13

Kinetic Theory of Gases

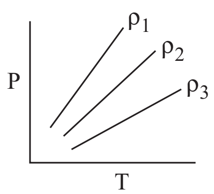
JEE-Main

Ideal Gas Laws

1. The temperature of a gas having 2.0×10^{25} molecules per cubic meter at 1.38 atm (Given, $k = 1.38 \times 10^{-23}$ JK^{-1}) is: **[29 Jan, 2024 (Shift-II)]**
(*a*) 500 K (*b*) 200 K (*c*) 100 K (*d*) 300 K

2. Two vessels A and B are of the same size and are at same temperature. A contains 1g of hydrogen and B contains 1g of oxygen. PA and PB are the pressures of the gases in A and B respectively, then $\frac{P_A}{P_B}$ is: **[29 Jan, 2024 (Shift-I)]**
(*a*) 16 (*b*) 8 (*c*) 4 (*d*) 32

3. P-T diagram of an ideal gas having three different densities ρ_1, ρ_2, ρ_3 (in three different cases) is shown in the figure. Which of the following is correct: **[04 April, 2024 (Shift-I)]**



(*a*) $\rho_2 < \rho_3$ (*b*) $\rho_1 > \rho_2$
(*c*) $\rho_1 < \rho_2$ (*d*) $\rho_1 = \rho_2 = \rho_3$

4. The pressure (P) and temperature (T) relationship of an ideal gas obeys the equation PT^2 = constant. The volume expansion coefficient of the gas will be: **[30 Jan, 2023 (Shift-I)]**
(*a*) $3T$ (*b*) $\frac{3}{T^2}$ (*c*) $\frac{3}{T^3}$ (*d*) $\frac{3}{T}$

5. 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: **[29 June, 2022 (Shift-II)]**
(*a*) 72×10^5 (*b*) 32×10^5 (*c*) 27×10^4 (*d*) 54×10^4

6. When a gas filled in a closed vessel is heated by raising the temperature by 1°C, its pressure increase by 0.4%. The initial temperature of the gas is ______K. **[25 June, 2022 (Shift-II)]**

7. 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: **[27 June, 2022 (Shift-I)]**
(*a*) $\frac{1}{3}$ (*b*) $\frac{3}{1}$ (*c*) $\frac{1}{16}$ (*d*) $\frac{16}{1}$

8. A balloon carries a total load of 185kg at normal pressure and temperature of 27°C. What load with the balloon carry on rising to a height at which the barometer pressure is 45 cm of Hg and the temperature. **[27 Aug, 2021 (Shift-I)]**
(*a*) 279.07 kg (*b*) 214.15 kg (*c*) 181.46 kg (*d*) 123.54 kg

9. 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: **[16 March, 2021 (Shift-I)]**
(*a*) $\frac{3RT}{V}$ (*b*) $\frac{5}{2}\frac{RT}{V}$ (*c*) $\frac{88RT}{V}$ (*d*) $\frac{4RT}{V}$

10. 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 $x \times 10^{-1}$. Value of x is **[26 Feb, 2021 (Shift-I)]**

11. 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) **[31 Aug, 2021 (Shift-I)]**
(*a*) 0°C (*b*) $\frac{aP_0}{eR}$ (*c*) $\frac{P_0}{aeR}$ (*d*) infinity

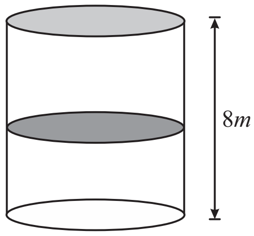
12. The change in the magnitude of the volume of an ideal gas when a small additional pressure ΔP is applied at a constant temperature, is the same as the change when the temperature is reduced by a small quantity ΔT at constant pressure. The initial temperature and pressure of the gas were 300 K and 2 atm. respectively. If $|\Delta T| = C|\Delta P|$ then value of C in (K/atm) is __. **[4 Sep, 2020 (Shift-II)]**

13. 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 $\frac{P_2}{P_1}$ is

[06 Sep, 2020 (Shift-I)]

14. A thermally isolated cylindrical closed vessel of height 8 m is kept vertically. It is divided into two equal parts by a diathermic (perfect thermal conductor) frictionless partition of mass 8.3 kg. Thus the partition is held initially at a distance of 4 m from the top, as shown in the schematic figure below. Each of the two parts of the vessel contains 0.1 mole of an ideal gas at temperature 300 K. The partition is now released and moves without any gas leaking from one part of the vessel to the other. When equilibrium is reached, the distance of the partition from the top (in m) will be _______ .
(Take the acceleration due to gravity =10 ms^{-2} and the universal gas constant = 8.3 J mol^{-1} K^{-1}). **[JEE Advance 2020]**



15. A vertical closed cylinder is separated into two parts by a frictionless piston of mass m and of negligible thickness. The piston is free to move along the length of the cylinder. The length of the cylinder above the piston is l_1, and that below the piston is l_2, such that $l_1 > l_2$. Each part of the cylinder contains n moles of an ideal gas at equal temperature T. If the piston is stationary, its mass, m, will be given by:(R is universal gas constant and g is the acceleration due to gravity) **[12 Jan, 2019 (Shift-II)]**

(*a*) $\frac{RT}{ng}\left[\frac{l_1-3l_2}{l_1l_2}\right]$ (*b*) $\frac{RT}{g}\left[\frac{2l_1+l_2}{l_1l_2}\right]$

(*c*) $\frac{nRT}{ng}\left[\frac{1}{I_2}+\frac{1}{l_1}\right]$ (*d*) $\frac{nRT}{g}\left[\frac{l_1-l_2}{l_{12}}\right]$

16. In a process, temperature and volume of one mole of an ideal monoatomic gas are varied according to the relation $VT = K$, where I is a constant. In this process the temperature of the gas is increased by ΔT. The amount of heat absorbed by gas is (R is gas constant) **[11 Jan, 2019 (Shift-II)]**

(*a*) $\frac{1}{2}R\Delta T$ (*b*) $\frac{1}{2}KR\Delta T$ (*c*) $\frac{3}{2}R\Delta T$ (*d*) $\frac{2K}{3}\Delta T$

RMS, Average and Most Probable Speed

17. At which temperature the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47ºC? **[30 Jan, 2024 (Shift-I)]**

(*a*) 80 K (*b*) –73 K (*c*) 4 K (*d*) 20 K

18. A sample contains mixture of helium and oxygen gas. The ratio of root mean square speed of helium and oxygen in the sample, is: **[06 April, 2024 (Shift-I)]**

(*a*) $\frac{1}{32}$ (*b*) $\frac{2\sqrt{2}}{1}$ (*c*) $\frac{1}{4}$ (*d*) $\frac{1}{2\sqrt{2}}$

19. At temperature 300 K, the rms speed of oxygen molecules is $\sqrt{\frac{\alpha+5}{\alpha}}$ times to that of its average speed in the gas. Then, the value of α will be (use $\pi = \frac{22}{7}$) **[29 Jan, 2023 (Shift-II)]**

(*a*) 32 (*b*) 28 (*c*) 24 (*d*) 27

20. If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 Km/s, the root mean square velocity of oxygen at the same condition in Km/s is: **[1 Feb, 2024 (Shift-II)]**

