

## NUMERICAL PROBLEMS :-

\* - The solutions of the problems are given here.

P. 11.1 :- As given:  $T = 0^\circ\text{C} + 273 = 273\text{K}$ ,  $P = 1\text{atm}$ .

$\langle v \rangle = ?$  for  $N_2$  molecules.

Sol. :- Using formula:  $T = \frac{2}{3K} \langle \frac{1}{2} m v^2 \rangle$

$$\text{or } T = \frac{2}{3K} \times \frac{1}{2} m \langle v^2 \rangle = \frac{m}{3K} \langle v^2 \rangle$$

$$\text{or } \langle v^2 \rangle = \frac{3KT}{m}, \quad K = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

mass of  $N_2$  molecule =  $\frac{\text{molecular mass}}{\text{Avo. No. } (=N_A)}$

$$m = \frac{28\text{g}}{6.022 \times 10^{23}} = \frac{28\text{kg}}{6.022 \times 10^{26}}$$

$$\therefore m = 4.65 \times 10^{-26} \text{ kg}$$

Putting these values in above eq. we get:

$$\langle v^2 \rangle = 2.43 \times 10^5 \text{ m}^2/\text{s}^2$$

$$\therefore \langle v \rangle = 493 \text{ m/s.}$$

P. 11.2 :- As given: masses of molecules =  $m_1, m_2$

Speeds " " =  $\langle v_1 \rangle, \langle v_2 \rangle$

temp. =  $T = \text{const.}$

Sol. :- Using formula:  $T = \frac{2}{3K} \langle \frac{1}{2} m v^2 \rangle$

$$\text{For 1st gas: } T_1 = \frac{2}{3K} \times \frac{1}{2} m_1 \langle v_1^2 \rangle$$

$$\text{" 2nd " : } T_2 = \frac{2}{3K} \times \frac{1}{2} m_2 \langle v_2^2 \rangle$$

$$\therefore T_1 = T_2$$

$$\text{So } \frac{2}{3K} \times \frac{1}{2} m_1 \langle v_1^2 \rangle = \frac{2}{3K} \times \frac{1}{2} m_2 \langle v_2^2 \rangle$$

$$\Rightarrow m_1 \langle v_1^2 \rangle = m_2 \langle v_2^2 \rangle$$

$$\frac{\langle v_1^2 \rangle}{\langle v_2^2 \rangle} = \frac{m_2}{m_1}$$

$$\text{or } \frac{\langle v_1 \rangle}{\langle v_2 \rangle} = \frac{\sqrt{m_2}}{\sqrt{m_1}} \quad (\text{Generally } \langle v \rangle \propto \frac{1}{\sqrt{m}})$$

P. 11.3 :- As given:  $V_1 = V$ ,  $V_2 = \frac{1}{2}V = ?$   
 $P = \text{const} = 1.25 \times 10^5 \text{ N m}^{-2}$ ,  $W = 100 \text{ J}$

Sol. :-  $\Delta V = V_1 - V_2 = V - \frac{V}{2} = \frac{1}{2}V$   
 $\Delta V = \frac{1}{2}V = ?$  ( $\because$  Final vol. = change in vol.)

We know that:  $W = P \Delta V$  or  $\Delta V = \frac{W}{P}$

$$\text{or } \Delta V = \frac{100}{1.25 \times 10^5} = 8 \times 10^{-4} \text{ m}^3$$

$$\therefore \Delta V = 8 \times 10^{-4} \text{ m}^3.$$

P. 11.4 :- As given :- Decrease in internal energy

$$= \Delta U = -300 \text{ J}, \Delta W = -120 \text{ J}$$

Sol. :- Using formula of  $\Delta Q = ?$  (on the system)

$$\text{1st law i.e. } \Delta Q = \Delta U + \Delta W = (-300) + (-120)$$

$$\therefore \Delta Q = -420 \text{ J} \quad (\because \text{Heat lost is -ve})$$

P. 11.5 :- As given:  $T_1 = 227^\circ\text{C} + 273 = 500 \text{ K}$

$$(i) \eta = ? \quad , \quad T_2 = 127^\circ\text{C} + 273 = 400 \text{ K}$$

$$(ii) \phi_1 = ? \quad , \quad (iii) \phi_2 = ? \quad W = 10,000 \text{ J}$$

Sol. :- using formula: (i)  $\eta(\%) = \left(1 - \frac{T_2}{T_1}\right) \times 100$

$$\eta(\%) = \left(1 - \frac{400}{500}\right) \times 100 = \left(\frac{500-400}{500}\right) \times 100 = 20\%$$

$$\therefore \eta(\%) = 20\%$$

$$(ii) \quad \therefore \eta = \frac{W}{\phi_1} \quad \text{or} \quad \frac{20}{100} = \frac{10000}{\phi_1}$$

