

Q5-10 q^h integrated
sp. heat
Task

①

①

$$Q = 30 \text{ kcal} \rightarrow m = 15 \text{ kg} \quad d\theta = (40 - 20) = 20^\circ\text{C}$$

$$\text{Thermal capacity} = \frac{dQ}{d\theta} = \frac{30 \text{ kcal}}{20}$$

$$= 1.5 \text{ kcal/}^\circ\text{C}$$

②

$$m = 20 \times 10^{-3} \text{ kg} : v = 210 \text{ m/s}$$

$$\begin{aligned} \text{Energy} &= \frac{1}{2} m v^2 = \frac{1}{2} \times 20 \times 10^{-3} \times (210)^2 \\ &= 10 \times 10^{-3} \times (210)^2 \Rightarrow 441000 \times 10^{-3} \\ &= 441 \text{ J} \end{aligned}$$

$$1 \text{ cal} = 4.2 \text{ J}$$

$$\therefore \text{Energy in cal} = 105 \text{ cal}$$

③

$$\text{Given } \frac{r_1}{r_2} = \frac{2}{3} : \frac{s_1}{s_2} = \frac{3}{4} : \frac{d_1}{d_2} = \frac{4}{5}$$

$$\text{water equivalent } w = m_s = d \times \text{vol} \times s = d \times \frac{4\pi}{3} \times r^3 \times s$$

$$\frac{w_1}{w_2} = \frac{d_1}{d_2} \times \left(\frac{r_1}{r_2} \right)^3 \times \frac{s_1}{s_2} = \frac{4}{5} \times \left(\frac{2}{3} \right)^3 \times \frac{3}{4} = \frac{8}{5 \times 27} \times 3$$

$$= \frac{8}{45}$$

(4)

$$v = 42 \text{ m/s}$$

KE is converted into heat

According to Joule's law

$$W = J Q$$

$$\Rightarrow \frac{1}{2} m v^2 = J Q$$

Here due to KE of bullets, the temp rising

$$\therefore Q = m s \Delta \theta$$

$$\Rightarrow \frac{1}{2} m v^2 = J m s \Delta \theta$$

$$\frac{v^2}{2 J s} = \frac{(42)^2}{2 \times 1263 \times 1}$$

$$\Delta \theta = 0.69 \text{ } ^\circ\text{C}$$

(5)

$$m = 21 \text{ kg} \quad : \quad v = 20 \text{ kmph} = 20 \times \frac{5}{18} \text{ m/s} = \frac{100}{18} \text{ m/s}$$

$$\mu = 0.05 \quad t = 1 \text{ hr} = 3600 \text{ sec.}$$

work done = Fr displacement

$$= \mu m g \times v \times t$$

$$= 0.05 \times 21 \times 10 \times \frac{100}{18} \times 3600$$

$$= 5000 \text{ J} \quad 5 \times 420000$$

$$\text{This work done } \frac{W}{J} = Q = 5000 \text{ J}$$

$$\Rightarrow \frac{5 \times 420000}{4200} = Q \Rightarrow Q = 500 \text{ J}$$

⑥

Given

height from which lead dropped $h = 210 \text{ m}$

50% of striking Energy converted into heat

ie

$$\frac{50}{100} \times PE = Q$$

$$\Rightarrow \frac{1}{2} \times \frac{mgh}{2} = ms \Delta \theta$$

[Here due to the conversion of P.E into heat there is rise in temperature of the lead]

$$\Rightarrow \frac{1}{2} m \cancel{v^2}^{\frac{gh}{J \cdot s}} = ms \Delta \theta$$

$$[s = 0.03 \text{ kcal/kg}]$$

$$\Rightarrow \frac{1}{2} \times \frac{gh}{J \cdot s} = \Delta \theta$$

$$\Rightarrow \Delta \theta = \frac{1}{2} \times \frac{10 \times 210}{4200 \times 0.03} = \frac{2100}{2 \times 4200 \times 3 \times 10^{-2}}$$

