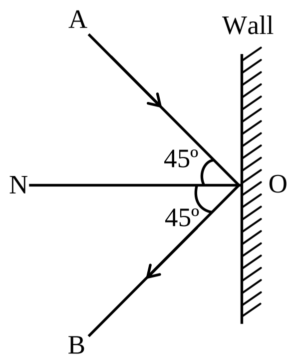
SOLVED EXAMPLES

Ex.1 The mass of hydrogen molecules is 3.32×10^{-27}kg. If 10^{23} hydrogen molecules strike a fixed wall of area 2 cm^2 at an angle 45º to the normal and rebound elastically with a speed of 10^3m/s calculate the pressure exerted on the wall –

(A) 2.347×10^3 N/m^2 (B) 23.47×10^4 N/m^2

(C) 234.7×10^3 N/m^2 (D) 23.47×10^3 N/m^2

Sol.[A]



The molecule strikes the wall along AO and rebound along OB such that

$\angle AON = \angle NOB = 45º$

The change in component momentum of each H_2 molecule in a perpendicular direction the wall = $\Delta P = 2\ mv \cos\theta$, where mv = momentum of molecule

$\therefore \quad \Delta P = (3.32 \times 10^{-27}) \times 10^3 \cos 45º$

$\Rightarrow \quad \Delta P = 4.692 \times 10^{-24}$ kg m/sec

Force exerted by N molecules on the wall

$= \Delta P \times N$

it A is the area of the wall on which the molecule strike, then pressure

$$P = F/A = \frac{N \times \Delta P}{A} = \frac{10^{23} \times 4.692 \times 10^{24}}{2 \times 10^{-4}}$$

$$= 2.347 \times 10^3 \text{ N/m}^2$$

Ex.2 Two ideal gases at temperature T_1 and T_2 are mixed. There is no loss of energy. If the masses of molecules of the two gases are m_1 and m_2 and number of their molecules are n_1 and n_2 respectively, the temperature of the mixture will be

(A) $\frac{T_1 + T_2}{n_1 + n_2}$ (B) $\frac{T_1}{n_1} + \frac{T_2}{n_2}$

(C) $\frac{n_2 T_1 + n_1 T_2}{n_1 + n_2}$ (D) $\frac{n_1 T_1 + n_2 T_2}{n_1 + n_2}$

Sol.[D] Total energy of molecules of first gas

$$= \frac{3}{2}\ n_1 K T_1$$

Total energy of molecules of second gas

$$= \frac{3}{2} n_2 L T_2$$

Total energy of molecules of mixture

$$= \frac{3}{2} K (n_1 T_1 + n_2 T_2)$$

$$\therefore \frac{3}{2}\ (n_1 + n_2) KT = \frac{3}{2} K(n_1 T_1 + n_2 T_2)$$

$$\Rightarrow T = \frac{n_1 T_1 + n_2 T_2}{(n_1 + n_2)}$$

Ex.3 The atomic weight of iodine is 127. A standing wave in a tube filled with iodine gas at 400 K has nodes that are 6.77cm apart when the frequency is 1000 vib/sec. iodine is

(A) Monoatomic (B)Diatomic

(C) Triatomic (D) None of these

Sol.[B] $\therefore\ \lambda = 2 \times 6.77$ cm = 13. 54cm

$\nu = n\lambda = 1000 \times 13.54 = 1.354 \times 10^4$cm/sec.

we know that

$\nu = \sqrt{\frac{VR}{T/M}}$ where molecular weight

M = Ax with x = 1 if iodine is monoatomic x = 2 it diatomic and A is atomic weight

$\therefore \qquad \gamma = \frac{Ax\nu^2}{RT} = 0.7x$

Where x = 2 as iodine is diatomic

$\therefore \qquad \gamma = 1.4$ (right value of diatomic gas)

Ex.4 Certain perfect gas is found obey $PV^{3/2}$ = const. during adiabatic process. If such a gas at initial temperature T is adiabatically compressed to half the initial volume, in final temperature will be –

(A) $\sqrt{2}$ T (B) 2T

(C) $2\sqrt{2}$ T (D) 4T

Sol.[A] $\therefore \qquad PV^{3/2}$ = constant (given)

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

$\therefore \qquad \left(\frac{nRT}{V}\right)(V^{3/2})$ = constant

When V changes to V/2 the temperature becomes $\sqrt{2}$ T.