(*a*) 2.0 (*b*) 0.5 (*c*) 1.5 (*d*) 1.0

21. If the r.m.s. speed of chlorine molecule is 490 m/s at 27°C, the r.m.s. speed of argon molecules at the same temperature will be (Atomic mass of argon = 39.9u, molecular mass of chlorine = 70.9u) **[12 Apr, 2023 (Shift-I)]**

(*a*) 751.7 m/s (*b*) 451.7 m/s (*c*) 651.7 m/s (*d*) 551.7 m/s

22. The root mean square velocity of molecules of a gas is **[25 Jan, 2023 (Shift-I)]**

(*a*) Proportional to square of temperature (T^2).
(*b*) Inversely proportional to square root of temperature $\sqrt{\frac{1}{T}}$
(*c*) Proportional to square root of temperature $\sqrt{T}$
(*d*) Proportional to temperature (T)

23. The rms speed of oxygen molecule in a vessel at particular temperature is $\left(1+\frac{5}{x}\right)^{\frac{1}{2}}\nu$, where ν is the average speed of the molecule. The value of x will be: (Take $\pi = \frac{22}{7}$) **[13 Apr, 2023 (Shift-I)]**

(*a*) 28 (*b*) 27 (*c*) 8 (*d*) 4

24. The temperature of an ideal gas is increased from 200 K to 800 K. If r.m.s. speed of gas at 200 K is v_0. Then, r.m.s. speed of the gas at 800 K will be: **[6 Apr, 2023 (Shift-II)]**

(*a*) v_0 (*b*) $4v_0$ (*c*) $\frac{v_0}{4}$ (*d*) $2v_0$

25. The root mean square speed of molecules of nitrogen gas at 27°C is approximately:
(Given mass of a nitrogen molecule –4.6 × 10^{-26} kg and take Boltzmann constant k_B = 1.4 × 10^{-23} JK^{-1}) **[11 Apr, 2023 (Shift-II)]**

(*a*) 523 *m/s* (*b*) 1260 *m/s* (*c*) 91 *m/s* (*d*) 27.4 *m/s*

26. Given below are two statements:
Statements I: The temperature of a gas is –73ºC. When the gas is heated to 527ºC, the root mean square speed of the molecules is doubled.
Statement II: The product of pressure and volume of an ideal gas will be equal to translational kinetic energy of the molecules.
In the light of the above statements, choose the correct answer from the options given below: **[24 Jan, 2023 (Shift-I)]**

(*a*) Both statement I and Statement II are true
(*b*) Statement I is true but Statement II is false
(*c*) Both Statement I and Statement II are false
(*d*) Statement I is false but Statement II is true

27. Three vessels of equal volume contain gases at the same temperature and pressure. The first vessel contains neon (monoatomic), the second contains chlorine (diatomic) and third contains uranium hexafloride (polyatomic). Arrange these on the basis of their root mean square speed (V_{rms}) and choose the correct answer from the options given below: **[11 Apr, 2023 (Shift-I)]**

(*a*) V_{rms} (mono) = V_{rms} (dia) = V_{rms} (poly)
(*b*) V_{rms} (mono) > V_{rms} (dia) > V_{rms} (poly)
(*c*) V_{rms} (dia) < V_{rms} (poly) < V_{rms} (mono)
(*d*) V_{rms} (mono) < V_{rms} (dia) < V_{rms} (poly)

28. 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 300K will be: **[25 June, 2022 (Shift-I)]**

(*a*) $v_{rms} = \sqrt{\frac{2}{3}} v_p$ (*b*) $v_{rms} = \sqrt{\frac{3}{2}} v_p$
(*c*) $V_{rms} = V_p$ (*d*) $v_{rms} = \sqrt{\frac{1}{3}} v_p$

29. 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? **[28 June, 2022 (Shift-II)]**

(*a*) The velocity of atomic oxygen remains same
(*b*) The velocity of atomic oxygen doubles
(*c*) The velocity of atomic oxygen becomes half
(*d*) The velocity of atomic oxygen becomes four times

30. 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 **[27 July, 2022 (Shift-I)]**

(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

(*a*) A and C only (*b*) B and D only
(*c*) A and B only (*d*) C and D only

31. 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 $k = 138 \times 10^{-23}\ Jk^{-1}$] **[29 July, 2022 (Shift-II)]**

(*a*) 60 mm s^{-1} (*b*) 12 mm s^{-1} (*c*) 15 mm s^{-1} (*d*) 36 mm s^{-1}

32. 0.056 kg of Nitrogen is enclose 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 mole^{-1} K^{-1}) **[24 June, 2022 (Shift-I)]**

33. The rms speed of the molecules of Hydrogen, Oxygen and Carbondioxide at the same temperature are V_{H}, V_{O} and V_{C} respectively then: **[26 Aug, 2021 (Shift-I)]**

(*a*) $V_C > V_O > V_H$ (*b*) $V_H > V_O > V_C$
(*c*) $V_H = V_O = V_C$ (*d*) $V_H = V_O > V_C$

34. 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: **[20 July, 2021 (Shift-I)]**

(*a*) $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$ (*b*) $v_A = v_B = v_C = 0$
(*c*) $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$ (*d*) $v_A = v_B \neq v_C$

35. 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: **[25 Feb, 2021 (Shift-II)]**

(*a*) Statement I is false but Statement II is true.
(*b*) Both Statement I and Statement II are true.
(*c*) Statement I is true but Statement II is false.
(*d*) Both Statement I and Statement II are false.

36. If the rms speed of oxygen molecules at 0°C is 160 m/s, find the rms speed of hydrogen molecules at 0°C. **[27 Aug, 2021 (Shift-II)]**

(*a*) 332 m/s (*b*) 640 m/s (*c*) 40 m/s (*d*) 80 m/s

37. Consider a sample of oxygen behaving like an ideal gas. At 300K, 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 JK^{-1} mol^{-1}) **[18 March, 2021 (Shift-II)]**

(*a*) $\sqrt{\frac{8\pi}{3}}$ (*b*) $\sqrt{\frac{8}{3}}$ (*c*) $\sqrt{\frac{3}{3}}$ (*d*) $\sqrt{\frac{3\pi}{8}}$

38. 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 ________. **[24 Feb, 2021 (Shift-II)]**

39. 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 10Å and 5Å 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 _______ $\times 10^{-2}$. **[25 July, 2021 (Shift-II)]**

40. In a dilute gas at pressure P and temperature T, the mean time between successive collisions of a molecule varies with T as **[6 Sep, 2020 (Shift-II)]**

(*a*) $\sqrt{T}$ (*b*) T (*c*) $\frac{1}{\sqrt{T}}$ (*d*) $\frac{1}{T}$

41. 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 ______.
(Molar mass of N_2 gas 28 g). **[05 Sep, 2020 (Shift-II)]**

42. 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 $\left[\frac{V_{\text{rms}}(\text{helium})}{V_{\text{rms}}(\text{argon})}\right]$, is close to: **[9 Jan, 2019 (Shift-I)]**

(*a*) 3.16 (*b*) 0.32 (*c*) 0.45 (*d*) 2.24

43. The area of a square is 5.29 cm^2. The area of 7 such squares taking into account the significant figures is **[9 April, 2019 (Shift-II)]**

