 4 N/m^2

13. The temperature, at which the root mean square velocity of hydrogen molecules equals their escape velocity from the earth, is closest to

[Boltzmann constant $k_B = 1.38 \times 10^{-23}$ J/K

Avogadro Number $N_A = 6.02 \times 10^{26}$ /kg

Radius of Earth : 6.4×10^6 m

Gravitational acceleration on Earth = 10 ms^{-2}]

[JEE (Main)-2019]

(1) 10^4 K (2) 650 K

(3) 800 K (4) 3×10^5 K

14. For a given gas at 1 atm pressure, rms speed of the molecules is 200 m/s at 127°C. At 2 atm pressure and at 227°C, the rms speed of the molecules will be **[JEE (Main)-2019]**

(1) $100\sqrt{5}$ m/s (2) 100 m/s

(3) $80\sqrt{5}$ m/s (4) 80 m/s

15. An HCl molecule has rotational, translational and vibrational motions. If the rms velocity of HCl molecules in its gaseous phase is $\bar{v}$, m is its mass and k_B is Boltzmann constant, then its temperature will be : **[JEE (Main)-2019]**

(1) $\frac{m\bar{v}^2}{5k_B}$ (2) $\frac{m\bar{v}^2}{6k_B}$

(3) $\frac{m\bar{v}^2}{7k_B}$ (4) $\frac{m\bar{v}^2}{3k_B}$

16. The specific heats, C_P and C_V of a gas of diatomic molecules, A, are given (in units of J mol^{-1} K^{-1}) by 29 and 22, respectively. Another gas of diatomic molecules, B, has the corresponding values 30 and 21. If they are treated as ideal gases, then **[JEE (Main)-2019]**

(1) A is rigid but B has a vibrational mode

(2) A has a vibrational mode but B has none

(3) Both A and B have a vibrational mode each

(4) A has one vibrational mode and B has two

17. A 25×10^{-3} m^3 volume cylinder is filled with 1 mol of O_2 gas at room temperature (300 K). The molecular diameter of O_2, and its root mean square speed, are found to be 0.3 nm and 200 m/s, respectively. What is the average collision rate (per second) for an O_2 molecule? **[JEE (Main)-2019]**

(1) $\sim 10^{12}$ (2) $\sim 10^{10}$

(3) $\sim 10^{11}$ (4) $\sim 10^{13}$

18. A cylinder with fixed capacity of 67.2 lit contains helium gas at STP. The amount of heat needed to raise the temperature of the gas by 20°C is : [Given that R = 8.31 J $mol^{-1}K^{-1}$] **[JEE (Main)-2019]**

(1) 700 J (2) 350 J

(3) 374 J (4) 748 J

19. Two moles of helium gas is mixed with three moles of hydrogen molecules (taken to be rigid). What is the molar specific heat of mixture at constant volume? **[JEE (Main)-2019]**

(R = 8.3 J/mol K)

(1) 19.7 J/mol K (2) 21.6 J/mol K

(3) 15.7 J/mol K (4) 17.4 J/mol K

20. The number density of molecules of a gas depends on their distance r from the origin as, $n(r) = n_0 e^{-\alpha r^4}$. Then the total number of molecules is proportional to **[JEE (Main)-2019]**

(1) $n_0 a^{-3/4}$ (2) $\sqrt{n_0}\, \alpha^{1/2}$

(3) $n_0 a^{1/4}$ (4) $n_0 a^{-3}$

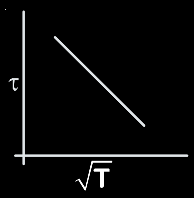
21. Two moles of an ideal gas with $\frac{C_P}{C_V} = \frac{5}{3}$ are mixed with 3 moles of another ideal gas with $\frac{C_P}{C_V} = \frac{4}{3}$. The value of $\frac{C_P}{C_V}$ for the mixture is **[JEE (Main)-2020]**

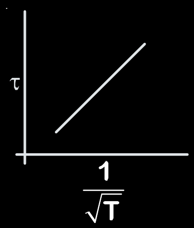
(1) 1.47 (2) 1.42

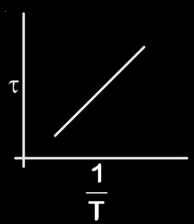
(3) 1.50 (4) 1.45

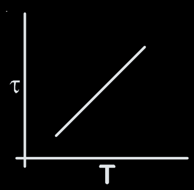
22. The plot that depicts the behavior of the mean free time t (time between two successive collisions) for the molecules of an ideal gas, as a function of temperature (T), qualitatively, is (Graphs are schematic and not drawn to scale)

[JEE (Main)-2020]

(1) 

(2) 

(3) 

(4) 

23. Consider a mixture of n moles of helium gas and $2n$ moles of oxygen gas (molecules taken to be rigid) as an ideal gas. Its C_p/C_v value will be

[JEE (Main)-2020]

(1) 40/27 (2) 19/13

(3) 67/45 (4) 23/15

24. Consider two ideal diatomic gases A and B at some temperature T. Molecules of the gas A are rigid, and have a mass m. Molecules of the gas B have an additional vibrational mode, and have a mass $\frac{m}{4}$. The ratio of the specific heats (C_V^A and C_V^B) of gas A and B, respectively is

[JEE (Main)-2020]

(1) 3 : 5 (2) 7 : 9

(3) 5 : 7 (4) 5 : 9

25. Two gases - argon (atomic radius 0.07 nm, atomic weight 40) and xenon (atomic radius 0.1 nm, atomic weight 140), have the same number density and are at the same temperature. The ratio of their respective mean free times is closest to

[JEE (Main)-2020]

(1) 1.09 (2) 4.67

(3) 2.3 (4) 3.67

26. A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Assuming the gases to be ideal and the oxygen bond to be rigid, the total internal energy (in units of RT) of the mixture is **[JEE (Main)-2020]**

(1) 13 (2) 15

(3) 20 (4) 11

27. An ideal gas in a closed container is slowly heated. As its temperature increases, which of the following statements are true? **[JEE (Main)-2020]**

(A) the mean free path of the molecules decreases.

(B) the mean collision time between the molecules decreases.

(C) the mean free path remains unchanged.

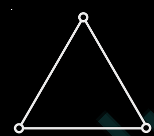
(D) the mean collision time remains unchanged.

(1) (C) and (D)

(2) (A) and (D)

(3) (B) and (C)

(4) (A) and (B)

28. 