$$\Rightarrow \frac{100}{4 \times 3} = \frac{25}{3} ^\circ \text{C}$$

⑦

$$m = 2 \text{ kg}; \quad v = 2 \text{ m/s}; \quad \mu = 0.3; \quad t = 5 \text{ s}$$

$$\text{work done} = f s = \mu mg vt$$

$$= 0.3 \times 2 \times 9.8 \times 2 \times 5 = 0.6 \times 98$$

$$= 58.8$$

$$\text{heat produced} = \frac{W}{J} \text{ [Joule's law]}$$

$$= \frac{58.8}{4.2} = 14 \text{ J}$$

⑧

$$Q = 270 \text{ kcal} \\ = 270 \times 10^3 \text{ cal}$$

$$t = 1 \text{ hr} \quad ; \quad L = 540 \text{ cal/gm}$$

Here heat is converted into water

$$\therefore Q = mL$$

$$\Rightarrow m = \frac{Q}{L} = \frac{270 \times 10^3}{540} = \frac{1}{2} \times 10^3 \text{ gm} \\ = 0.5 \times 10^3 \text{ gm} \\ = 0.5 \text{ kg}$$

⑨

$$m = 0.1 \text{ kg} \quad ; \quad h_1 = 10 \text{ m} \quad ; \quad h_2 = 7 \text{ m} \quad ; \quad S = 0.1 \text{ kcal/kg} \\ = 0.1 \times 4200 \text{ J/kg}$$

here loss of P.E converted in heat energy

$$\Rightarrow mg[h_1 - h_2] = dQ$$

and heat energy is used to rise the temperature

$$\Rightarrow \rho V g [h_1 - h_2] = m S d\theta \quad \left[S = \frac{1}{m} \frac{dQ}{d\theta} \right]$$

$$\Rightarrow g [h_1 - h_2] = S d\theta$$

$$\Rightarrow d\theta = \frac{g [h_1 - h_2]}{S} = \frac{10 \times [10 - 7]}{0.1 \times 4200}$$

$$= \frac{100 \times 3}{4200} = \frac{3}{42} = \frac{1}{14} = 0.07^\circ \text{C}$$

(10)

Force of friction = 100 N ; $m = 1 \text{ kg}$; $s = 600 \text{ J/kg}$
 distance = 30 m

work done by friction = friction $\times$ displacement
 $= 100 \times 30$
 $= 3000 \text{ J}$

Heat work done = dQ [heat produced from Joule's law]

$\Rightarrow dQ = \frac{3000}{1}$

we know $s = \frac{1}{m} \frac{dQ}{d\theta}$
 $\Rightarrow dQ = m s d\theta$

$\Rightarrow m s d\theta = 3000$

$\Rightarrow 1 \times 600 \times d\theta = 3000$

$d\theta = 5^\circ \text{ C}$

(11)

(i) Given

Angular velocity $\omega = 180 \text{ rpm}$;

$m = 180 \text{ gm} = 180 \times 10^{-3} \text{ kg}$

$\frac{d\theta}{dt} = 0.5^\circ / \text{sec}$ Speed = 420 J/sec

$dQ = m s d\theta$

$= 180 \times \frac{4200}{402} \times 0.5 \times 10^{-3}$

$= 9 \text{ cal/sec}$

work done = $Q \times T \Rightarrow 9 \times 4.2 \text{ cal/sec}$

$= 37.08 \text{ cal/sec}$

$= 37.08 \text{ cal/sec}$

(17)

(4)

Given

0.1% of ice melts on reaching ground

let 'm' be the mass of ice

 $m' = \text{mass of ice on reaching ground}$

$$= 0.01\% \, m$$

$$= \frac{0.01}{100} \times m = \frac{1}{10000} m$$

Here loss of P.E converted into heat energy.

