Kinetic Theory Important Questions With Answers

NEET Physics 2023

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1. Air inside a closed container is saturated with water vapour The air pressure is p and the saturated vapour pressure of water is $\bar{p}$.if the mixture is compressed to one half of its volume by maintaining temperatures constant, the pressure becomes ;
   a) $2(p+\bar{p})$ **b)** $2p+\bar{p}$ c) $\frac{(p+\bar{p})}{2}$ d) $p+2\bar{p}$
2. A closed vessel A having volume V contains N_2 at pressure P and temperature T. Another closed vessel B having the same volume V contains He at the same pressure P but temperature 2T. The ratio of masses of N_2 and He in the vessels A and B is
   a) 1 : 2 b) 3 : 2 c) 5 : 2 **d) 14 : 1**

   Solution : -
   $P=\frac{m_{N2}}{M_{N2}}\times\frac{RT}{V}$
   $P=\frac{m_{He}}{M_{He}}\times\frac{R(2T)}{V}$
   $\therefore \frac{m_{N2}}{28\times10^{-3}}\times\frac{RT}{V}=\frac{m_{He}}{4\times10^{-3}}\times\frac{RT\times2}{V}$
   $\therefore \frac{m_{N2}}{m_{He}}=\frac{28}{4}\times2=\frac{14}{1}$
3. At a given volume and temperature the pressure of a gas:
   a) varies inversely as its mass b) varies inversely as the square of its mass **c) varies linearly as its mass** d) is independent of its mass

   Solution : -
   $P=\frac{1}{3}\left(\frac{mN}{V}\right)V^{\bar{2}}$
   $p\infty mN$
4. If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 kg water at STP will be given by:
   a) 5.6 m^3 b) 4.5 m^3 c) 11.2 m^3 d) 5.6 m^3

   Solution : -
   When intermolecular force vanishes, the liquid is converted into vapours. Molecular mass of water va pours = 18 g = 18 x 10^{-3} k
   Now, 18 x 10^{-3} kg of water vapour occupies at STP a volume of 22400 cc or 22.4 litre = 22.4 x 10^{-3} m^3
   Hence , 4.5 kg occupies
   = $\frac{22.4\times10^{-3}}{18\times10^{-3}}$ x 4.5 = 5.6 m^3
5. Two monoatomic ideal gases A and B occupying the same volume V, are at the same temperature T and pressure P. If they are mixed, the resultant mixture has volume V and temperature T. The pressure of the mixture is:
   a) P b) $\frac{P}{2}$ c) 4P **d) 2P**

   Solution : -

Number of moles is conseved.

$\therefore n_A + n_B = nmix$

Where nA, nB and nmix represent the number of moles of gas A, B and their mixture respectively.

Using ideal gas equation , we get

$$\frac{P_A V_A}{RT_A} + \frac{P_B V_B}{RT_B} = \frac{P_{mixture} V_{mixture}}{RT_{mixture}}, \frac{PV}{RT} + \frac{PV}{RT} = \frac{P_{mixture} V}{RT}$$

or $P_{mixture} = 2P$

6. In two vessels of same volume atomic hydrogen and helium at pressure of 1 atm and 2 atm are filled. If temperature of both the samples is same, then average speed of hydrogen atom (UH) will be related to helium (UHe) as:

   a) $\langle v_H \rangle = \sqrt{2} \langle v_{He} \rangle$ b) $\langle v_H \rangle = \langle v_{He} \rangle$ **c)** $\langle v_H \rangle = 2 \langle v_{He} \rangle$ d) $\langle v_H \rangle = \langle v_{He}/2 \rangle$

7. The relation between rms velocity , v_{rms} and the most probable velocity , v_{rmp} , of a gas is:

   a) $v_{rms} = v_{mp}$ **b)** $\mathbf{v_{rms} = \sqrt{\frac{3}{2}} v_{mp}}$ **c)** $\mathbf{v_{rms} = \sqrt{\frac{2}{3}} v_{mp}}$ d) $v_{rms} = \frac{2}{3} v_{mp}$

