Calorimetry

Exercise – 1

Question 1.
Define calorie.

Answer:
CALORIE : "Is the amount of heat energy required to raise the temperature of 1 g of water from 14.5 °C to 15.5°C".

Question 2.
State the modern unit of heat energy. How is this unit related to calorie ?

Answer:
Modern unit of heat energy is joule
Relation of joule with calorie :
1 J = 2.4 calorie
or 1 calorie = 4 .186 J = 4.2 J (approx)

Question 3.
What do you understand by the term thermal capacity ? State its unit is SI system.

Answer:
Thermal capacity : "The amount of heat energy required to raise the temperature of a given mass of substance through 1°C (1k) is called thermal capacity".

Question 4.
Define specific heat capacity and state its SI and CGS units.

Answer:
Specific heat capacity : "Is the amount of heat energy required to raise the temperature

of unit mass of a substance through 1°C or 1K is called specific heat capacity."

Units :

$$S.I. \rightarrow \frac{J}{KgK} \text{ or } JKg^{-1}\ K^{-1}$$

$$\text{Or } \frac{J}{Kg^\circ C} \text{ or } JKg^{-1}\ {}^\circ C^{-1}$$

$$C.G.S. \rightarrow \frac{J}{g^\circ C} \text{ or } Jg^{-1}\ {}^\circ C^{-1}$$

Question 5.
Is the specific heat capacity of ice greater, equal to or less than water ?

Answer:
Specific heat capacity of ice is less than specific heat capacity of water.

Question 6.
Explain the following :

(a) Water is used in hot water bottles for fomentation purposes.

Answer:
Water provides heat energy for longer time and does not cool quickly as specific heat capacity of water is large.

(b) Water is used as a coolant in motor car radiators.

Answer:
When water is circulated in the pipes, it absorbs more amount of heat from surroundings (removes heat) without much rise in its temperature because of its high specific heat capacity.

(c) A wise farmer always waters his fields in the evening, if there is a forecast for frost.

Answer:
To save the crops on such cold nights farmers fill their fields with water as water has high sp. heat capacity. So water does not allow the temp, in the surrounding area of

plants to fall upto 0°C. Other wise when temp, falls below 0°C water in the fine capillaries of plants will freeze, so the veins will burst due to increase in volume of water on freezing.

(d) Wet soil does not get as hot as dry soil in the sun.

Answer:
Water has high sp. heat capacity as compared to soil (dry) and absorbs heat from surrounding for longer time and takes longer time to set as compared to dry soil.

(e) Water is sprinkled on the roads in the evening during hot summer.

Answer:
Water has high sp. heat capacity and removes heat from the hot soil and decreases its temperature during hot summer evening.

(f) Water is used for internal heating in cold countries.

Answer:
In cold countries water is used for internal heating as it can carry large amount of heat energy from the furnace to the rooms at a fairly moderate temperature.

(g) Cold water is poured on the burns caused on the skin by some hot object.

Answer:
Water has high sp. heat capacity and can remove more heat from the bums caused on the skin by hot object and releives of the pain.

(h) Water rubs are kept in warehouses storing fruits and vegetables in cold countries during winter.

Answer:
Water has high sp. heat capacity and water kept in tubs lose heat for a longer time and keep the surrounding hot for longer time and save the vegetables from busting due to increase in volume at low temp, of water present vegetables.

Question 7.
Explain how is land breeze caused ?

Answer:
Land breeze : Blowing of cold air from land towards sea. During night temp, of land falls more rapidly as compared to water. Since water has high sp. heat capacity Pressure over sea water decrease and hence air blows from land (high pressure) towards sea (low pressure)

Question 8.
Explain the formation of sea breeze.

Answer:
Sea breeze : Blowing of cool air from sea towards land. During day time land gets heated up rapidly due to low sp. heat of land as compared to water. Pressure at land decreases. Hence air blows from sea (high pressure) towards land (low pressure).

Question 9.
Why is the weather in coastal regions moderate ?

Answer:
The climate near coastal regions moderate : The sp. heat capacity of water is very high or sp. heat capacity of land is much low as compared to water. As such land (or sand) gets cooled more rapidly as compared to water under similar conditions. Thus, a large difference in temperature is developed between the land and the sea, due to which cold air blows from land towards sea during night (i.e. land breeze) and during the day cold air blows from sea towards land (i.e. sand breeze). These make the climate near coastal region moderate.

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. The specific heat capacity of a substance :
(a) changes with the mass of given substance.
(b) changes with the area or volume of substance.
(c) changes with rise or fall in temperature.
(d) is a constant quantity for a given substance.

Answer:
(d) is a constant quantity for a given substance.

2. Land and sea breezes are formed in coastal regions because :
(a) water has very high specific heat capacity than the land.

(b) land has very high specific heat capacity than the water.
(c) sea water cools the cooler regions. .
(d) all the above.

Answer:
(a) water has very high specific heat capacity than the land.

3. The base of cooking pans is made thicker and heavy because:
(a) it lowers the heat capacity of pan
(b) it increases the heat capacity of pan
(c) the food does not get charred and keeps hot for long time
(d) both (a) and (c)

Answer:
(d) both (a) and (c)

4. The S.I. unit of specific heat capacity is :
(a) JKg^{-1}
(b) JK^{-1}
(c) $JKg^{-1} K^{-1}$
(d) $kJkg^{-1} K^{-1}$

Answer:
(b) Jk^{-1}

5. The specific heat capacity of water in S.I. system is :
(a) 4.2 $Jkg^{-1} K^{-1}$
(b) 42 $JKg^{-1} K^{-1}$
(c) 4200 $JKg^{-1} k^{-1}$
(d) 420 $JKg^{-1} K^{-1}$

Answer:
(c) 4200 $JKg^{-1} K^{-1}$

6. S.I. unit of thermal capacity is :
(a) Jkg^{-1}
(b) kJ Kg^{-1}
(c) $Jkg^{-1} K^{-1}$
(d) cal $^{\circ}C^{-1}$

Answer:
(c) $Jkg^{-1} K^{-1}$

Numerical Problems on Specific Heat Capacity

Practice Problems 1

Question 1.
A solid of mass 0.15 kg is heated from 10°C to 90°C. If the specific heat capacity of the solid is 390 $Jkg^{-10} C^{-1}$, find the heat absorbed by the solid.

Answer:

(i) $m = 0.15 \text{ kg} = \frac{15}{100} \text{ kg} \qquad C = 390 \text{ Jkg}^{-1}°C^{-1}$

Rise in temp. $\Delta t = 90 - 10 = 80°C$

$\therefore$ Heat absorbed by solid $= mc\Delta t$

$$= \frac{15}{100} \times 390 \times 80 = 4680 \text{ J}$$

Question 2.
A liquid of mass 0.2 kg and temperature 135°C is cooled to 25°C. If the specific heat capacity of liquid is 750 $Jkg^{-10} C^{-1}$, find the heat energy given out.
Hint : O_F = (135 – 25) = 110°C

Answer:

Mass of liquid m = 0.2kg

Fall in temp. $\Delta t = 135 - 25 = 110°C$

Sp. heat capacity (c) = 750 $\text{Jkg}^{-1}°C^{-1}$

$\therefore$ Heat energy given out $= m(c)\ \Delta t$

$$= \frac{2}{10} \times 750 \times 110 = 16500 \text{ J}$$

Practice Problems 2

Question 1.
0.08 kg of a substance is heated from 30°C to 130°C when 2000 calories of energy is supplied to it Calculate the specific heat capacity of the substance in (a) calories, (b) joules.

Answer:
(a) Mass of substance $m = 0.08$ kg

Rise in temp. $\Delta t = 130 - 30 = 100°C$

Heat energy supplied = 2000 calories

Let c be the sp. heat capacity

$\therefore \quad m(c)\,\Delta t = 2000$

$$= \frac{8}{100} \times 100 \times (c) = 2000$$

$$c = \frac{2000}{8} = 250 \text{ cal kg}^{-1}\ °C^{-1}$$

(b) But 1 cal. = 4.2 J

$\therefore \quad C = 250 \times 4.2 = 1050 \text{ Jkg}^{-1}°C^{-1}$

Question 2.
0.50 kg of lead at 327°C is cooled to 27°C, when it gives off 22500 calories of energy. Calculate the specific heat 1 capacity of lead in (a) calories, (b) joules.

Answer:
Mass of lead $m = 0.50$ kg

(a) Fall in temp. $\Delta t = 327 - 27 = 300°C$

Let c be the sp. heat capacity of lead

$\therefore \quad m(c)\,\Delta t$ = Energy given off

$$\frac{50}{100} \times (c) \times 300 = 22500$$

$$C = \frac{22500}{50 \times 3} = 150 \text{ cal kg}^{-1}\ °C^{-1}$$

(b) But 1 cal. = 4.2 J

$\therefore \quad C = 4.2 \times 150 = 630 \text{ Jkg}^{-1}°C^{-1}$

Practice Problems 3

Question 1.
272 calories of heat is required to heat 0.02 kg of a metal of specific heat capacity 170 cal kg^{-10} C^{-1} to a temperature T. If the initial temperature of the metal is 20°C, calculate the final temperature T.

Answer:
H = 272 calories

Mass of metal = 0.02 kg

$C = 170 \text{ cal kg}^{-1}{}^{\circ}C^{-1}$

Rise in temp. $\Delta t = (T - 20)$

$H = mc\ \Delta t$

$$272 = \frac{2}{100} \times 170\ (T - 20)$$

$$T - 20 = \frac{272 \times 10}{2 \times 17} = 80$$

T = 80 + 20 = 100°C

Question 2.
3.75 × 10^5 calories of heat is given out by 5 kg of water at 100°C. Calculate the temperature of cooled water. Specific heat capacity of water is 1000 cal kg^{-1} $°C^{-1}$.