$$L_{ice} = 80 \text{ cal/gm} ; J = 4.2 \text{ J/cal}$$

$$\therefore P.E = m' dQ \quad \left[L_f = \frac{dQ}{m'} \right]$$

$$\Rightarrow m'gh = m' L$$

$$\Rightarrow \frac{m \times 100}{10000} h = \frac{m}{10000} \times 80 \times 4.2$$

$$\Rightarrow \frac{h}{10000} = 8 \times 4.2$$

$$\Rightarrow h = 8 \times 4.2 \times 10^3$$

$$= 33.6 \times 10^3$$

$$= 33.6 \text{ km}$$

(17)

let velocity of the bullet be v

Given $K.E = 20 \text{ cal}$ $[1 \text{ cal} = 4.2 \text{ J}]$

$$= 20 \times 4.2 \text{ J}$$

$$= 84 \text{ J}$$

mass of bullet $= 4.2 \text{ gm} = 4.2 \times 10^{-3} \text{ kg}$

$$\therefore K.E = \frac{1}{2} m v^2$$

$$\Rightarrow \frac{1}{2} m v^2 = 84$$

$$\Rightarrow \frac{1}{2} \times 4.2 \times 10^{-3} \times v^2 = 84$$

$$\Rightarrow 2.1 \times 10^{-3} \times v^2 = 84$$

$$\therefore v^2 = 4 \times 10^2$$

$$\Rightarrow v = \sqrt{4 \times 10^2} = 200 \text{ m/s}$$

Task

Ice melts level

(1)

$m = 200 \text{ gm} = 200 \times 10^{-3} \text{ kg}$; $Q = 252 \text{ J}$; $d\theta = 10^\circ$

Thermal capacity $= \frac{dQ}{d\theta} = \frac{252}{10} = 25.2 \text{ J/K}$

(2)

Given

S. No. d.

(2)

Given $\frac{S_1}{S_2} = \frac{2}{3} : \frac{d_1}{d_2} = \frac{6}{5}$

We know that Thermal capacity = mS

$$\Rightarrow C = d \times \text{vol} \times S$$

$$\Rightarrow \frac{C}{\text{Vol}} = d \times S$$

$$\therefore \frac{\left[\frac{C}{V}\right]_1}{\left[\frac{C}{V}\right]_2} = \frac{d_1 \times \frac{S_1}{S_2}}{\frac{6^2}{5} \times \frac{2}{3}}$$

$$= \frac{4}{5}$$

(3)

$$m = 300 \text{ gm} ; h = 3 \text{ m} : g = 9.8 \text{ m/s}^2$$

$$= 300 \times 10^{-3} \text{ kg}$$

According to Joule's law $W = JQ$

$$\Rightarrow Q = \frac{W}{J} = \frac{mgh}{J} = \frac{300 \times 9.8 \times 3 \times 10^{-3}}{42000}$$

$$= 2.1 \text{ cal}$$

(4)

$$V = 420 \text{ mls}$$

$$S_{\text{lead}} = 0.03 \text{ cal/gm}^\circ\text{C} = 0.03 \times 4200 \text{ J/kg}^\circ\text{C}$$

loss of $K.E = \text{heat produced}$

$$\Rightarrow \frac{1}{2} m v^2 = d\theta \quad \left[S = \frac{1}{m} \frac{d\theta}{d\theta} \right]$$

$$\Rightarrow \frac{1}{2} m v^2 = m S d\theta$$

$$\Rightarrow d\theta = \frac{v^2}{2S} = \frac{(420)^2}{2 \times 0.03 \times 4200} = \frac{700}{2} = 350^\circ\text{C}$$

5)

$$2 \times 10^{-3} \times 4200 \quad 4200 \cdot 03$$

Given $v = 100 \text{ m/s}$; $S = 100 \text{ J/kg K}$.