   Solution : -

   $$v_{rms} = \sqrt{\frac{3KT}{m}}, v_{mp} = \sqrt{\frac{2KT}{m}}$$

   $$\frac{u_{rms}}{u_{mp}} = \sqrt{\frac{3}{2}}$$

8. A mixture of2 moles of helium gas (atomic mass = 4 amu) and 1 mole of argon gas (atomic mass = 40 amu) is kept at 300K in a container. The ratio of the rms speed

   $\left[\frac{v_{rms}(helium)}{v_{rms}(argon)}\right]$ is:

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

   Solution : -

   $$v_{rms} = \sqrt{\frac{3RT}{M}}$$

   $\therefore$ Required ratio = $\sqrt{\frac{3RT}{M}} \quad \sqrt{\frac{M_{Ar}}{M_{He}}} = \sqrt{\frac{40}{4}} = \sqrt{10}$ = 3.16

9. An ideal gas is

   a) one which consists of massless particles **b) one satisfying assumption of kinetic theory**

   c) a gas consisting small particles d) one that consists of molecules

   Solution : -

   An ideal gas is one which satisfy assumption of kinetic theory.

10. Some gas at 300K is enclosed in a container.Now the container is placed on a fast moving jet.While the jet is in motion, the temperature of gas

    a) rises above 300K b) falls below 300K **c) remains unchanged** d) becomes unsteady

    Solution : -

    Motion of particle due to train is ordered motion.Motion of gas molecule in container is disordered motion.Its disordered motion causes change in temperature.In this case, the ordered motion of gas molecules remain unaffected.So, temperature will remain same.

11. Two gases of equal mass are in thermal equilibrium. If P_a ,P_b and V_a and V_b are their respective pressures and volumes, then which relation is true?

    a) $\mathbf{P_a V_a = P_b V_b}$ b) $P_a/V_a = P_b/V_b$ c) $P_a = P_b; V_a \neq V_b$ d) $P_a \neq P_b; V_a \neq V_b$

12. The temperature at which protons in proton gas would have enough energy to overcome Coulomb barrier of 4.14 x 10^{-14} is (Boltzmann constant 1.38 x 10^{-23} JK^{-1})

    a) 2 x 10^9 K b) 10^9 K c) 6 x 10^9 K d) 3 x 10^9 K e) 4.5 10^9 K

    Solution : -

The temperature at which protons in a proton gas would have enough energy to overcome coulomb barrier between them is given by :

$\frac{3}{2}k_BT = K^{av}$ ....(i)

Where K_{av} is the average Kinetic energy of the proton, T is the temperature of the proton gas and K_B is the Boltzmann's constant From eqn, (i) we get

$T = \frac{2K_{av}}{3K_B}$

Substituting the values , we get;

$T = \frac{2\times4.14\times10^{-14}J}{3\times1.38\times10^{-23}JK^{-1}}$ = 2 x 10^9 K

13. A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ.It is moving with speed v and is suddenly brought to rest.Assuming no heat is lost to the surroundings, its temperature increases by

    a) $\frac{(\gamma-1)}{2R}Mv^2K$ b) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2K$ c) $\frac{(\gamma-1)}{2\gamma R}Mv^2K$ d) $\frac{\gamma Mv^2}{2R}K$

    Solution : -

    Work done (W) in bringing the vessel at rest is equal to change in internal of gas (ΔU)

    So, W=ΔU

    $\Rightarrow \frac{1}{2}mv^2 = nC_vdT$

    $\Rightarrow \frac{1}{2}mv^2 = \frac{m}{M}\frac{R}{\gamma-1}dT$

    $\Rightarrow dT = \frac{M(\gamma-1)v^2}{2R}$ kelvin

    $dT = \frac{\gamma-1}{2R}Mv^2$ kelvin

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    $dT = \frac{\gamma-1}{2R}Mv^2$ kelvin

15. The mean square speed of 4 molecules of a gas having speeds 1,2,3 and 4 m/s is

    a) 2.44 m/s **b) 7.5 m/s** c) 2.5 m/s d) 9 m/s

16. A container has N molecules at absolute temperature T. If the number of molecules is doubled but kinetic energy in the box remains the same as before, the absolute temperature of the gas is:

    a) T **b) T/2** c) 2T d) zero

    Solution : -

    $\bar{KE} = \frac{3}{2}$kT

    On doubling the number of molecules and keeping total KE same, average KE ($\bar{KE}$) becomes half, resulting in half the temperature.