Ex.5 In a certain process the pressure of one mole ideal gas varies with volume according to the relation $P = \frac{a}{\left[1+\left(\frac{V}{b}\right)^2\right]}$, where a, b are constants, when the volume of gas V = b, the temperature of the gas will be -

(A) $\frac{ab}{2R}$ (B) ab/R

(C) ab (D) zero

Sol.[A] ∴ $T = \frac{PV}{R}$

at $V = b,\ P = \frac{a}{(1+1)} = \frac{a}{2}$

∴ $T = \frac{ab}{2R}$

Ex.6 An air bubble of volume V_0 is released by a fish at a depth h in a lake. The bubble rises to the surface. Assume constant temperature and standard atmospheric pressure above the lake. The volume of the bubble just before touching the surface will be (density) of water is ρ

(A) V_0 (B) $V_0(\rho gh/P)$

(C) $\frac{V_0}{\left(1+\frac{\rho gh}{P}\right)}$ (D) $V_0\left(1+\frac{\rho gh}{P}\right)$

Sol.[D] As the bubble rises the pressure gets reduced for constant temperature, if P is the standard atmospheric pressure, then

$(P + \rho gh)\,V_0 = PV$

or $V = V_0\left(1+\frac{\rho gh}{P}\right)$

Ex.7 Two gases occupy two containers A and B the gas in A, of volume 0.10m^3, exerts a pressure of 1.40 MPa and that in B of volume $0.15\ \text{m}^3$ exerts a pressure 0.7 MPa. The two containers are united by a tube of negligible volume and the gases are allowed to intermingle. Then it the temperature remains constant, the final pressure in the container will be (in MPa) –

(A) 0.70 (B) 0.98

(C) 1.40 (D) 2.10

Sol.[B] We Know that

$P_AV_A = n_ART,\ P_BV_B = n_B\,RT$

and $P_f\,(V_A + V_B) = (n_A + n_B)\,RT$

$P_f\,(V_A + V_B) = P_AV_A + P_BV_B$

∴ $P_f = \left(\frac{P_AV_A + P_BV_B}{V_A + V_B}\right)$

$= \frac{1.4\times0.1+0.7\times0.15}{0.1+0.15}$ MPa

= 0.98 MPa

Ex.8 If the pressure of a gas contained in a closed vessel is increased by 0.5% when heated by 2ºC, then the initial temperature must be

(A) 127ºC (B) 273ºC

(C) 400ºC (D) 673ºC

Sol.[A] Using PV = nRT, we note that

$P_1V = nRT_1$

$P_1\,(1.005)V = nR\,(T_1 + 2)$

(note $\Delta P = P_2 - P_1 = 0.005\,P_1$ and

$\Delta T = 2ºC = 2K$

Dividing we get $1.005 = \frac{T_1+2}{T_1}$

or $0.00T_1 = 2 \Rightarrow T_1 = 400$

Thus in 0ºC, $t_1 = 400 - 273 = 127ºC$.

Ex.9 What is the degree of freedom of gas ? If at STP the velocity of sound in it is 330 m/sec and gas density = 1.3 mg/cm^3.

(A) 2 (B) 3

(C) 5 (D) 4

Sol. [C] ∴ $\nu = \sqrt{\frac{\gamma P}{\rho}}$

$P = 1.013 \times 10^5\ \text{N/m}^2,\ \rho = 1.3\text{kg/m}^3,\ \nu = 330$ m/s

$\gamma = \frac{\nu^2 P}{\rho} = 1.4$

Let f be the number of degree of freedom then $C_v = f\,R/2$ and $C_p = fR/2 + R = R\,(1 + f/2)$

∴ $\gamma = \frac{C_P}{C_V} = \frac{2+f}{f} = 1.4$

⇒ (f = 5)

LEVEL # 1

Questions based on — Assumption of kinetic theory of gases

Q.1 The gas molecules are not accumulated at the bottom of the container because -
(A) These do not have gravitation force between them
(B) Molecules have less mass and high velocities and therefore no gravitational force
(C) The direction of motion of molecules is changing on account of collisions.
(D) These is cohesive force between the gas molecules and the wall of the container acting in all direction.

Q.2 In kinetic theory of gases, it is assumed that molecules -
(A) Have same mass but can have different volume
(B) Have same volume but masses can be different.
(C) Have both mass and volume different
(D) Have same mass but negligible volume.

Q.3 When two molecules of a gas come closer then -
(A) Their direction get changed
(B) There exists a force of attraction
(C) There exist a force of repulsion
(D) Kinetic energy is not conserved.

