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

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

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

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

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 $\left[\frac{V_{rms}(\text{helium})}{V_{rms}(\text{argon})}\right]$, 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) ~10^{12} (2) ~10^{10}

(3) ~10^{11} (4) ~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) $n_0\alpha^{-3/4}$ (2) $\sqrt{n_0}\ \alpha^{1/2}$

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

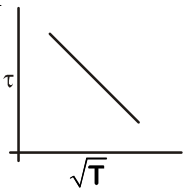
21. Two moles of an ideal gas with $\frac{C_P}{C_V} = \frac{5}{3}$ are mixed with 3 moles of another ideal gas with $\frac{C_P}{C_V} = \frac{4}{3}$. The value of $\frac{C_P}{C_V}$ for the mixture is **[JEE (Main)-2020]**

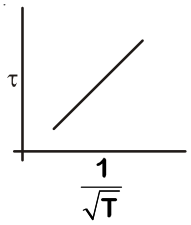
(1) 1.47 (2) 1.42

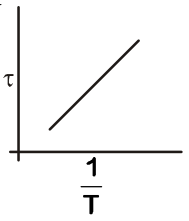
(3) 1.50 (4) 1.45

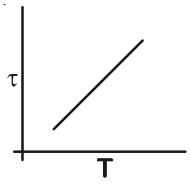
22. The plot that depicts the behavior of the mean free time τ (time between two successive collisions) for the molecules of an ideal gas, as a function of temperature (T), qualitatively, is (Graphs are schematic and not drawn to scale)

[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 $(C_V^A \text{ and } C_V^B)$ 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) 1.83 (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.

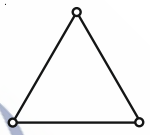
(D) the mean collision time remains unchanged.

(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]**

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