17. Consider I cc sample of air at absolute temperature To at sea level and another 1 cc sample of air at a height, where pressure is one-third atmosphere.The absolute temperature T of the sample at the height is:

a) equal to (T_0 / 3)   b) equal to (3 / T_0)   c) equal to T_o

d) cannot be determind in terms of T_0 from the above data

Solution : -

Mass of 1 cc of gas at sea level and at given height does not remain the same and gas laws hold good only for a constant mass.

18. Internal energy of n_1 mole of hydrogen at temperature T is equal to internal energy of n_2 mole of helium at temperature 2T.Then, ratio $\frac{n_1}{n_2}$ is

a) $\frac{3}{2}$ b) $\frac{2}{3}$ **c)** $\frac{6}{5}$ d) $\frac{3}{7}$

Solution : -

Internal energy of n moles of an ideal gas at temperature T is given by

U=$\frac{f}{2}$nRT   (f is degree of freedom)

U_1=U_2

$f_1n_1T_1=f_2n_2T_2$

$\frac{n_1}{n_2}=\frac{f_2T_2}{f_1T_1}=\frac{(3)(2)}{(5)(1)}=\frac{6}{5}$

f_1 is degree of freedom of H=5

f_2 is degree of freedom of He=3

19. Two containers of equal volume contain the same gas at the pressures p_1 and p_2 and absolute temperatures T_1 and T_2 respectively.On joining vessels, the gas reaches a common pressure p and a common temperature T.The ratio of p/T is

a) $\frac{p_1T_2+p_2T_2}{T_1\times T_2}$ b) $\frac{p_1T_2+p_2T_2}{T_1+T_2}$ **c)** $\frac{1}{2}\left[\frac{p_1T_2+p_2T_1}{T_1T_2}\right]$ d) $\frac{p_1T_2-p_2T_2}{T_1\times T_2}$

Solution : -

For a closed system, total number of moles remains constant.

So.

Initially, $p_1V=n_1RT_1$ and $p_2V=n_2RT_2$

then, $p(2V)=(n_1+n_2)RT$

$\therefore \frac{p}{T}=\frac{(n_1+n_2)}{2V}R=\frac{1}{2}(\frac{p_1}{T_1}+\frac{p_2}{T_2})$

$=\frac{1}{2}(\frac{p_1T_2+p_2T_1}{T_1T_2})$

20. At room temperature the nns speed of the molecules of a certain diatomic gas is found to be 1930 m/s; the gas is:

a) hydrogen   b) fluorine   c) oxygen   d) chlorine

21. The mean kinetic energy of the mole of gas per degree of freedom (on the basis of Kinetic theory of gases) is ;

a) $\frac{1}{2}$ kT   b) $\frac{3}{2}$ kT   **c) $\frac{3}{2}$ kT**   d) $\frac{1}{2}$ RT

22. 10,000 small balls, each weighing 1 g, strike one square em of area per second with a velocity 100 m/s in a normal direction and rebound with the same velocity. The value of pressure on the surface will be:

a) 2 x 10^3 N/m^2 b) 2 x 10^5 N/m^2 c) 10^7 N/m^2 **d) 2 x 10^7 N/m^2**

Solution : -

Change in momentum of one ball = 2mv = 2 x 1 x 10^{-3} x 100 Rate of change of momentum = force

i.e., F = 2 x 1 x 10^{-3} x 100 x 10,000 = 2 x 10^3 N

Pressure =$\frac{F}{A}=\frac{2\times10^3}{1\times10^{-4}}$=2 x 10^7 N/m^2

23. The root mean square and most probable speed of the molecules in a gas are:

a) same   b) different   c) cannot say   d) depends on nature of the gas

24. Half a mole of helium at 27° C and at a pressure of 2 atmosphere is mixed with l.5 mole of Nj at 77° C and at a pressure at 5 atmosphere so that the volume of the mixture is equal to the sum of their initial volumes. If the temperature of the mixture is 69° C, its pressure is:

