5. States of Matter – Multiple Choice Questions

1. Characteristics and Measurable Properties of Gases

1. If the four tubes of a car are filled to the same pressure with N_2, O_2, H_2 and Ne separately, then which one will be filled first

(a) N_2 (b) O_2

(c) H_2 (d) Ne

2. For a closed system consisting of a reaction $N_2O_4(g) \rightarrow 2NO_2(g)$, the pressure

(a) Remains constant (b) Decreases

(c) Increases (d) Becomes zero

3. Three different gases X, Y and Z of molecular masses 2, 16 and 64 were enclosed in a vessel at constant temperature till equilibrium is reached. Which of the following statement is correct

(a) Gas Z will be at the top of the vessel

(b) Gas Y will be at the top of the vessel

(c) Gas Z will be at the bottom and X will be at the top

(d) Gas X will be at the bottom and Z will be at the top

(e) Gases will form homogenous mixture

4. A person living in Shimla observed that cooking food without using pressure cooker takes more time. The reason for this observation is that at high altitude

(a) Pressure increases (b) Temperature decreases

(c) Pressure decreases (d) Temperature increases

5. $1°C$ rise in temperature is equal to a rise of

(a) $1°F$ (b) $9/5°F$

(c) $5/9°F$ (d) $33°F$

2. Ideal Gas Equation and Related Gas Laws

1. Which of the following statement is false

(a) The product of pressure and volume of fixed amount of a gas is independent of temperature

(b) Molecules of different gases have the same K.E. at a given temperature

(c) The gas equation is not valid at high pressure and low temperature

(d) The gas constant per molecule is known as Boltzmann constant

2. In the equation of state of an ideal gas $PV = nRT$, the value of the universal gas constant would depend only on

(a) The nature of the gas

(b) The pressure of the gas

(c) The units of the measurement

(d) None of these

3. 16 g of oxygen and 3 g of hydrogen are mixed and kept at 760 mm pressure and $0°C$. The total volume occupied by the mixture will be nearly

(a) 22.4 L (b) 33.6 L

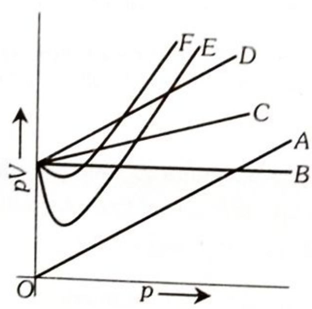
(c) 448 L (d) 44800 mL

4. Containers A and B have same gases. Pressure, volume and temperature of A are all twice that of B, then the ratio of number of molecules of A and B are

(a) $1:2$ (b) 2

(c) $1:4$ (d) 4

5. Which curve in figure represent the curve ideal gas



(a) Only B (b) C and D

(c) E and F (d) A and B

6. Densities of two gases are in the ratio 1 : 2 and their temperatures are in the ratio 2 : 1, then the ratio of their respective pressures is

(a) $1:1$ (b) $1:2$

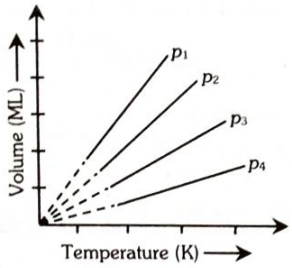
(c) $2:1$ (d) $4:1$

7. A gas of volume 100 cc is kept in a vessel at pressure 10^4 Pa maintained at temperature $24°C$. If now the pressure is increased to 10^5 Pa, keeping the temperature constant, then the volume of the gas becomes

(a) 10 cc (b) 100 cc

(c) 1 cc (d) 1000 cc

8. A plot of volume (V) versus temperature (T) for a gas at constant pressure is a straight line passing through the origin. The plots at different values of pressure are shown in figure. Which of the following order of pressure is correct for this gas



(a) $p_1 > p_2 > p_3 > p_4$ (b) $p_1 = p_2 = p_3 = p_4$

(c) $p_1 < p_2 < p_3 < p_4$ (d) $p_1 < p_2 = p_3 < p_4$

9. Air at sea level is dense. This is a practical application of

(a) Boyle's law (b) Charle's law

(c) Avogadro's law (d) Dalton's law

10. Equation of Boyle's law is

(a) $\frac{dP}{P} = -\frac{dV}{V}$ (b) $\frac{dP}{P} = +\frac{dV}{V}$

(c) $\frac{d^2P}{P} = -\frac{dV}{dT}$ (d) $\frac{d^2P}{P} = +\frac{d^2V}{dT}$

11. A bubble of gas released at the bottom of a lake increases to eight times its original volume when it reaches the surface. Assuming that atmospheric pressure is equivalent to the pressure exerted by a column of water 10 m height, the depth of the lake is

(a) 80 m (b) 90 m

(c) 40 m (d) 10 m

(e) 70 m

12. As the temperature increases, average kinetic energy of molecules increases. What would be the effect of increase of temperature on pressure provided the volume is constant

(a) Increases (b) Decreases

(c) Remains same (d) Becomes half

13. Use of hot air balloons in sports and meteorological observations is an application of

(a) Boyle's law (b) Newtonic law

(c) Kelvin's law (d) Charle's law

14. Steam distillation is based on

(a) Boyle's law

(b) Charle's law

(c) Dalton's law of partial pressure

(d) Avogadro's law

15. The pressure of a 1 : 4 mixture of dihydrogen and dioxygen enclosed in a vessel is one atmosphere. What would be the partial pressure of dioxygen

(a) $0.8 \times 10^5\ atm$ (b) $0.008\ Nm^{-2}$

(c) $8 \times 10^4\ Nm^{-2}$ (d) $0.25\ atm$

16. If three unreactive gases having partial pressures P_A, P_B and P_C and their moles are 1, 2 and 3 respectively then their total pressure will be

(a) $P = P_A + P_B + P_C$ (b) $P = \frac{P_A + P_B + P_C}{6}$

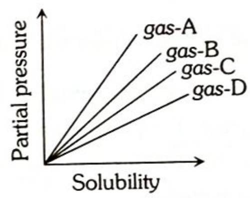
(c) $P = \frac{\sqrt{P_A + P_B + P_C}}{3}$ (d) None

17. 0.5 *mole* of each of H_2, SO_2 and CH_4 are kept in a container. A hole was made in the container. After 3 hours, the order of partial pressures in the container will be