Consider a gas of triatomic molecules. The molecules are assumed to be triangular and made of massless rigid rods whose vertices are occupied by atoms. The internal energy of a mole of the gas at temperature T is **[JEE (Main)-2020]**

(1) $3RT$

(2) $\frac{9}{2}RT$

(3) $\frac{3}{2}RT$

(4) $\frac{5}{2}RT$

29. To raise the temperature of a certain mass of gas by 50°C at a constant pressure, 160 calories of heat is required. When the same mass of gas is cooled by 100°C at constant volume, 240 calories of heat is released. How many degrees of freedom does each molecule of this gas have (assume gas to be ideal)?

[JEE (Main)-2020]

(1) 6 (2) 7

(3) 3 (4) 5

30. Hydrogen ion and singly ionized helium atom are accelerated, from rest, through the same potential difference. The ratio of final speeds of hydrogen and helium ions is close to **[JEE (Main)-2020]**

(1) 2 : 1 (2) 1 : 2

(3) 10 : 7 (4) 5 : 7

31. Match the C_p/C_v ratio for ideal gases with different type of molecules **[JEE (Main)-2020]**

	Molecule Type		C_p/C_v
(A)	Monatomic	(I)	7/5
(B)	Diatomic rigid molecules	(II)	9/7
(C)	Diatomic non-rigid molecules	(III)	4/3
(D)	Triatomic rigid molecules	(IV)	5/3

(1) (A)–(II), (B)–(III), (C)–(I), (D)–(IV)

(2) (A)–(IV), (B)–(II), (C)–(I), (D)–(III)

(3) (A)–(IV), (B)–(I), (C)–(II), (D)–(III)

(4) (A)–(III), (B)–(IV), (C)–(II), (D)–(I)

32. Number of molecules in a volume of 4 cm^3 of a perfect monoatomic gas at some temperature T and at a pressure of 2 cm of mercury is close to ? (Given, mean kinetic energy of a molecule (at T) is 4×10^{-14} erg, g = 980 cm/s^2, density of mercury = 13.6 g/cm^3) **[JEE (Main)-2020]**

(1) 5.8×10^{18} (2) 4.0×10^{16}

(3) 5.8×10^{16} (4) 4.0×10^{18}

33. Molecules of an ideal gas are known to have three translational degrees of freedom and two rotational degrees of freedom. The gas is maintained at a temperature of T. The total internal energy, U of a mole of this gas, and the value of $\gamma\left(=\frac{C_p}{C_v}\right)$ are given, respectively, by **[JEE (Main)-2020]**

(1) $U = 5RT$ and $\gamma = \frac{7}{5}$

(2) $U = \frac{5}{2}RT$ and $\gamma = \frac{6}{5}$

(3) $U = 5RT$ and $\gamma = \frac{6}{5}$

(4) $U = \frac{5}{2}RT$ and $\gamma = \frac{7}{5}$

34. In a dilute gas at pressure P and temperature T, the mean time between successive collisions of a molecule varies with T as **[JEE (Main)-2020]**

(1) $\sqrt{T}$ (2) T

(3) $\frac{1}{\sqrt{T}}$ (4) $\frac{1}{T}$

35. A closed vessel contains 0.1 mole of a monatomic ideal gas at 200 K. If 0.05 mole of the same gas at 400 K is added to it, the final equilibrium temperature (in K) of the gas in the vessel will be close to _________. **[JEE (Main)-2020]**

36. Nitrogen gas is at 300°C temperature. The temperature (in K) at which the rms speed of a H_2 molecule would be equal to the rms speed of a nitrogen molecule, is ___ . **[JEE (Main)-2020]**

(Molar mass of N_2 gas 28 g).

37. Initially a gas of diatomic molecules is contained in a cylinder of volume V_1 at a pressure P_1 and temperature 250 K. Assuming that 25% of the molecules get dissociated causing a change in number of moles. The pressure of the resulting gas at temperature 2000 K, when contained in a volume $2V_1$ is given by P_2. The ratio P_2/P_1 is _________. **[JEE (Main)-2020]**

38. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules: **[JEE (Main)-2021]**

(1) Suffer change in momentum when impinge on the walls of container

(2) Continuously stick to the walls of container

(3) Continuously lose their energy till it reaches wall

(4) Are attracted by the walls of container

39. The root mean square speed of molecules of a given mass of a gas at 27°C and 1 atmosphere pressure is 200 ms^{-1}. The root mean square speed of molecules of the gas at 127°C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}}$ ms^{-1}. The value of x will be_______. **[JEE (Main)-2021]**

40. A monoatomic gas of mass 4.0 u is kept in an insulated container. Container is moving with velocity 30 m/s. If container is suddenly stopped then change in temperature of the gas (R = gas constant) is $\frac{x}{3R}$. Value of x is __________. **[JEE (Main)-2021]**

41. Given below are two statements :

Statement I : In a diatomic molecule, the rotational energy at a given temperature obeys Maxwell's distribution.

Statement II : In a diatomic molecule, the rotational energy at a given temperature equals the translational kinetic energy for each molecule.

In the light of the above statements, choose the correct answer from the options given below:

[JEE (Main)-2021]

(1) Both Statement I and Statement II are false

(2) Statement I is false but Statement II is true

(3) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are true

42. A container is divided into two chambers by a partition. The volume of first chamber is 4.5 litre and second chamber is 5.5 litre. The first chamber contain 3.0 moles of gas at pressure 2.0 atm and second chamber contain 4.0 moles of gas at pressure 3.0 atm. After the partition is removed and the mixture attains equilibrium, then, the common equilibrium pressure existing in the mixture is $x \times 10^{-1}$ atm. Value of x is ________. **[JEE (Main)-2021]**

43. The volume V of an enclosure contains a mixture of three gases, 16 g of oxygen, 28 g of nitrogen and 44 g of carbon dioxide at absolute temperature T. Consider R as universal gas constant. The pressure of the mixture of gases is :

[JEE (Main)-2021]

(1) $\frac{88RT}{V}$ (2) $\frac{4RT}{V}$

(3) $\frac{3RT}{V}$ (4) $\frac{5}{2}\frac{RT}{V}$

44. Calculate the value of mean free path (l) for oxygen molecules at temperature 27°C and pressure 1.01×10^{5} Pa. Assume the molecular diameter 0.3 nm and the gas is ideal. ($k = 1.38 \times 10^{-23}$ JK^{-1})
[JEE (Main)-2021]

(1) 86 nm

(2) 32 nm

(3) 58 nm

(4) 102 nm

45. Two ideal polyatomic gases at temperatures T_1 and T_2 are mixed so that there is no loss of energy. If F_1 and F_2, m_1 and m_2, n_1 and n_2 be the degrees of freedom, masses, number of molecules of the first and second gas respectively, the temperature of mixture of these two gases is:
[JEE (Main)-2021]

