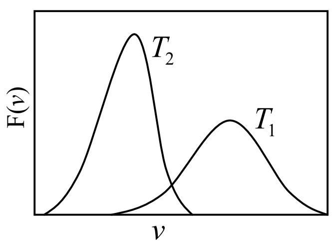
Practice Set (Kinetic Theory)

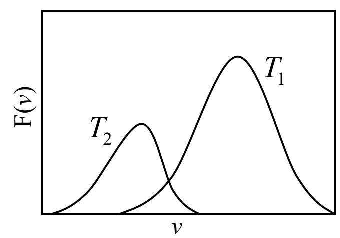
Q1. Consider a Maxwellian distribution of the velocity of the molecules of an ideal gas. Let v_{mp} and v_{rms} denote the most probable velocity and the root mean square velocity, respectively.

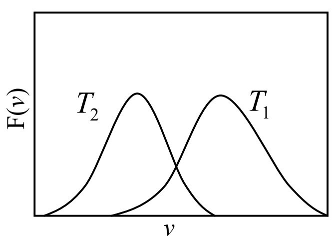
The magnitude of the ratio $\frac{v_{rms}}{v_{mp}}$ is

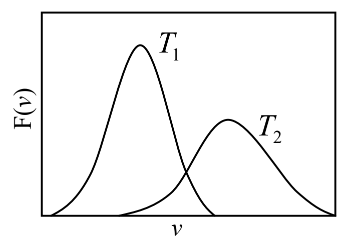
(a) $\sqrt{\frac{3}{2}}$ (b) 2/3 (c) $\sqrt{2/3}$ (d) 3 / 2

Q2. For temperature $T_1 > T_2$, the qualitative temperature dependence of the probability distribution $F(v)$ of the speed v of a molecule in three dimensions is correctly represented by the following figure

(a) 

(b) 

(c) 

(d) 

Q3. The speed v of the molecules of mass m of an ideal gas obeys Maxwell's velocity distribution law at an equilibrium temperature T. Let $(v_x, v_y v_z)$ denote the components of the velocity and k_B the Boltzmann constant. The average value of $(\alpha v_x - \beta v_y)^2$, where α and β are constants, is

(a) $(\alpha^2 - \beta^2)k_B T / m$ (b) $(\alpha^2 + \beta^2)k_B T / m$

(c) $(\alpha + \beta)^2 k_B T / m$ (d) $(\alpha - \beta)^2 k_B T / m$

Q4. The speed v of the molecules of mass m of an ideal gas obeys Maxwell's velocity distribution law at an equilibrium temperature T. Let $(v_x, v_y v_z)$ denote the components of the velocity and k_B the Boltzmann constant. The average value of $(\alpha v_x v_y)^2$, where α and β are constants, is

(a) 0

(b) $\alpha^2\left(\frac{k_BT}{m}\right)^2$

(c) $\alpha^2\left(\frac{k_BT}{2m}\right)^2$

(d) $\alpha^2\left(\frac{2k_BT}{m}\right)^2$

Q5. The statistical energy distribution underlying an ideal gas law gives the number of molecules with kinetic energies between E and $E+dE$ as $N(E)dE$. Which one of the following expressions can be used to obtain average kinetic energy over the collection of N molecules?

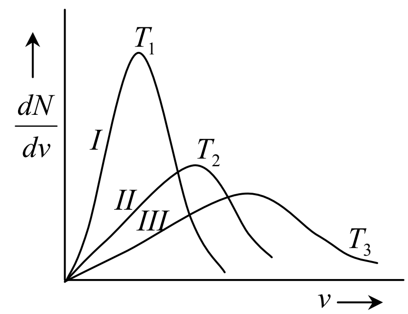
(a) $\frac{1}{N}\int_0^\infty EN(E)dE$

(b) $\frac{1}{N}\int_{-\infty}^{+\infty} N(E)dE$

(c) $\frac{1}{N}\int_0^\infty N(E)dE$

(d) $\frac{1}{N}\int_{-\infty}^{\infty} E\,dE$

Q6. The plots of Maxwell's distribution fraction $\left(\frac{dN}{dv}\right)$ *versus* speed (c) for a given sample of a gas at three different temperatures T_1, T_2 and T_3 respectively, are shown in the above diagram. If the areas on the c-axis under three curve I, II and III be denoted by A_{I}, A_{II} and A_{III} respectively, then which one of the following is correct?



