Calorimetry

Heat lost = Heat gain

Thermal / Heat capacity: – Amount of heat required to raise the temp of a body by 1°C or 1K.

→ Thermal capacity = M c (sp. heat of body)
(mass of body)

Specific heat capacity: – Amount of heat required to raise the temp of unit mass of a body by 1°C or 1K.

→ Specific heat capacity ⇒

From heat equation:– $Q = ms\,d\theta$

$m = 1,\ d\theta = 1$

$\therefore Q = s$

→ Specific heat capacity depends upon state of substance.

Gas > Liquid > Solid.

→ Heavier the substance, less will be the value of sp. heat capacity.

Q. Which of the following substance has highest sp. heat capacity?

(a) Al (Solid.) (b) H_2O (Liquid.) (c) O_2 (Heavy gas.) (d) H_2 (Light.)

→ sp. heat capacity of H_2 ⇒ 3.5 cal/gm°c

→ sp. heat capacity of H_2O → 1 cal/gm°c.

→ sp. heat capacity of Ice ⇒ 0.5 cal/gm°c

* sp. heat capacity of

Isothermal process → slow process.

→ Temp^r constant.

$dT = 0$ ∴ $S = \infty$.

$S = \frac{dQ}{m\,dT} = \infty$

Adiabatic process → No exchange of heat b/w system & surrounding

→ Fast process.

$dQ = 0$.

$S = \frac{dQ}{m\,dT} = 0$. ∴ $S = 0$

→ Sp. heat capacity for saturated vapour → Negative.

Q. The ratio of density of two substance is 2:3 and the ratio of their sp. heat capacity is 3:2. Find the ratio of their thermal capacity?

$M = \rho V$ (volume equal)

$M \propto \rho$.

→ $\frac{(T\cdot C)_1}{(T\cdot C)_2} = \frac{M_1 C_1}{M_2 C_2} = \frac{\rho_1 C_1}{\rho_2 C_2}$

$= 1:1$.

Q. The ratio of radius of 2 ~~balls~~ spheres of same materials is 2:3 and the ratio of their sp. heat capacity is 3:2. find the ratio of their thermal capacities?

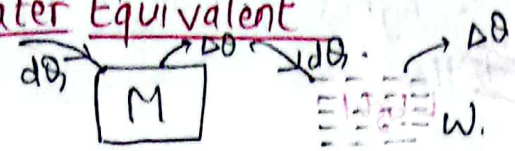
$M = \rho V$

$M \propto V \propto r^3$.

→ $\frac{(T\cdot C)_1}{(T\cdot C)_2} = \frac{M_1 C_1}{M_2 C_2} = \left(\frac{2}{3}\right)^3 \times \frac{3}{2}$

$= 4:9$.

Water Equivalent



$W \rightarrow dQ = W s\, d\theta$ — mass of water; sp. heat capacity of water

$dQ = M c\, d\theta$ — mass of body; sp. heat capacity of body

$\because M c\, \cancel{d\theta} = W s\, \cancel{d\theta}$

$Mc = Ws$

$$\boxed{W = \frac{Mc}{s}}$$

$$\boxed{W = \frac{\text{mass of body} \times \text{sp. heat capacity of body}}{\text{sp. heat capacity of water}}}$$

$W = \frac{Mc}{s}$ In (SI)

In CGS, $s = 1$.

$W \rightarrow$ kg or gm.

$W = Mc$ = Thermal capacity.

Q. What is the water equivalent mass of 400g copper having sp. heat capacity 300 J/kg°C?

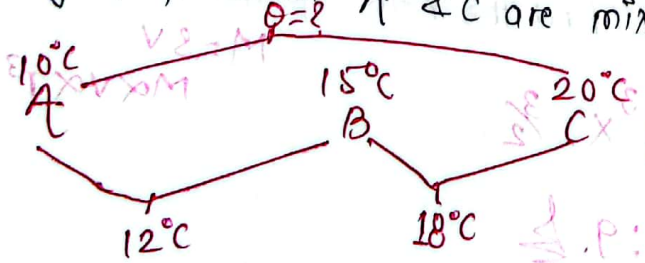
$\rightarrow$ $W = \frac{Mc}{s} = \frac{0.4 \times \cancel{300}}{14\ \cancel{4200}}$ (400g = 0.4 kg)

$= \frac{0.4}{14}$

$= 0.02$ kg.

Q. 3 substances A, B and C of equal mass having tempr - 10°C, 15°C and 20°C. When A and B are mixed the resulting tempr becomes 12°C, B & C are mixed resulting tempr becomes 18°C. Find the resulting tempr when A & C are mixed?

$\rightarrow$



$\cancel{M_A} s_A (12-10) = \cancel{M_B} s_B (15-12)$

$2 s_A = 3 s_B$.