$$\text{or} \quad \frac{1}{5} = \frac{10000}{\phi_1} \quad \Rightarrow \quad \phi_1 = 50000 \text{ J}$$

$$(iii) \quad \therefore W = \phi_1 - \phi_2 \quad \text{or} \quad \phi_2 = \phi_1 - W$$

$$\text{or} \quad \phi_2 = 50000 - 10000 = 40000 \text{ J}$$

$$\therefore \phi_2 = 40,000 \text{ J}.$$

P. 11.6 :- As given:  $\Delta T = 100^\circ\text{C} = 100\text{K}$ .

$$Q_1 = 746\text{J}, \quad Q_2 = 546\text{J}, \quad T_1 = ?, \quad T_2 = ?$$

Sol. :- Using formula:  $\eta = 1 - \frac{Q_2}{Q_1}$

$$\text{or } \eta = 1 - \frac{546}{746} = \frac{746 - 546}{746} = 0.268$$

$$\therefore \eta = 0.268$$

As  $\Delta T = T_1 - T_2$  or  $T_1 = \Delta T + T_2$

or  $T_1 = 100 + T_2$  ... Now using formula:

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{T_2}{(T_2 + 100)}$$

or

$$0.268 = 1 - \frac{T_2}{(T_2 + 100)}$$

or

$$\frac{T_2}{T_2 + 100} = 1 - 0.268 = 0.732$$

$$\text{or } T_2 = 0.732(T_2 + 100) = 0.732T_2 + 73.2$$

$$\text{or } T_2 = 0.732T_2 + 73.2$$

$$\text{or } T_2 - 0.732T_2 = 73.2$$

$$\text{or } 0.268T_2 = 73.2, \quad \text{or } T_2 = \frac{73.2}{0.268}$$

$$\therefore T_2 = 273\text{K} = 0^\circ\text{C}$$

$$\Rightarrow T_1 = \Delta T + T_2 = 100^\circ\text{C} + 0^\circ\text{C} = 100^\circ\text{C}$$

P. 11.7 :- As given:  $T_1 = 327^\circ\text{C} + 273 = 600\text{K}$

$$T_2 = 27^\circ\text{C} + 273 = 300\text{K}$$

To check  $\eta = 52\%$  or not.

Sol. :- Using formula:  $\eta(\%) = \left(1 - \frac{T_2}{T_1}\right) \times 100$

$$\text{or } \eta(\%) = \left(1 - \frac{300}{600}\right) \times 100 = \left(\frac{600 - 300}{600}\right) \times 100 = 50\%$$

$\therefore \eta(\%) = 50\%$  and not  $52\%$ . Hence his claim is wrong.

P. 11.8 :- As given:  $W = 100 \text{ J}$ ,  $Q_2 = 400 \text{ J}$   
 $\eta = ?$        $Q_1 = ?$

Sol. :- We know that:  $W = Q_1 - Q_2$

$$\text{or } Q_1 = W + Q_2 = 100 + 400 = 500 \text{ J}$$

$$\therefore Q_1 = 500 \text{ J.}$$

$$\therefore \eta = \frac{W}{Q_1} = \frac{100}{500} = 0.2$$

$$\text{or } \eta(\%) = 0.2 \times 100 = 20\%$$

$$\therefore \eta(\%) = 20\%.$$

P. 11.9 :- As given:  $T_2 = 7^\circ\text{C} + 273 = 280 \text{ K}$

$$\eta = 50\% , \eta' = 70\% , T_1 = ? , T_1' = ?$$

Sol. :- Using formula:

$$\eta = 1 - \frac{T_2}{T_1}$$

Putting values:

$$\frac{50}{100} = 1 - \frac{280}{T_1}$$

$$\text{or } \frac{1}{2} = 1 - \frac{280}{T_1}$$

$$\text{or } \frac{280}{T_1} = 1 - \frac{1}{2} = \frac{1}{2}$$

$$\text{or } \frac{280}{T_1} = \frac{1}{2}$$

$$T_1 = 280 \times 2 = 560 \text{ K}$$

$$\therefore T_1 = 560 \text{ K.}$$

Increase in Temp. =  $T_1' - T_1$

$$\text{or } = 933 - 560 = 373 \text{ K}$$

$$\therefore T_1' - T_1 = 373 \text{ K.}$$

Again using formula:

$$\eta' = 1 - \frac{T_2}{T_1'}$$

$$\frac{70}{100} = 1 - \frac{280}{T_1'}$$

$$0.7 = 1 - \frac{280}{T_1'}$$

$$\text{or } \frac{280}{T_1'} = 1 - 0.7 = 0.3$$

$$\text{or } \frac{280}{T_1'} = 0.3$$

$$\text{or } T_1' = \frac{280}{0.3} = 933 \text{ K}$$

$$\therefore T_1' = 933 \text{ K.}$$