(a) $A_{\text{I}} > A_{\text{II}} > A_{\text{III}}$

(b) $A_{\text{I}} = A_{\text{II}} = A_{\text{III}}$

(c) $A_{\text{I}} < A_{\text{II}} < A_{\text{III}}$

(d) $A_{\text{II}} < A_{\text{I}} < A_{\text{III}}$

Q7. Temperature of an ideal gas is increased such that the most probable velocity of molecules increase by a factor of 4. By what factor will the rms velocity increase?

(a) $\frac{\sqrt{3}}{2}$

(b) 2

(c) 4

(d) 16

Q8. A gas at thermal equilibrium satisfying Maxwell's velocity distribution

Given $\bar{v} =$ average speed of the molecules

$v_p =$ most probable speed

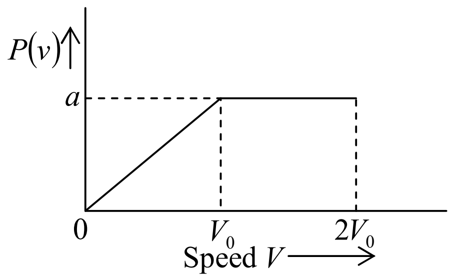
$v_{rms} =$ root mean square speed

Select the correct sequence for $\bar{v}, v_p, v_{rms}$:

(a) $\bar{v} > v_{rms} > v_p$ (b) $v_{rms} > v_p > \bar{v}$

(c) $\bar{v} > v_p > v_{rms}$ (d) $v_{rms} > \bar{v} > v_p$

Q9. A hypothetical speed distribution for a sample of N gas particles is shown below. Here $P(v) = 0$ for $v > 2v_0$. How many particles have speeds between $1.2v_0$ and $1.9v_0$?



(a) $\frac{N}{5}$ (b) $\frac{7N}{15}$ (c) $\frac{2N}{21}$ (d) None of these

Q10. A parallel beam of nitrogen molecules moving with velocity v m/s impinges on a wall at an angle θ to its normal. The concentration of molecules in the beam n cm^3. The pressure exerted by the beam on the wall assuming the molecules to scatter in accordance with the perfectly elastic collision law is given by

(a) $2nmv^2 \cos\theta$ (b) $nmv^2 \cos\theta$

(c) $2nmv^2 \sin\theta$ (d) $nmv^2 \sin\theta$

Q11. If The mass of each molecule is equal to m then The temperature of a gas will the number of molecules, whose velocities fall within the given interval from v to $v + dv$ be the greatest

(a) $T = \frac{mv^2}{k_B}$ (b) $T = \frac{mv^2}{2k_B}$ (c) $T = \frac{mv^2}{3k_B}$ (d) $T = \frac{mv^2}{4k_B}$

Q12. Using the Maxwell distribution function, the mean value of the modulus of the modulus of this projection in x direction .e. $\langle |v_x| \rangle$ if the mass of each molecule is equal to m and the gas temperature T is given by

(a) 0 (b) $\sqrt{\frac{k_B T}{\pi m}}$ (c) $\sqrt{\frac{k_B T}{m}}$ (d) $\sqrt{\frac{2k_B T}{\pi m}}$

Q13. Making use of the Maxwell distribution function, if $\left\langle \frac{1}{v} \right\rangle$ the mean value of the reciprocal of the velocity of molecules in an ideal gas and $\langle v \rangle$ is the average velocity at a temperature T ,if the mass of each molecule is equal to m .then which one of the following is correct.