(a) $pSO_2 > pCH_4 > pH_2$ (b) $pH_2 > pSO_2 > pCH_4$

(c) $pH_2 > pCH_4 > pSO_2$ (d) $pSO_2 > pH_2 > pCH_4$

18. From the given graph at constant temperature, which gas has the least solubility



(a) $Gas - D$ (b) $Gas - B$

(c) $Gas - A$ (d) $Gas - C$

19. If rate of diffusion of A is 5 times that of B, what will be the density ratio of A and B

(a) 1/25 (b) 1/5

(c) 25 (d) 4

20. How will you separate mixture of two gases

(a) Fractional distillation technique

(b) Grahams law of diffusion technique

(c) Osmosis

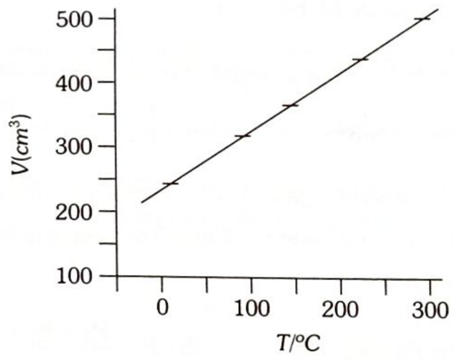
(d) Chromatography

21. At identical temperature and pressure, the rate of diffusion of hydrogen gas is $3\sqrt{3}$ times that of a hydrocarbon having molecular formula C_nH_{2n-2}. What is the value of n

(a) 1 (b) 4

(c) 3 (d) 8

22. At constant pressure, the volume of a fixed mass of a gas varies as a function of temperature as shown in the graph.



The volume of the gas at $300°C$ is larger than that at $0°C$ by a factor of

(a) 3 (b) 4

(c) 1 (d) 2

23. Consider two sealed jars of equal volume. One contains $2\,g$ of hydrogen at $200K$ and the other contains $28\,g$ of nitrogen at $400K$. The gases in the two jars will have

(a) The same pressure

(b) The same average kinetic energy

(c) The same number of molecules

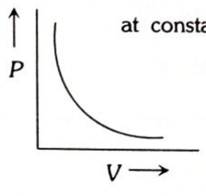
(d) The same average molecular speed

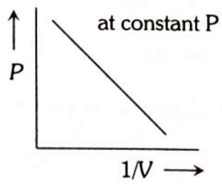
24. Two balloons A and B containing 0.2 mole and 0.1 mole of helium at room temperature and 2.0 *atm*, respectively, are connected. When equilibrium is established, the final pressure of He in the system is

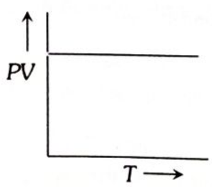
(a) 1.0 *atm* (b) 1.5 *atm*

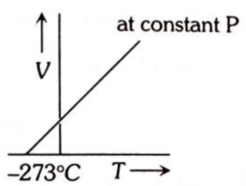
(c) 0.5 *atm* (d) 2.0 *atm*

25. The graph that does not represent the behaviour of an ideal gas is

(a) 

(b) 

(c) 

(d) 

26. In a closed vessel, an ideal gas at 1 atm is heated from $27°C$ to $327°C$. The final pressure of the gas will approximately be

(a) 3 *atm* (b) 0.5 *atm*

(c) 2 *atm* (d) 12 *atm*

27. At a constant pressure P, the plot of volume (V) as a function of temperature (T) for 2 moles of an ideal gas gives a straight line with a slope $0.328LK^{-1}$. The value of P (in atm) is closest to [Gas constant, $R = 0.0821L$ atm $mol^{-1}K^{-1}$]

(a) 0.25 (b) 0.5

(c) 1.0 (d) 2.0

3. Kinetic Molecular Theory of Gases and Molecular Collisions

1. With increase of pressure, the mean free path

(a) Decreases (b) Increases

(c) Does not change (d) Becomes zero

2. At the same temperature and pressure, which of the following gases will have the highest kinetic energy per mole

(a) Hydrogen (b) Oxygen

(c) Methane (d) All the same

3. In two vessels of 1 L each at the same temperature, 1 g of H_2 and 1 g of CH_4 are taken, for these

(a) V_{rms} values will be same

(b) Kinetic energy per mol will be same

(c) Total kinetic energy will be same

(d) Pressure will be same

4. The average $K.E.$ of an ideal gas in *calories* per mole is approximately equal to

(a) Three times the absolute temperature

(b) Absolute temperature

(c) Two times the absolute temperature

(d) 1.5 times the absolute temperature

5. According to kinetic theory of gases, for a diatomic molecule

(a) The pressure exerted by the gas is proportional to the mean velocity of the molecules

(b) The pressure exerted by the gas is proportional to the root mean square velocity of the molecules

(c) The root mean square velocity is inversely proportional to the temperature

(d) The mean translational kinetic energy of the molecules is proportional to the absolute temperature

6. According to Graham's law, the rate of diffusion of CO, O_2, N_2 and CO_2 follows the order

(a) $CO = N_2 > O_2 > CO_2$ (b) $CO = N_2 > CO_2 > O_2$

(c) $O_2 > CO = N_2 > CO_2$ (d) $CO_2 > O_2 > CO = N_2$

7. At $298K$, assuming ideal behaviour, the average kinetic energy of a deuterium molecule is

(a) Two times that of a hydrogen molecule

(b) Four times that of a hydrogen molecule

(c) Half of that of a hydrogen molecule

(d) Same as that of a hydrogen molecule

4. Molecular Speeds

1. The temperature at which RMS velocity of SO_2 molecules is half that of He molecules at 300 K is

(a) 150 K (b) 600 K

(c) 900 K (d) 1200 K

2. Molecular velocities of the two gases at the same temperature are u_1 and u_2. Their masses are m_1 and m_2 respectively. Which of the following expressions is correct

(a) $\frac{m_1}{u_1^2} = \frac{m_2}{u_2^2}$ (b) $m_1u_1 = m_2u_2$

(c) $\frac{m_1}{u_1} = \frac{m_2}{u_2}$ (d) $m_1u_1^2 = m_2u_2^2$

3. The rms velocity of CO gas molecules at $27\,^\circ C$ is approximately 1000 m/s. For N_2 molecules at 600 K the rms velocity is approximately

(a) 2000 m/s (b) 1414 m/s

(c) 1000 m/s (d) 1500 m/s

4. If the average velocity of N_2 molecule is $0.3\,m/s$ at $27^\circ C$, then the velocity will be $0.6\,m/s$ at

(a) $1200K$ (b) $600K$

(c) $400K$ (d) $1800K$

5. The rms speed of N_2 molecules in a gas is u. If the temperature is doubled and the nitrogen molecules dissociate into nitrogen atoms, the rms speed becomes

(a) $u/2$ (b) $2u$

(c) $4u$ (d) $14u$

6. For an ideal system at thermal equilibrium, the velocity distribution of the constituting particles will be governed by