Answer:
$H = 3.75 \times 10^5$ calories $\quad m = 5kg$

Let t be the temp. of cooled water

∴ fall in temp. $\Delta t = (100 - T)$

$C = 1000 \text{ cal kg}^{-1}\ {}^{\circ}C^{-1}$

$mc\ \Delta t = H$

$5 \times 1000 \times (100 - T) = 3.75 \times 10^5$

$$(100 - T) = \frac{375}{100} \times \frac{100000}{5 \times 1000} = 75$$

T = 100 – 75 = 25°C

Question 3.
A burner, supplies heat energy at a rate of 20 Js^{-1} Find the specific heat capacity of a solid of mass 25 g, if its temperature rises by 80°C in one minute.

Answer:
Heat supplied by burner in
1 minute $H = (60 \times 20)$ J
Mass of solid $m = 25$ g
Rise in temp. $\Delta t = 80°C$
$C = ?$
$mc\ \Delta t = H$
$25 \times c \times 80 = 1200$

$$C = \frac{1200}{25 \times 80} = \frac{3}{5} = 0.6\ Jg^{-1}°C^{-1}$$

Question 4.
A liquid of mass 100 g loses heat at a rate of 200 Js^{-1} for 1 minute. If the temperature of liquid drops by 100°C, calculate the specific heat capacity of the liquid.

Answer:
Mass of liquid $m = 100$ g
Heat lost in 1 minute $= (200 \times 60)$ J
$C = ?$ fall in temp. $\Delta t = 100°C$
$\therefore\ mc\ \Delta t = H$
$100 \times C \times 100 = 200 \times 60$

$$C = \frac{200 \times 60}{100 \times 100} = 1.2\ Jg^{-1}°C^{-1}$$

Practice Problems 4

Question 1.
A heater, rated 1000 W, is used to heat 1.5 kg of water at 40°C to its boiling point.

Calculate the time in which the water starts to boil Specific heat capacity of water is 4200. J kg^{-10} C^{-1}.

Answer:

Let t be the time in seconds

$\therefore$ Heat supplied $H = P \times t = (1000 \times t)$ J

$m = 1.5$ kg Rise in temp. $\Delta t = (100 - 40) = 60°C$

$C = 4200 \ Jkg^{-1} \ °C^{-1}$

$H = mc \ \Delta t$

$$1000\ t = \frac{15}{10} \times 60 \times 4200$$

$$t = \frac{90 \times 4200}{1000} = 378 \text{ seconds}$$

Question 2.

400 g of mercury of specific heat capacity 0.14 Jg^{-1} $°C^{-1}$ is heated by a 200 W heater for 1 min. and 40 s. If initially mercury is at 0°C, calculate its final temperature.

Answer:

Mass of mercury $m = 400$ g

$C = 0.14 \ Jg^{-1} \ °C^{-1}$

Heat supplied in 1 minute $= P \times t$

and 40S $= (200 \times 100)$ J

Rise in temp. $\Delta t = (T - 0)°C$

$\therefore$ $mc \ \Delta t = H$

$$400 \times \frac{14}{100} \times (T - 0) = (200 \times 100)$$

$$(T - 0) = \frac{200 \times 100}{4 \times 14} = 357.1$$

$\therefore$ $T = 357.1°C$

Question 3.
A power drill of 400 W makes a hole in a lead cube of specific heat capacity 0.13 Jg^{-1} $°C^{-1}$ in 80 s. If the temperature of lead rises from 27°C to 327°C, calculate the mass of the lead cube.

Answer:

$C = 0.13\ g^{-1}\ °C^{-1}$

Heat produced in 80S $= P \times t = (400 \times 80)$ J

Rise in temp. $\Delta t = (327 - 27) = 300°C$

Mass of Lead m = ?

$\therefore\ mc\ \Delta t = H$

$m \times 0.13 \times 300 = (400 \times 80)$

$$m = \frac{(400 \times 80) \times 100}{300 \times 13} = \frac{3200}{39} = 820.5\ g$$

Practice Problems 5

Question 1.
A solid of mass 150 g at 200°C is placed in 0.4 kg of water at 20°C till a constant temperature is attained. If the S.H.C. of the solid is 0.5 Jg^{-1} K^{-1}, find the resulting temperature of the mixture.

Answer:

Solid	Water
M = 150 g	m = 0.4 kg = 400 g
T = 200°C	t = 20°C
$C_1 = 0.5 = \frac{1}{2}$	$C_2 = 4.2 = \frac{42}{10}$

Let θ be the final temp.

$\therefore$ Heat lost by solid = Heat gained by water

$M\,C_1(T - \theta) = mC_2(\theta - t)$

$$150 \times \frac{1}{2} \times (200 - \theta) = 400 \times \frac{42}{10} (\theta - 20)$$

$15000 - 75\,\theta = 16800 - 33600$

$$(1680 + 75)\,\theta = 33600 + 15000$$

$$1755\theta = 48600$$

$$\theta = \frac{48600}{1755} = \frac{9270}{351} = 27.7°C$$

Question 2.

A liquid of mass 100 g at 120°C is poured in water at 20°C, when the final temperature recorded is 40°C. If the specific heat capacity of the liquid is 0.8 $Jg^{-1}\,°C^{-1}$, calculate the initial mass of water.

Answer:

Liquid	$\theta = 40°C$	Water
$M = 100g$	final temp.	$m = ?$
$C_1 = 0.8$		$C_2 = 4.2$
$T = 120°C$		$t = 20°C$

Heat lost by liquid = Heat gained by water

$$MC_1\,(T - \theta) = mC_2\,(\theta - t)$$

$$100 \times \frac{8}{10}\,(120 - 40) = m\,\frac{42}{10}\,(40 - 20)$$

$$80 \times 80 = m\,\frac{42}{10} \times 20$$

$$84m = 6400$$

$$\therefore \quad m = \frac{6400}{84} = 76.19 \text{ g}$$

Question 3.

A solid of mass 50 g at 150°C is placed in 100 g of water at 11°C, when the final temperature recorded is 20°C. Find the specific heat capacity of the solid.

Answer:

Solid — Final temp. θ — Water

$M = 50g$ — $\theta = 20°C$ — $m = 100$ g

$T = 150°C$ — $t = 11°C$

$C_1 = ?$ — $C_2 = 4.2$

Heat lost by liquid = Heat gained by water

$MC_1 (T - \theta) = mC_2 (\theta - t)$

$$50\ C_1 (150 - 20) = 100 \times \frac{42}{10} (20 - 11)$$

$$50 \times 130\ C_1 = 420 \times 9$$

$$C_1 = \frac{420 \times 9}{50 \times 130} = 0.58\ Jg^{-1}°C^{-1}$$

Practice Problems 6

Question 1.
20 g of hot water at 80°C is poured into 60 g of cold water, when the temperature of cold water rises by 20°C. Calculate the initial temperature of cold water.

Answer:

Hot water — Final temp. — Cold water

$M = 20g$ — θ — $m = 60$ g

Sp. heat capacity C — C

fall in temp. $= (80 - \theta)(\theta - t) = 20$

Heat lost = Heat gained

$20 \times C \times (80 - \theta) = 60 \times C \times 20$

$(80 - \theta) = 60$ $\therefore \theta = 80 - 60 = 20$

But $(\theta - t) = 20$

$20 - t = 20$

$t = 20 - 20$

$t = 0°C$

Question 2.
50 g of a hot solid of specific heat capacity 0.25 Jg^{-10} C^{-1} and at 100°C is placed in 80 g of cold water, when the temperature of cold water rises by 3°C. Find the initial temperature of cold water.

Answer:

Hot solid

$M = 50g \qquad C_s = 0.25 = \frac{25}{100} = \frac{1}{4}$

$T = 100°C$

Let θ be the final temp.

$\therefore$ fall in temp. = $(100 - \theta)°C$

Cold water at t °C

$m = 80$ g $\qquad C = 4.2 = \frac{42}{10}$

Rise in temp. = $\theta - t = 3$

Heat lost by hot solid = Heat gained by water

$MCs\,(T - \theta) = mcw\,(\theta - t)$

$$50 \times \frac{1}{4}(100 - \theta) = 80 \times \frac{42}{10} \times 3$$

$$1250 - \frac{25}{2}\theta = 1008$$

$$\therefore \frac{25}{2}\theta = 1250 - 1008 = 242$$

$$\theta = 1250 \times \frac{2}{25} = 19.36$$

But $\theta - t = 3$

$1936 - t = 3$

$t = 19.36 - 3 = 16.36°C$

Practice Problems 7

Question 1.
What mass of a solid of specific heat capacity 0.75 Jg^{-10} C^{-1} will have heat capacity 93.75 Jg^{-1} $°C^{-1}$?

Answer:

Heat capacity = mass × sp. heat capacity

93.75 = mass × 0.75

$$\text{mass} = \frac{93.75}{0.75} = 125 \text{ g}$$

Question 2.
A solid of mass 1.2 kg has sp. heat capacity of 1.4 Jg^{-1} $°C^{-1}$. Calculate its heat capacity in SI units.

Answer:

Heat capacity = mass × sp.heat capacity

$= 1.2 \text{ kg} \times 1.4 \text{ Jg}^{-1}\,°\text{C}^{-1}$

$= 1.2 \text{ kg} \times 1.4 \times 1000 \text{ JKg}^{-1}\,°\text{C}^{-1}$

$$= \frac{12}{10} \times \frac{14}{10} \times 1000 \quad \left[\because \frac{J}{g°C} = \frac{J}{\frac{g}{1000}°C} = 1000 \text{ JKg}^{-1}\,°\text{C}^{-1}\right]$$

Heat capacity = 1680 JK^{-1}

Practice Problems 8

Question 1.
A solid of mass 0.15 kg and at 100°C is placed in 0.25 kg of water, contained in a copper calorimeter of mass 0. 12 kg at 10°C. If the final temperature of the mixture is 20°C, calculate the sp. heat capacity of the solid.
(given, H.C of water = 4200 Jkg^{-1} k^{-1}, SHC of copper = 400 J Kg^{-1} k^{-1})

Answer:

Solid

M = 0.15 kg

fall in temp. (100 – 20) = 80°C

sp. heat capacity C = ?

