CHAPTER = 15 MOLECULAR THEORY OF GASES

BOOK NUMERICAL

1 **Convert the freezing point of mercury -39°C into °F and the comfort level temperature of 20° into Kelvin.**

DATA $T_{°C} = -39\ °C$ $T_{°F} = ?$ $T_{°C} = 20\ °C$ $T_k = ?$ **SOLUTIONS** **Celsius to kelvin** $T_k = T_{°C} + 273$ $T_k = 20 + 273 = 293\ K$	**Celsius to Fahrenheit** $T_{°F} = \frac{9}{5} \times T_{°C} + 32$ $T_{°F} = \frac{9}{5} \times (-39) + 32$ $T_{°F} = -72.2 + 32$ $T_{°F} = -38.2\ °F$

2 **The boiling point of liquid nitrogen is -321 ^{0}F. Change it into equivalent kelvin temperature.**

DATA $°F = -321\ °F$ $T_k = ?$ **SOLUTIONS** **Celsius to kelvin** $T_k = T_{°C} + 273$ $T_k = 20 + 273 = 293\ K$	**SOLUTIONS** **Fahrenheit to kelvin** $T_K = \frac{5}{9}(T_{°F} + 459.67)$ $T_K = \frac{5}{9}(-321 + 459.67)$ $T_K = \frac{5}{9}(138.67)$ $T_K = 77\ K$

3 **Calculate the volume occupied by a gram-mole of a gas at 0 ^{0}C and a pressure of 1.0 atmosphere.**

DATA	SOLUTIONS
$T = 0\,℃$ $T = 0 + 273 = 273\ K$ $P = 1\ atm$ $number\ of\ mole\ n = 1$ $R = 0.0821\ \frac{L\ atm}{mol\ K}$ $V = ?$	$PV = n R T$ $V = \frac{n R T}{p}$ $V = \frac{(1)(0.0821)(273)}{1}$ $V = 22.41\ liter/mol$

4 **An air storage took whose volume is 112 liters contains 3 kg of air at a pressure of 18 atmospheres. How much air would have to be forced into the tank to increase the pressure to 21 atmosphere, assuming no change in temperature**

DATA	SOLUTIONS
$V_1 = 112\ litres$ $P_1 = 18\ atm$ $m_1 = 3\ kg$ $P_2 = 21\ atm$ $V_1 = V_2 = V$ $m_2 = ?$	$\frac{P_1 V_1}{m_1} = \frac{P_2 V_2}{m_2}$ $\frac{18 \times V}{3} = \frac{21 \times V}{m_2}$ $\frac{18}{3} = \frac{21}{m_2}$ $m_2 = \frac{3 \times 21}{18}$ $m_2 = 3.5\ kg$ Required of air forced into the tank $m = m_2 - m_1$ $m = 3.5 - 3 = 0.5\ kg$

5 **A ballon contain 0.04 m^3 of air at pressure of 120 KPa. Calculating the pressure required to reduce its volume to 0.025 m^3 at constant temperature**

DATA	SOLUTIONS
$V_1 = 0.04\, m^3$ $P_1 = 120\, KPa = 120 \times 10^3\, Pa$ $P_1 = 1.20 \times 10^5\, Pa$ $P_2 = ?$ $V_2 = 0.025\, m^3$	$P_1 V_1 = P_2 V_2$ $(1.20 \times 10^5)(0.04) = P_2\,(0.025)$ $4800 = P_2\,(0.025)$ $\frac{4800}{0.025} = P_2$ $P_2 = 192000$ $P_2 = 1.92 \times 10^5 Pa$

6 **The molar mass of nitrogen is 28 g mol^{-1}. For 100 g of nitrogen, calculate.**
(a) the number of moles.
(b) the volume occupied at room temperature (20°C) and pressure of $1.01 \text{x} 10^5$ Pa

(a)	(b) DATA
The atomic mass of nitrogen (N) is approximately 14 g/mol. the molar mass of nitrogen gas (N_2) is $m = 2 \times 14 = 28\, g/mol$ $Number\ of\ moles = \frac{mass\ in\ gram}{molar\ mass(\ g/mol}$ $n = \frac{100}{28} = 3.57\, mol$	$T = 20\,℃ = 20 + 273 = 293\, K$ $P = 1.01 \times 10^5\, Pa$ SOLUTION $P\,V = n\,R\,T$ $V = \frac{n\,R\,T}{P}$ $V = \frac{(3.57)(8.313)(293)}{1.01 \times 10^5}$ $V = 0.086\, m^3$