(1) $\frac{n_1F_1T_1 + n_2F_2T_2}{F_1 + F_2}$

(2) $\frac{n_1T_1 + n_2T_2}{n_1 + n_2}$

(3) $\frac{n_1F_1T_1 + n_2F_2T_2}{n_1 + n_2}$

(4) $\frac{n_1F_1T_1 + n_2F_2T_2}{n_1F_1 + n_2F_2}$

46. A polyatomic ideal gas has 24 vibrational modes. What is the value of g? **[JEE (Main)-2021]**

(1) 1.30 (2) 10.3

(3) 1.37 (4) 1.03

47. If one mole of the polyatomic gas is having two vibrational modes and b is the ratio of molar specific heats for polyatomic gas $\left(\beta = \frac{C_P}{C_V}\right)$ then the value of b is: **[JEE (Main)-2021]**

(1) 1.35 (2) 1.2

(3) 1.25 (4) 1.02

48. What will be the average value of energy along one degree of freedom for an ideal gas in thermal equilibrium at a temperature T? (k_B is Boltzmann constant) **[JEE (Main)-2021]**

(1) $\frac{3}{2}k_BT$ (2) $\frac{1}{2}k_BT$

(3) k_BT (4) $\frac{2}{3}k_BT$

49. Consider a sample of oxygen behaving like an ideal gas. At 300 K, the ratio of root mean square (rms) velocity to the average velocity of gas molecule would be :

(Molecular weight of oxygen is 32 g/mol; R = 8.3 J K^{-1} mol^{-1}) **[JEE (Main)-2021]**

(1) $\sqrt{\frac{8\pi}{3}}$ (2) $\sqrt{\frac{3}{3}}$

(3) $\sqrt{\frac{8}{3}}$ (4) $\sqrt{\frac{3\pi}{8}}$

50. Consider a mixture of gas molecule of types A, B and C having masses $m_A < m_B < m_C$. The ratio of their root mean square speeds at normal temperature and pressure is : **[JEE (Main)-2021]**

(1) $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$ (2) $v_A = v_B\ {}^1\ v_C$

(3) $v_A = v_B = v_C = 0$ (4) $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$

51. The correct relation between the degrees of freedom *f* and the ratio of specific heat g is

[JEE (Main)-2021]

(1) $f = \frac{1}{\gamma + 1}$ (2) $f = \frac{2}{\gamma - 1}$

(3) $f = \frac{2}{\gamma + 1}$ (4) $f = \frac{\gamma + 1}{2}$

52. What will be the average value of energy for a monoatomic gas in thermal equilibrium at temperature *T*? **[JEE (Main)-2021]**

(1) $\frac{3}{2}k_BT$ (2) k_BT

(3) $\frac{2}{3}k_BT$ (4) $\frac{1}{2}k_BT$

53. A system consists of two types of gas molecules A and B having same number density $2 \times 10^{25}/m^3$. The diameter of A and B are 10 Å and 5 Å respectively. They suffer collision at room temperature. The ratio of average distance covered by the molecule A to that of B between two successive collision is_____ $\times 10^{-2}$

[JEE (Main)-2021]

54. A mixture of hydrogen and oxygen has volume 500 cm^3, temperature 300 K, pressure 400 kPa and mass 0.76 g. The ratio of masses of oxygen to hydrogen will be: **[JEE (Main)-2021]**

(1) 3 : 16 (2) 16 : 3

(3) 3 : 8 (4) 8 : 3

55. The rms speeds of the molecules of hydrogen, oxygen and carbondioxide at the same temperature are V_H, V_O and V_C respectively then:

[JEE (Main)-2021]

(1) $V_H = V_O > V_C$ (2) $V_H = V_O = V_C$

(3) $V_C > V_O > V_H$ (4) $V_H > V_O > V_C$

56. A cylindrical container of volume 4.0×10^{-3} m^3 contains one mole of hydrogen and two moles of carbon dioxide. Assume the temperature of the mixture is 400 K. The pressure of the mixture of gases is:

[Take gas constant as 8.3 J mol^{-1} K^{-1}]

[JEE (Main)-2021]

(1) 24.9×10^3 Pa

(2) 24.9×10^5 Pa

(3) 24.9 Pa

(4) 249×10^1 Pa

57. A balloon carries a total load of 185 kg at normal pressure and temperature of 27°C. What load will the balloon carry on rising to a height at which the barometric pressure is 45 cm of Hg and the temperature is –7°C. Assuming the volume constant? **[JEE (Main)-2021]**

(1) 214.15 kg

(2) 181.46 kg

(3) 219.07 kg

(4) 123.54 kg

58. An ideal gas is expanding such that PT^3 = constant. The coefficient of volume expansion of the gas is: **[JEE (Main)-2021]**

(1) $\frac{4}{T}$ (2) $\frac{3}{T}$

(3) $\frac{1}{T}$ (4) $\frac{2}{T}$

59. If the rms speed of oxygen molecules at 0°C is 160 m/s, find the rms speed of the hydrogen molecules at 0°C. **[JEE (Main)-2021]**

(1) 40 m/s

(2) 80 m/s

(3) 640 m/s

(4) 332 m/s

60. For an ideal gas the instantaneous change in pressure 'p' with volume 'v' is given by the equation $\frac{dp}{dv} = -ap$. If $p = p_0$ at $v = 0$ is the given boundary condition, then the maximum temperature one mole of gas can attain is:

(Here *R* is the gas constant)

[JEE (Main)-2021]

(1) Infinity (2) $\frac{ap_0}{e R}$

(3) 0°C (4) $\frac{p_0}{a e R}$

61. 0.056 kg of Nitrogen is enclosed in a vessel at a temperature of 127°C. The amount of heat required to double the speed of its molecules is ___ k cal.