(*a*) 37 cm^2 (*b*) 37.0 cm^2 (*c*) 37.03 cm^2 (*d*) 37.030 cm^2

44. 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: **[9 April, 2019 (Shift-I)]**

(*a*) 80 m/s (*b*) $80\sqrt{5}$ m/s (*c*) 100 m/s (*d*) $100\sqrt{5}$ m/s

45. 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: **[12 April, 2019 (Shift-II)]**

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

46. The temperature, at which the root mean square velocity of hydrogen molecules equals their escape velocity from the earth is closest to: [Boltzmans Constant 23 $k_B = 1.38 \times 10^{-23}$ J / K

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

Radius of Earth: 6.4×10^6 m

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

[8 April, 2019 (Shift-II)]

(*a*) 800 *k* (*b*) 10^4 *K* (*c*) 3×10^5 (*d*) 650 *K*

47. 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: [Take R = 8.3 J/K mole] **[9 Jan, 2019 (Shift-II)]**

(*a*) 0.9 *KJ* (*b*) 6 *KJ* (*c*) 10 *KJ* (*d*) 14 *KJ*

Energy and Pressure of Gas

48. Given below are two statements:

Statement (I): The mean free path of gas molecules is inversely proportional to square of molecular diameter.

Statement (II): Average kinetic energy of gas molecules is directly proportional to absolute temperature of gas.

In the light of the above statements, choose the correct answer from the option given below: **[08 April, 2024 (Shift-II)]**

(*a*) Statement I is false but Statement II is true.
(*b*) Statement I is true but Statement II is false.
(*c*) Both Statement I and Statement II are false
(*d*) Both Statement I and Statement II are true.

49. A flask contains hydrogen and oxygen in the ratio of 2 : 1 by mass at temperature 27ºC. The ratio of average kinetic energy per molecule of hydrogen and oxygen respectively is: **[30 Jan, 2023 (Shift-II)]**

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

50. A flask contains Hydrogen and Argon in the ratio 2 : 1 by mass. The temperature of the mixture is 30°C. The ratio of average kinetic energy per molecule of the two gases (K argon/K hydrogen) is: (Given: Atomic Weight of Ar = 39.9) **[15 Apr, 2023 (Shift-I)]**

(*a*) 1 (*b*) 2 (*c*) $\frac{39.9}{2}$ (*d*) 39.9

51. The temperature at which the kinetic energy of oxygen molecules becomes double than its value at 27°C is **[8 Apr, 2023 (Shift-II)]**

(*a*) 1227° C (*b*) 927ºC (*c*) 327°C (*d*) 627° C

52. The average kinetic energy of a molecule of the gas is **[1 Feb, 2023 (Shift-I)]**

(*a*) Proportional to absolute temperature
(*b*) Proportional to volume
(*c*) Proportional to pressure
(*d*) Dependent on the nature of the gas

53. According to kinetic theory of gases, **[27 June, 2022 (Shift-II)]**

(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: **[27 June, 2022 (Shift-II)]**

(*a*) *A* and *C* only (*b*) *B* and *C* only
(*c*) *A* and *B* only (*d*) *C* and *D* only

54. Following statements are given: **[25 July, 2022 (Shift-I)]**

(A) The average kinetic energy of a gas molecule decreases when the temperature is reduced.
(B) The average kinetic energy of a gas molecule increases with increase in pressure at constant temperature.
(C) The average kinetic energy of a gas molecule decreases with increase in volume.
(D) Pressure of a gas increases with increase in temperature at constant pressure.
(E) The volume of gas decreases with increase in temperature.

Choose the correct answer from the options given below:

(*a*) (A) and (D) only (*b*) (A), (B) and (D) only
(*c*) (B) and (D) only (*d*) (A), (B) and (E) only

55. 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 doubles and the oxygen molecules dissociate into oxygen atoms, the rms speeds will become 2*v*. In the light of the above statements, choose the correct answer from the options given below: **[28 July, 2022 (Shift-I)]**

(*a*) Both Statement I and Statement II are true
(*b*) Both Statement I and Statement II are false
(*c*) Statements I is true but Statement II is false
(*d*) Statement I is false but Statement II is true

56. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules: **[24 Feb, 2021 (Shift-II)]**

(*a*) Continuously lose their energy till it reaches wall.
(*b*) Suffer change in momentum when impinge on the walls of container.
(*c*) Are attracted by the walls of container.
(*d*) Continuously stick to the walls of container.

57. The number of molecules in one litre of an ideal gas at 300 *K* and 2 atmospheric pressure with mean kinetic energy 2×10^{-9} J per molecule is: **[27 July, 2021 (Shift-I)]**

(*a*) 0.75×10^{11} (*b*) 3×10^{11} (*c*) 6×10^{11} (*d*) 1.5×10^{11}

58. A mono-atomic 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 **[25 Feb, 2021 (Shift-I)]**

59. 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)

[5 Sep, 2020 (Shift-I)]

(*a*) 5.8×10^{18} (*b*) 4.0×10^{16} (*c*) 5.8×10^{16} (*d*) 4.0×10^{18}

60. 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 _________. **[04 Sep, 2020 (Shift-I)]**

61. 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: **[9 April, 2019 (Shift-I)]**

(*a*) $\frac{m\bar{v}^2}{3k_B}$ (*b*) $\frac{m\bar{v}^2}{7k_B}$ (*c*) $\frac{m\bar{v}^2}{5k_B}$ (*d*) $\frac{m\bar{v}^2}{6k_B}$

Equipartion Theory, Degrees of Freedom, Specific Heat Capacity

62. The average kinetic energy of a monatomic molecule is 0.414 eV at temperature: **[27 Jan, 2024 (Shift-I)]**

(Use $K_B = 1.38 \times 10^{-23}$ J/mol-K)

(*a*) 3000 K (*b*) 3200 K (*c*) 1600 K (*d*) 1500 K

63. The total kinetic energy of 1 mole of oxygen at 27° C is:

[Use universal gas constant (R) = 8.31 J/mole K]

[27 Jan, 2024 (Shift-II)]

(*a*) 6845.5 J (*b*) 5942.0 J (*c*) 6232.5 J (*d*) 5670.5 J

64. N moles of a polyatomic gas ($f = 6$) must be mixed with two moles of a monoatomic gas so that the mixture behaves as a diatomic gas. The value of N is: **[29 Jan, 2024 (Shift-II)]**

(*a*) 6 (*b*) 3 (*c*) 4 (*d*) 2

65. The parameter that remains the same for molecules of all gases at a given temperature is: **[31 Jan, 2024 (Shift-I)]**

(*a*) kinetic energy (*b*) momentum

(*c*) mass (*d*) speed

66. A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature T. Neglecting all vibrational modes, the total internal energy of the system is **[31 Jan, 2024 (Shift-II)]**

(*a*) 29 RT (*b*) 20 RT (*c*) 27 RT (*d*) 21 RT

67. Two moles a monoatomic gas is mixed with six moles of a diatomic gas. The molar specific heat of the mixture at constant volume is: **[1 Feb, 2024 (Shift-I)]**

(*a*) $\frac{9}{4}R$ (*b*) $\frac{7}{4}R$ (*c*) $\frac{3}{2}R$ (*d*) $\frac{5}{2}R$

68. The translational degrees of freedom (f_t) and rotational degrees of freedom (f_r) of CH_4 molecule are: [04 April, 2024 (Shift-II)]