a) 3.5 atm **b) 3.8 atm** c) 3.95 atm d) 4.25 atm

Solution : -

$P_1V_1 = u_1RT_1$

or $V_1 = \frac{u_1RT_1}{P_1} = \frac{1}{2}\frac{R(300)}{2} = 75R$

$P_2V_2 = u_2RT_2$

or $V_2 = u2\frac{RT_2}{P_2} = 1.5\frac{R(350)}{5} = 105R$

$P(V_1 + V_2) = (u_1 + u_2)Rt$

or $P(75R + 105R) = \left(\frac{1}{2} + 1.5\right) R\ (273 + 69)$

or $P \times 180R = 2 \times R \times 342$

$P = \frac{342}{90} = 3.8$ atm

25. Equal volume of monoatomic and diatomic gases at the same temperature are given equal quantities of heat. Then:

a) the temperature of diatomic gas will be more **b) the temperature of monoatomic gas will be more**

c) the temperature of both will be zero d) nothing can be said

Solution : -

Since, monoatomic gas has one degree of freedom, so rise of temperature will be more in its case.

26. A gas is heated through 1°C in a closed vessel. Its pressure is increased by 0.4%. The initial temperature of the gas is:

a) 250^oC b) 100^oC c) -75^oC **d) -23^oC**

Solution : -

$T_1 = T$; $P_1 = P$

P_2 = 0.4% more than $P_1 = P + \frac{0.4P}{100} = \frac{100.4P}{100}$

So, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{PV}{T} = \frac{100.4P}{100}.\frac{V}{T+1}$

Solving, we get; T = 250 K = -23^oC.

27. The root mean square speed of hydrogen molecules at a certain temperature is 300 m/s. If the temperature is doubled and hydrogen gas dissociates into atomic hydrogen, the rms speed will become:

a) 424.26 mls b) 300 m/s **c) 600 M/s** d) 150 M/s

Solution : -

$v_{rms} = \sqrt{\frac{3RT}{M}}$

T is doubled and M is halved. Thereforce, rms speed will become two times or 600 m/s.

28. For a gas, $\frac{R}{C_V} = 0.67$, the gas is made up of molecules which are

a) monoatomic b) diatomic c) triatomic d) polyatomic

Solution : -

$\frac{R}{C_V} = 067 = \frac{2}{3} \Rightarrow C_V = \frac{3}{2}R$

So, the gas must be monoatomic.

29. The average kinetic energy of a gas molecule is:

a) proportional to pressure of gas b) inversely proportional to volume of gas

c) inversely proportional to absolute temperature of gas **d) proportional to absolute temperature of gas**

30. If the masses of all molecules of a gas are halved and their speeds doubled, then the ratio of initial and final pressures would be

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

Solution : -

$P=\frac{1}{3}\frac{mN}{V}v^2, \quad p'=\frac{1}{3}\frac{(m/2)N}{v}(2\bar{v})^2$

$\therefore \frac{P'}{P}=\frac{2}{1}$ or $\frac{P}{P'}=1:2$

31. Three perfect gases at absolute temperatures T_1 ,T_2 and T_3 are mixed. The masses of molecules are m_1 , m_2 and m_3 and the number of molecules are n_1 ,n_2 and n_3 respectively. Assuming no loss of energy, the final temperature of the mixture is:

a) $\frac{(T_1+T_2+T_3)}{3}$ **b)** $\frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$ c) $\frac{n_1T_1^2+n_2T_2^2+n_3T_3^2}{n_1T_1+n_2T_2+n_3T_3}$ d) $\frac{n_1^2T_1^2+n_2^2T_2^2+n_3^2T_3^2}{n_1T_1+n_2T_2+n_3T_3}$