(Take R = 2 cal $mol^{-1} K^{-1}$) **[JEE (Main)-2022]**

62. The relation between root mean square speed (v_{rms}) and most probable speed (v_p) for the molar mass *M* of oxygen gas molecule at the temperature of 300 K will be **[JEE (Main)-2022]**

(1) $v_{rms} = \sqrt{\frac{2}{3}} v_p$

(2) $v_{rms} = \sqrt{\frac{3}{2}} v_p$

(3) $v_{rms} = v_p$

(4) $v_{rms} = \sqrt{\frac{1}{3}} v_p$

63. A thermally insulated vessel contains an ideal gas of molecular mass *M* and ratio of specific heats 1.4. Vessel is moving with speed v and is suddenly brought to rest. Assuming no heat is lost to the surrounding and vessel temperature of the gas increases by

(*R* = universal gas constant) **[JEE (Main)-2022]**

(1) $\frac{Mv^2}{7R}$ (2) $\frac{Mv^2}{5R}$

(3) $2\frac{Mv^2}{7R}$ (4) $7\frac{Mv^2}{5R}$

64. A mixture of hydrogen and oxygen has volume 2000 cm^3, temperature 300 K, pressure 100 kPa and mass 0.76 g. The ratio of number of moles of hydrogen to number of moles of oxygen in the mixture will be:

[Take gas constant *R* = 8.3 JK^{-1} mol^{-1}]

[JEE (Main)-2022]

(1) $\frac{1}{3}$ (2) $\frac{3}{1}$

(3) $\frac{1}{16}$ (4) $\frac{16}{1}$

65. According to kinetic theory of gases,

A. The motion of the gas molecules freezes at 0°C

B. The mean free path of gas molecules decreases if the density of molecules is increased.

C. The mean free path of gas molecules increases if temperature is increased keeping pressure constant.

D. Average kinetic energy per molecule per degree of freedom is $\frac{3}{2}k_BT$ (for monoatomic gases).

Choose the most appropriate answer from the options given below: **[JEE (Main)-2022]**

(1) A and C only

(2) B and C only

(3) A and B only

(4) C and D only

66. What will be the effect on the root mean square velocity of oxygen molecules if the temperature is doubled and oxygen molecule dissociates into atomic oxygen? **[JEE (Main)-2022]**

(1) The velocity of atomic oxygen remains same

(2) The velocity of atomic oxygen doubles

(3) The velocity of atomic oxygen becomes half

(4) The velocity of atomic oxygen becomes four times

67. A cylinder of fixed capacity of 44.8 litres contains helium gas at standard temperature and pressure. The amount of heat needed to raise the temperature of gas in the cylinder by 20.0°C will be

(Given gas constant *R* = 8.3 JK^{-1}-mol^{-1})

[JEE (Main)-2022]

(1) 249 J

(2) 415 J

(3) 498 J

(4) 830 J

68. A vessel contains 16 g of hydrogen and 128 g of oxygen at standard temperature and pressure. The volume of the vessel in cm^3 is:

[JEE (Main)-2022]

(1) 72×10^5 (2) 32×10^5

(3) 27×10^4 (4) 54×10^4

69. Sound travels in a mixture of two moles of helium and n moles of hydrogen. If rms speed of gas molecules in the mixture is $\sqrt{2}$ times the speed of sound, then the value of n will be **[JEE (Main)-2022]**

(1) 1 (2) 2

(3) 3 (4) 4

70. Same gas is filled in two vessels of the same volume at the same temperature. If the ratio of the number of molecules is 1 : 4, then

A. The r.m.s. velocity of gas molecules in two vessels will be the same.

B. The ratio of pressure in these vessels will be 1 : 4.

C. The ratio of pressure will be 1 : 1.

D. The r.m.s. velocity of gas molecules in two vessels will be in the ratio of 1 : 4.

Choose the correct answer from the options given below **[JEE (Main)-2022]**

(1) A and C only

(2) B and D only

(3) A and B only

(4) C and D only

71. Given below are two statements :

Statement I : The average momentum of a molecule in a sample of an ideal gas depends on temperature.

Statement II : The rms speed of oxygen molecules in a gas is v. If the temperature is doubled and the oxygen molecules dissociate into oxygen atoms, the rms speed will become $2v$.

In the light of the above statements, choose the **correct** answer from the options given below:

[JEE (Main)-2022]

(1) Both **Statement I** and **Statement II** are true

(2) Both **Statement I** and **Statement II** are false

(3) **Statement I** is true but **Statement II** is false

(4) **Statement I** is false but **Statement II** is true

72. A vessel contains 14 g of nitrogen gas at a temperature of 27°C. The amount of heat to be transferred to the gas to double the r.m.s speed of its molecules will be: Take $R = 8.32\ \text{J mol}^{-1}\,\text{K}^{-1}$. **[JEE (Main)-2022]**

(1) 2229 J (2) 5616 J

(3) 9360 J (4) 13,104 J

73. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. The molecular specific heat of mixture at constant volume is $\frac{\alpha^2}{4}R$ J/mol K; then the value of α will be ________.

(Assume that the given diatomic gas has no vibrational mode). **[JEE (Main)-2022]**

74. The root mean square speed of smoke particles of mass 5×10^{-17} kg in their Brownian motion in air at NTP is approximately. [Given $k = 1.38 \times 10^{-23}\ \text{JK}^{-1}$]

[JEE (Main)-2022]

(1) 60 mm s^{-1}

(2) 12 mm s^{-1}

(3) 15 mm s^{-1}

(4) 36 mm s^{-1}

75. A flask contains argon and oxygen in the ratio of 3 : 2 in mass and the mixture is kept at 27°C. The ratio of their average kinetic energy per molecule respectively will be **[JEE (Main)-2022]**

(1) 3 : 2 (2) 9 : 4

(3) 2 : 3 (4) 1 : 1

76. A gas has n degrees of freedom. The ratio of specific heat of gas at constant volume to the specific heat of gas at constant pressure will be

[JEE (Main)-2022]

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

(3) $\frac{n}{2n+2}$ (4) $\frac{n}{n-2}$

Chapter 12

Kinetic Theory of Gases

1. Answer (1)

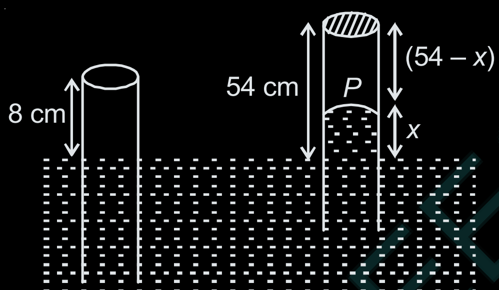
$$E = \frac{f}{2}PV$$

$$E = \frac{5}{2}PV$$

$$= \frac{5}{2} \times P \times \frac{m}{\rho}$$

$$= \frac{5 \times 8 \times 10^4 \times 1}{2 \times 4} = 5 \times 10^4 \text{ J}$$

2. Answer (1)



$P + x = P_0$

$P = (76 - x)$

$8 \times A \times 76 = (76 - x) \times A \times (54 - x)$

$x = 38$

Length of air column = 54 – 38 = 16 cm.