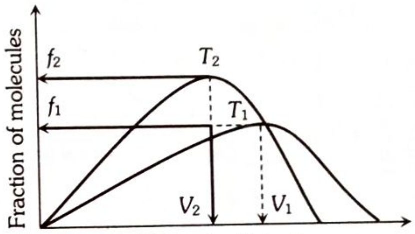
(a) Gaussian distribution

(b) Maxwell-Boltzmann distribution

(c) Lorentzian distribution

(d) Log-normal distribution

7. Plot of Maxwell's distribution of velocities is given below



(a) $T_1 > T_2$ (b) $T_1 < T_2$

(c) $V_1 < V_2$ (d) $f_1 > f_2$

5. Real Gases and van der Waals Equation

1. In the corrections made to the ideal gas equation for real gases, the reduction in pressure due to attractive forces is directly proportional to

(a) n/V (b) nb

(c) n^2/V^2b (d) n^2/V^2

2. Any gas shows maximum deviation from ideal gas at

(a) $0^\circ C$ and 1 atmospheric pressure

(b) $100^\circ C$ and 2 atmospheric pressure

(c) $-100^\circ C$ and 5 atmospheric pressure

(d) $500^\circ C$ and 1 atmospheric pressure

3. A gas deviates from ideal behaviour at a high pressure because its molecules

(a) Have kinetic energy

(b) Are bound by covalent bonds

(c) Attract one another

(d) Show the Tyndall effect

4. Pressure exerted by 1 mole of methane in a 0.25 litre container at 300K using vander Waal's equation (given a $= 2.253\,atm\,l^2\,mol^{-2}, b = 0.0428\,lit\,mol^{-1}$) is

(a) 82.82 atm (b) 152.51 atm

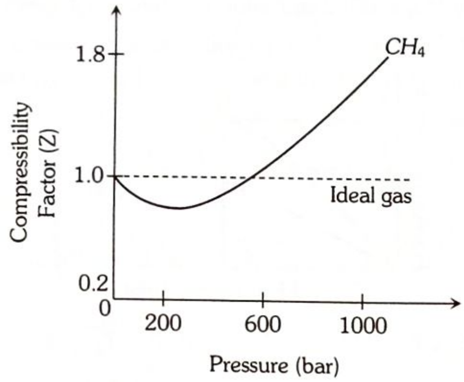
(c) 190.52 atm (d) 70.52 atm

5. The units of constant a in Vander Waal's equation is

(a) $dm^6 atm\,mol^{-2}$ (b) $dm^3 atm\,mol^{-1}$

(c) $dm\,atm\,mol^{-1}$ (d) $atm\,mol^{-1}$

6. In the following compressibility factor (Z) vs pressure graph at $300K$, the compressibility of CH_4 at pressure < 200 bar deviates from ideal behaviour because



(a) The molar volume of CH_4 is less than its molar volume in the ideal state

(b) The molar volume of CH_4 is same as that in its ideal state

(c) Intermolecular interactions between CH_4 molecules decreases

(d) The molar volume of CH_4 is more than its molar volume in the ideal state

6. Critical State and Liquefaction of Gases

1. A gas can be liquefied

(a) Above critical temperature and below critical pressure

(b) Below critical temperature and above critical pressure

(c) Below critical temperature and pressure

(d) Above critical temperature and pressure

2. Gases possess characteristic critical temperature which depends upon the magnitude of intermolecular forces between the particles. Following are the critical temperatures of some gases

Gases	H_2	He	O_2	N_2
Critical temperature in Kelvin	33.2	5.3	154.3	126

From the above data what would be the order of liquefaction of these gases ? Start writing the order from the gas liquefying first

(a) H_2, He, O_2, N_2 (b) He, O_2, H_2, N_2

(c) N_2, O_2, He, H_2 (d) O_2, N_2, H_2, He

3. The Van der Waals parameters for gases W, X, Y and Z are

Gas	a (atm L^2 mol^{-2})	b (L mol^{-1})
W	4.0	0.027
X	8.0	0.030
Y	6.0	0.032
Z	12.0	0.027

Which one of these gases has the highest critical temperature

(a) W (b) X

(c) Y (d) Z

4. The critical temperatures of O_2, N_2, H_2 and CO_2 are 154.3 K, 126 K, 33.2 K and 304 K. The extent of adsorption on tungsten may be highest in case of

(a) H_2 (b) N_2

(c) O_2 (d) CO_2

5. The ratio $\gamma, \left(\frac{C_p}{C_v}\right)$ for inert gases is

(a) 1.33 (b) 1.66

(c) 2.13 (d) 1.99

6. For the equation $C_P - C_V = R$, the significance of R is

(a) Work done per mole per Kelvin

(b) Heat absorbed per mole per Kelvin

(c) Heat released per mole per Kelvin

(d) Work done per mole per degree Celsius

7. When helium is allowed to expand into vacuum, heating effect is observed. Its reason is that

(a) Helium is an ideal gas

(b) Helium is an inert gas

(c) The inversion temperature of helium is very low

(d) The boiling point of helium is the lowest among the elements

7. IIT-JEE/ AIEEE

1. A gas mixture contains O_2 and N_2 in the ratio of 1 : 4 by weight. The ratio of their number of molecules is **[2014]**

(a) 1 : 8 (b) 1 : 4

(c) 3 : 16 (d) 7 : 32

2. At 100°C and 1 atm, if the density of liquid water is 1.0 g cm^{-3} and that of water vapour is 0.0006 g cm^{-3}, then the volume occupied by water molecules in 1 *litre* of steam at that temperature is **[2000]**

(a) 6 cm^3 (b) 60 cm^3

(c) 0.6 cm^3 (d) 0.06 cm^3

3. For an ideal gas, number of moles per litre in terms of its pressure P, gas constant R and temperature T is **[2002]**

(a) PT/R (b) PRT

(c) P/RT (d) RT/P

4. If $10^{-4} dm^3$ of water is introduced into a $1.0 dm^3$ flask at 300 K, how many moles of water are in the vapour phase, when equilibrium is established

(Given : Vapour pressure of H_2O at 300 K is 3170 Pa; $R = 8.314\ JK^{-1}\ mol^{-1}$) **[2010]**

