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CLASS 11 PHYSICS · NCERT CHAPTER 12 · IMU CET PRACTICE

Kinetic Theory

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Questions: 45 MCQs

Each question has exactly one correct option. Attempt all questions first, then check the Answer Key and Solutions at the end.

- 1 The pressure exerted by an ideal gas is $P = \frac{1}{3}\rho v_{\text{rms}}^2$. This relation shows that pressure is proportional to
 - (A) mean kinetic energy per unit volume
 - (B) temperature only
 - (C) number of molecules only
 - (D) total momentum
- 2 The average translational kinetic energy of a gas molecule at temperature T is
 - (A) $(1/2)kT$
 - (B) $(5/2)kT$
 - (C) $(3/2)kT$
 - (D) kT
- 3 The rms speed of gas molecules is proportional to
 - (A) T^2
 - (B) $\sqrt{T}$
 - (C) T
 - (D) $1/T$
- 4 If the absolute temperature of a gas is made four times, the rms speed of its molecules becomes
 - (A) half
 - (B) 16 times
 - (C) 2 times
 - (D) 4 times
- 5 The ratio of rms speeds of hydrogen and oxygen molecules at the same temperature is
 - (A) 4 : 1
 - (B) 1 : 4
 - (C) 1 : 16
 - (D) 16 : 1
- 6 At what temperature will the rms speed of oxygen molecules double its value at 27°C ?
 - (A) 108°C
 - (B) 54°C
 - (C) 927°C
 - (D) 1200°C
- 7 The correct order of molecular speeds is
 - (A) $v_{\text{avg}} > v_{\text{rms}} > v_{\text{mp}}$
 - (B) $v_{\text{rms}} > v_{\text{avg}} > v_{\text{mp}}$
 - (C) $v_{\text{mp}} > v_{\text{avg}} > v_{\text{rms}}$
 - (D) all equal
- 8 According to the law of equipartition of energy, each degree of freedom contributes an average energy of
 - (A) $(3/2)kT$
 - (B) $2kT$
 - (C) kT
 - (D) $\frac{1}{2}kT$



- 9 The number of degrees of freedom of a monatomic gas molecule is
(A) 6 (B) 3
(C) 5 (D) 7
- 10 A rigid diatomic molecule has degrees of freedom
(A) 3 (B) 7
(C) 5 (D) 6
- 11 The molar specific heat at constant volume of a monatomic ideal gas is
(A) $3R$ (B) $(5/2)R$
(C) $(3/2)R$ (D) R
- 12 The molar specific heat at constant volume of a rigid diatomic ideal gas is
(A) $(7/2)R$ (B) $(5/2)R$
(C) $3R$ (D) $(3/2)R$
- 13 For a gas with f degrees of freedom, γ equals
(A) $2/f$ (B) $1 + f/2$
(C) $f/(f + 2)$ (D) $1 + 2/f$
- 14 According to the Dulong–Petit law, the molar specific heat of solids is approximately
(A) $(5/2)R$ (B) $(3/2)R$
(C) R (D) $3R$
- 15 The mean free path of gas molecules is inversely proportional to
(A) temperature
(B) volume
(C) number density and square of molecular diameter
(D) molecular speed
- 16 If the pressure of a gas is doubled at constant temperature, its mean free path
(A) doubles (B) becomes four times
(C) remains same (D) becomes half
- 17 Avogadro's number is
(A) 6.02×10^{23} per mole (B) 1.38×10^{-23} per mole
(C) 6.02×10^{20} per mole (D) 8.31 per mole
- 18 The Boltzmann constant k_B is related to R and N_A by
(A) $k_B = R + N_A$ (B) $k_B = RN_A$
(C) $k_B = N_A/R$ (D) $k_B = R/N_A$
- 19 At STP, one mole of an ideal gas occupies
(A) 224 L (B) 22.4 L
(C) 2.24 L (D) 11.2 L
- 20 Which assumption is NOT part of the kinetic theory of ideal gases?
(A) Collisions are perfectly elastic (B) Molecules attract each other strongly
(C) Molecules move randomly (D) Molecules are point masses