Q.4 Which of the following statement is not according to the postulates of kinetic theory of gases.-
(A) Gas molecules are of small size
(B) Gas molecules are always in motion with all possible velocities
(C) There is no force between the molecules
(D) None of these

Questions based on — Different velocities of gas molecules

Q.5 The molecular weight of O_2 and H_2 are 32 and 2 respectively. Then the ratio of the rms velocities of H_2 and oxygen is -
(A) 4 : 1 (B) 2 : 3
(C) 1 : 4 (D) 16 : 1

Q.6 If velocities of 5 molecules of certain gas are –7, 5, 4, –3 and 1 m/sec respectively then mean speed of molecules is (m/sec) -
(A) Zero (B) 20 (C) 4 (D) $\sqrt{20}$

Q.7 If the rms speed of the nitrogen molecules of the gas at room temperature is 500 m/s, then the rms speed of the hydrogen molecules at the same temperature will be –
(A) 1870 m/s (B) 1935 m/s
(C) 7000 m/s (D) 83.7 m/s

Q.8 The rms velocity of molecules of a gas at temperature T is v_{rms}. Then the root mean square of the component of velocity in any one particular direction will be –
(A) $v_{rms}/\sqrt{3}$ (B) $\sqrt{3}\, v_{rms}$
(C) $v_{rms}/3$ (D) $3v_{rms}$

Q.9 The root mean square speed of molecules of ideal gases at the same temperature are –
(A) The same
(B) Inversely proportional to the square root of the molecular weight.
(C) Directly proportional to molecular weight.
(D) Inversely proportional to the molecular weight.

Q.10 The temperature of an ideal gas is increased from 27ºC to 927ºC. The rms speed of its molecules becomes –
(A) Twice (B) Half
(C) Four times (D) One fourth

Q.11 At what temperature rms speed of gaseous hydrogen molecules equal to that of oxygen molecules at 47ºC –
(A) 20 K (B) 80 K (C) –73 K (D) 3 K

Q.12 At what temperature, pressure remaining unchanged will the rms. velocity of hydrogen molecule be twice its value at S.T.P.?
(A) 1000K (B) 1050 K
(C) 1092 K (D) 2010K

Q.13 The mass of an oxygen molecule is about 16 times that of hydrogen molecules. At room temperature, the rms speed of oxygen molecule is V. The rms speed of the hydrogen molecule at the same temperature will be –
(A) V/6 (B) V/4
(C) 4V (D) 16V

Q.14 RMS velocity of which of the following gas at a given temperature is minimum –
(A) O_2 (B) N_2
(C) Cl_2 (D) He

Q.15 At 0ºC temperature root mean square speed of which of the following gases be maximum –
(A) H_2 (B) N_2
(C) O_2 (D) SO_2

Q.16 The root mean square velocity of the molecules of an ideal gas is –

(A) $\sqrt{RT/M}$ (B) $\sqrt{3RT/TM}$

(C) $\sqrt{3RT/M}$ (D) $\sqrt{RT/3M}$

Q.17 N_2 molecule is 14 times heavier than a H_2 molecule. At what temperature will the rms speed of H_2 molecules be equal to that of N_2 molecule at 27ºC –

(A) 50ºC (B) 2ºC

(C) 21.4ºC (D) 21.4 K

Questions based on

Calculation of pressure

Q.18 Equal masses of H_2 , He having molecular weight of 2 and 4 respectively are filled at same temperature in two containers of equal volumes. If H_2 gas has a pressure of 4 atmospheres, then He gas will have pressure as –

(A) 1 atmosphere (B) 4 atmosphere

(C) 2 atmosphere (D) 8 atmosphere

Q.19 The ratio of number of collisions per second at the wall of containers by H_2 and Ne gas molecules kept at same volume and temperature is given by -

(A) 10 : 1 (B) 1 : 10

(C) 1 : $\sqrt{10}$ (D) $\sqrt{10}$: 1

Q.20 The mass of a gas molecules is 4×10^{-30} kg. If such 10^{23} molecules per second strikes onto $4m^2$ area with velocity 10^7 m/sec, then the exerted pressure will be -

(A) 1 dyne/cm^2 (B) 1 N/m^2

(C) 2 N/m^2 (D) 2 dyne/cm^2

Q.21 The mass of hydrogen molecules is 3.32×10^{-24} gm. If 10^{23} H_2 molecules strike 2 sq. cm are per second with velocity of 10^5 cm/sec at an angle of 45º to the normal to wall, then the exerted pressure will be -