(a) $1.27 \times 10^{-3}\ mol$ (b) $5.56 \times 10^{-3}\ mol$

(c) $1.53 \times 10^{-2}\ mol$ (d) $4.46 \times 10^{-2}\ mol$

5. When an ideal gas undergoes unrestrained expansion, no cooling occurs because the molecules **[1984, 89]**

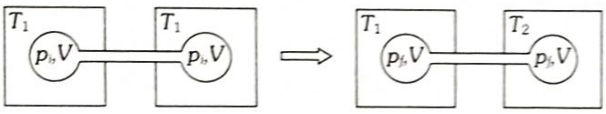
(a) Are above the inversion temperature

(b) Exert no attractive force on each other

(c) Do work equal to loss in kinetic energy

(d) Collide without loss of energy

6. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is

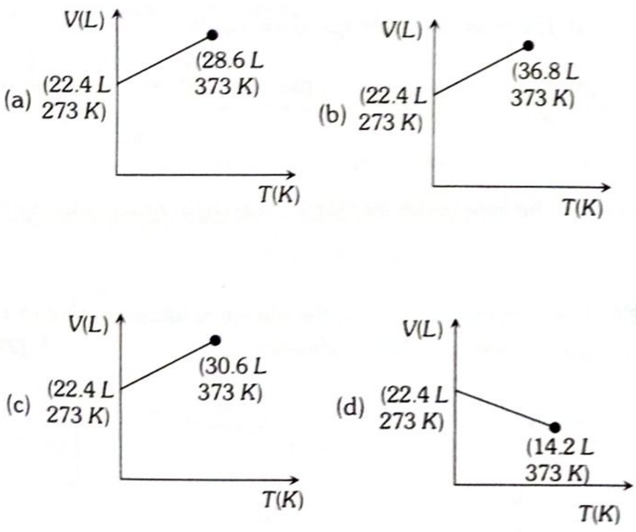


[2016]

(a) $2p_i\left(\frac{T_1}{T_1+T_2}\right)$ (b) $2p_i\left(\frac{T_2}{T_1+T_2}\right)$

(c) $2p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ (d) $p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$

7. Which of the following volume (V) – temperature (T) plots represents the behaviour of one mole of an ideal gas at one atmospheric pressure **[2002]**



8. Equal masses of ethane and hydrogen are mixed in an empty container at 25°C. The fraction of total pressure exerted by hydrogen is **[1993]**

(a) 1 : 2 (b) 1 : 1

(c) 1 : 16 (d) 15 : 16

9. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is **[2007]**

(a) $\frac{2}{3}$ (b) $\frac{1}{3} \times \frac{273}{298}$

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

10. Same mass of CH_4 and H_2 is taken in container. The partial pressure caused by H_2 is **[1989]**

(a) 8 / 9 (b) 1 / 9

(c) 1 / 2 (d) 1

11. Rate of diffusion of a gas is **[1985]**

(a) Directly proportional to its density

(b) Directly proportional to its molecular mass

(c) Directly proportional to the square root of its molecular mass

(d) Inversely proportional to the square root of its molecular mass

12. At constant volume and temperature conditions, the rate of diffusion D_A and D_B of gases A and B having densities ρ_A and ρ_B are related by the expression **[1993]**

(a) $D_A = \left[D_B \cdot \frac{\rho_A}{\rho_B}\right]^{1/2}$ (b) $D_A = \left[D_B \cdot \frac{\rho_B}{\rho_A}\right]^{1/2}$

(c) $D_A = D_B\left(\frac{\rho_A}{\rho_B}\right)^{1/2}$ (d) $D_A = D_B\left(\frac{\rho_B}{\rho_A}\right)^{1/2}$

13. The ratio of the rate of diffusion of helium and methane under identical condition of pressure and temperature will be **[2005]**

(a) 4 (b) 2

(c) 1 (d) 0.5

14. According to Graham's law at a given temperature, the ratio of the rates of diffusion r_A / r_B of gases A and B is given by **[1998]**

(a) $(P_A / P_B)(M_A / M_B)^{1/2}$ (b) $(M_A / M_B)(P_A / P_B)^{1/2}$

(c) $(P_A / P_B)(M_B / M_A)^{1/2}$ (d) $(M_A / M_B)(P_B / P_A)^{1/2}$

(where P and M are the pressures and molecular weights of gases A and B respectively)

15. A bottle of ammonia and a bottle of dry hydrogen chloride connected through a long tube are opened simultaneously at both ends, the white ammonium chloride ring first formed will be **[1988]**

(a) At the centre of the tube

(b) Near the hydrogen chloride bottle

(c) Near the ammonia bottle

(d) Throughout the length of the tube

16. X mL of H_2 gas effuses through a hole in a container in 5 *seconds*. The time taken for the effusion of the same volume of the gas specified below under identical condition is **[1996]**

(a) 10 *seconds* : *He* (b) 20 *seconds* : O_2

(c) 25 *seconds* : *CO* (d) 55 *seconds* : CO_2

17. Helium atom is two times heavier than a hydrogen molecule at 298 *K*, the average kinetic energy of helium is **[1982]**

(a) Two times that of a hydrogen molecule

(b) Same as that of a hydrogen molecule

(c) Four times that of a hydrogen molecule

(d) Half that of a hydrogen molecule

18. As the temperature is raised from $20°C$ to $40°C$ the average kinetic energy of neon atoms changes by a factor of which of the following **[2004]**

(a) 313/293 (b) $\sqrt{(313/293)}$

(c) 1/2 (d) 2

19. The ratio of root mean square velocity to average velocity of gas molecules at a particular temperature is **[1981]**

(a) 1.086 : 1 (b) 1 : 1.086

(c) 2 : 1.086 (d) 1.086 : 2

20. For gaseous state, if most probable speed is denoted by C^*, average speed by $\overline{C}$ and root mean square speed by C, then for a large number of molecules the ratios of these speeds are **[2013]**

(a) $C^* : \overline{C} : C = 1.225 : 1.128 : 1$

(b) $C^* : \overline{C} : C = 1.128 : 1.225 : 1$

(c) $C^* : \overline{C} : C = 1 : 1.128 : 1.225$

(d) $C^* : \overline{C} : C = 1 : 1.225 : 1.128$

21. At constant volume, for a fixed number of moles of a gas, the pressure of the gas increases with increase in temperature due to **[1992]**

(a) Increase in the average molecular speed

(b) Increased rate of collision amongst molecules

(c) Increase in molecular attraction

(d) Decrease in mean free path

22. The ratio between the root mean square velocity of H_2 at 50 K and that of O_2 at 800 K is **[1996]**

(a) 4 (b) 2

(c) 1 (d) 1/4

23. The root mean square velocity of an ideal gas at constant pressure varies with density (d) as **[2000]**

(a) d^2 (b) d

(c) $\sqrt{d}$ (d) $1/\sqrt{d}$

24. The root mean square velocity of one mole of a monoatomic having molar mass M is u_{rms}. The relation between the average kinetic energy (E) of the u_{rms} is **[2004]**