Heat lost by solid = MC × 80 (0.15 × C × 80) J

Heat gained by water + cal. water + calorimeter

$$\left[m_1 \times \left(\frac{4200}{cw}\right) + (m_2\ c_c)\right] \times \text{ rise in temp.}$$

[0.25 × 4200 + (0.12 × 400)] × (20 – 10)

(1050 + 48) × 10

10980 J

Heat lost by solid = heat gained by calorimeter

12.00 C = 10980

$$C = \frac{10980}{12} = 915\ \text{Jkg}^{-1}\ \text{K}^{-1}$$

Question 2.

A piece of brass of mass 200 g and 100°C, is placed in 400 g of turpentine oil, contained in a copper calorimeter of mass 50 g at 15°C. The final temperature recorded is 23CC. Find the sp. heat capacity of turpentine oil.

[SHC for brass = 370 J kg^{-1} k^{-1} ; SCH of copper = 390 J Kg^{-1} k^{-1}]

Answer:

θ = final temp. = 23°C

Heat lost by brass = mC_s (100 – 23)

$$m = \frac{200}{1000}\text{ kg} = \frac{200}{1000} \times 370 \times 77 = 5698\text{ J}$$

fall in temp. = 100 – 23

= 77°C

Heat gained by turpintine + calorimeter

$$\left[\left(\frac{400}{1000}\times C_t\right)+\left(\frac{50}{1000}\times C\right)\right](23-15)$$

$$\left(\frac{2}{5}C_t+\frac{1}{20}\times 390\right)\times 8$$

$$\left(\frac{2}{5}C_t+\frac{39}{2}\right)8$$

$$\left(\frac{16}{5}C_t+156\right)J$$

Heat gained = Heat lost

$$\frac{16}{5}C_t+156=5698$$

$$\frac{16}{5}C_t=5698-156=5542$$

$$C_t=\frac{5542\times 5}{16}=1731.8\text{ JKg}^{-1}\text{K}^{-1}$$

Practice Problems 9

Question 1.
A copper vessel contains 200 g of water at 24°C. When 112 g of water at 42°C is added,

the resultant temperature of water is 30°C. Calculate the thermal capacity of the calorimeter.

Answer:

Let $mc = x$ be the thermal capacity of calorimeter

final temp. of mixture 30°C

$\therefore$ Heat gained by cold water + calorimeter = $[x + m_1 \times 4.2]$ rise in temp.

$= [x + (200 \times 4.2) \times (30 - 24)]$

$= (x + 840) \times 6$

Heat lost by (hot water)

$[112 \times 4.2]$ fall in temp.

$(470.4)(42 - 30)$

$(470.4)\ 12$

Heat lost = Heat gained

$(12 \times 470.4) = 6\ (C + 840)$

$(C + 840) = 2 \times 470.4$

heat capacity of cal. $mc = 940.8 - 840 = 100.8$ J°C^{-1}

Question 2.

A copper calorimeter contains 50 g of water at 16°C. When 40 g of water at 36°C is added, the resulting temperature of the mixture is 24°C. Calculate the heat capacity of the calorimeter.

Answer:

Let $mc = x$ be the heat capacity of calorimeter

resulting temp. of mixture = 24°C

on adding hot water at 36°C when added to cold water at 16°C, hot water loses heat and cold water and calorimeter gains heat till the temp. becomes 24°C

Heat gained by calorimeter + cold water

$$= (x + 50 \times 4.2)(24 - 16) \text{ J}$$

Heat lost by hot water = (40 × 4.2) fall in temp.

$$= (4 \times 42)(36 - 24)$$

$$= 168 \times 12 \text{ J}$$

Heat gained = Heat lost

$$(x + 210)\, 8 = 168 \times 12$$

$$x = 210 = \frac{168 \times 12}{8} = 21 \times 12$$

$$x = 252 - 210 = 42 \text{ J°C}^{-1}$$

Heat capacity calorimeter = mc = 42 J° C^{-1}

Practice Problems 10

Question 1.

A liquid X of specific heat capacity 1050 J kg^{-1} K^{-1} and at 90°C is mixed with a liquid Y of specific heat capacity 2362,5 J kg^{-1} K^{-1} and 20°C, when the final temperature recorded is 50°C. Find in what proportion the weights of the liquids are mixed.

Answer:

Let the ratio of weights

$\therefore$ Heat lost by x = Heat gained by y

$\theta = 50°C$

$m_1 C_n (T - \theta) = m_2 C_y (\theta - t)$

$$X\ 1050(90 - 50) = y\ \frac{23625}{10}\ (50 - 20)$$

$$x \times 1050 \times 40 = y \times \frac{4725}{2} \times 30$$

$$\therefore \frac{x}{y} = \frac{4725 \times 15}{1050 \times 40}$$

$$\frac{x}{y} = \frac{27}{16}$$

$x : y = 27 : 16$

Question 2.

Your are required to make a water bath of 50 kg at 45°C, by mixing hot water at 90°C, with cold water at 20°C. Calculate the amount of hot water required.

Hint : Let amt. of hot water = x

∴ Amount of cold water = (50 – x) kg

Answer:

Total mixture of water = 50 kg

Resulting temp. $\theta°C$

Let mass of hot water = x kg

$\therefore$ mass of cold water $(50 - x)$ kg

Heat lost by hot water = Heat gained by cold water

$mC (T - \theta) = mC (\theta - t)$

$x.4200 (90 - 45) = (50 - x) 4200 (45 - 20)$

$45x = 25 (50 - x)$

$45x = 1250 - 25x$

$45x + 25x = 1250$

$70x = 1250$

$$\text{Mass of hot water} = \frac{1750}{70} = 17.871 \text{ kg}$$

Practice Problems 11

Question 1.
Heat energy is given to 100 g of water, such that its temperature rises by 10 K. When the same heat energy is given to a liquid L of mass 50 g its temperature rises by 50 K. Calculate

1. heat energy given to water
2. the specific heat capacity of liquid L.

[Take sp. heat capacity of water = 4200 J Kg^{-1} k^{-1}]

Answer:

Heat energy given to water = $mc\ \Delta t$

$= 100g \times 4.2\ Jg^{-1}\ kg^{-1} \times 10k$

$= 4200\ J$

Heat energy given to liquid L = 4200 J

$mC\ \Delta t = 4200$

$50\ g \times C \times 50\ k = 4200$

$C = \frac{4250}{2500} = 1.68\ J\ Kg^{-1}\ K^{-1}$

$= 1.68 \times 1000$

$C = 1680\ J\ Kg^{-1}\ K^{-1}$

Question 2.
Heat energy is given to 80 g of alcohol (sp. heat capacity 2200 J kg^{-1} K^{-1}) when its temperature rises by 20 K. If the same heat energy is given to 200 g of mercury of sp. heat capacity 140 J kg^{-1} K^{-1}, what is the rise in temperature.

Answer:

Heat energy given to $\left(\frac{80}{1000} kg\right)$ of alcohol

$= mC \ \Delta t$

$= \frac{80}{1000} \times 2200 \times 20 = 3520 \text{ J}$

Energy given to $\frac{200}{1000}$ kg of mercury

$\left(\frac{200}{1000}\right) \times 140 \times \Delta t = 3520$

$\Delta = \frac{3520}{28} = 125.7 \text{ K}$

Practice Problems 12

Question 1.
A copper ball is dropped from a vertical height of 1200 m. If the initial temperature of copper ball at the height is 12°C, what is its temperature of copper is 400 Jkg^{-1} $°C^{-1}$ and g = 10 ms^{-2}.

Answer:

Let m be the mass of copper ball K.E. of falling ball = P.E. at the top = mgh

K.E of falling ball = Heat produced in ball $mgh = mc\,\Delta t$

$10 \times 1200 = c \times$ rise in temp.

$c \times \Delta t = 10 \times 1200$

$400\,\Delta t = 12000$

$$\Delta t = \frac{12000}{400} = 30$$

$(T - 12) = 30$

$\therefore$ Final temp. on reaching the ground $T = 30 + 12 = 42°C$

Question 2.

A waterfall is 1.5 km high. If the temperature of water at its top is 20°C find its temperature at the bottom of waterfall, assuming all the kinetic energy is converted into heat energy.

[Take g – 10 ms^{-2} and sp. heat capacity of water = 4200 J Kg^{-1} c^{-1}]

Answer:

Height of water fall = 1.5 km = 1500 m

K.E. of falling water = P.E. of water at top = mgh

$\therefore$ P.E. = K.E. = Heat produced in water

$mgh = mC\,\Delta t$

$10 \times 1500 = 4200\,\Delta t$

$$\Delta t = \frac{15000}{4200} = \frac{150}{42} = \frac{25}{7} = 3.57°C$$

$T - 20 = 3.57$ $\quad$ ($\therefore$ $T = 23.57°C$)

$\Rightarrow$ $T = 23.57\ °C$

Exercise – 2

Question 1.
(a) What do you understand by the term latent heat of fusion?

Answer:
Latent heat of fusion : When a solid is heated change in phase from solid to liquid takes place at a constant temp. "The heat supplied to change solid to liquid at constant temp, is called latent heat of fusion."

(b) Why does the temperature remain constant during the fusion of a substance ?

Answer:
"The heat absorbed by solid is utilised in increasing the potential energy of the molecules."

Question 2.
What do you understand by the term specific latent heat of fusion ? State its C.GS. and S.I. unit.

Answer:
Specific latent heat of fusion : "The heat energy required to convert unit mass of the substance from solid to liquid state without change in temperature."
Units :
C.G.S. → Cal g^{-1}
S.I. J kg^{-1}

Question 3.
Define specific latent heat of fusion of ice. State its magnitude in calories and joules.

Answer:
Specific latent heat of fusion of ice : "Is the heat energy required to convert unit mass of ice to water without the change in temp, (or ice at 0°C to water at 0°C)."
Specific latent heat of fusion of ice = 80 cal g^{-1} or 336000 Jkg^{-1}

Question 4.
The specific heat of fusion of lead is 27 Jg^{-1}. What do you understand from the statement ?