(*a*) $f_t = 2$ and $f_r = 2$ (*b*) $f_t = 3$ and $f_r = 3$

(*c*) $f_t = 3$ and $f_r = 2$ (*d*) $f_t = 2$ and $f_r = 3$

69. Energy of 10 non rigid diatomic molecules at temperature T is:

[06 April, 2024 (Shift-II)]

(*a*) $\frac{7}{2}RT$ (*b*) 70 K_BT (*c*) 35 RT (*d*) 35 K_BT

70. A mixture of one mole of monoatomic gas and one mole of a diatomic gas (rigid) are kept at room temperature (27°C). The ratio of specific heat of gases at constant volume respectively is:

[08 April, 2024 (Shift-I)]

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

71. The temperature of a gas is –78°C and the average translational kinetic energy of its molecules is K. The temperature at which the average translational kinetic energy of the molecules of the same gas becomes $2K$ is: **[09 April, 2024 (Shift-II)]**

(*a*) –39°C (2) 117°C (*c*) 127°C (4) –78°C

72. A closed container contains a homogeneous mixture of two moles of an ideal montomic gas ($\gamma = 5/3$) and one mole of an ideal diatomic gas ($\gamma = 7/5$). Here, γ is the ratio of the specific heats at constant pressure and constant volume of an ideal gas. The gas mixture does a work of 66 Joule when heated at constant pressure. The change in its internal energy is______ Joule. **[JEE Advance 2023]**

73. Let γ_1 be the ratio of molar specific heat at constant pressure and molar specific heat at constant volume of a monoatomic gas and γ_2 be the similar ratio of diatomic gas. Considering the diatomic gas molecule as a rigid rotator, the ratio, $\frac{\gamma_1}{\gamma_2}$ is

[24 Jan, 2023 (Shift-II)]

(*a*) $\frac{27}{35}$ (*b*) $\frac{35}{27}$ (*c*) $\frac{25}{21}$ (*d*) $\frac{21}{25}$

74. According to law of equipartition of energy the molar specific heat of a diatomic gas at constant volume where the molecule has one additional vibrational mode is: **[25 Jan, 2023 (Shift-II)]**

(*a*) $\frac{9}{2}R$ (*b*) $\frac{5}{2}R$ (*c*) $\frac{3}{2}R$ (*d*) $\frac{7}{2}R$

75. A gas mixture consists of 2 moles of oxygen and 4 moles of neon at temperature T. Neglecting all vibrational modes, the total internal energy of the system will be: **[10 Apr, 2023 (Shift-II)]**

(*a*) 8 RT (*b*) 16 RT (*c*) 4 RT (*d*) 11 RT

76. Heat energy of 735 J is given to a diatomic gas allowing the gas to expand at constant pressure. Each gas molecule rotates around an internal axis but do not oscillate. The increase in the internal energy of the gas will be: **[31 Jan, 2023 (Shift-II)]**

(*a*) 525 J (*b*) 441 J (*c*) 572 J (*d*) 735 J

77. The correct relation between $\gamma = \frac{C_p}{c_v}$ and temperature T is:

[31 Jan, 2023 (Shift-I)]

(*a*) $\gamma \propto \frac{1}{\sqrt{T}}$ (*b*) $\gamma \propto T^o$ (*c*) $\gamma \propto \frac{1}{T}$ (*d*) $\gamma \propto T$

78. Match List-I with List-II:

	List-I		List-II
A.	3 Translational degrees of freedom	I.	Monoatomic gases
B.	3 Translational, 2 rotational degrees of freedoms	II.	Polyatomic gases
C.	3 Translational, 2 rotational and 1 vibrational degrees of freedom	III.	Rigid diatomic gases
D.	3 Translational, 3 rotational and more than one vibrational degrees of freedom	IV.	Nonrigid diatomic gases

Choose the correct answer from the options given below:

[10 Apr, 2023 (Shift-I)]

(*a*) A → IV; B → III; C → II; D → I
(*b*) A → IV; B → II; C → I; D → III
(*c*) A → I; B → III; C → IV; D → II
(*d*) A → I; B → IV; C → III; D → II

79. 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:

[25 July, 2022 (Shift-II)]

(*a*) 1 (*b*) 2 (*c*) 3 (*d*) 4

80. A vessel contains 14 g of nitrogen gas at a temperature of 27ºC. The amount of heat to be transferred to the gas to double the r.m.s speed of its molecules will be: Take $R = 8.32$ J mole^{-1} k^{-1}.

[28 July, 2022 (Shift-II)]

(*a*) 2229 J (*b*) 5616 J (*c*) 9360 J (*d*) 13,104 J

81. A small object is placed at the center of a large evacuated hollow spherical container. Assume that the container is maintained at 0 *K*. At time $T = 0$, the temperature of the object is 200 *K*. The temperature of the object becomes 100 *K* at $t = t_1$ and at 50 *K*. Assume the object and the container to be ideal black bodies. The heat capacity of the object does not depend on temperature. The ratio (t_2/t_1) is **[JEE Adv. 2021]**

82. 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 mass *m*/4. The ratio of the specific heats (C_V^A and C_V^B) of gas *A* and *B*, respectively is: **[9 Jan, 2020 (Shift-I)]**

(*a*) 3 : 5 (*b*) 5 : 7 (*c*) 7 : 9 (*d*) 5 : 9

83. Consider a mixture of n moles of helium gas and 2*n* moles of oxygen gas (molecules taken to be rigid) as an ideal gas. It C_P/C_V value will be: **[8 Jan, 2020 (Shift-II)]**

(*a*) 19/13 (*b*) 40/27 (*c*) 67/45 (*d*) 23/15

84. 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: **[7 Jan, 2020 (Shift-I)]**

(*a*) 1.42 (*b*) 1.47 (*c*) 1.45 (*d*) 1.50

85. Match the C_p/C_v ratio for ideal gases with different type of molecules **[4 Sep, 2020 (Shift-I)]**

Molecule Type		C_p/C_v	
A.	Monoatomic	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

(*a*) A → II, B → III, C → I, D → IV
(*b*) A → IV, B → II, C → I, D → III
(*c*) A → IV, B → I, C → II, D → III
(*d*) A → III, B → IV, C → II, D → I

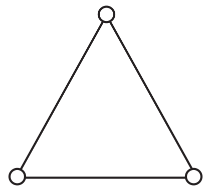
86. To raise the temperature of a certain mass of gas by 50°C at a constant pressure, 160 calories of heat is required. When the same mass of gas is cooled by 100°C at constant volume, 240 calories of heat is released. How many degrees of freedom does each molecule of this gas have (assume gas to be ideal)? **[3 Sep, 2020 (Shift-II)]**

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

87. 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 **[2 Sep, 2020 (Shift-I)]**

(*a*) 13 (*b*) 15 (*c*) 20 (*d*) 11

88. 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 **[3 Sep, 2020 (Shift-I)]**



(*a*) 3*RT* (*b*) $\frac{9}{2}RT$ (*c*) $\frac{3}{2}RT$ (*d*) $\frac{5}{2}RT$

89. 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 **[6 Sep, 2020 (Shift-I)]**