(a) $u_{rms} = \sqrt{\frac{3E}{2M}}$ (b) $u_{rms} = \sqrt{\frac{2E}{3M}}$

(c) $u_{rms} = \sqrt{\frac{2E}{M}}$ (d) $u_{rms} = \sqrt{\frac{E}{3M}}$

25. If C_1, C_2, C_3...... represent the speeds of n_1, n_2, n_3..... molecules, then the root mean square speed is **[1993]**

(a) $\left(\frac{n_1C_1^2 + n_2C_2^2 + n_3C_3^2 + ...}{n_1 + n_2 + n_3 + ...}\right)^{1/2}$

(b) $\frac{(n_1C_1^2 + n_2C_2^2 + n_3C_3^2 + ...)^{1/2}}{n_1 + n_2 + n_3 + ...}$

(c) $\frac{(n_1C_1^2)^{1/2}}{n_1} + \frac{(n_2C_2^2)^{1/2}}{n_2} + \frac{(n_3C_3^2)^{1/2}}{n_3} + ...$

(d) $\left[\frac{(n_1C_1 + n_2C_2 + n_3C_3 + ...)^2}{(n_1 + n_2 + n_3 + ...)}\right]^{1/2}$

26. Which one of the following statements is NOT true about the effect of an increase in temperature on the distribution of molecular speeds in a gas **[2005]**

(a) The most probable speed increases

(b) The fraction of the molecules with the most probable speed increases

(c) The distribution becomes broader

(d) The area under the distribution curve remains the same as under the lower temperature

27. The term that corrects for the attractive forces present in a real gas in the vander Waals equation is **[2009]**

(a) nb (b) $\frac{an^2}{V^2}$

(c) $-\frac{an^2}{V^2}$ (d) $-nb$

28. The compressibility factor of a gas is defined as Z = PV/RT. The compressibility factor of ideal gas is **[1997]**

(a) 0 (b) Infinity

(c) 1 (d) –1

29. In Vander Waal's equation of state for a non-ideal gas, the term that accounts for intermolecular forces is **[1988]**

(a) $(V-b)$ (b) $(RT)^{-1}$

(c) $\left(P+\frac{a}{V^2}\right)$ (d) RT

30. Vander Waal's equation of state is obeyed by real gases. For n moles of a real gas, the expression will be **[1992]**

(a) $\left(\frac{P}{n}+\frac{na}{V^2}\right)\left(\frac{V}{n-b}\right)=RT$

(b) $\left(P+\frac{a}{V^2}\right)(V-b)=nRT$

(c) $\left(P+\frac{na}{V^2}\right)(nV-b)=nRT$

(d) $\left(P+\frac{n^2a}{V^2}\right)(V-nb)=nRT$

31. A gas is said to behave like an ideal gas when the relation $PV/T=$ constant . When do you expect a real gas to behave like an ideal gas **[1999]**

(a) When the temperature is low

(b) When both the temperature and pressure are low

(c) When both the temperature and pressure are high

(d) When the temperature is high and pressure is low

32. In Vander Waal's equation of state of the gas law, the constant 'b' is a measure of **[2004]**

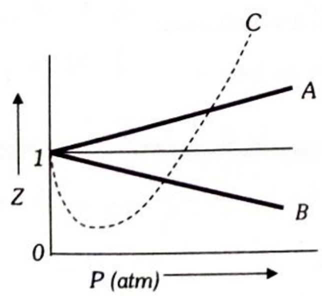
(a) Volume occupied by the molecules

(b) Intermolecular attraction

(c) Intermolecular repulsions

(d) Intermolecular collisions per unit volume

33. The given graph represents the variation of Z(compressibility factor = $\frac{PV}{nRT}$) versus P, for three real gases A, B and C. Identify the only incorrect statement **[2006]**



(a) For the gas A, $a=0$ and its dependence on P is linear at all pressure

(b) For the gas B, $b=0$ and its dependence on P is linear at all pressure

(c) For the gas C, which is typical real gas for which neither a nor $b=0$. By knowing the minima and the point of intersection, with Z = 1, a and b can be calculated

(d) At high pressure, the slope is positive for all real gases

34. The compressibility of a gas is less than unity at STP. Therefore **[2000]**

(a) $V_m>22.4$ litres (b) $V_m<22.4$ litres

(c) $V_m=22.4$ litres (d) $V_m=44.8$ litres

35. The temperature at which real gases obey the ideal gas laws over a wide range of pressure is called **[1981, 94]**

(a) Critical temperature (b) Boyle temperature

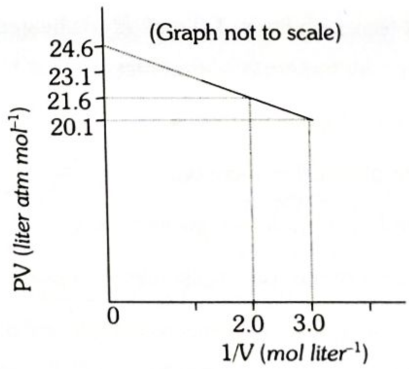
(c) Inversion temperature (d) Reduced temperature

36. The compression factor (compressibility factor) for 1 mole of a van der Waal's gas at $0°C$ and 100 atm pressure if found to be 0.5. Assuming that the volume of a gas molecule is negligible, calculate the van der Waal's constant 'a' **[2001]**

(a) $0.253\,L^2mol^{-2}atm$ (b) $0.53\,L^2mol^{-2}atm$

(c) $1.83L^2mol^{-2}atm$ (d) $1.253L^2mol^{-2}atm$

37. For one mole of a Vander Waals gas when $b=0$ and $T=300K$, the PV vs $1/V$ plot is shown below. The value of the van der Waals constant a ($atm.\ liter^2\ mol^{-2}$) is **[2006]**



(a) 1.0 (b) 4.5

(c) 1.5 (d) 3.0

38. The compressibility factor for a real gas at high pressure is **[2012]**

(a) $1+RT/pb$ (b) 1

(c) $1+pb/RT$ (d) $1-pb/RT$

39. If Z is a compressibility factor, Vander Waals equation at low pressure can be written as **[2014]**

(a) $Z = 1 + \frac{RT}{Pb}$ (b) $Z = 1 - \frac{a}{VRT}$

(c) $Z = 1 - \frac{Pb}{RT}$ (d) $Z = 1 + \frac{Pb}{RT}$

40. The Vander Waal's constant 'a' for the gases O_2, N_2, NH_3 and CH_4 are 1.3, 1.390, 4.170 and 2.253 $L^2\,atm\,mol^{-2}$ respectively. The gas which can be most easily liquefied is **[1989]**