7 A sample of gas contains 3.0×10^{24} atoms. Calculate the volume of the gas at a temperature of 300K and a pressure of 120K Pa

<u>DATA</u> $N = 3.0 \times 10^{24}\ atoms$ $N_A = 6.02 \times 10^{23}\ atoms$ $n = ?$ $T = 300\ K$ $P = 120\ kPa = 120 \times 1000\ Pa$ $P = 1.20 \times 10^5\ Pa$ SOLUTIONS $n = \frac{N}{N_A} = \frac{3.0 \times 10^{24}}{6.02 \times 10^{23}}$ $n = 4.98\ mol$	$P\,V = n\,R\,T$ $V = \frac{n\,R\,T}{P}$ $V = \frac{(4.98)\,(8.313)\,(300)}{1.20 \times 10^5}$ $V = \frac{12419.6}{1.20 \times 10^5}$ $V = 0.103\ m^3$

8 Calculate the root mean square velocity of hydrogen molecules at 0°C and 1.0 atm pressure. Assuming hydrogen to be an ideal gas. Under these conditions hydrogen has a density ρ of 8.99×10^{-2} kg/m^3.

<u>DATA</u> $T = 0\ ℃$ $T = 0 + 273 = 273\ K$ $P = 1\ atm = 1.01 \times 10^5\ Pa$ $\rho = 8.99 \times 10^{-2}\ kg/m^3$ $v_{rms} = ?$	SOLUTIONS $P = \frac{1}{3}\,\rho\,\overline{v^2}$ $\overline{v^2} = \frac{3\,P}{\rho}$ Taking root on both the side $\sqrt{\overline{v^2}} = \sqrt{\frac{3\,P}{\rho}}$ $v_{rms} = \sqrt{\frac{3\,P}{\rho}}$ $v_{rms} = \sqrt{\frac{3\,(1.01 \times 10^5)}{8.99 \times 10^{-2}}}$ $v_{rms} = 1835.86\ m/s$

9 **Calculate the root mean square speed of hydrogen molecule at 500K (mass of proton = 1.67x10^{-27} kg and K = 1.38x10^{-23} J/ K)**

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DATA

$T = 500\ K$

$m_p = 1.67 \times 10^{-27}\ kg$

$m_H = 2 \times 1.67 \times 10^{-27}\ kg$

$m_H = 3.34 \times 10^{-27}\ kg$

$k = 1.38 \times 10^{-23}$ J/K

$v_{rms} = ?$

SOLUTIONS

$\frac{1}{2} m_H \overline{v^2} = \frac{3}{2} K\,T$

$\overline{v^2} = \frac{3\,k\,T}{m_H}$

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Taking root on both the side

$\sqrt{\overline{v^2}} = \sqrt{\frac{3\,k\,T}{m_H}}$

$v_{rms} = \sqrt{\frac{3\,k\,T}{m_H}}$

$v_{rms} = \sqrt{\frac{3\,(1.38 \times 10^{-23})(500)}{3.34 \times 10^{-27}}}$

$v_{rms} = 2489.49\ m/s$

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10 (a) **Determine the average value of the Kinetic energy of the particles of an ideal gas at 10°C and at 40°C.**

(b) **What is the Kinetic energy per mole of an ideal gas at these temperatures?**

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DATA

(a)

$T = 10\ ℃ = 10 + 273 = 283\ K$

$T = 40\ ℃ = 40 + 273 = 313\ K$

(b)

$kinetic\ energy\ per\ mole = ?$

SOLUTIONS

Average K.E at 10 ^{0}C

$(K.E)_{av} = \frac{3}{2}\,k\,T$

$(K.E)_{av} = \frac{3}{2}\,(1.38 \times 10^{-23})\,(283)$

$(K.E)_{av} = 5.858 \times 10^{-21}\ J$

Average K.E at 40 ^{0}C

$(K.E)_{av} = \frac{3}{2}\,k\,T$

$(K.E)_{av} = \frac{3}{2}\,(1.38 \times 10^{-23})\,(313)$

$(K.E)_{av} = 6.479 \times 10^{-21}\ J$

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Kinetic energy per mole at 10 ^{0}C

$E = N_A\ (K.E)_{av}$

$E = (6.02 \times 10^{23})\,(5.858 \times 10^{-21})$

$E = 3521.7\ J$

Kinetic energy per mole at 40 ^{0}C

$E = N_A\ (K.E)_{av}$

$E = (6.02 \times 10^{23})\,(6.479 \times 10^{-21})$

$E = 3900.35\ J$

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