(a) $\left\langle \frac{1}{v} \right\rangle = \frac{1}{\langle v \rangle}$ (b) $\left\langle \frac{1}{v} \right\rangle = \frac{4}{\pi \langle v \rangle}$ (c) $\left\langle \frac{1}{v} \right\rangle = \frac{2}{\pi \langle v \rangle}$ (d) $\left\langle \frac{1}{v} \right\rangle = \frac{4\pi}{\langle v \rangle}$

Q14. If the root mean square velocity of hydrogen molecules exceeds their most probable velocity by Δv m/s then temperature is given by

(a) $T = \frac{m\Delta v^2}{k_B\left(\sqrt{3}-\sqrt{2}\right)^2}$

(b) $T = \frac{m\Delta v}{k_B\left(\sqrt{3}-\sqrt{2}\right)^2}$

(c) $T = \frac{m\Delta v}{\sqrt{k_B}\left(\sqrt{3}-\sqrt{2}\right)^2}$

(d) $T = \frac{m\Delta v}{k_B\left(\sqrt{3}-\sqrt{2}\right)}$

Q15. In the case of ideal gaseous in three dimensional the temperature at which the velocities of the molecules $v_1 m/s$ and $v_2 m/s$ are associated with equal values of the Maxwell distribution function $F(v)$

(a) $T = \frac{m\left(v_2^2 - v_1^2\right)}{4k_B \ln v_2 / v_1}$

(b) $T = \frac{m\left(v_2^2 + v_1^2\right)}{4k_B \ln v_2 / v_1}$

(c) $T = \frac{m\left(v_2^2 - v_1^2\right)}{4k_B \ln v_1 / v_2}$

(d) $T = \frac{m\left(v_2^2 + v_1^2\right)}{4k_B \ln v_1 / v_2}$

Q16. A gas consists of molecules of mass m and is at a temperature T in three dimension. Making use of the Maxwell velocity distribution function, the corresponding distribution of the molecules over the kinetic energies E is given by .

(a) $f(E)dE = \pi\left(\frac{1}{\pi k_B T}\right)^{3/2} e^{-\frac{E}{k_B T}} \sqrt{E}.dE$

(b) $f(E)dE = 2\pi\left(\frac{1}{\pi k_B T}\right)^{3/2} e^{-\frac{E}{k_B T}} \sqrt{E}.dE$

(c) $f(E)dE = \pi\left(\frac{1}{\pi k_B T}\right)^{3/2} e^{-\frac{E}{k_B T}} E.dE$

(d) $f(E)dE = 2\pi\left(\frac{1}{\pi k_B T}\right)^{3/2} e^{-\frac{E}{k_B T}} E.dE$

Q17. A gas consists of molecules of mass m and is at a temperature T in two dimensions. Making use of the Maxwell velocity distribution function, the corresponding distribution of the molecules over the momentum p is given by

(a) $f(p)=\left(\frac{1}{2\pi mk_BT}\right)e^{-\frac{p^2}{2mk_BT}}pdp$ (b) $f(p)=\left(\frac{1}{mk_BT}\right)e^{-\frac{p^2}{2mk_BT}}pdp$

(c) $f(p)=\left(\frac{1}{2\pi mk_BT}\right)e^{-\frac{p^2}{2mk_BT}}dp$ (d) $f(p)=\left(\frac{1}{mk_BT}\right)e^{-\frac{p^2}{2mk_BT}}dp$

Q18. A gas behaves as an ideal gas at:

(a) Very low pressure and high temperature

(b) High pressure and low temperature

(c) High temperature and high pressure

(d) Low pressure and low temperature

Q19. In the van der Waals equation, the terms $\left(\frac{a}{V^2}\right)$ and (b) are introduced to account for the:

(a) Inter-molecular attraction and the total volume occupied by the gas

(b) Molecular size and the size of the containing vessel

(c) Inter-molecular attraction and the volume of the molecules

(d) Inter-molecular attraction and the force exerted by the molecules on the walls of the container

Q20. 'Critical temperature' is defined as the:

(a) Lowest temperature at which the gas can be liquefied at constant pressure

(b) Lowest temperature at which the gas can be liquified by increase of pressure alone

(c) Highest temperature at which the gas can beliquified by increase of pressure alone

(d) Highest temperature at which the gas can be liquified at constant pressure

Answer

Ans. 1: (a)	Ans. 2: (a)	Ans. 3: (c)	Ans. 4: (b)	Ans. 5: (a)	Ans. 6: (b)
Ans. 7: (c)	Ans. 8: (d)	Ans. 9: (b)	Ans. 10: (a)	Ans. 11: (c)	Ans. 12: (d)
Ans. 13: (b)	Ans. 14: (a)	Ans. 15: (a)	Ans. 16: (b)	Ans. 17: (b)	Ans. 18: (a)
Ans. 19: (a)	Ans. 20: (c)				