(a) O_2 (b) N_2

(c) NH_3 (d) CH_4

41. 'a' and 'b' are Vander Waal's constants for gases. Chlorine is more easily liquefied than ethane because **[2011]**

(a) a and b for $Cl_2 >$ a and b for C_2H_6

(b) a and b for $Cl_2 <$ a and b for C_2H_6

(c) a and $Cl_2 <$ a for C_2H_6 but b for $Cl_2 > b$ for C_2H_6

(d) a for $Cl_2 > a$ for C_2H_6 but b for $Cl_2 < b$ for C_2H_6

42. A mono-atomic ideal gas undergoes a process in which the ratio of P to V at any instant is constant and equals to 1. What is the molar heat capacity of the gas **[2006]**

(a) $\frac{4R}{2}$ (b) $\frac{3R}{2}$

(c) $\frac{5R}{2}$ (d) 0

8. NEET/ AIPMT/ CBSE-PMT

1. In a closed flask of 5 *litres*, 1.0 *g* of H_2 is heated from 300 to 600 *K*. which statement is not correct **[1991]**

(a) Pressure of the gas increases

(b) The rate of collision increases

(c) The number of moles of gas increases

(d) The energy of gaseous molecules increases

2. The maximum number of molecules is present in **[2004]**

(a) 0.5 *g* of H_2 gas (b) 10 *g* of O_2 gas

(c) 15 *L* of H_2 gas at STP (d) 5 *L* of N_2 gas at STP

3. A mixture of gases contains H_2 and O_2 gases in the ratio of 1 : 4 (w/w). What is the molar ratio of the two gases in the mixture **[2015]**

(a) 4 : 1 (b) 16 : 1

(c) 2 : 1 (d) 1 : 4

4. A weather balloon filled with hydrogen at 1 *atm* and 27°C has volume equal to 12000 *L*. On ascending it reaches a place where the temperature is $-23°C$ and pressure is 0.5 *atm*. The volume of the balloon is **[1991]**

(a) 24000 *L* (b) 20000 *L*

(c) 10000 *L* (d) 12000 *L*

5. If P, V, M, T and R are pressure, volume, molar mass, temperature and gas constant respectively, then for an ideal gas, the density is given by **[1989, 91]**

(a) $\frac{RT}{PM}$ (b) $\frac{P}{RT}$

(c) $\frac{M}{V}$ (d) $\frac{PM}{RT}$

6. A bubble of air is underwater at temperature 15°C and the pressure 1.5 bar. If the bubble rises to the surface where the temperature is 25°C and the pressure is 1.0 bar, what will happen to the volume of the bubble **[2011]**

(a) Volume will become smaller by a factor of 0.70

(b) Volume will become greater by a factor of 2.5

(c) Volume will become greater by a factor of 1.6

(d) Volume will become greater by a factor of 1.1

7. The pressure exerted by 6.0 *g* of methane gas in a 0.03 m^3 vessel at 129°C is (Atomic masses : C=12.01, H= 1.01 and $R = 8.314\ JK^{-1}\,mol^{-1}$) **[2010]**

(a) 215216 *Pa* (b) 13409 *Pa*

(c) 41648 *Pa* (d) 31684 *Pa*

8. What is the density of N_2 gas at 227°C and 5.00 *atm.* pressure ($R = 0.082\ L\ Atm\ K^{-1}\,mol^{-1}$) **[2013]**

(a) 1.40 g/L (b) 2.81 g/L

(c) 3.41 g/L (d) 0.29 g/L

9. A gas such as carbon monoxide would be most likely to obey the ideal gas law at **[2015]**

(a) High temperatures and low pressures

(b) Low temperatures and high pressures

(c) High temperatures and high pressures

(d) Low temperatures and low pressures

10. The density of neon will be highest at **[1990]**

(a) S.T.P. (b) 0°C, 2 *atm*

(c) 273°C, 1 *atm* (d) 273°C, 2 *atm*

11. One *litre* of a gas weighs 2 *g* at 300 *K* and 1 *atm* pressure. If the pressure is made 0.75 *atm*, at which of the following temperatures will one *litre* of the same gas weigh one *gram* **[1992]**

(a) 450 *K* (b) 600 *K*

(c) 800 *K* (d) 900 *K*

12. Under what conditions will a pure sample of an ideal gas not only exhibit a pressure of 1 *atm* but also a concentration of 1 *mole* $litre^{-1}$ $(R = 0.082\, litre\, atm\, mol^{-1}\, deg^{-1})$ **[1993]**

(a) At STP

(b) When $V = 22.4\, litres$

(c) When $T = 12\, K$

(d) Impossible under any conditions

13. At constant temperature, in a given mass of an ideal gas **[1991]**

(a) The ratio of pressure and volume always remains constant

(b) Volume always remains constant

(c) Pressure always remains constant

(d) The product of pressure and volume always remains constant

14. Pressure remaining the same, the volume of a given mass of an ideal gas increases for every degree centigrade rise in temperature by definite fraction of its volume at **[1989]**

(a) 0^oC (b) Its critical temperature

(c) Absolute zero (d) Its Boyle temperature

15. The density of a gas at 27^oC and 1 *atm* is *d*. Pressure remaining constant at which of the following temperatures will its density become 0.75 *d* **[1992]**

(a) 20^oC (b) 30^oC

(c) 400 *K* (d) 300 *K*

16. A certain gas takes three times as long to effuse out as helium. Its molecular mass will be **[2012]**

(a) 27*u* (b) 36*u*

(c) 64*u* (d) 9*u*

17. Equal masses of H_2, O_2 and methane have been taken in a container of volume V at temperature 27°C in identical conditions. The ratio of the volumes of gases $H_2 : O_2$: methane would be **[2014]**

(a) 16 : 1 : 2 (b) 8 : 1 : 2

(c) 8 : 16 : 1 (d) 16 : 8 : 1

18. Which of the following mixtures of gases does not obey Dalton's law of partial pressure **[1996]**

(a) O_2 and CO_2 (b) N_2 and O_2

(c) Cl_2 and O_2 (d) NH_3 and HCl

19. Equal amounts of two gases of molecular weight 4 and 40 are mixed. The pressure of the mixture is 1.1 *atm*. The partial pressure of the light gas in this mixture is **[1991]**

(a) 0.55 *atm* (b) 0.11 *atm*

(c) 1 *atm* (d) 0.12 *atm*

20. If a mixture of CO and N_2 in equal amount have total 1 *atm* pressure, then partial pressure of N_2 in the mixture is **[2011]**