(*a*) $U = 5RT$ and $\gamma = \frac{7}{5}$ (*b*) $U = \frac{5}{2}RT$ and $\gamma = \frac{6}{5}$
(*c*) $U = 5RT$ and $\gamma = \frac{6}{5}$ (*d*) $U = \frac{5}{2}RT$ and $\gamma = \frac{7}{5}$

90. An ideal gas occupies a volume of 2 m^3 at a pressure of 3×10^6 Pa. The energy of the gas is: **[12 Jan, 2019 (Shift-I)]**

(*a*) 9×10^6 J (*b*) 6×10^4 J
(*c*) 10^8 J (*d*) 3×10^2 J

91. An unknown metal of mass 192 g heated to a temperature of 100ºC was immersed into a brass calorimeter of mass 128 g containing 240 g of water at a temperature of 8.4°C. Calculate the specific heat of the unknown metal if water temperature stabilizes at 21.5°C. (Specific heat of brass is 394 J kg^{-1} K^{-1}): **[10 Jan, 2019 (Shift-II)]**

(*a*) 458 J kg^{-1} K^{-1} (*b*) 1232 J kg^{-1} K^{-1}
(*c*) 916 J kg^{-1} K^{-1} (*d*) 654 J kg^{-1} K^{-1}

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

[11 Jan, 2019 (Shift-I)]

(*a*) 15 RT (*b*) 12 RT (*c*) 4 RT (*d*) 20 RT

93. 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: [Take R = 8.3 J/K mole]

[9 Jan, 2019 (Shift-II)]

(*a*) 0.9 kJ (*b*) 6 kJ (*c*) 10 kJ (*d*) 14 kJ

Mean Free Path

94. If the collision frequency of hydrogen molecules in a closed chamber at 27°C is Z, then the collision frequency of the same system at 127°C is: **[05 April, 2024 (Shift-I)]**

(*a*) $\frac{\sqrt{3}}{2}Z$ (*b*) $\frac{4}{3}Z$

(*c*) $\frac{2}{\sqrt{3}}Z$ (*d*) $\frac{3}{4}Z$

95. If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e. mean free path) is represented by: **[05 April, 2024 (Shift-II)]**

(*a*) $\frac{1}{\sqrt{2n\pi d^2}}$ (*b*) $\sqrt{2}n\pi d^2$

(*c*) $\frac{1}{\sqrt{2}n\pi d^2}$ (*d*) $\frac{1}{\sqrt{2}n^2\pi^2 d^2}$

96. The mean free path of molecules of a certain gas at STP is 1500d, where d is the diameter of the gas molecules. While maintaining the standard pressure, the mean free path of the molecules at 373K is approximately: **[13 Apr, 2023 (Shift-II)]**

(*a*) 1098 d (*b*) 2049 d (*c*) 750 d (*d*) 1500 d

97. The number of air molecules per cm^3 increased from 3×10^{19} to 12×10^{19}. The ratio of collision frequency of air molecules before and after the increase in number respectively is **[06 Apr, 2023 (Shift-I)]**

(*a*) 1.25 (*b*) 0.25 (*c*) 0.75 (*d*) 0.50

98. Calculate the value of mean free path (λ) 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}) **[16 March, 2021 (Shift-II)]**

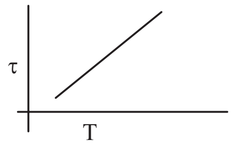
(*a*) 58 nm (*b*) 86 nm (*c*) 32 nm (*d*) 102 nm

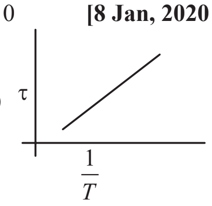
99. An ideal gas in a closed container is slowly heated. As its temperature increases, which of the following statements are true? **[2 Sep, 2020 (Shift-II)]**

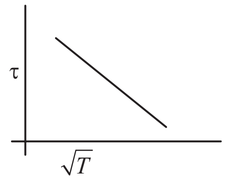
A. The mean free path of the molecules decreases.
B. The mean collision time between the molecules decreases.
C. The mean free path remains unchanged.
D. The mean collision time remains unchanged

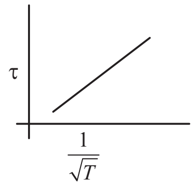
(*a*) C and D (*b*) A and D (*c*) B and C (*d*) A and B

100. 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) 0 **[8 Jan, 2020 (Shift-I)]**

(*a*)


(*b*)


(*c*)


(*d*)


101. 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: **[9 Jan, 2020 (Shift-II)]**

(*a*) 1.83 (*b*) 2.3 (*c*) 3.67 (*d*) 4.67

102. 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? **[10 April, 2019 (Shift-I)]**

(*a*) $\sim 10^{10}$ (*b*) $\sim 10^{11}$ (*c*) $\sim 10^{12}$ (*d*) $\sim 10^{13}$

JEE-Advanced

RMS and KTG

Single Correct

1. Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is **C-65.69, W-32.21, UA-2.11 (JEE Adv. 2013)**

(*a*) 1: 4 (*b*) 1: 2 (*c*) 6 : 9 (*d*) 8 : 9

2. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the root mean square velocity of the gas molecules is v, at 480 K it becomes **(IIT-JEE 1996)**

(*a*) 4 v (*b*) 2 v (*c*) v/2 (*d*) v/4

3. The average translational kinetic energy of O_2 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational kinetic energy of N_2 (molar mass 28) molecules in eV at the same temperature is **(IIT-JEE 1997)**

(*a*) 0.0015 (*b*) 0.003 (*c*) 0.048 (*d*) 0.768

4. The average translational energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J and 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour) **(IIT-JEE 1997)**

(*a*) 12.42×10^{-21} J,968 m/s (*b*) 8.78×10^{-21} J,684 m/s

(*c*) 6.21×10^{-21} J,968 m/s (*d*) 12.42×10^{-21} J,684 m/s

5. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to per N_2 molecule is **(IIT-JEE 1998)**

(*a*) 1 : 1 (*b*) 1 : 2 (*c*) 2 : 1

(*d*) depends on the moment of inertia of the two molecules

6. Three closed vessels A, B and C at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of the O_2 molecules in vessel A is v_1, that of the N_2 molecules in vessel B is v_2, the average speed of the O_2 molecules in vessel C is **(IIT-JEE 1992)**

(*a*) $(v_1 + v_2)/2$ (*b*) v_1 (*c*) $(v_1 v_2)^{½}$ (*d*) $\sqrt{3kT/M}$

Multiple Correct

7. A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statements is/are **(JEE Adv. 2015)**

(*a*) The average energy per mole of the gas mixture is $2RT$

(*b*) The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{\frac{6}{5}}$

(*c*) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $\frac{1}{2}$

(*d*) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $\frac{1}{\sqrt{2}}$

8. Let $\bar{v}$, v_{ms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then, **(IIT-JEE 1998)**

(*a*) no molecule can have a speed greater than $\sqrt{2}v_{\text{ms}}$

(*b*) no molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

(*c*) $v_p < \bar{v} < v_{\text{rms}}$

(*d*) the average kinetic energy of a molecule is $\frac{3}{4}mv_P^2$

Subjective

9. A cubical box of side 1 m contains helium gas (atomic weight 4) at a pressure of 100 N/m^2 . During an observation time of 1 s, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 500 hits with a particular wall, without any collision with other atoms. Take, **(IIT-JEE 2002)**

$R = \frac{25}{3}$ J/mol-K and $k = 1.38 \times 10^{-23}$ J/K.