Answer:
The specific latent heat of lead is 27 Jg^{-1} means 1 g of lead will absorb 27 J of heat in changing from solid to liquid at constant temperature.

Question 5.
Why should bits of ice to wiped dry before adding them to the calorimeter during the determination of specific latent heat of fusion of ice ?

Answer:
If bits of ice are not wiped dry waterdrops are already in liquid state will absorb less heat and result will not be correct.

Question 6.
Explain the following :

(a) Why does the weather become moderate in cold countries when the freezing of lakes and other water bodies start ?
(b) Why does it become very cold when ice starts melting in the cold countries ?
(c) Why is melting of ice a better coolant than water at zero degree Celsius ?
(d) Why does ice-cream feel more colder than water at 0°C ?
(e) Why does the weather become warm, when it snows ?
(f) Why does the weather become very cold after a hail storm ?
(g) Why are icebergs carried thousands of kilometers away without melting substantially ?
(h) Why does snow/ice not melt rapidly on the mountains during summer ?

Answer:
Reasons used : 1 kg of ice on meting absorbs 336000 J of heat energy and 1 kg of water to freeze will absorb 336000 J of heat energy.
(a) When freezing of lakes and other water bodies start in cold countries every 1 kg of water gives out 336000 J of heat and temp, of atmosphere increase making the weather moderate.
(b) When ice start meting heat is absorbed from the atmosphere (336000 J for every 1 kg of ice) and temp, falls in the surrounding and it becomes very cold.
(c) Sp. Latent heat of ice is 336000 J for every 1 kg ice. Hence to change ice at 0°C to water at 0°C, it will extract 336000 J of heat from the hot engine and will cool the engine for longer time.
(d) Sp. latent heat of ice is very high and it is 336000 J Hence ice will absorb more heat from mouth and temp, of mouth will fall considerably and ice cream feels more colder than water.
(e) When it snows, water evolves heat i.e. it gives out 336000 J for every 1 kg, in the surrounding and it becomes warm.
(f) After hail storm, to melt ice balls very large amount of heat is extracted from surroundings (sp. heat capacity of ice 336000 J) hence temp, falls and it becomes very cold.
(g) Specific latent heat of ice and also density of ice (less than water) makes it flow in water and ice bergs lose heat slowly and are carried to large distance.

(h) It is the high latent heat of ice (336000 J) for every 1 kg to change into under at 0°C. Snow melts slowly on the mountains in summer and water is available in the rivers.

PQ. (a) What do you understand by the term greenhouse effect ?
(b) Name the two main greenhouse gases and how they enter the atmosphere.

Answer:
(a) Green house effect : Sun rays from the Sun pass the earth's atmosphere and infrared radiations of short wave length reach the earth's surface and objects (plants) on it. They get warmed during day time. At night the same earth's At mosphere becomes opaque i.e. does not allow infra-red radiations of long wavelength to go back. In other words atmosphere entraps (or long wavelengths are absorbed by green house gases like CO_2 methane, chlorofluorocarbons) and hence atmosphere acts as green house with glass walls and raises the temp, inside. Hence green house effect "is the phenomenon in which infrared radiations of long wavelength given out from the surface of earth are absorbed by its atmospheric gases to keep the environment at the earth's surface and its lower atmosphere warm".
(b) Two main green house gases are :

1. Carbon dioxide CO_2
2. Methane gas CH_4

CO_2 enters the atmosphere through

1. Fossil fuel based power plants
2. Deforestation
3. Internal combustion engines.
4. Increasing population and their activities.

Methane (CH_4) enters the atmosphere when dead vegetable matter decays. It is mainly produced due to the decaying dead plant remains in the paddy fields.
It is also produced in marshly lands, sewage, coal mines and bio gas plants.

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. The amount of heat energy required to melt a given mass of a substance at its melting point without any rise in temperature is called :
(a) heat capacity
(b) sp. heat capacity

(c) latent heat of fusion
(d) sp. latent heat of fusion

Answer:
(c) latent heat of fusion

2. The SI unit of specific latent heat is :
(a) Jg^{-1}
(b) cal g^{-1}
(c) J kg^{-1}
(d) J kg^{-1} K^{-1}

Answer:
(c) J kg^{-1}

3. The sepcific latent heat of fusion of ice in SI system is :
(a) 80 cal g^{-1}
(b) 336×10^3 J kg^{-1}
(c) 2260×10^3 J kg^{-1}
(d) 336 J kg^{-1}

Answer:
(b) 336×10^3 J kg^{-1}

4. Global warming will result in :
(a) increase in agricultural production
(b) decrease in the level of sea water
(c) decrease in disease caused by bacteria
(d) increase in the level of sea water

Answer:
(d) increase in the level of sea water

5. Which is not a greenhouse gas :
(a) methane
(b) ozone
(c) carbon dioxide
(d) chlorofluorocarbons

Answer:
(b) ozone

6. With the increase in carbon dioxide in the atmosphere the acidity of oceans will :
(a) decrease
(b) remain unaffected
(c) increase
(d) none of these

Answer:
(d) none of these

Practice Problems 1

Question 1.
4000 calories of heat energy is supplied to crushed ice at 0°C, such that it completely melts to form water at 0°C. If sp. latent heat of fusion of ice is 80 cal g^{-1}, what is the mass of ice ?

Answer:

Heat required to melt ice = 4000 cal

$mL = 4000$

$m \times 80 = 4000$

$$\text{Mass of melted ice} = m = \frac{4000}{80} = 50\text{ g}$$

Question 2.
A solid of mass 80 g and at 80°C melts completely to form liquid at 80°C by absorbing 640 J of heat energy. What is the sp. latent heat of fusion of solid ?

Answer:

Mass of solid $m = 80$ g at 80°C

on melting 80 g of liquid at 80°C

$mL = 640$

$80\text{ L} = 640$

$$\text{Latent heat of solid} = L = \frac{640}{80} = 8\text{ J}g^{-1}$$

Practice Problems 2

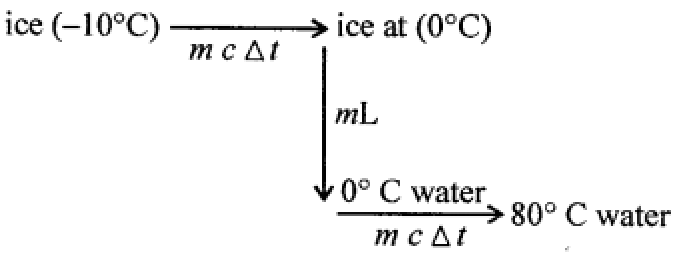
Question 1.

100 g of ice at -10°C is heated on a gas stove till it forms water at 80°C. Calculate :

1. Heat energy required to bring the ice to 0°C.
2. Heat energy required to melt the ice
3. Heat energy required to bring water to 80°C.

[Sp. heat capacity of ice = 2 J g^{-1} $°C^{-1}$, Sp. heat capacity of water = 4.2 J g^{-1} $°C^{-1}$, and Sp. heat capacity of liquid wax = 1.8 J g^{-1} $°C^{-1}$]

Answer:



(i) Heat energy required to bring ice at 0°C

$= mc_{\Delta t} = 100 \times 2 \times 0 - (-10)$

$= 200 \times 10 = 2000$ J

(ii) Heat energy required to melt ice from 0°C to 0°C water = mL

$= 100 \times 336 = 33600$ J

(iii) Heat energy required to bring water from 0°C water to 80°C water = $mC\Delta t$

$$= 100 \times 4.2 \times (80 - 0) = 100 \times \frac{42}{10} \times 80 = 33600 \text{ J}$$

Question 2.

400 g of wax at 10°C is heated to 80°C, when it starts melting. On complete melting wax is further heated so that temperature rises to 130°C. Calculate

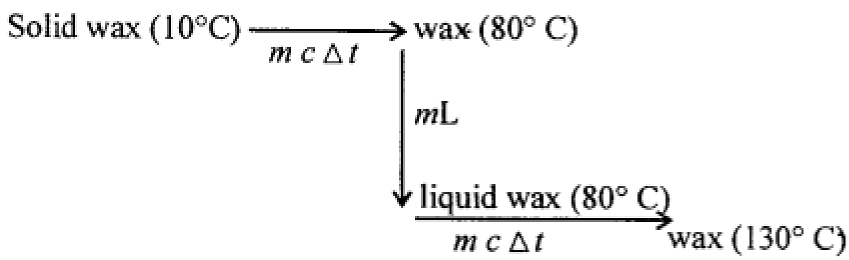
(a) Heat energy required to bring the wax to its melting point

(b) Heat energy required to melt the wax

(c) Heat energy required to bring the molten wax to 130° C.

[Sp. heat capacity of solid wax = 1.5 J g^{-1} $°C^{-1}$, Sp. heat capacity of liquid wax = 1.8 Jg^{-1} $°C^{-1}$ and Sp. latent heat of wax = 80 J g^{-1}]

Answer:



(i) Heat energy required to heat at 80°C

$$= mc \quad \Delta t$$

$$= 400 \times 15 \times (80 - 10)$$

$$= 400 \times \frac{15}{10} \times 70 = 42000 \text{ J}$$

(ii) Heat energy required to melt wax (solid) to wax liquid at 80°C $= m$L

$m\text{L} = 400 \times 80 = 32000 \text{ J}$

(iii) Heat energy required to heat liquid wax at 80°C

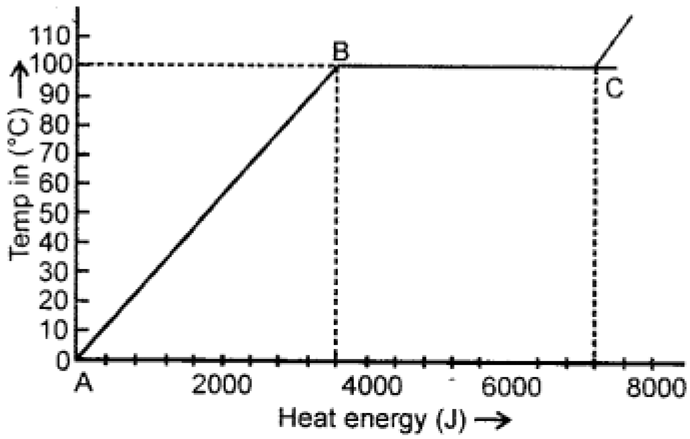
$$= mc\ \Delta t$$

$$= 400 \times 1.8 \times (130 - 80)$$

$$= 400 \times \frac{18}{10} \times 50 = 36000 \text{ J}$$

Practice Problems 3

Question 1.
A solid initially at 0°C is heated. The graph shows variation in temperature with the amount of heat energy supplied. If the specific heat capacity of solid 0.8 Jg^{10} $°C^{-1}$, from the graph, calculate (a) the mass of solid and (b) specific latent heat offusion of solid.