(a) 1 *atm* (b) 0.50 *atm*

(c) 2 *atm* (d) 3 *atm*

21. A gaseous mixture was prepared by taking equal mole of CO and N_2. If the total pressure of the mixture was found 1 atmosphere, the partial pressure of the nitrogen (N_2) in the mixture is **[2011]**

(a) 1 *atm* (b) 0.5 *atm*

(c) 0.8 *atm* (d) 0.9 *atm*

22. Equal volumes of two gases which do not react together are enclosed in separate vessels. Their pressures at 100 *mm* and 400 *mm* respectively. If the two vessels are joined together, then what will be the pressure of the resulting mixture (temperature remaining constant) **[1981]**

(a) 125 *mm* (b) 500 *mm*

(c) 1000 *mm* (d) 250 *mm*

23. A sample of O_2 gas is collected over water at 23^oC at a barometric pressure of 751 *mm Hg* (vapour pressure of water at 23^oC is 21 *mm Hg*). The partial pressure of O_2 gas in the sample collected is **[1993]**

(a) 21 *mm Hg* (b) 751 *mm Hg*

(c) 0.96 *atm* (d) 1.02 *atm*

24. Two gases A and B having the same volume diffuse through a porous partition in 20 and 10 seconds respectively. The molecular mass of A is $49u$. Molecular mass of B will be **[2011]**

(a) 25.00 *u* (b) 50.00 *u*

(c) 12.25 *u* (d) 6.50 *u*

25. 50 *mL* of each gas *A* and of gas *B* takes 150 and 200 seconds respectively for effusing through a pin hole under the similar conditions. If molecular mass of gas *B* is 36, the molecular mass of gas *A* will be **[2012]**

(a) 96 (b) 20.25

(c) 32 (d) 64

26. 50 *mL* of hydrogen diffuses out through a small hole from a vessel in 20 *minutes*. The time needed for 40 *mL* of oxygen to diffuse out is **[1994]**

(a) 12 *min* (b) 64 *min*

(c) 8 *min* (d) 32 *min*

27. At what temperature, the rate of effusion of N_2 would be 1.625 times that of SO_2 at $50^\circ C$ **[1996]**

(a) $110\,K$ (b) $173\,K$

(c) $373\,K$ (d) $273\,K$

28. A 20 *litre* container at 400 K contains $CO_2(g)$ at pressure 0.4 *atm* and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of CO_2 attains its maximum value, will be

(Given that : $SrCO_3(s) \rightleftharpoons SrO(s) + CO_2(g), Kp = 1.6\,atm$)

[2017]

(a) $5\,L$ (b) $10\,L$

(c) $4\,L$ (d) $2\,L$

29. If a gas expands at constant temperature, it indicates that **[2008]**

(a) Kinetic energy of molecules remains the same

(b) Number of the molecules of gas increases

(c) Kinetic energy of molecules decreases

(d) Pressure of the gas increase

30. Internal energy and pressure of a gas per unit volume are related as **[1993]**

(a) $P = \frac{2}{3}E$ (b) $P = \frac{3}{2}E$

(c) $P = \frac{1}{2}E$ (d) $P = 2E$

31. At STP, 0.50 mol H_2 gas and 1.0 mol He gas **[1993, 2000]**

(a) Have equal average kinetic energies

(b) Have equal molecular speeds

(c) Occupy equal volumes

(d) Have equal effusion rates

32. Which of the following expressions correctly represents the relationship between the average molar kinetic energy, $\overline{K.E.}$, of CO and N_2 molecules at the same temperature **[2000]**

(a) $\overline{K.E.}_{CO} = \overline{K.E.}_{N_2}$

(b) $\overline{K.E.}_{CO} > \overline{K.E.}_{N_2}$

(c) $\overline{K.E.}_{CO} < \overline{K.E.}_{N_2}$

(d) Cannot be predicted unless the volumes of the gases are given

33. Absolute zero is defined as the temperature **[1990]**

(a) At which all molecular motion ceases

(b) At which liquid helium boils

(c) At which ether boils

(d) All of the above

34. Which is not true in case of an ideal gas **[1991]**

(a) It cannot be converted into a liquid

(b) There is no interaction between the molecules

(c) All molecules of the gas move with same speed

(d) At a given temperature, PV is proportional to the amount of the gas

35. The ratio among most probable velocity, mean velocity and root mean square velocity is given by **[1993]**

(a) $1:2:3$ (b) $1:\sqrt{2}:\sqrt{3}$

(c) $\sqrt{2}:\sqrt{3}:\sqrt{8/\pi}$ (d) $\sqrt{2}:\sqrt{8/\pi}:\sqrt{3}$

36. The temperature of the gas is raised from $27^\circ C$ to $927^\circ C$, the root mean square velocity is **[1994]**

(a) $\sqrt{927/27}$ times the earlier value

(b) Same as before

(c) Halved

(d) Doubled

37. At what temperature is the average velocity of O_2 molecule equal to the root mean square velocity at $27^\circ C$ **[2005]**

(a) $80.57^\circ C$ (b) $80^\circ C$

(c) $83^\circ C$ (d) $86.5^\circ C$

38. By what factors does the average velocity of a gaseous molecule increase when the temperature (in Kelvin) is doubled **[2011]**

(a) 1.4 (b) 2.0

(c) 2.8 (d) 4.0

39. The root mean square speeds at STP for the gases H_2, N_2, O_2 and HBr are in the order **[1991]**

(a) $H_2 < N_2 < O_2 < HBr$

(b) $HBr < O_2 < N_2 < H_2$

(c) $H_2 < N_2 = O_2 < HBr$

(d) $HBr < O_2 < H_2 < N_2$

40. The Vander Waal's equation reduces itself to the ideal gas equation at **[2002]**

(a) High pressure and low temperature

(b) Low pressure and low temperature

(c) Low pressure and high temperature

(d) High pressure and high temperature

41. For real gases Vander Waal's equation is written as

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Where 'a' and 'b' are Vander Waal's constants.