- 21 Real gases behave like ideal gases at
(A) low pressure and high temperature (B) high pressure and low temperature
(C) high pressure and high temperature (D) low pressure and low temperature
- 22 The average kinetic energy of a gas molecule at 0 K (classically) is
(A) maximum (B) zero
(C) $(3/2)k \times 273$ (D) infinite
- 23 Two gases at the same temperature have the same
(A) rms speed (B) density
(C) average kinetic energy per molecule (D) momentum per molecule
- 24 The rms speed of nitrogen molecules at 27°C is ($M = 28$ g/mol, $R = 8.31$ J/mol K)
(A) about 517 m/s (B) about 160 m/s
(C) about 1000 m/s (D) about 300 m/s
- 25 The total kinetic energy of one mole of a monatomic gas at temperature T is
(A) RT (B) $(1/2)RT$
(C) $(3/2)RT$ (D) $(5/2)RT$
- 26 The equation of state of an ideal gas is $PV = nRT$. Here n is
(A) number of moles (B) refractive index
(C) number density (D) number of molecules
- 27 A gas at 27°C and 2 atm is heated at constant volume to 327°C. The new pressure is
(A) 1 atm (B) 3 atm
(C) 24.2 atm (D) 4 atm
- 28 Volume of a gas at constant pressure is doubled. Its absolute temperature becomes
(A) half (B) double
(C) unchanged (D) four times
- 29 Boyle's law holds for an ideal gas during
(A) adiabatic process (B) isochoric process
(C) isobaric process (D) isothermal process
- 30 The pressure of an ideal gas is given in terms of the number density n and average KE E as
(A) $P = (3/2)nE$ (B) $P = nE$
(C) $P = \frac{2}{3}nE$ (D) $P = \frac{1}{3}nE$
- 31 The kinetic energy per unit volume of a gas at pressure P is
(A) P (B) $(3/2)P$
(C) $(2/3)P$ (D) $3P$
- 32 For a mixture of 1 mole of He and 1 mole of O_2 (rigid diatomic), the molar specific heat at constant volume of the mixture is
(A) $(3/2)R$ (B) $4R$
(C) $(5/2)R$ (D) $2R$

- 33** Vibrational degrees of freedom of a diatomic molecule become active at
(A) all temperatures **(B)** low temperatures
(C) absolute zero **(D)** high temperatures
- 34** At high temperature, if vibration is also excited, C_v of a diatomic gas becomes
(A) $(3/2)R$ **(B)** $3R$
(C) $(7/2)R$ **(D)** $(5/2)R$
- 35** The value of γ for a polyatomic (non-linear, rigid) gas molecule is
(A) $4/3$ **(B)** $7/5$
(C) $5/3$ **(D)** 1
- 36** Gas molecules in a container at the same temperature exert pressure due to
(A) their weight
(B) intermolecular attraction
(C) their potential energy
(D) change in momentum on collision with the walls
- 37** The rms speed of a gas at a given temperature is v . If the gas is replaced by another of four times molecular mass at the same temperature, the rms speed becomes
(A) $v/2$ **(B)** $2v$
(C) $4v$ **(D)** $v/4$
- 38** The density of a gas at STP is 1.43 kg/m^3 . Its rms speed at STP is ($P = 1.01 \times 10^5 \text{ Pa}$)
(A) about 460 m/s **(B)** about 330 m/s
(C) about 230 m/s **(D)** about 1000 m/s
- 39** Brownian motion provides evidence for
(A) gravitational force **(B)** the random motion of molecules
(C) the wave nature of light **(D)** nuclear forces
- 40** Which of the following is constant for a gas at a fixed temperature?
(A) Position of each molecule **(B)** Momentum of each molecule
(C) Speed of each molecule **(D)** Average kinetic energy of molecules
- 41** The ratio of v_{rms} to v_{mp} for gas molecules is
(A) $\sqrt{3/2}$ **(B)** $3/2$
(C) $\sqrt{3}$ **(D)** $\sqrt{2/3}$
- 42** The temperature at which the average kinetic energy of a gas molecule equals 1 eV is about ($k = 1.38 \times 10^{-23} \text{ J/K}$)
(A) 1160 K **(B)** 3870 K
(C) 7700 K **(D)** 11600 K
- 43** According to Avogadro's law, equal volumes of all gases at the same temperature and pressure contain
(A) equal number of molecules **(B)** equal densities
(C) equal rms speeds **(D)** equal masses

- 44** A cylinder contains 2 moles of an ideal gas at 300 K. The total translational kinetic energy is ($R = 8.31 \text{ J/mol K}$)
- (A) 7479 J (B) 12465 J
(C) 2493 J (D) 4986 J
-
- 45** Absolute zero is the temperature at which, classically,
- (A) water freezes (B) molecular motion ceases
(C) all gases liquefy (D) pressure is maximum

Answer Key

1	2	3	4	5	6	7	8	9	10
A	C	B	C	A	C	B	D	B	C
11	12	13	14	15	16	17	18	19	20
C	B	D	D	C	D	A	D	B	B
21	22	23	24	25	26	27	28	29	30
A	B	C	A	C	A	D	B	D	C
31	32	33	34	35	36	37	38	39	40
B	D	D	C	A	D	A	A	B	D
41	42	43	44	45					
A	C	A	A	B					