3. Answer (3)

$$\tau = \frac{\lambda}{v_{\text{rms}}} = \frac{1}{\sqrt{2}\pi d^2 \left(\frac{N}{V}\right)\sqrt{\frac{3RT}{M}}} \qquad \text{...(i)}$$

$$\tau \propto \frac{V}{\sqrt{T}} \qquad \text{...(ii)}$$

$$TV^{\gamma - 1} = k \qquad \text{...(iii)}$$

$$\Rightarrow \quad \tau \propto V^{\frac{\gamma+1}{2}}$$

4. Answer (4)

n_1 = initial number of moles

$$n_1 = \frac{P_1V_1}{RT_1} = \frac{10^5 \times 30}{8.3 \times 290} \approx 1.24 \times 10^3$$

n_2 = final number of moles

$$= \frac{P_2V_2}{RT_2} = \frac{10^5 \times 30}{8.3 \times 300} \approx 1.20 \times 10^3$$

Change of number of molecules :

$n_f - n_i = (n_2 - n_1) \times 6.023 \times 10^{23}$

$\approx -2.5 \times 10^{25}$

5. Answer (1)

$F = nmv\cos\theta \times 2$

$$P = \frac{F}{A} = \frac{2.nmv\cos\theta}{A}$$

$$= \frac{2 \times 10^{23} \times 3.32 \times 10^{-27} \times 10^3}{\sqrt{2} \times 2 \times 10^{-4}} \text{N/m}^2$$

$= 2.35 \times 10^3 \text{ N/m}^2$

6. Answer (3)

$$\frac{v_{\text{rms(helium)}}}{v_{\text{rms(argon)}}} = \sqrt{\frac{M_{\text{ar}}}{M_{\text{He}}}} \text{ at same temperature}$$

$$\frac{v_{\text{rms(helium)}}}{v_{\text{rms(argon)}}} = \sqrt{\frac{40}{4}} = 3.16$$

7. Answer (3)

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$T_2 = 1200$ K

$Q = n\, C_V\, (T_2 - T_1)$

$$= \frac{15}{28} \times 5 \times \frac{R}{2} \times 900$$

$= 10$ kJ

8. Answer (3)

$$V = \left(\frac{m}{\rho}\right) = \frac{2}{8} = \frac{1}{4}\,\text{m}^3$$

$$PV = nRT \Rightarrow 4 \times 10^4 \times \frac{1}{4} = nRT$$

$$\Rightarrow nRT = 10^4$$

$$\therefore \text{Internal Energy} = \frac{3}{2}nRT = \frac{3}{2} \times 10^4$$

$$= 1.5 \times 10^4\ \text{J}$$

$$\Rightarrow \text{Order} = 10^4\ \text{J}$$

9. Answer (3)

$$U = 3 \times \frac{5}{2}RT + 5 \times \frac{3}{2}RT$$

$$\Rightarrow U = 15RT$$

10. Answer (2)

$U = \frac{3}{2}nRT$ for monoatomic gas

$$= \frac{3}{2} \times (PV)$$

$$= \frac{3}{2} \times 3 \times 10^6 \times 2 = 9 \times 10^6\ \text{J}$$

11. Answer (4)

$$t \propto \frac{V}{\sqrt{T}}$$

$$V \propto \frac{T}{P}$$

$$t \propto \frac{\sqrt{T}}{P}$$

$$\frac{t_1}{t_2} = \sqrt{\frac{5}{3}} \times \frac{1}{2} \times 6 \times 10^{-8}$$

$$= 3.87 \times 10^{-8}\ \text{s}$$

12. Answer (2)

$$P = \frac{N \times (2mv)}{\Delta t \times A}$$

$$= \frac{10^{22} \times 2 \times 10^{-26} \times 10^4}{1 \times 1} = 2\ \text{N/m}^2$$

13. Answer (1)

$$V_{\text{rms}} = \sqrt{\frac{3RT}{M}} = 11.2 \times 10^3\ \text{m/s}$$

$$\Rightarrow T = \frac{M}{3R} \times (11.2 \times 10^3)^2$$

$$= \frac{2 \times 10^{-3}}{3 \times 8.3} \times 125.44 \times 10^6 \simeq 10^4\ \text{K}$$

14. Answer (1)

$$V \propto \sqrt{T}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{200}{V_2} = \sqrt{\frac{400}{500}}$$

$$V_2 = 200\sqrt{\frac{5}{4}} = 100\sqrt{5}\ \text{m/s}$$

15. Answer (4)

$$\bar{v} = \sqrt{\frac{3\,RT}{M}}$$

$$\bar{v} = \sqrt{\frac{3\,RT}{mN_A}}$$

$$\bar{v} = \sqrt{\frac{3\,k_BT}{m}}$$

16. Answer (2)

For (A) $C_P = 29$, $C_V = 22$

For (B) $C_P = 30$, $C_V = 21$

$$\therefore \quad \gamma_A = \frac{C_{P_A}}{C_{V_A}} = \frac{29}{22} = 1.31$$

When A has vibrational degree of freedom, then $\gamma_A = 9/7 \simeq 1.29$.

$$\gamma_B = \frac{C_{P_B}}{C_{V_B}} = \frac{30}{21} = 1.42$$

$\Rightarrow$ B has no vibrational degree of freedom.

17. Answer (2)

$V = 25 \times 10^{-3}\ \text{m}^3$, $N = 1$ mole of O_2

$T = 300$ K

$V_{rms} = 200$ m/s

$\because \quad \lambda = \dfrac{1}{\sqrt{2}N\pi r^2}$

Average time $\dfrac{1}{\tau} = \dfrac{<V>}{\lambda} = 200 \cdot N\pi r^2 \cdot \sqrt{2}$

$= \dfrac{\sqrt{2} \times 200 \times 6.023 \times 10^{23}}{25 \times 10^{-3}} \cdot \pi \times 10^{-18} \times 0.09$

Average no. of collision $\approx 10^{10}$

18. Answer (4)

No. of moles of He at STP $= \dfrac{67.2}{22.4} = 3$

As the volume is constant $\rightarrow$ Isochoric proces

$Q = nC_v\Delta T = 3 \times \dfrac{3R}{2} \times 20 = 90R = 90 \times 8.31 \simeq 748$ J.