Two sets of gases are

(I) O_2, CO_2, H_2 and He (II) CH_4, O_2 and H_2

The gases given in set-I increasing order of 'b' and gases given in set-II in decreasing order of 'a', are arranged below. Select the correct order from the following **[2012]**

(a) (I) $He < H_2 < CO_2 < O_2$ (II) $CH_4 > H_2 > O_2$

(b) (I) $O_2 < He < H_2 < CO_2$ (II) $H_2 > O_2 > CH_4$

(c) (I) $He < H_2 < O_2 < CO_2$ (II) $CH_4 > O_2 > H_2$

(d) (I) $H_2 < O_2 < He < CO_2$ (II) $O_2 > CH_4 > H_2$

42. Maximum deviation from ideal gas is expected from **[2013]**

(a) $NH_3(g)$ (b) $H_2(g)$

(c) $N_2(g)$ (d) $CH_4(g)$

43. The correction factor 'a' to the ideal gas equation corresponds to **[2018]**

(a) Density of the gas molecules

(b) Volume of the gas molecules

(c) Electric field present between the gas molecules

(d) Forces of attraction between the gas molecules

44. An ideal gas can't be liquefied because **[1992]**

(a) Its critical temperature is always above 0^oC

(b) Its molecules are relatively smaller in size

(c) It solidifies before becoming a liquid

(d) Forces operative between its molecules are negligible

45. An ideal gas obeying kinetic theory of gases can be liquefied if **[1995]**

(a) Its temperature is more than critical temperature T_c

(b) Its pressure is more than critical pressure P_c

(c) Its pressure is more than P_c at a temperature less than T_c

(d) It cannot be liquefied at any value of P and T

46. Ratio of C_p and C_v of a gas 'X' is 1.4. The number of atoms of the gas 'X' present in 11.2 *litres* of it at N.T.P. is **[1989, 99]**

(a) 6.02×10^{23} (b) 1.2×10^{24}

(c) 3.01×10^{23} (d) 2.01×10^{23}

47. Given van der Waals constant for NH_3, H_2, O_2 and CO_2 are respectively $4.17, 0.244, 1.36$ and 3.59 which one of the following gases is most easily liquefied **[2018]**

(a) NH_3 (b) H_2

(c) O_2 (d) CO_2

9. AIIMS

1. The density of air is 0.00130 *g/ml*. The vapour density of air will be **[2007]**

(a) 0.00065 (b) 0.65

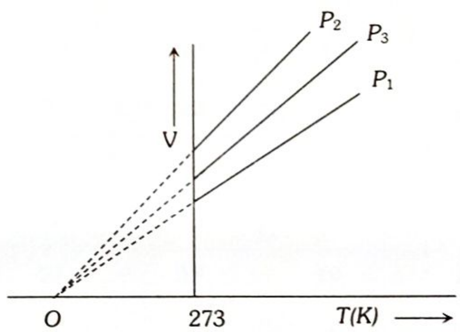
(c) 14.4816 (d) 14.56

2. Pressure of a mixture of 4 *g* of O_2 and 2 *g* of H_2 confined in a bulb of 1*L* at 0^oC is **[2000]**

(a) 25.215 *atm* (b) 31.205 *atm*

(c) 45.215 *atm* (d) 15.210 *atm*

3. The volume-temperature graph of a given mass of an ideal gas at constant pressure are shown below



What is the correct order of pressures **[2008]**

(a) $P_1 > P_3 > P_2$ (b) $P_1 > P_2 > P_3$

(c) $P_2 > P_3 > P_1$ (d) $P_2 > P_1 > P_3$

4. Dominance of strong repulsive forces among the molecules of the gas (Z = compressibility factor) **[2006]**

(a) Depends on Z and indicated by $Z = 1$

(b) Depends on Z and indicated by $Z > 1$

(c) Depends on Z and indicated by $Z < 1$

(d) Is independent of Z

10. Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : Compressibility factor for hydrogen varies with pressure with positive slope at all pressures.

Reason : Even at low pressures, repulsive forces dominate hydrogen gas. **[AIIMS 2005]**

2. Assertion : Pressure exerted by gas in a container increases with increasing temperature of the gas.

Reason : With the rise in temperature, the average speed of gas molecules increases. **[AIIMS 1995]**

3. Assertion : Gases do not settle at the bottom of container.

Reason : Gases have high kinetic energy. **[AIIMS 1997]**

4. Assertion : A mixture of He and O_2 is used for respiration for deep sea divers.

Reason : He is soluble in blood. **[AIIMS 1998]**

5. Assertion : Wet air is heavier than dry air.

Reason : The density of dry air is more than density of water vapour. **[AIIMS 1999]**

6. Assertion : All molecules in a gas have same speed.

Reason : Gas contains molecules of different size and shape. **[AIIMS 2001]**

7. Assertion : Effusion rate of oxygen is smaller than nitrogen.

Reason : Molecular size of nitrogen is smaller than oxygen. **[AIIMS 2004]**

8. Assertion : At high pressure, the compression factor Z is $\left(1+\frac{Pb}{RT}\right)$.

Reason : At high pressure vander Waals' equation is modified as $P(V-b)=RT$. **[AIIMS 2007]**

5. States of Matter – Answers Keys

1. Characteristics and Measurable Properties of Gases

1	c	2	c	3	e	4	c	5	b

2. Ideal Gas Equation and Related Gas Laws

1	a	2	c	3	d	4	b	5	a
6	a	7	a	8	c	9	a	10	a
11	e	12	a	13	d	14	c	15	c
16	a	17	a	18	c	19	a	20	b
21	b	22	d	23	c	24	d	25	bc
26	c	27	b						

3. Kinetic Molecular Theory of Gases and Molecular Collisions

1	a	2	d	3	b	4	a	5	d
6	a	7	d						

4. Molecular Speeds

1	d	2	d	3	b	4	a	5	b
6	b	7	a						

5. Real Gases and van der Waals Equation

1	d	2	c	3	c	4	a	5	a
6	a								

6. Critical State and Liquefaction of Gases

1	b	2	d	3	d	4	d	5	b
6	a	7	c						

7. IIT-JEE/ AIEEE

1	d	2	c	3	c	4	a	5	b
6	b	7	c	8	d	9	c	10	a
11	d	12	d	13	b	14	c	15	b
16	b	17	b	18	a	19	a	20	c
21	a	22	c	23	d	24	c	25	a
26	b	27	b	28	c	29	c	30	d
31	d	32	a	33	b	34	b	35	b
36	d	37	c	38	c	39	b	40	c
41	d	42	a						

8. NEET/ AIPMT/ CBSE-PMT

1	c	2	c	3	a	4	b	5	d
6	c	7	c	8	c	9	a	10	b
11	a	12	c	13	d	14	a	15	c
16	b	17	a	18	d	19	c	20	b
21	b	22	d	23	c	24	c	25	b
26	b	27	c	28	a	29	a	30	a
31	a	32	a	33	a	34	c	35	d
36	d	37	a	38	a	39	b	40	c
41	c	42	a	43	d	44	d	45	d
46	a	47	a						

9. AIIMS

1	d	2	a	3	a	4	b

10. Assertion & Reason

1	a	2	a	3	a	4	c	5	e
6	d	7	c	8	a				