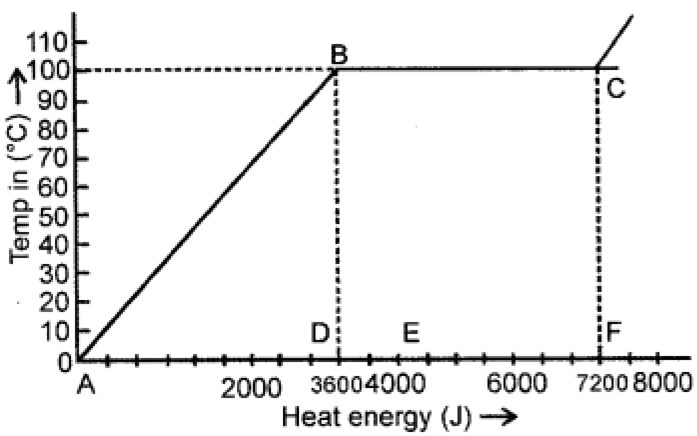


Answer:

From A to B

Rise in temp. $\Delta t = (100 - 0) = 100°C$

Heat energy supplied $({}_{C}A^{D} = 3600 \text{ J})$



$\therefore \quad mc\,\Delta t = 3600 \text{ J}$

$m \times 0.8 \times 100 = 4000$

$m = \frac{3600}{80}$

$m = 45 \text{ g}$

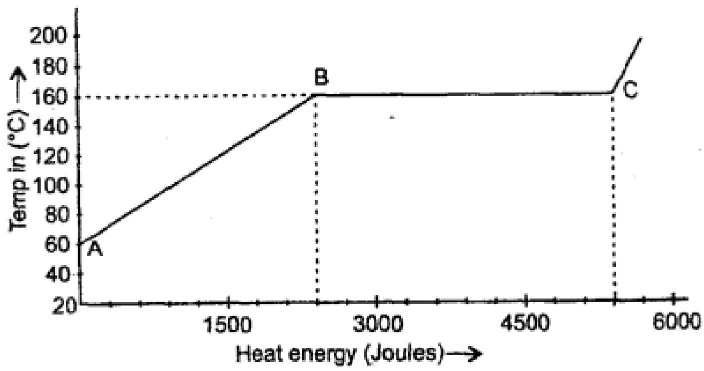
(ii) Sp. latent of heat of fusion = 'L'

$mL\,(7200 - 3600)\; mL = DF$

$45\,L = 3600$

$L = \frac{3600}{45} = 80 \text{ Jg}^{-1}$

Question 2.
A solid initially at 60°C is heated. The graph shows variation in temperature with the amount of heat energy supplied. If the specific heat capacity of solid is 1.2 Jg^{1} $°C^{-1}$, from the graph, calculate (i) the mass of solid and (ii) specific latent heat offusion of solid.



Answer:

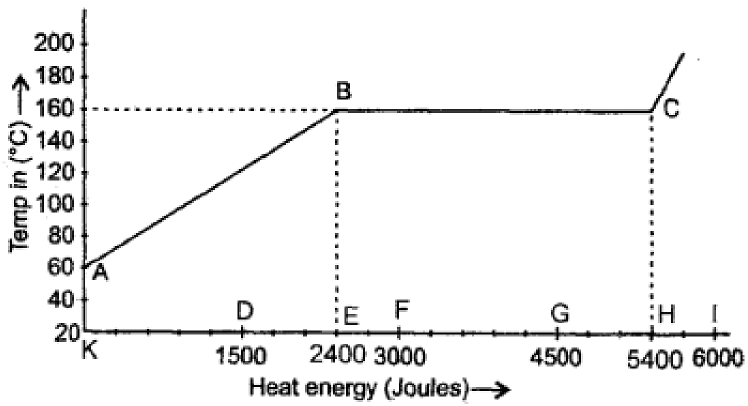
(i) Heat supplied from K to E = 2400 J

Rise in temp. = 160 – 60 = 100°C = Δt

$\therefore$ $mc\,\Delta t = H$

$m \times 1.2 \times 100 = 2400$

$$m = \frac{2400}{120} = 20 \text{ g}$$



(ii) Sp. Latent heat of fusion L = ?

Heat supplied to melt solid = EH

$m\text{L} = (5400 - 2400)$

$20\,\text{L} = 3000$

$$\text{L} = \frac{3000}{20} = 150 \text{ Jg}^{-1}$$

Practice Problems 4

Question 1.
Water at 80°C is poured into a bucket containing 1.5 kg of crushed ice at 0°C, such that all the ice melts and the final temperature records is 0°C. Calculate the amount of hot water added to the ice.
[Take sp. H.C. of water 4200 J g^{-1} $°C^{-1}$ and sp. latent heat of ice = 336 × 10^3 J kg^{-1}]

Answer:
Let mass of hot water = 'x' kg

Heat given get by hot water = $mc\,\Delta t$

$$= x \times 4200 \times (80 - 0)$$

Heat absorbed by ice to form water at 0°C = mL

$$\therefore \quad mL = x \times 4200 \times 80$$

$$1.5 \times 336 \times 10^3 = x \times 4200 \times 80$$

$$x = \frac{15}{10} \times \frac{336000}{42 \times 80} = 1.5 \text{ kg}$$

Question 2.
1.6 kg of boiling water at 100°C is poured into 2 kg of crushed ice at [336 × 10^3 J kg^{-1}]0 °C, such that final temperature recorded is 0°C. Calculate the specific heat of ice.

Answer:
Let 'L Jkg^{-1}' be the specific latent heat capacity of ice.

Heat gained by ice = Heat lost by boiling water

$$mL = mc_1\theta_R$$

$$2L = 1.6 \times 4200 \times 100$$

$$L = 336000$$

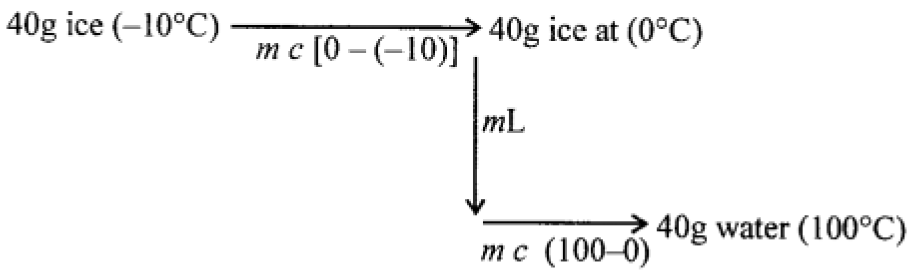
$$L = 336 \times 10^3 \text{ Jkg}^{-1}$$

Practice Problems 5

Question 1.
40 g of ice at – 10° C is heated by a heater of power 250 W, such that water formed from it, attains the temp, equal to the boiling point of water. For how long is the heater

switched on?
[Sp. h.c. of ice = 2 $Jg^{-1}\ °C^{-1}$; Sp. latent heat of ice = 340 Jg^{-1}]

Answer:



(i) Heat reqd. to change ice at –10°C to ice at 0°C = $mc_1\theta_R$

$= 40 \times 2 \times [0 - (-10)] = 40 \times 2 \times 10 = 800$ J

(ii) Heat reqd. to change ice at 0°C to water at 0°C = mL

$= 40 \times 340 = 13600$ J

(iii) Heat reqd. to change water at 0°C to water at 100°C

$= mc_2\theta_R = 40 \times 4.2 \times (100 - 0) = 40 \times 4.2 \times 100 = 16800$ J

Total heat reqd. = 800 + 13600 + 16800 = 31200 J

P = 250 W = 250 J/s

$$\therefore \text{Time } (t) = \frac{\text{Energy consumed}}{\text{Power}} = \frac{31200}{250} = 124.8 \text{ s}$$

Question 2.
An immersion heater is placed in crushed ice at – 40°C, contained in a perpex jar, such that water at 50°C is formed. If the power of heater is 200 W and it is switched on for 3 min. and 20s. Calculate the initial mass of ice S.H.C. of ice – 2.1 $Jg^{-1}\ °C^{-1}$ and latent heat of ice = 336 Jg^{-1}

Answer:

Let mass of ice = m g

(i) Heat reqd. to change ice at –40°C to ice at 0°C = $mc_1\theta_R$

$= m \times 2.1 \times [0 - (-40)] = m \times 2.1 \times 40 = 84m$ J

(ii) Heat reqd. to change ice at 0°C to water at 0°C = mL

$= m \times 336 = 336m$ J

(iii) Heat reqd. to change water at 0°C to water at 50°C

$= mc_2\theta_R$

$= m \times 4.2 \times (50 - 0) = m \times 4.2 \times 50 = 210m$ J

Total heat reqd. = $84m + 336m + 210m = 630m$ J

Power of Heater = 200W

Heat energy produced in 3 min 20 sec = P × T

$= 200 \times (200\text{ s}) = 40000$ J

Heat energy required = Heat energy produced

$630m = 40000$

$$m = \frac{40000}{630} = 63.49 \text{ g}$$

Hence, Mass of ice = 63.49 g

Question 3.

A burner supplies heat energy at a rate of 434 JS^{-1} for 60 seconds when 40 g of ice at 0°C changes to water at 75°C. Calculate latent heat of ice.