(A) 2.35 N/m^2 (B) 23.5 N/m^2

(C) 235 N/m^2 (D) 2350 N/m^2

Q.22 Molecules of a gas of mass m and velocity $\vec{v}$ after colliding normally with the wall change in momentum of the molecule will be -

(A) mv (B) 2mv (C) – mv (D) – 2mv

Q.23 In a cubical box of volume V, there are N molecules of a gas moving randomly. If m is mass of each molecule and v^2 is the mean square of x component of the velocity of molecules, then the pressure of the gas is –

(A) $P = \frac{1}{3}\frac{mNv^2}{V}$ (B) $P = \frac{mNv^2}{V}$

(C) $P = \frac{1}{3}mNv^2$ (D) $P = mNv^2$

Q.24 Pressure exerted by a gas is –

(A) Independent of density of the gas.

(B) Inversely proportional to the density of the gas.

(C) Directly proportional to the density of the gas.

(D) Directly proportional to the square root of the density of the gas.

Q.25 Two containers are of equal volume. One contains O_2 while the other has H_2. Both are kept at same temperature. The ratio of their pressure will be (rms velocity of these gases have ratio as 1 : 4) for 1 mole of each gas –

(A) 1 : 1 (B) 1 : 4 (C) 1 : 8 (D) 1 : 2

Questions based on

Kinetic energy of gas molecules and degree of freedom

Q.26 O_2 is 16 times heavier that H_2. If at same temperature the O_2 molecules have average kinetic energy E than at the same temperature the average kinetic energy of H_2 molecules will be -

(A) E/4 (B) 4E (C) E (D) E/16

Q.27 The average translational kinetic energy of 10 gram H_2 at 27 º C is -

(A) 37250 J (B) 18675 J

(C) 12450 (D) 3737 J

Q.28 At 27ºC, the average total energy of O_2 molecule is approximately -
(A) 6×10^{21} J (B) 10×10^{-21} J
(C) 6×10^{3} J (D) 6×10^{-23} J

Q.29 If the total translational kinetic energy of H_2 molecules is 7.5×10^3 J for the filled in a container of 10 litre capacity, then the pressure will be in Nm^{-2} -
(A) 5×10^2 (B) 3×10^2
(C) 2×10^2 (D) 5×10^5

Q.30 Degree of freedom of a monoatomic gas due to its rotational motion will be –
(A) 3 (B) 5 (C) 0 (D) 6

Q.31 Degree of freedom of hydrogen and ozone gases will be respectively –
(A) 3 and 5 (B) 5 and 6
(C) 6 and 5 (D) 5 and 3

Q.32 Mean translational kinetic energy of each degree of freedom of one molecule of a gas will be –
(A) RT/2 (B) kT/2
(C) 3RT/2 (D) 3RT/2

Q.33 The value of rotational K.E. at temperature T of one gram molecule of a diatomic gas will be –
(A) RT (B) 3RT/2 (C) 5RT (6) RT/2

Q.34 CO_2 is linear triatomic molecule. The average K.E. at temperature T will be –
(A) 3kT/2 (B) 5kT/2 (C) 6kT/2 (D) 7kT/2

Q.35 The kinetic energy of rotation of diatomic gas at 27º C will be (K = 1.38×10^{-23} Joule/K) –
(A) 2.07×10^{-21} Joule/molecule
(B) 4.14×10^{-21} Joule/molecule
(C) 6.14×10^{-23} Joule/molecule
(D) 3.07×10^{-23} Joule/molecule

Q.36 The gases are at the absolute temperature 300ºK and 350ºK respectively. The ratio of average kinetic energy of their molecules –
(A) 7 : 6 (B) 6 : 7 (C) 36 : 49 (D) 49 : 36

Q.37 Mean kinetic energy of one gram helium at 27º C will be –
(A) 3527×10^{-7} Joule (B) 6×10^{-18} Joule
(C) 933×10^{-3} Joule (D) 933.7 Joule

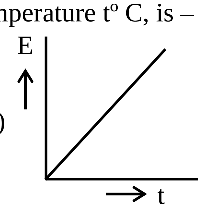
Q.38 The pressure of a gas is P N/m^2. The mean kinetic energy of one gram - mole gas at NTP (in joule) will be –
(A) 3.36×10^{-2} P (B) 3/2 P
(C) 2.24×10^{-2} P (D) 3.36 P