19. Answer (4)

$5C_V = 2 \times \dfrac{3R}{2} + 3 \times \dfrac{5R}{2}$

$C_V = \dfrac{21R}{10}$

20. Answer (1)

$n = n_0 e^{-\alpha r^4}$

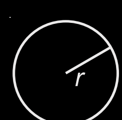
$\Rightarrow \quad \int dN = \int n_0 e^{-\alpha r^4} \times 4\pi r^2 dr$

$\Rightarrow \quad N = 4\pi n_0 \cdot \int_0^\infty r^2 e^{-\alpha r^4} dr$

Put $\sqrt{\alpha}\, r^2 = t$

$2\sqrt{\alpha}\, r\, dr = dt$

$N = \dfrac{4\pi n_0}{2\sqrt{\alpha}} \int_0^\infty \dfrac{t^{\frac{1}{2}} e^{-t^2}}{\alpha^{\frac{1}{4}}} dt$



$= \dfrac{4\pi n_0}{2\alpha^{\frac{3}{4}}} \int t^{\frac{1}{2}} e^{-t^2} dt$

$N \propto n_0 \alpha^{-\frac{3}{4}}$

21. Answer (2)

$\because \quad \dfrac{n_1}{\gamma_1 - 1} + \dfrac{n_2}{\gamma_2 - 1} = \dfrac{n_1 + n_2}{\gamma_m - 1}$

$\Rightarrow \dfrac{3}{\frac{4}{3} - 1} + \dfrac{2}{\frac{5}{3} - 1} = \dfrac{5}{\gamma_m - 1}$

$\Rightarrow \dfrac{9}{1} + \dfrac{2 \times 3}{2} = \dfrac{5}{\gamma_m - 1}$

$\Rightarrow \gamma_m - 1 = \dfrac{5}{12}$

$\Rightarrow \gamma_m = \dfrac{17}{12} = 1.42$

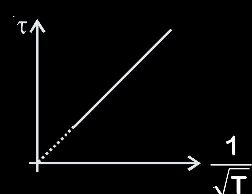
22. Answer (2)

Relaxation time $(\tau) \propto \dfrac{\text{mean free path}}{\text{speed}}$

$\therefore \quad \tau \propto \dfrac{1}{v}$

or $\tau \propto \dfrac{1}{\sqrt{T}}$

Graph between τ v/s $\dfrac{1}{\sqrt{T}}$ is a straight line,



23. Answer (2)

$\gamma = \dfrac{N_1 C_{P_1} + N_2 C_{P_2}}{N_1 C_{v_1} + N_2 C_{v_2}}$

$\gamma = \dfrac{n.\frac{5}{2}R + 2n.\frac{7}{2}R}{n.\frac{3}{2}R + 2n.\frac{5}{2}R} = \dfrac{19nR \times 2}{2(13nR)}$

$\gamma = \left(\dfrac{C_p}{C_v}\right)_{\text{mixture}} = \dfrac{19}{13}$

24. Answer (3)

$$C_V^A = \frac{5R}{2}$$

$$C_V^B = \frac{7R}{2}$$

$$\frac{C_V^A}{C_V^B} = \frac{5}{7}$$

25. Answer (1)

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

Mean free time, $\tau = \frac{\lambda}{v}$

$$\tau \propto \frac{\sqrt{M}}{d^2}$$

$$\frac{\tau_1}{\tau_2} = \frac{\sqrt{M_1}}{d_1^2} \times \frac{d_2^2}{\sqrt{M_2}}$$

$$= \sqrt{\frac{40}{140}} \times \left(\frac{0.1}{0.07}\right)^2 = 1.09$$

26. Answer (2)

$$E = 3\times\frac{5}{2}RT + 5\times\frac{3}{2}\times RT = 15\ RT$$

27. Answer (3)

Mean free path is independent of temperature and relaxation time decreases as temperature increases.

28. Answer (1)

$$U = \frac{nfRT}{2}$$

f = 6 (for triatomic)

$\Rightarrow$ U = 3RT

29. Answer (1)

$160 = nC_p\ 50$ ...(i)

$240 = nC_v\ 100$ ...(ii)

From (i) and (ii),

$$\frac{160}{240} = \frac{C_p}{C_v} \times \frac{1}{2}$$

$$\Rightarrow \gamma = \frac{C_p}{C_v} = 1 + \frac{2}{f} = \frac{4}{3}$$

$\Rightarrow$ f = 6

30. Answer (1)

k = qV

$$\frac{1}{2}mv^2 = qV$$

$$\Rightarrow v = \sqrt{\frac{2qV}{m}}$$

$$\frac{V_H}{V_{He}} = \sqrt{\frac{q_H m_{He}}{m_H q_{He}}} = 2:1$$

31. Answer (3)

For Monatomic

$$C_V = \frac{3R}{2}, C_P = \frac{5R}{2}$$

For Diatomic

rigid $C_V = \frac{5R}{2}, C_P = \frac{7R}{2}$

non-rigid $C_V = \frac{7R}{2}, C_P = \frac{9R}{2}$

32. Answer (4)

PV = NkT

$$E = \frac{3}{2}kT$$

$$N = \frac{3PV}{2E} \qquad (P = h\rho g)$$

$= 4 \times 10^{18}$

33. Answer (4)

f = 5

$$\therefore U = \frac{5}{2}RT$$

and $\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{5} = \frac{7}{5}$

34. Answer (3)

$$\tau \propto \frac{1}{\sqrt{T}}$$

$\because \quad \ell_{mean} = \dfrac{1}{\sqrt{2}\,\pi n D^2}$ and $V \propto \sqrt{T}$

$\therefore \quad \tau_{mean} = \dfrac{\ell_{mean}}{v}$

$\Rightarrow \quad T \propto \dfrac{1}{\sqrt{T}}$

35. Answer (266.67)

$$\left(0.1 \times \frac{3}{2} R \times 200\right) + \left(0.05 \times \frac{3}{2} R \times 400\right) = 0.15 \times \frac{3}{2} R \cdot T_f$$

$\Rightarrow \quad (20 + 20) = 0.15\ T_f$

$\Rightarrow \quad T_f = \dfrac{40}{15} \times 100 \simeq 266.67$

36. Answer (40.93)

V_{rms} for $N_2 = \sqrt{\dfrac{3KT}{28}} = \sqrt{\dfrac{3 \times K \times 573}{28}}$

V_{rms} for $H_2 = \sqrt{\dfrac{3KT_1}{2}}$

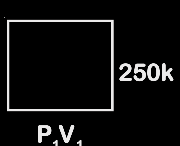
$\because \quad V_{rms}$ for $N_2 = V_{rms}$ *for* H_2