Hints & Solutions

- (A) $P = \frac{1}{3}\rho v_{\text{rms}}^2 = \frac{2}{3} \times (\frac{1}{2}\rho v_{\text{rms}}^2) = \frac{2}{3} \times (\text{KE per unit volume})$.
- (C) $E = (3/2)k_B T$.
- (B) $v_{\text{rms}} = \sqrt{(3RT/M)} \propto \sqrt{T}$.
- (C) $v_{\text{rms}} \propto \sqrt{T} \rightarrow \sqrt{4} = 2$.
- (A) $v_{\text{rms}} \propto 1/\sqrt{M} \rightarrow \sqrt{(32/2)} = 4$.
- (C) $v \propto \sqrt{T} \rightarrow T' = 4 \times 300 = 1200 \text{ K} = 927^\circ\text{C}$.
- (B) $v_{\text{rms}} = \sqrt{(3RT/M)}$, $v_{\text{avg}} = \sqrt{(8RT/\pi M)}$, $v_{\text{mp}} = \sqrt{(2RT/M)}$; $3 > 8/\pi \approx 2.55 > 2$.
- (D) Each quadratic term in energy gets $\frac{1}{2}k_{\text{BT}}$ per molecule.
- (B) Only three translational degrees of freedom.
- (C) 3 translational + 2 rotational = 5.
- (C) $U = (3/2)RT$ per mole $\rightarrow C_v = 3R/2$.
- (B) $f = 5 \rightarrow C_v = (f/2)R = 5R/2$.
- (D) $C_v = fR/2$, $C_p = (f/2 + 1)R \rightarrow \gamma = 1 + 2/f$.
- (D) Each atom has 6 quadratic energy terms (3 KE + 3 PE) $\rightarrow U = 3RT \rightarrow C = 3R$.
- (C) $\lambda = 1/(\sqrt{2} \pi d^2 n)$.
- (D) $n \propto P$ at constant T , and $\lambda \propto 1/n \rightarrow$ halves.
- (A) $N_A \approx 6.022 \times 10^{23} \text{ mol}^{-1}$.
- (D) $k_B = R/N_A = 8.314/6.022 \times 10^{23} \approx 1.38 \times 10^{-23} \text{ J/K}$.
- (B) Molar volume at STP (0°C , 1 atm) $\approx 22.4 \text{ L}$.
- (B) Ideal gas molecules have no intermolecular forces except during collisions.
- (A) At low P and high T , molecular volume and intermolecular forces become negligible.
- (B) $E = (3/2)kT = 0$ at $T = 0$ (classical result).
- (C) Average KE depends only on T ; speeds depend on molecular mass.

24. (A) $v = \sqrt{(3 \times 8.31 \times 300/0.028)} = \sqrt{267107} \approx 517 \text{ m/s}$.
25. (C) $N_A \times (3/2)kT = (3/2)RT$.
26. (A) n is the amount of gas in moles; with N molecules, $PV = Nk_{BT}$.
27. (D) $P \propto T$: $2 \times 600/300 = 4 \text{ atm}$.
28. (B) Charles' law: $V \propto T$.
29. (D) $PV = \text{constant}$ at constant T .
30. (C) $P = \frac{1}{3}nm v_{rms}^2 = \frac{2}{3}n(\frac{1}{2}mv_{rms}^2) = \frac{2}{3}nE$.
31. (B) From $P = \frac{2}{3}E_v \rightarrow E_v = (3/2)P$.
32. (D) $C_{v,mix} = (1 \times 3R/2 + 1 \times 5R/2)/2 = 2R$.
33. (D) Vibrational modes require larger energy quanta, so they are excited at high temperatures.
34. (C) Vibration adds 2 quadratic terms (KE + PE) $\rightarrow f_{eff} = 7 \rightarrow C_v = 7R/2$.
35. (A) $f = 6 \rightarrow \gamma = 1 + 2/6 = 4/3$.
36. (D) Momentum transferred per unit time per unit area to the walls is the pressure.
37. (A) $v_{rms} \propto 1/\sqrt{M} \rightarrow v/2$.
38. (A) $v = \sqrt{(3P/\rho)} = \sqrt{(3 \times 1.01 \times 10^5/1.43)} = \sqrt{211888} \approx 460 \text{ m/s}$.
39. (B) Random bombardment by fluid molecules causes the zig-zag motion of suspended particles.
40. (D) Individual speeds vary randomly, but the average KE is fixed by temperature.
41. (A) $v_{rms}/v_{mp} = \sqrt{(3RT/M)}/\sqrt{(2RT/M)} = \sqrt{(3/2)}$.
42. (C) $(3/2)kT = 1.6 \times 10^{-19} \rightarrow T = 2 \times 1.6 \times 10^{-19}/(3 \times 1.38 \times 10^{-23}) \approx 7730 \text{ K}$.
43. (A) $PV = Nk_{BT} \rightarrow$ same P, V, T gives same N .
44. (A) $E = (3/2)nRT = 1.5 \times 2 \times 8.31 \times 300 = 7479 \text{ J}$.
45. (B) Classical kinetic theory predicts zero molecular KE at 0 K.

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