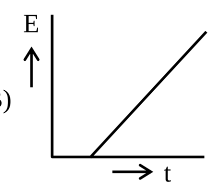
Q.39 CO_2 (O–C–O) is a triatomic gas. Mean kinetic energy of one gram gas will be –
(If N - Avogadro number, k - Boltzmann constant and molecular weight of CO_2 = 44) –
(A) 3/88 N k T (B) 5/88 N k T
(C) 6/88 N k T (D) 7/88 N k T

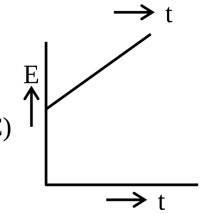
Q.40 The kinetic energy of gas molecules at 300 K is 75 joule. This energy at 500 K will be –
(A) 125 Joule (B) 208 Joule
(C) 270 Joule (D) 375 Joule

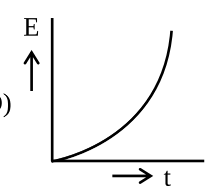
Q.41 In a container the number of hydrogen molecules is double of the number of oxygen molecules. Both gases are at a temperature 300 K. The ratio of mean kinetic energy per molecule of these gas molecules will be -
(A) 1 : 1 (B) 2 : 1 (C) 1 : 4 (D) 1 : 8

Q.42 The graph which represent the variation of mean kinetic energy of molecules with temperature tº C, is –

(A)


(B)


(C)


(D)


Q.43 The average translational kinetic energy of molecule of ideal gas at 47º C will be –
(A) 0.41×10^{-2} eV (B) 4.1×10^{-2} eV
(C) 0.41×10^{-3} eV (D) 4.1×10^{-4} eV

Q.44 If the number of molecules of hydrogen gas is double the number of molecules of oxygen gas, then the ratio of total kinetic energy of hydrogen and total kinetic energy of oxygen at 300 K is –
(A) 1 : 1 (B) 1 : 2
(C) 2 : 1 (D) 1 : 16

Questions based on ## Gas laws & gas equations

Q.45 **n** molecules of an ideal gas are enclosed in cubical box at temperature T and pressure P. If the number of molecules in the box is trippled then new temperature and pressure become T´ and P´ respectively, but the total energy of gas system remains unchanged, then –

(A) P = P´ and T = T´

(B) P = 3P´ and T´ = $\frac{1}{3}$T

(C) P´ = 3P and T´ = T

(D) P´ = P and T´ = $\frac{T}{3}$

Q.46 An 8 gram sample of a gas occupies 12.3 liters at a pressure of 40.0 cm Hg. Then the volume when the pressure is increased to 60.0 cm Hg will be at constant temperature –

(A) 18.45 L (B) 12.30 L

(C) 8.20 L (D) None

Q.47 The volume of a gas at 20ºC is 200 ml, if the temperature is reduced to –20ºC at constant pressure. Its volume will be –

(A) 172.6 ml (B) 17.26 ml

(C) 192.7 ml (D) 19.27 ml

Q.48 A perfect gas at 27ºC is heated at constant pressure so as to double its volume. The temperature of the gas will be –

(A) 300ºC (B) 327ºC

(C) 600ºC (D) 54ºC

Q.49 It is required to double the pressure of helium gas, contained in a steel cylinder, by heating. If the initial temperature of helium be 27ºC the temperature up to which it ought to be heated is –

(A) 54ºC (B) 108ºC

(C) 273ºC (D) 327ºC

Q.50 If pressure of a gas contained in a closed vessel is increased by 0.4%. When heated by 1ºC the initial temperature must be –

(A) 250 K (B) 250ºC

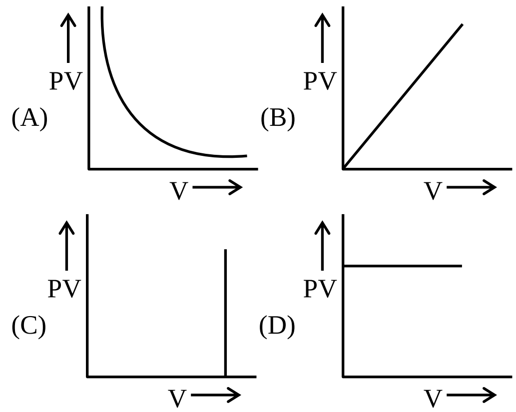
(C) 2500K (D) 25ºC

Q.51 The volumes of two vessels are 5 litre and 3 litre respectively. Air is filled in them at pressure of 3 atmos and 5 atmos respectively. At constant temperature if they are connected through a tube, the resultant pressure will be –