(*a*) Evaluate the temperature of the gas.

(*b*) Evaluate the average kinetic energy per atom.

(*c*) Evaluate the total mass of helium gas in the box.

10. One gram mole of oxygen at 27°C and one atmospheric pressure is enclosed in a vessel. **(IIT-JEE 1983)**

(*a*) Assuming the molecules to be moving with v_{ms}, find the number of collisions per second which the molecules make with one square meter area of the vessel wall.

(*b*) The vessel is next thermally insulated and moved with a constant speed v_0. It then suddenly stopped. The process results in a rise of the temperature of the gas by 1°C. Calculate the speed v_0.

True/False

11. The root mean square (rms) speed of oxygen molecules (O_2) at a certain temperature T (degree absolute) is V. If the temperature is doubled and oxygen gas dissociates into atomic oxygen, the rms speed remains unchanged. **(IIT-JEE 1987)**

12. The root mean square speeds of the molecules of different ideal gases, maintained at the same temperature are the same. **(IIT-JEE 1981)**

13. Two different gases at the same temperature have equal root mean square velocities. **(IIT-JEE 1982)**

Assertion and Reason

14. **Assertion (A):** The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

Reason (R): The molecules of a gas collide with each other and the velocities of the molecules change due to the collision. **(IIT-JEE 2007)**

(*a*) Both A and R are correct and R is the correct explanation of A

(*b*) Both A and R are correct and R is not the correct explanation of A

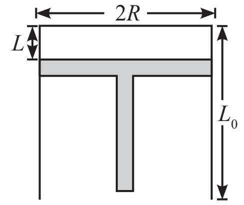
(*c*) A is correct but R is not correct

(*d*) A is not correct but R is correct

Gas Law

Paragraph for Q.No. 72 to 74

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is p_0.



15. The piston is now pulled out slowly and held at a distance $2L$ from the top. The pressure in the cylinder between its top and the piston will be

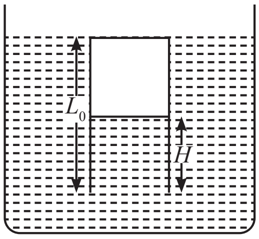
(*a*) p_0 (*b*) $\frac{p_0}{2}$ (*c*) $\frac{p_0}{2} + \frac{Mg}{\pi R^2}$ (*d*) $\frac{p_0}{2} - \frac{Mg}{\pi R^2}$

16. While the piston is at a distance $2L$ from the top, the hole at the top is sealed. The piston is then released to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is **(IIT-JEE 2007)**

(*a*) $\left(\frac{2p_0\pi R^2}{\pi R^2 p_0 + Mg}\right)(2L)$ (*b*) $\left(\frac{p_0\pi R^2 - Mg}{\pi R^2 p_0}\right)(2L)$

(*c*) $\left(\frac{p_0\pi R^2 + Mg}{\pi R^2 p_0}\right)(2L)$ (*d*) $\left(\frac{p_0\pi R^2}{\pi R^2 p_0 - Mg}\right)(2L)$

17. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as show in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies **(IIT-JEE 2007)**



(a) $\rho g(L_0 - H)^2 + p_0(L_0 - H) + L_0 p_0 = 0$

(b) $\rho g(L_0 - H)^2 - p_0(L_0 - H) - L_0 p_0 = 0$

(c) $\rho g(L_0 - H)^2 + p_0(L_0 - H) - L_0 p_0 = 0$

(d) $\rho g(L_0 - H)^2 - p_0(L_0 - H) + L_0 p_0 = 0$

18. A vessel contains 1 mole of O_2 gas (molar mass 32) at a temperature T. The pressure of the gas is p. An identical vessel containing one mole of the gas (molar mass 4) at a temperature $2T$ has a pressure of **(IIT-JEE 1997)**

(a) $p/8$ (b) p (c) $2\,p$ (d) $8\,p$

Multiple Correct

19. From the following statements concerning ideal gas at any given temperature T, select the correct one (s). **(IIT-JEE 1995)**

(a) The coefficient of volume expansion at constant pressure is the same for all ideal gases

(b) The average translational kinetic energy per molecule of oxygen gas is 3 kT, k being Boltzmann constant

(c) The mean-free path of molecules increases with decrease in the pressure

(d) In a gaseous mixture, the average translational kinetic energy of the molecules of each component is different

Numerical Types/Integer Types

20. A gas thermometer is used as a standard thermometer for measurement of temperature. When the gas container of the thermometer is immersed in water at its triple point 273.16K, the pressure in the gas thermometer reads 3.0×10^4 N/m^2. When the gas container of the same thermometer is immersed in another system, the gas pressure reads 3.5×10^4 N/m^2. The temperature of this system is therefore…………C. **(IIT-JEE 1997)**

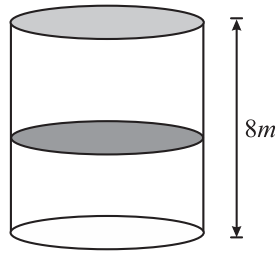
21. A closed container of volume 0.02m^3 contains a mixture of neon and argon gases, at a temperature of 27°C and pressure of 1×10^5Nm^{-2}. The total mass of the mixture is 28g. If the molar masses of neon and argon are 20 and 40g mol^{-1} respectively, find the masses of the individual gases in the container assuming them to be ideal.
(Universal gas constant = 8.314 J/mol – K). **(IIT-JEE 1994)**

22. A thin tube of uniform cross-section is sealed at both ends. It lies horizontally, the middle 5cm containing mercury and the two equal ends containing air at the same pressure p. When the tube is held at an angle of 60° with the vertical direction, the length of the air column above and below the mercury column are 46cm and 44.5cm respectively. Calculate the pressure p in centimeters of mercury. (The temperature of the system is kept at 30°C). **(IIT-JEE 1986)**

23. Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0°C and a pressure of 76cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in a water bath maintained at 62°C . What is the new value of the pressure inside the bulbs? The volume of the connecting tube is negligible. **(IIT-JEE 1985)**

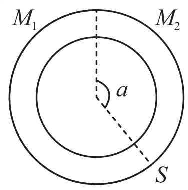
Fill in the Blanks

24. A thermally isolated cylindrical closed vessel of height 8 m is kept vertically. It is divided into two equal parts by a diathermic (perfect thermal conductor) frictionless partition of mass 8.3 kg. Thus the partition is held initially at a distance of 4 m from the top, as shown in the schematic figure below. Each of the two parts of the vessel contains 0.1 mole of an ideal gas at temperature 300 K. The partition is now released and moves without any gas leaking from one part of the vessel to the other. When equilibrium is reached, the distance of the partition from the top (in m) will be _______ .
(Take the acceleration due to gravity =10 ms^{-2} and the universal gas constant = 8.3 J mol^{-1} K^{-1}). **(JEE Adv. 2020)**



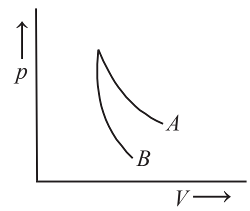
25. During an experiment, an ideal gas is found to obey an additional law p^2V = constant. The gas is initially at a temperature T and volume V. When it expands to a volume $2V$, the temperature becomes ……… . **(IIT-JEE 1987)**

26. A ring shaped tube contains two ideal gases with equal masses and relative molar masses $M_1 = 32$ and $M_2 = 28$. The gases are separated by one fixed partition and another movable stopper S which can move freely without friction inside the ring. The angle as shown in the figure is........... degrees. **(IIT-JEE 1997)**



True/False

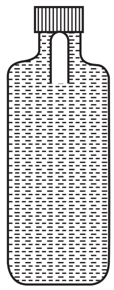
27. The curves A and B in the figure show p-V graphs for an isothermal and an adiabatic process for an ideal gas. The isothermal process is represented by the curve A. **(IIT-JEE 1985)**



Comprehension Based/Passage Based

A soft plastic bottle, filled with water of density 1gm/cc, carries an inverted glass test-tube with some air (ideal gas) trapped as shown in the figure. The test-tube has a mass of 5gm, and it is made of a thick glass of density 2.5gm/cc.