32. A balloon contains 1500 m^3 of helium at 27°C and 4 atmospheric pressure. The volume of helium at -3°C temperature and 2 atmospheric pressure will be:

a) 1500 m^3 b) 1700 m^3 c) 1900 m^3 **d) 2700 m^3**

Solution : -

V_1 = 1500 m^3, T1 = 27°C = 300 K

P_1 = 4 atm, T_2 =-3°C = 270 K

P_2 = 2atm

$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$

$\therefore V_2=\frac{P_1V_1}{T_1}\times\frac{T_2}{P_2}=\frac{4\times1500\times270}{300\times20}2700m^3.$

33. A sealed container with negligible thermal coefficient of expansion contains helium (a monoatomic gas). When it is heated from 300 K to 600 K, the average kinetic energy of helium atoms is:

a) halved b) left unchanged **c) doubled** d) increases by a factor of $\sqrt{2}$

34. A bubble is at the bottom of the lake of depth h. As the bubble comes to sea level, its radius increases three times. If atmospheric pressure is equal to 1metres of water column, then h is equal to:

a) 26 l b) l c) 25 l d) 30 l

Solution : -

From Boyle's law p_V = constant

$\therefore$ p_1V_1 = p_2V_2

Here, p_1 = (h + 1),V_1 = $\frac{4}{3}\pi r^3$

p_2 = l, V_2 = $\frac{4}{3}\pi(3r)^3$

$\therefore$ (h+ l)$\frac{4}{3}\pi r^3$ = l x $\frac{4}{3}\pi(3r)^3$

or h + l = 27l $\therefore$ h = 26 l

35. Let $\bar{v},\bar{v}$ 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 the molecule is m. Then:

a) No molecules can have a speed greater than $\left(\sqrt{2}v_{rms}\right)$

b) No molecules can have a speed less than $\frac{v_p}{(\sqrt{2})}$ c) $\bar{v}$ < v_p < v_{rms}

d) the average kinetic energy of the molecules is $\frac{3}{4}(mv_p^2)$

Solution : -

$v_{rms}=\sqrt{\frac{3RT}{m}}$

$\bar{v}=\sqrt{\frac{8RT}{\pi m}}=\sqrt{\frac{2.5RT}{m}}$

and vp = $\sqrt{\frac{2RT}{m}}$

Form these expressions , we can see that

$v_p < \bar{v} < v_{rms}$

Again, $v_{rms} = v_p\sqrt{\frac{3}{2}}$

and average kinetic energy of a gas molecule

Ek = $\frac{1}{2}$mv^2

Ek = $\frac{1}{2}m\left(\sqrt{\frac{3}{2}}v_p\right)^2 = \frac{1}{2}m \times \frac{3}{2}v_p^2 = \frac{3}{4}mvv_p^2$

36. The gas in a vessel is subjected to a pressure of 20 atmosphere at a temperature 27° C. The pressure of the gas in the vessel after one half of the gas is released from the vessel and the temperature of the remainder is raised by, 50° C, is:

    a) 8.5 atm   b) 10.8 atm   **c) 11.67 atm**   d) 17 atm

    Solution : -

    PV=$\frac{m}{M}$RT

    20 x V=$\frac{m}{M}R \times 300, P' \times V = \frac{(m/)}{M}R \times 350$

    ∴ P'=$\frac{140}{12}$=11.67 atm.

37. Some gas at 300 K is enclosed in a container. Now, the container is placed on a fast moving train. While the train is in motion, the temperature of the gas:

    a) rises above 300 K   b) falls below 300 K   **c) remains unchanged**   d) becomes unsteady

    Solution : -

    Random motion of molecules and not ordered motion causes rise of temperature.