Answer:

Heat supplied by burner = Q = P × t = Heat used in melting ice and converting into water at 75°C

$434 \times 60 = mL_i + mC_w(75 - 0)$

$$26040 = 40L_i + 40 \times \frac{42}{10} \times 75$$

$40L_i = 26040 - 12600 = 13440$

$$L_i = \frac{13440}{40} = 336\ Jg^{-1}$$

Practice Problems 6

Question 1.
A vessel of mass 80 g (S.H.C. =0.8 Jg^{-1} $°C^{-1}$) contains 250 g of water at 35°C. Calculate the amount of ice at 0°C, which must be added to it, so that final temperature is 5°C.
[Sp. latent heat of ice = 340 Jg^{-1}]

Answer:

Heat gained by ice = Heat lost by (container + water)

Let mass of ice added = Mg

$$ML_i + MC_w(5-0) = [m_1 C_s + m_2 C_w](T_2 - T)$$

$$M[L_1 + (C_w \times 5)] = \left[\left(80\times\frac{8}{10}\right)+250\times\frac{42}{10}\right](35-5)$$

$$M\left[340+\left(\frac{42}{10}\times 5\right)\right] = (64 + 1050) \times 30$$

$$361\ M = 33420 \qquad \because M = \frac{33420}{361}$$

$$M = 92.57\ g$$

Question 2.
A vessel of mass 100 g (S.H.C. = 0.2 cal g^{-1} $°C^{-1}$] contains 500 g of water at 37°C. Calculate the amount of ice, which should be added to the vessel, so that the final temperature is 17°C.
[S.H.C. of water = 1 cal g^{-1} $°C^{-1}$ and S.L.H. of ice = 80 cal g^{-1}]

Answer:

Let mass of ice added be = Mg

Sp. heat capacity of water C_w = 1 cal. g^{-1} $^oC^{-1}$

Sp. heat capacity of vessel C_v = 0.2 cal. g^{-1} $^oC^{-1}$

S.L.H of ice = 80 cal. g^{-1}

Heat gained by ice = Heat lost by [vessel + water]

$$[ML_i + MC_w \times (17 - 0) = [m_1 C_v + m_2 C_w] [37 - 17]$$

$$M [80 + (1 \times 17)] = \left[\left(100 \times \frac{2}{10}\right) + (500 \times 1)\right] \times 20$$

$$M [97] = [520] \times 20$$

$$M = \frac{520 \times 20}{97} = 107.2 \ g$$

Question 3.
10g of ice at 0°C is added to 10g of water at 80°C, such that the temperature of mixture is 0°C. Calculate the sp. latent heat of ice.
[S.H.C. of water = 4.2 Jg^{-1} $°C^{-1}$]

Answer:

Let sp. Latent heat capacity of ice = L_i

∴ Heat gained by ice = Heat lost by water

$$ML_i = mC_w (T_2 - T)$$

$$(10 \times L_i) = 10 \times \frac{42}{10} (80 - 0)$$

$$L_1 = \frac{10 \times 42 \times 8}{10} = 336 \ Jg^{-1}$$

Practice Problems 7

Question 1.
A metal ball of mass 0.5 kg and at 900°C is placed on a block of ice, till it attains the temperature of ice. If the S.H.C. of metal ball is 850 J kg^{-1} K^{-1}, calculate the amount of ice, which melts. Take S.L.H of ice 34 × 10^4 J kg^{-1}.

Answer:

Let mass of ice melted = 'M' kg

Heat absorbed by ice = Heat evolved by ball

$$M \times L_i = m \times C_{m_1} \times \text{fall in temp.}$$

$$M \times 34 \times 10^4 = 0.5 \times 850 \times (900 - 0)$$

$$M = \frac{5}{10} \times \frac{850 \times 900}{34 \times 10000} = \frac{2.25}{2} = 1.125 \text{ kg}$$

Question 2.

Calculate the temperature of a furnace, when a 400 g of copper ball, taken out from it, melts only 400 g of ice to form water at 0°C. Take S.H.C. of copper = 0.4 Jg^{-1} $°C^{-1}$ and S.L.H. of ice = 336 Jg^{-1}

Answer:

Let temp. of furnace i.e. of copper ball = T°C

∴ Heat lost by copper ball = Heat gained by ice to melt to 0°C water

$$MC_s (T - 0) = m L_i$$

$$M \times \frac{4}{10} \times T = 400 \times 336$$

$$400 \times \frac{4}{10} T = 400 \times 336$$

$$T = 336 \times \frac{10}{4} = 840^o C$$

Question 3.

A metal ball of 0.20 kg and at 200°C, when placed on an ice block melts 100 g of ice, when its temp, stops falling. If sp. latent heat of ice is 340 Jg^{-1}. Calculate specific heat capacity of metal ball

Answer:

Let Sp. heat Capacity of solid ball = C

$\therefore$ Heat lost by hot ball = Heat gained by ice

$MC (T - 0) = mL_i$

$(0.20 \times 1000) \times C (200 - 0) = 100 \times 340$

$200 \times 200 C = 100 \times 340$

$$C = \frac{34000}{2 \times 20000} = \frac{34}{2 \times 20} = \frac{1.7}{2}$$

$$C = 0.85 \ Jg^{-1} \ {}^{o}C^{-1}$$

Practice Problems 8

Question 1.

A 30 watt immersion heater just keeps 600 g of molten metal at its melting point. The heater is switched off and the temperature starts falling after 6 min. Calculate sp. latent heat of fusion of the metal

Answer:

Let sp. Latent heat of fusion of metal = L

$Q = P \times t = 30 \times (6 \times 60)$ J

Mass of molten metal M = 600 g

$\therefore$ $ML = Q$

$600 \times L = 30 \times 6 \times 60$

$$\text{Sp. Latent heat of ball} = L = \frac{600 \times 18}{600} = 18 \ Jg^{-1}$$

Question 2.

A hydrocarbon of mass 1.5 kg is just kept in molten state by a heater of 500 W. If the heater is switched off, the temperature starts dropping after 4 mins. Calculate sp. latent heat of fusion of hydrocarbon.

Answer:

Let Sp. latent heat of fusion of hydrocarbon = L

Heat absorbed by hydrocarbon = Heat lost by heater

$\therefore \quad ML = Q = P \times t$

$1.5\ L = 500 \times (4 \times 60)$

$$L = \frac{500 \times 240 \times 10}{15} = 80{,}000\ J\ kg^{-1}$$

Practice Problems 9

Question 1.
500 g of water at 60°C is contained in a vessel of negligible heat capacity. Into this water is added 400 g of ice at 0°C. Calculate the amount of ice which does not melt.
[Take SHC of water = 4.2 J g^{-1} °C^{-1} and SLH of ice = 336 Jg^{-1}]

Answer:

Heat lost by 500 g water at 60°C to cool to 0°C = $mc(T - 0)$

$= 500 \times 4.2 \times (60 - 0)$ J

This heat lost is used in melting m gram of ice at 0°C

$$\therefore \quad mL = 500 \times \frac{42}{10} \times 60$$

$$m \times 336 = 3000 \times 42$$

$$m = \frac{3000 \times 42}{336}\ 375\ g$$

$\therefore$ Amount of ice which does not melt = 400 – 375 = 25 g

Question 2.
2 kg of water at 100° is contained in a vessel of negligible heat capacity. Into this water is added 3 kg of ice at 0°C. Calculate the amount of water at 0°C at the end of experiment.
[Take SHC of water = 4.2 J g^{-1} °C^{-1} and SLH of ice = 336×10^3 J]

Answer:

Let mass of ice at 0°C is melted to water at 0°C

Heat energy lost by 2 kg of water at 100°C to cool to 0°C water

$= mc\,(100 - 0)$

$\therefore$ Heat lost by water = Heat gained by m kg of ice

$MC\,(100 - 0) = mL$

$2 \times 42 \times 100 = m \times 336000$

$$m = \frac{8400 \times 100}{336000} = 2.5 \text{ kg}$$

$\therefore$ Amount of water at 0°C

= 2kg + 2.5 kg obtained by melting of ice

= 4.5 kg

Practice Problems 10

Question 1.

A vessel with a negligible heat capacity contains 1000 g ice at 0°C. Into it is poured 100 g of water at 100°C. What would be the result at the end of experiment ?

[Take SHC of water = 4.2 J g^{-1} $°C^{-1}$ and SLH of ice = 336 Jg^{-1}]

Answer:

Heat given out by water in cooling from 100°C to 0°C

$= mc(100 - 0)$

$$= 100 \times \frac{42}{10} \times 100 = 42000 \text{ J}$$

Heat absorbed by 1000 g ice 0°C in changing into 0°C water

$= mL$

$= 1000 \times 336 = 336000 \text{ J} > 42000 \text{ J}$

This means whole of ice is not melted is heat given out by hot water is less than needed.

Let 'm' be the mass of ice which melts by heat supplied by not water.

$\therefore$ $Q = mL$

$\therefore$ $336\,m = 42000$

$$m = \frac{42000}{336} = 125 \text{ g (mts)}$$

$\therefore$ 1000 – 125 = 875 of ice does not melt and final temp. is 0.°C

Question 2.
What will be the result whn 400 g of copper clips at 500°C with 800 g of crushed ice at 0°C ?
[Sp. heat capacity of copper = 0.42 J g^{-1} K^{-1}, Sp. latent heat of fusion of ice = 340 J g^{-1}]

Answer:
Heat given out of copper lips in cooling to 0°C = mc (T – 0)
= 400 × 0.42 (500 – 0) = 84000 J

Heat absorbed by 800 g ice 0°C to 0°C water
= mL = 800 × 340
= 272000 J > 84000 J

This means heat given out by copper clips is insufficient to melt all 800 g ice.

Let 'm' be the mass of ice melted by heat given out by copper clips

$\therefore$ Q = mL = 340 m

$\therefore$ 340 m = 84000

$$m = \frac{84000}{340} = 247 \text{ g (melts)}$$

$\therefore$ 800 – 247
= 553 g of ice does not melt and final temp. is 0°C

Questions from ICSE Examination papers

2006

Question 1.
Give two reasons as to why copper Le preferred over other metals for making calorimeters.