$\therefore \quad \dfrac{3KT_1}{2} = \dfrac{3K \times 573}{28} \quad \Rightarrow \quad T_1 = \dfrac{573}{14} K$

$T_1 = 40.93$ kelvin

37. Answer (05.00)

$n_0 = \dfrac{P_1 V_1}{R \times 250}$



$n' = 0.75\ n_0 + 0.5\ n_0$

$= 1.25\ n_0$ moles

$P_2 \times 2V_1 = (1.25) \dfrac{P_1 V_1}{R \times 250} \times R \times 2000$

$\Rightarrow \quad \dfrac{P_2}{P_1} = 5$

38. Answer (1)

Pressure is due to force exerted by molecules on wall

39. Answer (400)

$u_{rms} = \sqrt{\dfrac{3RT}{M}}$

$\dfrac{u_2}{u_1} = \sqrt{\dfrac{T_2}{T_1}}$

$u_2 = \sqrt{\dfrac{273 + 127}{273 + 27}}\,.u_1$

$= \dfrac{2}{\sqrt{3}}.200$

$= \dfrac{400}{\sqrt{3}}$ m/s

40. Answer (3600)

$nC_v \Delta T = \dfrac{1}{2} mv^2$

$\Delta T = \dfrac{1}{2}\left(\dfrac{m}{n}\right).\dfrac{2}{3R}(30)^2 = \dfrac{\mathbf{3600}}{\mathbf{3R}}$

* Assuming mass per mole $= 4\ \dfrac{kg}{mol}$.

41. Answer (3)

$K_R = kT$

$K_T = \dfrac{3}{2} kT$

K_T for each molecule $\dfrac{3}{4} kT$

42. Answer (25.5)

*Assuming, identical gas in both chamber

3 moles at 2 atm	**4 moles at 3 atm**
4.5 litre	**5.5 litre**

$P = \dfrac{P_1 V_1 + P_2 V_2}{V_1 + V_2} = 2.55$ atm

$\Rightarrow \quad x = 25.5$

43. Answer (4)

$$P \times V = \left(\frac{16}{32} + \frac{28}{28} + \frac{44}{44}\right) \times R \times T$$

$$\Rightarrow P \times V = \frac{5}{2} RT$$

$$\Rightarrow P = \frac{5RT}{2V}$$

44. Answer (4)

$$l_{mean} = \frac{RT}{\sqrt{2}\pi d^2 N_A P}$$

$$= \frac{1.38 \times 300 \times 10^{-23}}{\sqrt{2} \times 3.14 \times \left(0.3 \times 10^{-9}\right)^2 \times 1.01 \times 10^5}$$

$= 102 \times 10^{-9}$ m

= 102 nm

45. Answer (4)

$\because \quad n_1F_1(T_1 - T) = n_2F_2(T - T_2)$

$$\Rightarrow \quad T = \frac{n_1F_1T_1 + n_2F_2T_2}{n_1F_1 + n_2F_2}$$

46. Answer (4)

$$\gamma = 1 + \frac{2}{f}$$

$f = 2 \times 24 + 3 + 3 = 54$

$$\gamma = 1 + \frac{2}{54} = 1.03$$

47. Answer (2)

$$\beta = \frac{C_P}{C_V} = 1 + \frac{2}{f}$$

$f = 3 + 3 + 2 \times 2 = 10$

$$\therefore \beta = 1 + \frac{2}{10}$$

$$= \frac{6}{5}$$

= 1.2

48. Answer (2)

Each degree of freedom as per law of equipartition of energy is associated with $\frac{1}{2}k_BT$ energy per molecule.

49. Answer (4)

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$V_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

$$\Rightarrow \frac{V_{rms}}{V_{avg}} = \sqrt{\frac{3\pi}{8}}$$

50. Answer (4)

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\Rightarrow \quad v \propto \frac{1}{\sqrt{m}} \Rightarrow \frac{1}{v} \propto \sqrt{m}$$

$$\therefore \quad \frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$$

51. Answer (2)

$$\because \quad \gamma = 1 + \frac{2}{f}$$

$$\Rightarrow \frac{2}{f} = \gamma - 1$$

$$\Rightarrow f = \frac{2}{\gamma - 1}$$

52. Answer (1)

$$E = \frac{3}{2}k_BT$$

53. Answer (25)

$$\lambda \propto \frac{1}{d^2}$$

$$\frac{\lambda_{10}}{\lambda_5} = \frac{1}{4} = 0.25$$

54. Answer (2)

PV = nRT

$$\Rightarrow \quad n = \frac{400 \times 10^3 \times 500 \times 10^{-6}}{R \times 300}$$

$$n = \frac{8}{100} = \frac{m_{H_2}}{2} + \frac{m_{O_2}}{32} \qquad ...(i)$$

and $m_{H_2} + m_{O_2} = 0.76$ ...(ii)

$\therefore\ m_{H_2} = 0.12$ g and $m_{O_2} = 0.64$ g

So ratio $= \frac{16}{3}$

55. Answer (4)

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$V_{rms} \propto \frac{1}{\sqrt{M}} \text{ if } T \to \text{constant}$$

$\Rightarrow\ V_H > V_O > V_C$

56. Answer (2)

No. of mole, n = 1 + 2 = 3

using PV = nRT

$$P = \frac{nRT}{V} = \frac{3 \times 8.3 \times 400}{4 \times 10^{-3}}$$

$= 24.9 \times 10^5$ Pa

57. Answer (4)

$$\frac{\rho_1 T_1}{P_1} = \frac{\rho_2 T_2}{P_2}$$

$$M = V\rho_1 \quad \Rightarrow \quad \frac{M_1}{M_2} = \frac{\rho_1}{\rho_2} = \frac{P_1 T_2}{P_2 T_1}$$

$$\Rightarrow\ M_2 = \frac{P_2 T_1}{P_1 T_2} M_1$$

$$= \frac{(45) \times 300}{76 \times 266} \times 185 = 123.54 \text{ kg}$$

58. Answer (1)

$PT^3 = C$

$PV = nRT$

$$P = \frac{nRT}{V}$$

$$\frac{nRT}{V} T^3 = C$$

$$V = \frac{nR}{C} T^4 \quad \text{...(i)}$$

$$\frac{dV}{V} = \frac{4}{T} dT \qquad \frac{1}{V}\frac{dV}{dT} = \frac{4}{T}$$

59. Answer (3)

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$V_{O_2} = 160$

$$V_{H_2} = V_{O_2} \times \sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

= 640 m/s

60. Answer (4)

$$\frac{dp}{dv} = -ap \Rightarrow \int_{p_0}^{p} \frac{dp}{p} = -\int_0^v a dv$$

$\Rightarrow p = p_0 e^{-av}$

Now, $pv = nRT \Rightarrow T = \frac{pv}{R}$ [n = 1]

$$\therefore \quad T = \frac{p_0 e^{-av} \times v}{R}$$

So, T to be max, $\frac{dT}{dv} = 0 \Rightarrow v = \frac{1}{a}$

$$\therefore \quad T_{max} = \frac{p_0}{e\,a\,R}$$

61. Answer (12)

Because the vessel is closed, it will be an isochoric process.