38. What is an ideal gas?

    a) One that consists of molecules   **b) A gas satisfying the assumptions of kinetic theory**

    c) A gas having Maxwellian distribution of speed   d) A gas consisting of massless particles

39. The root mean square velocity of the molecules of a gas is 1260 m/s. The average speed of the molecules is

    a) 1029 ms^{-1} **b) 1161 ms^{-1}**   c) 1671 ms^{-1} d) 917 ms^{-1}

    Solution : -

    v$_{av}$=$\sqrt{\frac{8kY}{m\pi}}$, vrms=$\sqrt{\frac{3kT}{m}}$

    ∴ $\frac{v_{av}}{v_{rmp}} = \frac{\sqrt{8/\pi}}{\sqrt{3}}$

    or $\frac{v_{av}}{1260} = \sqrt{\frac{8}{3\pi}}$

    ∴ v$_{av}$=$1260 \times \sqrt{\frac{8}{3\pi}}$=1161 ms^{-1}.

40. On any planet, the presence of atmosphere implies; (v_{rms} = root mean square velocity of molecules and v_e = escape velocity))

    a) $v_{rms} << v_e$ b) $u_{rms} > v_e$ c) $v_{rms} = v_e$ d) $v_{rms} = 0$

41. If C_8 be the velocity of sound in air and C be the rms velocity, then:

    a) Cs < C   b) Cs = C   **c) Cs = C$\sqrt{\gamma/3}$**   d) none of these

42. The root mean square velocity, vrms, the avaerage velocity, v_{av} and the most probable velocity , v_{mp} of the molecules of the gas are in the order:

    a) $v_{mp} > v_{av} > v_{rms}$ **b) $v_{rms} > v_{av} > v_{mp}$**   c) $v_{av} > v_{mp} > v_{rms}$ d) $v_{mp} > v_{rms} > v_{av}$

    Solution : -

$v_{rms} = \sqrt{\frac{3KT}{m}}, v_{av} = \sqrt{\frac{8KT}{m\pi}}$

and $v_{mp} = \sqrt{\frac{2KT}{m}}$

$\therefore$ $v_{rms} > v_{av} > v_{mp}$

43. IF both the temperature and the volume of an ideal gas are doubled , the pressure:
    a) Increases by a factor of 4 b) is also doubled **c) remains unchanged** d) is diminshed by a factor $\frac{1}{4}$
44. If the pressure of an ideal gas contained in a closed vessel increased by 0.5%, the increase in temperature is 2 K. The initial temperature of the gas is:
    a) 27°C **b) 127°C** c) 300^0C d) 400^0C
45. At what temperature the molecules of nitrogen will have the same rms velocity as the molecules of oxygen a 127^0 C
    a) 77^0C b) 350^0C c) 273^0C **d) 457^0C**
46. A real gas behaves like an ideal gas if its:
    a) pressure and temperature are both high b) pressure and temperature are both low
    c) pressure is high and temperature is low **d) pressure is low and temperature is high**
47. A vessel contains a mixture of Imole of oxygen and 2 moles of nitrogen at 300 K. The ratio of average rotational kinetic energy per 0_2 molecule to that of per N_2 molecule is:
    a) 1:1 b) 1 : 2 c) 2 : 1
48. An insulated box containing a diatomic gas of molar mass M is moving with a velocity u. The box is suddenly stopped. The resulting change in temperature is:
    a) $\frac{mv^2}{2R}$ b) $\frac{mv^2}{3R}$ **c)** $\frac{mv^2}{5R}$ d) $\frac{2mv^2}{5R}$
49. In an ideal gas without preferred direction of motion molecules,
    a) None of the above b) $v_x = v_y = v_z$ c) $v_x^2 = v_x^y = v_z^2$ **d)** $\bar{v}_x^2 = \bar{v}_y^2 = \bar{v}_z^2$

    Solution : -

    An isotropic gas is one which have same properties throughout and their molecules are all moving in random direction, so only average of square of their velocity components are equal.
50. By what percentage should the pressure of a given mass of a gas be increased so as to decrease its volume by 10% at a constant temperature?
    a) 8.1% b) 9.1% c) 10.1% **d) 11.1%**

    Solution : -

    $\frac{PV}{T} = \frac{p' \times \frac{90}{100} V}{T}$

    $\therefore \frac{P'}{P} = \frac{100}{90} = 1 + \frac{10}{90}$

    $\therefore \frac{P' - P}{P} = \frac{10}{90} \times 100 = 11.1\%$