Answer:

1. Copper is very good conductor of heat and has low sp. heat capacity 0.093 cal. g^{-1} $°C^{-1}$ to attain the temp. of contents soon
2. The low sp. heat capacity and heat cner taken by calorimeter from its content to acquire the temp, of its contents is negligible.

Question 2.
Calculate the amount of heat released when 5.0 g of water at 20°C is changed to ice at 0°C.
(Specific heat capacity of water = 4.2 Jg^{-1} $°C^{-1}$)
[Sp. latent heat of fusion of ice = 336 J g^{-1}]

Answer:
Water T = 20°C

$m = 5$ g

$C = 4.2\ Jg^{-1}\ °C^{-1}$

$L = 336\ Jg^{-1}$

Heat energy released in changing water at 20°C to 0°C water + 0°C with to 0°C ice.

$$= mC\,(T - 0) + mL$$

$$= 5 \times 4.2 \times (20-0) + (5 \times 336)$$

$$= 5 \times \frac{42}{10} \times 20 + 1680$$

$$Q = 420 + 1680 = 2100$$

Question 3.
A piece of iron of mass 2 kg has a thermal capacity of 966 $J°C^{-1}$.

(a) How much heat is needed to warm it by 15°C ?
(b) What is its specific heat capacity in S.I. units ?
(c) What is the principle calorimetry ?

Answer:

(a) Mass of iron = 2 kg

Thermal capacity C = 966 J/°C

Rise in temp. T = 15°C

$\therefore$ Q = C × T = 966 × 15 = 14490 J

(b) $$\text{Sp. heat capacity} = \frac{\text{Thermal capacity}}{\text{Mass of iron}}$$

$$= \frac{966}{2} = 483 \text{ Jkg}^{-1}\,{}^{\circ}\text{C}^{-1}$$

(c) Principle of calorimetry :

Heat energy lost by hot body = Heat energy gained by the cold body.

Question 4.
Explain why water is used in hot water bottles for fomentation and also as a universal coolant.

Answer:
For specific heat capacity of water being very high i.e. 4200 J Kg^{-1} k^{-1}, water extracts more heat from hot surrounding and loses it very slowly and acts as effective coolant.

2007

Question 5.
Some hot water was added to three times the mass of cold water at 10°C and the resulting temperature was found to be 20°C. What was the temperature of the hot water ?

Answer:

Let m be mass of hot water

Then, Mass of cold water $= 3\,m$

Temperature of cold water $= 10°C$

Temperature of mixture $= 20°C$

Let θ be the temperature of hot water.

Heat lost by hot water in cooling from θ °C to 20°C

$$= m \times c \times (\theta - 20)$$

Heat gained by cold water $= 3m \times c \times (20 - 10) = 3mc \times 10$

Since heat lost = heat gained

$$mc(\theta - 20) = 3mc \times 10$$

$$\theta - 20 = 30$$

$$\theta = 30 + 20$$

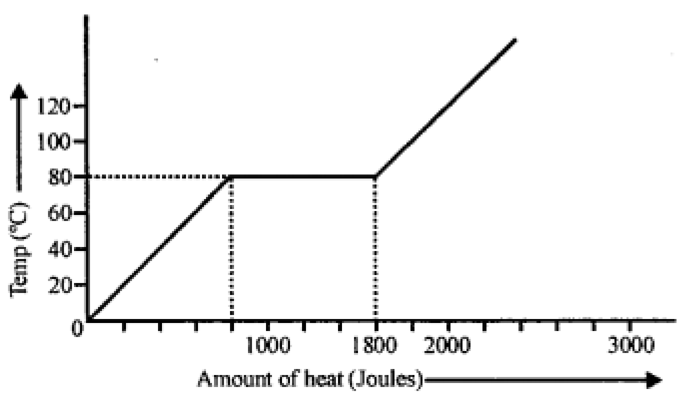
$$= 50°C.$$

Question 6.

(a) (i) What is meant by Specific heat capacity of a substance ?

(ii) Why does the heat supplied to substance during its change of state not cause any rise in its temperature? (3)

(b) A substance is in the form of a solid at 0°C. The amount of heat added to this substance and the temperature of the substance are plotted on the following graph :



If the specific heat capacity of the solid substance is 500J/kg°C, find from the graph :

1. the mass of the substance
2. the specific latent heat of fusion of the substance in the liquid state.

Answer:

(a) *(i)* Specific heat capacity of a substance is defined as the amount of heat required to raise the temperature of a unit mass of the substance through 1°C. It is denoted by *c*.

$$Q = mc\theta$$

$$c = \frac{Q}{m\theta}$$

(ii) The heat supplied during the change of state does not appear on thermometer because it is used up in bringing about a change of state i.e., in changing the distance between the molecules of the substance.

(b) *(i)* From the given graph. It is clear that 800 joules of heat energy is used to raise the temperature of the substance from 0 to 80°C.

$\therefore$ $Q = mc\theta$, $c = 500\ Jkg^{-1}\ {}^{o}C^{-1}$

$$m = \frac{Q}{c\theta} = \frac{800}{500 \times 80} = \frac{1}{50}\ kg$$

$= 0.02\ kg$

(ii) Heat used up in changing the state at 80°C

$= 1600 - 800 = 800\ J$

Also $mL = Q$ (During change of state)

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

$$= \frac{800}{0.02}$$

$= 40000\ J\ kg^{-1}$

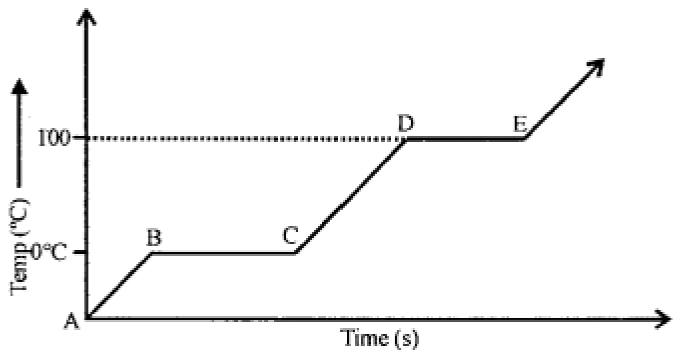
2008

Question 7.
In what way will the temperature of water at the bottom of a waterfall be different from the temperature at the top ? Give a reason for your answer.

Answer:
Stored water has potential energy. On falling potential energy of water get converted into kinetic energy and ultimately into heat energy. So water at the bottom will have slightly high temperature as compared to top.

Question 8.
A certain quantity of ice at 0°C is heated till it changes into steam at 100°C. Draw a time-temperature heating curve to represent it. Label the two phase changes in your graph.

Answer:



Question 9.

1. Define heat capacity of a given body. What is its SI unit?
2. What is the relation between heat capacity and specific heat capacity of a substance ?

Answer:

1. The heat capacity of a body is the amount of heat energy required to rise its temperature by 1°C or IK. SI unit J $°C^{-1}$ or JK^{-1}
2. Heat Capacity = Mass specific heat capacity

Question 10.
A piece of ice of mass 40 g is dropped into 200 g of water at 50°C.
Calculate the final temperature of water after all the ice has melted.
(specific heat capacity of water = 4200 J/kg °C, specific latent heat of fusion of ice = 336×10^3 J/kg)

Answer:

Mass of water = 200 g Mass of ice = 40 g

$t_1 = 50°C$ $t_1 = 0°C$

final temperature $t_2 = ?$ $t = ?$

mL (of ice) + mcθ (of water formed from ice) = mcθ (of water)

$40 \times 336 + 40 \times 4.2 \times t_2 = 200 \times 4.2 \times (50 - t_2)$

$\Rightarrow 13440 + 168\, t_2 = 840\,(50 - t_2)$ $13440 + 168\, t_2 = 4200 - 840\, t_2$

$168\, t_2 + 840\, t_2 = 42000 - 13440$

$1008\, t_2 = 28560$

$$t_2 = \frac{28560}{1008} = 28.33°C$$

2009

Question 11.

(a) Why do pieces of ice added to a drink cool it much faster than ice cold water added to it ?

Answer:

Ice absorbs 336 J/g heat energy extra from the drink as compared to ice cold water. So it cools the drink much faster.

(b) 40g of water at 60°C is poured into a vessel containing 50g of water at 20° C. The final temperature recorded is 30°C. Calculate the thermal capacity of the vessel. (Take specific heat capacity of water as 4.2 Jg^{-1} $°C^{-1}$).

Answer:

Hot water	Vessel	Cold water
$m = 40$ kg	$mc = ?$	$m = 50$ g
$t_1 = 60°C$	(thermal capacity)	$t_1 = 20°C$
$C = 4.2\ Jg^{-1}C^{-}$	$t_2 = 30°C$	$C = 4.2\ Jg^{-1}°C^{-1}$

Heat lost by hot water = Heat gained by cold water + Heat gained by vessel

$40 \times 4.2 \times (60\text{-}30) = mc \times (30 - 20) + 50 \times 4.2 \times (30 - 20)$

$168 \times 30 = 210 \times 10 + 10\ mc$

$5040 = 2100 + 10\ mc$

$mc = 294\ J°C^{-1}$

Question 12.

(a) State in brief, the meaning of each of the following:

1. The heat capacity of a body is 50 J $°C^{-1}$.
2. The specfic latent heat of fusion of ice is 336000 J kg^{-1}.
3. The specific heat capacity of copper is 0.4 J g1 $°C^{-1}$.

Answer:

1. The heat capacity of the body is 50 J $°C^{-1}$ means the body will absorb 50 J of heat energy to raise its temp by 1 °C
2. The specific latent heat of fusion of ice is 336000 J kg^{-1} means to melt 1 kg of ice at 0°C to 1 kg water at 0 °C it will absorb 336000 J of heat energy.
3. The specific heat capacity of copper is 0.4 Jg^{-1} $°C^{-1}$ means 1 g of copper will absorb 0.4 J of heat energy to raise its temp, by 1°C.

(b) (i) What is the principle of the method of mixtures ?,(ii) Name the law on which this principle is based.