$M_B S_B (\theta - 15) = M_C S_C (20 - \theta)$

$3 S_B = 2 S_C$ $\quad \because S_A = S_C$

$\therefore M_A S_A (\theta - 10) = M_C S_C (20 - \theta)$

$\theta - 10 = 20 - \theta$

$\therefore \boxed{\theta = 15^\circ C}$

Latent heat :- only state change but temp constant.

0°C Ice $\xrightarrow{\downarrow Q}$ 0°C

solid. liquid. → latent heat of fusion.

* Latent heat of fusion of ice :-

Amount of heat required to convert ice at 0°C to water at 0°C.

$\boxed{L_f = 80 \text{ cal/gm}}$ (C.G.S)

$= \frac{80 \times 4.2}{10^3}$ J/kg

$\boxed{L_f = 3.32 \times 10^5 \text{ J/kg}}$ (SI).

* Latent heat of vaporization

100°C water $\xrightarrow{Q}$ 100°C vapour

→ Amount of heat required to convert water at 100°C to vapour at 100°C.

→ $\boxed{L_v = 536 \text{ cal/gm}}$ (C.G.S).

$= \frac{536 \times 4.2}{10^3}$

$\boxed{L_v = 2.25 \times 10^6 \text{ J/kg}}$ (SI)

Q. What is the amount of heat required to convert 10gm of ice from -10°C to steam at 100°C?

-10°C ice 10gm $\xrightarrow{Q_1}$ 0°C ice 10gm $\xrightarrow{Q_2}$ 0°C water $\xrightarrow{Q_3}$ 100°C water 10gm $\xrightarrow{Q_4}$ 100°C steam 10gm.

$Q_1 = ms\,d\theta$ $\quad Q_2 = L_f = mL_f$ gm $\quad Q_3 = ms\,d\theta$ $\quad Q_4 = mL_v$

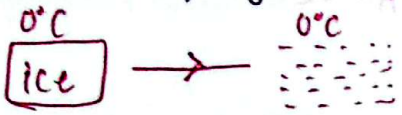
$10 \times \frac{1}{2} \times (0 - (-10)) = 50 \text{ cal}$ $\quad 10 \times 80 = 800 \text{ cal}$ $\quad 10 \times 1 \times (100 - 0) = 1000 \text{ cal}$ $\quad 10 \times 540 = 5400 \text{ cal}$

$\therefore Q = 7250 \text{ cal}$

Q. 20gm of ice at 0°C is mixed with 20gm of hot water at 80°C. Find the resultant temp^r of the mixture?

$d\theta = 60°C$

→



Heat req^r for complete melting of ice;

$Q = mL_f$

$= 20 \times 80$

$= 1600$ cal.

Heat that can given by hot water;

$Q = ms d\theta$

$= 20 \times 1 \times 60$

$= 1200$ cal.

पुरै ice melt हुनलाई heat पुग्ने

↓

So, resulting temp$^r \Rightarrow 0°C$

- Mass of ice melted $\Rightarrow$?

$1200\text{cal} \rightleftharpoons m' L_f$

$m' = \frac{1200}{80} = 15\text{gm}.$

- Mass of ice remaining $\rightarrow 20 - 15 = 5\text{gm}.$

- Total amt. of water in the mixture $= 20 + 15$

$= 35\text{gm}.$

Q. If 20gm of ice at 0°C is mixed with 20gm of hot water at 90°C. Find the resultant temp^r of mixture?

→

Heat req^r

$Q = mL_f$

$= 20 \times 80 = 1600$ cal.

Heat given

$Q = ms d\theta$

$= 20 \times 1 \times 90$

$= 1800$ cal.

पुरै ice melt भो।

Temp^r rise गराउन कति heat $= 200$ cal.

$Q = ms\Delta t$

$200 = (20 + 20) \times 1 \times dt$

$\therefore d\theta = 5°C.$

Trick → when equal mass of ice at 0C and hot water at θ°C ($\because \theta \leq 80$) are mixed :-

(i) Resulting temp of mixture = 0°C.

(ii) Amount of water in mixture → $\frac{M}{80}(80+\theta)$

(iii) Amount of ice in mixture = $\frac{m}{80}(80-\theta)$.

→ Equal mass of ice at 0°C and hot water at θ°C ($\because \theta \gtrless 80$) are mixed :-

① Resulting temp of mixture → $\frac{\theta - 80°C}{2}$

#



50% K.E is converted into heat energy.

$Q = 50\%$ of K.E

$= \frac{1}{2}mgh$

How much ice is melted →

$Q = m'L$

$m' = \frac{Q}{L}$

Q. 10gm of ice at 0°C is mixed with 5gm of steam at 100°C. What will be the resulting temp of mixture?

→ Heat required to convert 10gm of ice from 0°C to 100°C water,

$Q = mL_f + ms\theta$

$= 10 \times 80 + 10 \times 1 \times 100$

$= 1800$ cal.