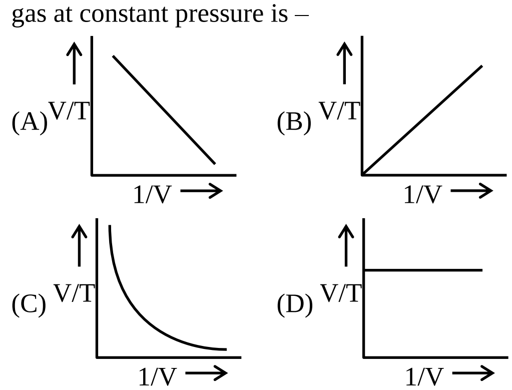
(A) 3.5 atmos (B) 3.75 atmos

(C) 4 atmos (D) 4.25 atmos

Q.52 If a gas obeys Boyle's law, then the shape of graph between PV and V will be –



Q.53 The correct curve between V/T and 1/V for a gas at constant pressure is –



Q.54 For ideal gas equation PV = XT, X is proportional to –

(A) Absolute temperature

(B) Density of gas

(C) Number of molecules of the gas in container

(D) None of these

Q.55 The Boyle's law is stated by PV = k, k depends on –

(A) Nature of gas

(B) Atomic weight of gas

(C) Temperature of gas

(D) Quantity and temperature of gas

Q.56 A gas has thermodynamical variables P, V and T and is in container A. Another gas in container b has variables 2P, V/4 and 2T. The ratio of molecules in container A to B is –

(A) 4 : 1 (B) 2 : 1 (C) 1 : 2 (D) 1 : 1

Q.57 The size of container B is double that of A and gas in B is at double the temperature and pressure than that in A. The ratio of molecules in the two containers will then be –

(A) $\frac{N_B}{N_A} = \frac{1}{1}$ (B) $\frac{N_B}{N_A} = \frac{2}{1}$

(C) $\frac{N_B}{N_A} = \frac{4}{1}$ (D) $\frac{N_B}{N_A} = \frac{1}{2}$

Q.58 8 gm O_2, 14gm N_2 and 22gm CO_2 is mixed in a container of 10 litre capacity at 27º C. The pressure exerted by the mixture in terms of atmospheric pressure will be –

(A) 1 (B) 3 (C) 9 (D) 18

Q.59 Two gases each having pressure P, volume V and temperature T are mixed so that mixture has volume V and temperature T, then the composite pressure will be –

(A) P (B) 2P (C) P/2 (D) 4P

Q.60 Two containers of equal volumes contain H_2 and O_2 at same temperature. If the number of molecules of these two gases is also equal than the ratio of pressure exerted by these will be –

(A) 1 : 1 (B) 4 : 1

(C) 8 : 1 (D) 16 : 1

Q.61 Some container contains on average 5 molecules/cm^3. If the gas has temperature of 3º K, then its pressure will be (N/m^2) –

(A) 2×10^{-15} (B) 2×10^{-16}

(C) 2×10^{-18} (D) 2×10^{-20}

Questions based on Real gas

Q.62 Real gas behaves like an ideal gas at –

(A) High temperature

(B) Low pressure

(C) High temperature and low pressure

(D) Low temperature and high pressure

Q.63 The constant 'a' in the equation $\left(P + n^2\frac{a}{V^2}\right)$ (V – nb) = n R T for a real gas has unit of –

(A) $N\text{-}m^{-4}$ (B) $N\text{-}m^{-2}$

(C) $N\text{-}m^2$ (D) $N\text{-}m^4$

Q.64 The unit of a × b in Vander Wal's equation is –

(A) N/m^2 (B) $N–m^7$ (C) $N\text{-}m^4$ (D) N/m^3

Q.65 The value of $\frac{RT_c}{P_cV_c}$ is –

(A) 8/3 (B) 3/8 (C) 2/7 (D) 1/2

Q.66 The temperature which the gas cannot be liquefied by applying pressure alone, is called -

(A) Temperature of inversion

(B) Boyle temperature

(C) Neutral temperature

(D) Critical temperature

Q.67 The critical temperature of a Vander Wal's gas is -

(A) $\frac{a}{27b^2}$ (B) $\frac{3a}{8b}$ (C) $\frac{8a}{27Rb}$ (D) $\frac{8a}{3Rb}$

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