To double the speed, temperature must be 4 times

$(v\ \alpha \sqrt{T})$

So T_f = 1600 K, T_i = 400 K

number of moles are $\frac{56}{28} = 2$

so $Q = nCv\ \Delta T = 2 \times \frac{5}{2} \times 2 \times 1200$

= 12000 cal = 12 k cal

62. Answer (2)

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$v_p = \sqrt{\frac{2RT}{M}}$$

$$\Rightarrow \quad v_{rms} = \sqrt{\frac{3}{2}} v_p$$

$\Rightarrow$ option (2)

63. Answer (2)

$$\frac{1}{2}mv^2 = n\frac{5}{2}R\Delta T$$

$$\Rightarrow \quad \Delta T = \frac{mv^2}{5nR}$$

$$= \frac{Mv^2}{5R}$$

Option (2)

64. Answer (2)

$P_1V = n_1RT$

$P_2V = n_2RT$

$\Rightarrow$ (100 kPa) $V = (n_1 + n_2)RT$

$$\Rightarrow \quad n_1 + n_2 = \frac{(100 \text{ kPa})(2000 \text{ cm}^3)}{8.3 \times 300} \qquad \ldots(1)$$

Also, $n_1 \times 2 + n_2 \times 32 = 0.76$ ...(2)

Solving (1) and (2),

$n_1 = 0.06$

$n_2 = 0.02$

$$\Rightarrow \frac{n_1}{n_2} = 3$$

65. Answer (2)

According to kinetic theory of gases,

(1) The motion of the gas molecules freezes at 0 K.

(2). The mean free path decreases on increasing the number density of the molecules as

$$\mu = \frac{1}{\sqrt{2}\pi nd^2} \Rightarrow \mu \propto \frac{1}{n}.$$

(C) The mean free path increases on increasing the volume. Now if temperature is increased by keeping the pressure constant the volume should increase that is mean free path increases.

(D) K.E.$_{avg}$ per molecule per degree of freedom is $\frac{1}{2}k_BT$.

$\Rightarrow$ Option (2) and (3) only are correct.

66. Answer (2)

As $v_{rms} = \sqrt{\frac{3RT}{M_0}}$

T is doubled and oxygen molecule is dissociated into atomic oxygen molar mass is halved.

So, $v'_{rms} = \sqrt{\frac{3R \times 2T_0}{M_0 / 2}} = 2v_{rms}$

So velocity of atomic oxygen is doubled.

67. Answer (3)

$\Delta Q = nC_v\Delta T$ (Isochoric process)

$$= 2 \times \frac{3R}{2} \times 20$$

$= 498$ J

68. Answer (3)

Total number of moles are

$$n = n_{H_2} + n_{O_2}$$

$$= \frac{16}{2} + \frac{128}{32}$$

$= 12$ moles

Using $PV = nRT$

$$V = \frac{nRT}{P}$$

$$= \frac{12 \times 8.31 \times 273.15}{10^5} \text{ m}^3$$

$= 0.27 \text{ m}^3 = 27 \times 10^4 \text{ cm}^3$

69. Answer (2)

$$\text{Molar mass } M = \frac{2 \times 4 + n \times 1}{2 + n} \qquad \ldots(i)$$

$$\text{Also, } \gamma = \frac{n_1C_{P_1} + n_2C_{P_2}}{n_1C_{V_1} + n_2C_{V_2}} = \frac{2 \times 5R + n \times 7R}{2 \times 3R + n \times 5R}$$

$$\Rightarrow \quad \gamma = \frac{10 + 7n}{6 + 5n} \qquad \ldots(ii)$$

Given that $V_{rms} = \sqrt{2}\ V_{sound}$

$$\Rightarrow \sqrt{\frac{3RT}{M}} = \sqrt{2}\sqrt{\frac{\gamma RT}{M}}$$

$$\Rightarrow \gamma = \frac{3}{2}$$

$\Rightarrow n = 2$

70. Answer (3)

$$v_{rms} = \sqrt{\frac{3RT}{M_0}}$$ because T is same

v_{rms} will be same so, A is correct D is incorrect

$$\frac{P_1}{P_2} = \frac{n_1RT_1/V_1}{n_2RT_2/V_2} = \frac{n_1}{n_2} = \frac{1}{4}$$

B is correct

C is incorrect

71. Answer (4)

Average momentum = $\langle \vec{P} \rangle = 0$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

If temperature is doubled and oxygen atoms are used then

$$v'_{rms} = \sqrt{\frac{3R(2T)}{M/2}} = 4v_{rms}$$

72. Answer (3)

$n = 0.5$

$T = 300$

For v_{rms} to be doubled $T' = 4 \times 300 = 1200$

$\Rightarrow$ Heat transferred

$$= (0.5)\left(\frac{5}{2}\right)(8.32)(900)$$

= 9360 J

73. Answer (3)

$$C_V = \frac{f}{2}R$$

total degree of freedoms = 1 × 3 + 3 × 5 = 18

$$\frac{\alpha^2}{4} = \frac{18}{2n} = \frac{18}{2\times4}$$

$\Rightarrow \alpha^2 = 9$

$\alpha = 3$

74. Answer (3)

At NTP, $T = 298$ K

$$\Rightarrow v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3kN_A \times 298}{5\times10^{-17}\times N_A}}$$

$\simeq 15$ mm/s

75. Answer (4)

$\text{KE}_{avg} = \frac{3}{2}kT$ (At lower temperature)

As temperature is same for both the gases.

$\Rightarrow$ Both gases will have same average kinetic energy.

$$\Rightarrow \frac{(\text{KE}_{avg})_{argon}}{(\text{KE}_{avg})_{oxygen}} = \frac{1}{1}$$

76. Answer (1)

$$C_V = \frac{nR}{2}$$

And $C_P = \frac{nR}{2} + R$

$$\Rightarrow \frac{C_V}{C_P} = \frac{\frac{nR}{2}}{\frac{nR}{2}+R} = \frac{n}{n+2}$$

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