Heat given by steam, $Q = mL_f$

$= 5 \times 540$

$= 2700$ cal.

resulting temp of mixture = 100°C.

∴ Amt of steam condensed into water =

$Q = m'L_v$

$m' = \frac{Q}{L_v} = \frac{1800}{540} = 3\frac{1}{3}$ gm

Q. ~~m ma~~ equal mass of ice at $-10°C$ and hot water at $60°C$ are mixed together. What fraction of ice is melted?

→ m mass of ice लाई 0°C के water मा लग्न :-

$$Q = m s_i (0-(-10)) + m L_f$$
$$= m \times 0.5 \times 10 + m \times 80$$
$$= 85m \text{ cal.}$$

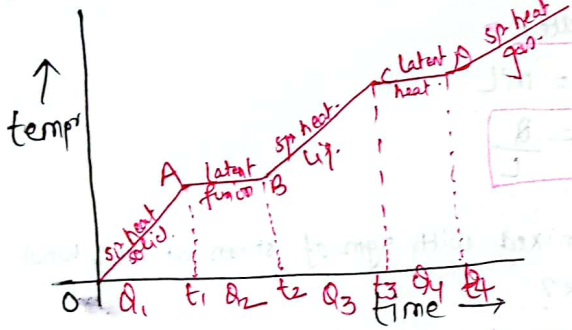
Heat given by water, $Q = m s_w d\theta$
$$= m \times 1 \times 60$$
$$Q = 60m \text{ cal.}$$

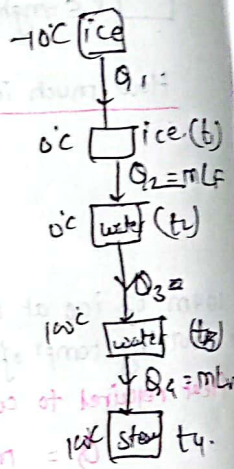
60m → 5m - ice लाई ... 55m → कोई fraction of ice melted

$$55m = m' L_f$$
$$m' = \frac{55}{80} m \Rightarrow \frac{m'}{m} = \frac{55}{80} = \frac{11}{16}$$

$\therefore$ $\boxed{m' : m = 11 : 16}$ of ice melted.

Heating curve :-





$$dQ = ms\,dT \qquad \left(P = \frac{dQ}{dt}\right)$$
$$P.dt = ms\,dT$$
$$\left(\frac{dT}{dt}\right) = \frac{P}{ms}$$

P → const.

$$\boxed{\text{Slope} \propto \frac{1}{\text{sp. heat}}}$$

Slope of OA gives → reciprocal of sp. heat of solid

~~Slope of AB gives → reciprocal of latent heat of fusion.~~

Slope of BC gives → reciprocal of sp. heat of liquid.

→ length of AB → latent heat of fusion

→ length of CD → latent heat of vaporization

Clausius Clypeyron relation

$$\frac{dP}{dt} = \frac{JL}{T(V_2 - V_1)}$$

Rate of change of pressure

→ During boi...

→ During mel...

① If subst...

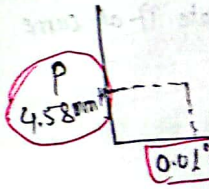
② If subst...

Conclusion

↑es in Pressure ...

but in ...

Triple point :-



Clausius Clyperon relation

$$\frac{dp}{dt} = \frac{JL}{T(V_2 - V_1)}$$

L → latent heat (fusion or vaporization).

$\frac{dp}{dt}$ → Rate of change of pressure.

→ During boiling volume of substance always increases.

$$\frac{dp}{dt} = +ve.$$

↑es in pressure = ↑es Boiling point

→ During melting,

① If substance expands on melting. $(V_2 > V_1)$.

e.g. wax, ghee, sulphure, etc.

$$\frac{dp}{dt} = +ve.$$

↑es in pressure = ↑es in ~~Boiling~~ melting point.

② If substance contracts on melting → $(V_1 > V_2)$

e.g. ice and rubber only.

$$\frac{dp}{dt} = -ve.$$

↑es in pressure = ↓es m.pt.

Conclusion

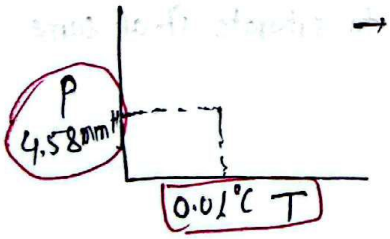
↑es in Pressure ⇒ ↑es B.pt & m.pt.

but in case of ice & rubber

↑es P → ↓es mpt

Triple point :- All the state co-exist.

→ Standard state. P = 4.58 mm of Hg.
T = 0.01°C



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