Given Total K-E converted into heat

$$\Rightarrow \frac{1}{2} m v^2 = dQ \quad \left[S = \frac{1}{m} \frac{dQ}{d\theta} \right]$$

$$\Rightarrow \frac{1}{2} m v^2 = m S d\theta$$

$$\Rightarrow d\theta = \frac{v^2}{2S} = \frac{[100]^2}{2 \times 100} = \frac{100}{2} = 50^\circ \text{K}$$

6)

$$\frac{m_A}{m_B} = \frac{1}{2} \quad ; \quad \frac{S_A}{S_B} = \frac{2}{3}$$

we know $d\theta = \frac{gh}{S \cdot f}$

$$\Rightarrow \frac{d\theta_1}{d\theta_2} = \frac{h_1}{h_2} \times \frac{S_2}{S_1} = 1 \times \frac{3}{2} = \frac{3}{2}$$

7.

$$\frac{d_1}{d_2} = \frac{S_1}{S_2} \therefore \frac{S_1}{S_2} = \frac{4}{3}$$

Thermal capacity = $m \times S$

$$C = \text{density} \times \text{Vol} \times S$$

$$\therefore \frac{C}{\text{Vol}} = d \times S$$

$$\therefore \left[\frac{\frac{C}{V}}{\left[\frac{C}{V} \right]_2} = \frac{d_1 \times \frac{S_1}{S_2}}{\frac{C}{V}} \right]$$

$$= \frac{3}{4} \times \frac{4}{3}$$

$$= 1$$

8.

$$d_A = 0.5 \text{ gm/cc} \quad d_B = 0.6 \text{ gm/cc}$$

$$V_A = 8 \text{ lit}$$

$$V_B = 10 \text{ lit}$$

we know heat capacity = $m \times S$
 $C = d \times \text{Vol} \times S$

$C = \text{constant}$

$$\frac{S_A}{S_B} = \frac{d_B}{d_A} \times \frac{V_B}{V_A}$$

$$= \frac{0.6}{0.5} \times \frac{10}{8}$$

$$= \frac{3}{8} \times \frac{10}{8}$$

$$= \frac{3}{2}$$

6.

(9)

let m be the original mass.

$$\text{mass melted } m' = 75\% m \quad ; L_{ice} = 80 \text{ cal/gm}$$

$$\text{loss of P.E} = \text{Heat Energy} \quad = 80 \times 10^3 \text{ cal/g} \\ = 80 \times 10^3 \times 4.2 \text{ J/kg}$$

$$\Rightarrow mgh = dq \quad [L = \frac{dq}{m}]$$

$$\Rightarrow mgh = m' L_{ice} \quad m' L = dq$$

$$\Rightarrow m \times 10 \times h = \frac{75}{100} m \times 80 \times 10^3 \times 4.2$$

$$\Rightarrow h = \frac{3}{4} \times 8^2 \times 4.2 \times 10^3$$

$$= 25.2 \times 10^3 = 25.2 \text{ km}$$

(10)

$$m = 0.42 \text{ kg} ; v = 200 \text{ m/s}$$

$$\text{Given Thermal Energy } Q = k.E$$

$$\Rightarrow JQ = \frac{1}{2} m v^2$$

$$= \frac{1}{2} (0.42) (200)^2$$

$$= 0.42 \times \frac{40000}{2}$$

$$\Rightarrow Q = 0.42 \times \frac{20000}{1} \text{ cal}$$

$$\Rightarrow 0.42 \times \frac{20000}{4.2}$$

$$= 2 \text{ kcal}$$

2

(16)

(i) $h = 500 \text{ m}$;

we know that

$$\text{rise in temperature } d\theta = \frac{gh}{Js}$$

$$\Rightarrow d\theta = \frac{9.8 \times 500}{4200} = \frac{49}{42} = 1.16^\circ\text{C}$$

(ii)

$$m_w = 100 \text{ kg}$$

$$L = \frac{dQ}{m} = S d\theta = 4200 \times 1.16 \\ \approx 4900 \text{ J/kg.}$$