Initially the bottle is sealed at atmospheric pressure $p_0 = 10^5$ Pa so that the volume of the trapped air is $v_0 = 3.3$cc. When the bottle is squeezed from outside at constant temperature, the pressure inside rises and the volume of the trapped air reduces. It is found that the test tube begins to sink at pressure $p_0 + \Delta p$ without changing its orientation. At this pressure, the volume of the trapped air is $v_0 - \Delta v$. Let $\Delta v = X$cc and $\Delta p = Y \times 10^3$ Pa.



28. The value of X is ___ C5.14 W-62.38 UA-32.48 **(JEE Adv. 2021)**

29. The value of Y is ___ C3.29 W-63.79 UA-32.92 **(JEE Adv. 2021)**

Internal Energy, Specific Heat, Degrees of Freedom

Single Correct

30. An ideal gas is in thermodynamic equilibrium. The number of degrees of freedom of a molecule of the gas is n. The internal energy of one mole of the gas is U_n and the speed of sound in the gas is v_n. At a fixed temperature and pressure, which of the following is the correct option? **C-29.36, W-30.17, UA-40.47 (JEE Adv. 2023)**

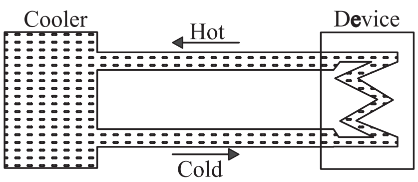
(*a*) $v_3 < v_6$ and $U_3 > U_6$

(*b*) $v_5 > v_3$ and $U_3 > U_5$

(*c*) $v_5 > v_7$ and $U_5 < U_7$

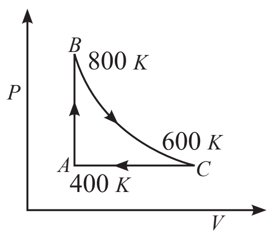
(*d*) $v_6 < v_7$ and $U_6 < U_7$

31. A water cooler of storage capacity 120 litres can cool water at a constant rate of P watts. In a closed circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3kW of heat (thermal load). The temperature of water fed into the device cannot exceed 30°C and the entire stored 120 litres of water is initially cooled to 10°C. The entire system is thermally insulated. The minimum value of P (in watts) for which the device can be operated for 3 hours is (Specific heat of water is 4.2 kJ^{-1}K^{-1} and the density of water is 1000 kg m^{-3}) **C-11.2, W-21.48, UA-67.32 (JEE Adv. 2016)**



(*a*) 1600 (*b*) 2067 (*c*) 2533 (*d*) 3933

32. One mole of diatomic ideal gas undergoes a cyclic process ABC as shown in figure. The process BC is adiabatic. The temperatures at A, B and C are 400 K, 800 K and 600 K respectively. Choose the correct statement: **(JEE Adv. 2014)**



(*a*) The change in internal energy in the process AB is -350R

(*b*) The change in internal energy in the process BC is -500R.

(*c*) The change in internal energy in whole cyclic process is 250R.

(*d*) The change in internal energy in the process CA is 700R.

33. Water of volume 2L in a container is heated with a coil of 1kW at 27°C. The lid of the container is open and energy dissipates at rate of 160J/s. In how much time temperature will rise from 27°C to 77°C? [Specific heat of water is 4.2 kJ/kg] **(IIT-JEE 2005)**

(*a*) 8 min 20 s (*b*) 6 min 2 s (*c*) 7 min (*d*) 14 min

34. 2 kg of ice at –20°C is mixed with 5 kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/°C and 0.5 kcal/kg/°C while the latent heat of fusion of ice is 80 kcal/g. **(IIT-JEE 2003)**

(*a*) 7 kg (*b*) 6 kg (*c*) 4 kg (*d*) 2 kg

35. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is **(IIT-JEE 1999)**

(*a*) 4 RT (*b*) 15 RT (*c*) 9 RT (*d*) 11 RT

36. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300 K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is **(IIT-JEE 1998)**

(*a*) 30 K (*b*) 18 K (*c*) 50 K (*d*) 42 K

37. If one mole of a monoatomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is **(IIT-JEE 1988)**

(*a*) 1.40 (*b*) 1.50 (*c*) 1.53 (*d*) 3.07

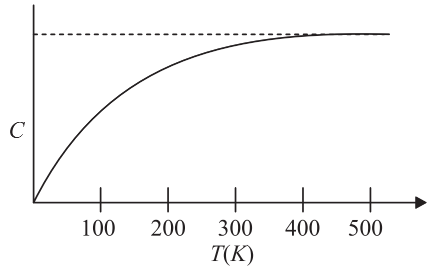
38. 70 cal of heat are required to raise the temperature of 2 moles of an ideal diatomic gas at constant pressure from 30°C to 35°C. The amount of heat required (in calorie) to raise the temperature of the same gas through the same range (30°C to 35°C) at constant volume is **(IIT-JEE 1986)**

(*a*) 30 (*b*) 50 (*c*) 70 (*d*) 90

Multiple Correct

39. The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500K at a constant rate. Ignoring any volume change, the following statement(s) is (are) correct to reasonable approximation.

C-22.11, W-43.12, UA-34.77 (JEE Adv. 2013)



(*a*) The rate at which heat is absorbed in the range 0–200K varies linearly with temperature T

(*b*) Heat absorbed in increasing the temperature from 0–100K is less than the heat required for increasing the temperature from 400–500K

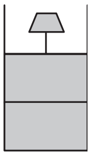
(*c*) There is no change in the rate of heat absorption in the range 400–500K

(*d*) The rate of heat absorption increases in the range 200–300K

Comprehension Based/Passage Based

40. In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat.

The lower compartment of the container is filled with 2 moles of an ideal monoatomic gas at 700K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400K. The heat capacities per mole of an ideal monoatomic gas are $C_V = \frac{3}{2}R, C_p = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_V = \frac{5}{2}R, C_p = \frac{7}{2}R$.



Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be **C-4.88, W-47.62, UA-47.5 (JEE Adv. 2014)**

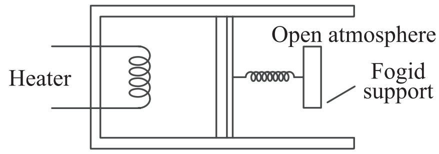
(*a*) 550K (*b*) 525K (*c*) 513K (*d*) 490K

Numerical Types/Integer Types

41. An ideal gas has a specific heat at constant pressure $C_p = \frac{5R}{2}$. The gas is kept in a closed vessel of volume 0.0083 m^3, at a temperature of 300K and a pressure of 1.6×10^6 N/m^2. An amount of 2.49×10^4 J of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas. **(IIT-JEE 1987)**

42. A 5m long cylindrical steel wire with radius 2×10^{-3}m is suspended vertically from a rigid support and carries a bob of mass 100kg at the other end. If the bob gets snapped, calculate the change in temperature of the wire ignoring losses. (For the steel wire : Young's modulus 5.1×10^{11} Pa. Density = 7860 kg/m^3; Specific heat = 420 J/kg – K) **(IIT-JEE 2001)**

43. An ideal mono atomic gas is confined in a cylinder by a spring-loaded piston of cross-section $8.0 \times 10^{-3} m^3$. Initially the gas is at 300K and occupies a volume of $2.4 \times 10^{-3} m^3$ and the spring is in its relaxed (unstretched, uncompressed) state. The gas is heated by a small electric heater until the piston moves out slowly by 0.1m.



Calculate the final temperature of the gas and the heat supplied (in joules) by the heater. The force constant of the spring is 8000 N/m, and the atmospheric pressure 1.0×10^5 Nm^{-2}. The cylinder and the piston are thermally insulated. The piston is massless and there is no friction between the piston and the cylinder. Neglect heat loss through the lead wires of the heater. The heat capacity of the heater coil is negligible. Assume the spring to be massless.

(IIT-JEE 1989)

44. A lead bullet just melts when stopped by an obstacle. Assuming that 25 per cent of the heat is absorbed by the obstacle, find the velocity of the bullet if its initial temperature is 27°C. **(IIT-JEE 1981)**

Fill in the Blanks

45. A substance of mass M kg requires a power input of P watts to remain in the molten state at its melting point. When the power source is turned off, the sample completely solidifies in time t seconds. The latent heat of fusion of the substance is.... **(IIT-JEE 1992)**

46. 300g of water at 25°C is added to 100g of ice at 0°C. The final temperature of the mixture is ....°C. **(IIT-JEE 1989)**

47. One mole of a monoatomic ideal gas is mixed with one mole of a diatomic ideal gas. The molar specific heat of the mixture at constant volume is …… . **(IIT-JEE 1984)**

48. A closed container contains a homogeneous mixture of two moles of an ideal monotonic gas ($\gamma = 5/3$) and one mole of an ideal diatomic gas ($\gamma = 7/5$). Here, γ is the ratio of the specific heats at constant pressure and constant volume of an ideal gas. The gas mixture does a work of 66 Joule when heated at constant pressure. The change in its internal energy is______ Joule.

C-10.26 W-60.44 UA-29.3 [JEE Adv. 2023]

Subjective

49. An insulated box containing a monoatomic gas of molar mass M moving with a speed v_0 is suddenly stopped. Find the increment in gas temperature as a result of stopping the box. **(IIT-JEE 2003)**

50. A solid sphere of copper of radius R and a hollow sphere of the same material of inner radius r and outer radius R are heated to the same temperature and allowed to cool in the same environment. Which of them starts cooling faster? **(IIT-JEE 1982)**

Integer Type

51. A small object is placed at the center of a large evacuated hollow spherical container. Assume that the container is maintained at 0 K. At time $t = 0$, the temperature of the object is 200 K. The temperature of the object becomes 100 K at $t = t_1$ and 50 K at $t = t_2$. Assume the object and the container to be ideal black bodies. The heat capacity of the object does not depend on temperature. The ratio (t_2/t_1) is **C-2.71 W-80.51 UA-16.78 (JEE Adv. 2021)**

ANSWER KEY

JEE-Main

1. (*a*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*c*)	**6.** [250]	**7.** (*b*)	**8.** (*d*)	**9.** (*b*)	**10.** [26]
11. (*c*)	**12.** [150]	**13.** [05.00]	**14.** [6]	**15.** (*d*)	**16.** (*a*)	**17.** (*d*)	**18.** (*b*)	**19.** (*b*)	**20.** (*b*)
21. (*c*)	**22.** (*c*)	**23.** (*a*)	**24.** (*d*)	**25.** (*a*)	**26.** (*b*)	**27.** (*b*)	**28.** (*b*)	**29.** (*b*)	**30.** (*c*)
31. (*c*)	**32.** [12]	**33.** (*b*)	**34.** (*c*)	**35.** (*c*)	**36.** (*b*)	**37.** (*d*)	**38.** [400]	**39.** [25]	**40.** (*c*)
41. [40.93]	**42.** (*a*)	**43.** (*b*)	**44.** (*d*)	**45.** (*a*)	**46.** (*b*)	**47.** (*c*)	**48.** (*d*)	**49.** (*b*)	**50.** (*a*)
51. (*c*)	**52.** (*a*)	**53.** (*b*)	**54.** (*a*)	**55.** (*d*)	**56.** (*b*)	**57.** (*d*)	**58.** [3600]	**59.** (*d*)	**60.** [266.67]
61. (*a*)	**62.** (*b*)	**63.** (*c*)	**64.** (*c*)	**65.** (*a*)	**66.** (*c*)	**67.** (*a*)	**68.** (*b*)	**69.** (*d*)	**70.** (*c*)
71. (*b*)	**72.** [121]	**73.** (*c*)	**74.** (*d*)	**75.** (*d*)	**76.** (*a*)	**77.** (*b*)	**78.** (*c*)	**79.** (*b*)	**80.** (*c*)
81. [9]	**82.** (*b*)	**83.** (*a*)	**84.** (*a*)	**85.** (*c*)	**86.** (*a*)	**87.** (*b*)	**88.** (*a*)	**89.** (*d*)	**90.** (*)
91. (*c*)	**92.** (*a*)	**93.** (*c*)	**94.** (*c*)	**95.** (*c*)	**96.** (*b*)	**97.** (*b*)	**98.** (*d*)	**99.** (*c*)	**100.** (*d*)
101. (*a*)	**102.** (*a*)								

JEE-Advanced

1. (*d*)	**2.** (*b*)	**3.** (*c*)	**4.** (*d*)	**5.** (*a*)	**6.** (*b*)	**7.** (*a*, *b*, *d*)	**8.** (*c*, *d*)	**11.** [False]	**12.** [False]
13. [False]	**14.** (*b*)	**15.** (*a*)	**16.** (*d*)	**17.** (*c*)	**18.** (*c*)	**19.** (*a*, *c*)	**20.** [45.53]	**21.** [4.0744, 23.926]	
22. [75.4]	**23.** [83.75]	**24.** [6]	**27.** [True]	**28.** [0.30]	**29.** [10]	**30.** (*c*)	**31.** (*b*)	**32.** (*b*)	**33.** (*a*)
34. (*b*)	**35.** (*d*)	**36.** (*d*)	**37.** (*b*)	**38.** (*b*)	**39.** (*b*, *c*, *d*)	**40.** (*d*)	**41.** [675, 3.6×10^6]		
42. [4.54×10^{-3}]		**43.** [800, 720]		**44.** [410]	**48.** [121]	**51.** [9]			