Answer:

1. When there is no loss or gain of heat from surroundings, heat lost by hot body or bodies is equal to heat gained by cold body or bodies.
2. It is based on the law of conservation of energy.

(c) Calculate the amount of ice which is required to cool 150 g of water contained in a vessel of mass 100 g at 30°C, such that the final temperature of the mixture is 5°C. (Take specific heat capacity of material of vessel as 0. 4 Jg^{-1} $°C^{-1}$, specific latent heat of fusion of ice = 336 Jg^{-1}, specific heat capacity of water – 4.2 J g^{-1} $°C^{-1}$.)

Answer:

Water	Vessel	Ice
$m = 150g$	$m = 100g$	$m = ?$
$t_1 = 30°C$	$t_1 = 30°C$	$t_2 = 5°C$

Heat gained by ice to melt and to come to final temperature
= Heat lost by water and vessel

$m \times 336 + m \times 4.2 \times 5 = 150 \times 4.2 (30 - 5) + 100 \times 0.4 \times (30 - 5)$

$336\,m + 21m = 630 \times 25 + 40 \times 25$

$357\,m = 15750 + 1000 = 16750/357 = 46.92\,g$

2010

Question 13.

(a) (i) Define the term 'specific latent heat of fusion of a substance.
(ii) Name the liquid which has the highest specific heat capacity.
(iii) Name two factors on which the heat absorbed or given out by a body depends.
(b) (i) An equal quantity of heat is supplied to two substances A and B. The substance A shows a greater rise in temperature. What can you say about the heat capacity of A as compared to that of B ?
(ii) What energy change would you expect to take place in the molecules of a substance when it undergoes
1. a change in its temperature ?
2. a change in its state without any change in its temperature?
(c) 50 g of ice at 0°C is added to 300g of a liquid at 30°C. What will be the final temperature of the mixture when all the ice has melted ? The specific heat capacity of the liquid as 2.65 J g^{-1} $°C^{-1}$ while that of water is 4.2 J g^{-1} $°C^{-1}$. Specific latent heat of fusion of ice = 336 J g^{-1}.

Answer:
(a) (i) **Specific latent heat of fusion :** It is defined as the heat required to melt one kilogram of a substance at its melting point without any change in temperature.
(ii) Water has the highest specific heat capacity.

(iii) The heat absorbed or given out by a substance depends upon (i) mass of the body, (ii) rise or fall of temperature

(b) (i) Heat absorbed by a substance is given by

H = ms θ

H = Heat capacity × rise of temperature.

Since, H is same for both A and B, it is a clear that heat capacity is inversely proportional to the rise of temperature.

Since, the rise of temperature A is more its heat capacity must be less.

∴ Heat capacity of A is less than that of B.

1. The energy of the molecules of a body increases with the rise in temperature and decreases with the fall of temperature.

2. Since, temperature remains constant there is no change in the kinetic energy of the molecules. The energy given to substance to change the state of the substances increases potential energy of the molecules.

(c) Here

Ice	Liquid
Mass of ice = 50g Temperature of ice = 0°C Latent heat of fusion of ice = 336 Jg^{-1}	Mass of the liquid = 300 g Temperature of the liquid = 30°C
Specific heat capacity of water = 4.2 $Jg^{-1}\ {}^{\circ}C^{-1}$	Specific heat capacity of liquid = 2.65 $Jg^{-1}\ {}^{\circ}C^{-1}$

Let θ be the final temperature of the mixture.

Heat gained by 50g of ice at 0°C during its change of state to water $= mL = 50 \times 336 = 16800$ J

Heat gained by 50g of water when its temperature rises to

$\theta°C = 50 \times 4.2 \times \theta = 210\theta$

Total heat gained = $16800 + 210\theta J$

Heat lost by the liquid = $300 \times 2.65 \times (30 - \theta)$

$= 300 \times 2.65 \times 30 - 300 \times 2.65\theta = 23850 - 795\theta$

Now, Heat gained = Heat lost

$16800 + 210\theta = 23850 - 795\theta$

or $1005\theta = 23850 - 16800 = 7050$

$$\therefore \theta = \frac{7050}{1005} = 7.01\ °C$$

2011

Question 14.
(a) (i) Differentiate between heat and temperature. (ii) Define Calorimetry. (2)
(b) 200 g of hot water at 80°C is added to 300 g of cold water at 10°C. Calculate the final temperature of the water. Consider the heat taken by the container to by negligible, [specific heat capacity of water is 4200 J kg^{-1} $°C^{-1}$]

Answer:
(a) (i)
Heat :

1. Heat is the energy of transit.
2. Its S.I. unit is Joule.
3. It is the measured by the principle of Calorimetry.
4. It is an addictive quantity.

Temperature :

1. Temperature is the fundamental quantity which determines the direction of flow of heat.
2. Its S.I. unit is Kelvin.
3. It is measured by Thermometer.
4. It is not an addictive quantity.

(ii) Calorimetery : The measurement of the quantity of heat is called Callorimetery.

(b) Let the final temperature be T°C. By the principle of calorimetry, we know

Heat lost = Heat gained

$$\frac{200}{1000} \times 4200 \times (80 - T) = \frac{300}{1000} \times 4200 \times (T - 10)$$

$$2(80 - T) = 3(T - 10)$$

$$\Rightarrow 160 - 2T = 3T - 30$$

$$\Rightarrow 160 + 30 = 3T + 2T$$

$$\Rightarrow 5T = 190$$

$$\therefore T = \frac{190}{5} = 38°C$$

Question 15.

(a) (i) Explain why the weather becomes very cold after a hailstorm.
(ii) What happens to the heat supplied to a substance when the heat supplied causes no change in the temperature of the substance ? (3)
(b) (i) When 1 g of ice at 0 °C melts to form 1 g of water at 0 °C then, is the latent heat absorbed by the ice or given out by the ice ?
(ii) Give one example where high specific heat capacity of water is used as a heat reservoir.
(iii) Give one example where high specific heat capacity of water is used for cooling purposes. (3)
(c) 250 g of water at 30°C is present in a copper vessel of mass 50 g. Calculate the mass of ice required to bring down the temperature of the' vessel and its contents to 5°C.
Specific latent heat of fusion of ice = 336×10^3 J kg^{-1}
Specific heat capacity of copper vessel = 400 J kg^{-1} $°C^{-1}$
Specific heat capacity of water = 336×10^3 J kg^{-1} $°C^{-1}$ (4)

Answer:

(a) (i) As the ice starts melting after a hailstorm, it absorbs latent heat of fusion from the surrounding air. This leads to the cooling of atmosphere.
(ii) Heat supplied to a substance during its change of state is called latent heat. It is used up in increasing the potential energy of the molecules of the substance and in doing work against external pressure if there is an increase in volume. Hence there is no change of temperature.

(b) (i) Water at 0°C has more heat than ice at 0°C. This is because each gram of ice absorbs nearly 336 J of heat when it melts into water at 0°C.
(ii) In cold countries water is used as heat reservoir for wine and juice bottle to avoid freezing. Due to high specific heat capacity imports a large amount of heat before reaching to the freezing temp. Hence bottles kept in water remains warm and do not freeze.
(iii) It is used as coolant by flowing it in pipes around the heated part of machines.

(c) Let m be the mass of ice

$\therefore$ Heat lost by ice $= mL + mC\,(5-0)$

$= 336\text{ m} + m \times 4.2 \times 5 = 357\text{ m}$

Heat gained by water + vesel to cool to 5 °C

$= [mC_w + mC_v]$ fall in temp.

$$= \left(250 \times 4.2 + 50 \times \frac{400}{1000}\right)(30-5)$$

$= (1050 + 20) \times 25$

$= 26750$ J

By the principle of Calorimetery

Heat gained = Heat lost

$357\text{ m} = 26750$

$$m = \frac{26750}{357}$$

$m = 74.93$ g

2012

Question 16.
(a) Differentiate between heat capacity and specific heat capacity

Answer:

	Heat Capacity	Sp. Heat Capacity
(i)	S.I. unit is K^{-1}	S.I. unit $J\ Kg^{-1}\ k^{-1}$
(ii)	Heat capacity = mass of sub × sp. heat capacity	Sp. heat capacity = $\frac{\text{Heat capacity}}{\text{mass }(m)}$
(iii)	It changes with change in mass	It is constant quantity
(iv)	It is the amount of heat reqd to raise the temp. of a given mass of substance through 1 k or 1 °C	It is the amount of heat energy reqd. to raise the temp. of a unit mass of substance through 1 k or 1 °C

(b) A hot solid of mass 60 g at 100°C is placed in 150 g of water at 20°C. The final steady temperature recorded is 25°C. Calculate the specific heat capacity of the solid. [Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$]

Answer:

$$m_{solid} \times C_{solid} \times \theta_{fall} = m_{water} \times C_{water} \times \theta_R$$

$$\frac{60}{1000}\ kg \times C_{solid} \times 75°C = \frac{150}{1000}\ kg \times 4200\ Jkg^{-1}{}°C^{-1} \times 5°C$$

$$\therefore\ C_{solid} = \frac{150 \times 4200 \times 5 \times 1000}{1000 \times 60 \times 75}\ J\ kg^{-1}{}°C^{-1} = 700\ J\ kg^{-1}{}°C^{-1}$$

Question 17.

(a) (i) Write an expression for the heat energy liberated by a hot body.
(ii) Some heat is provided to a body to raise its temperature by 25°C.
What will be the corresponding rise in temperature of the body as shown on the kelvin scale ?
(iii) What happens to the average kinetic energy of the molecules as ice melts at 0°C ?
(b) A piece of ice at 0°C is heated at a constant rate and its temperature recorded at regular intervals till steam is formed at 100°C. Draw a temperature – time graph to represent the change in phase. Label the different parts of your graph. [3]
(c) 40 g of ice at 0°C is used to bring down the temperature of a certain mass of water

at 60°C to 10°C. Find the mass of water used.
[Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$]
[Specific latent heat of fusion of ice = 336 × 10^3 J kg^{-1}] [4]

Answer:

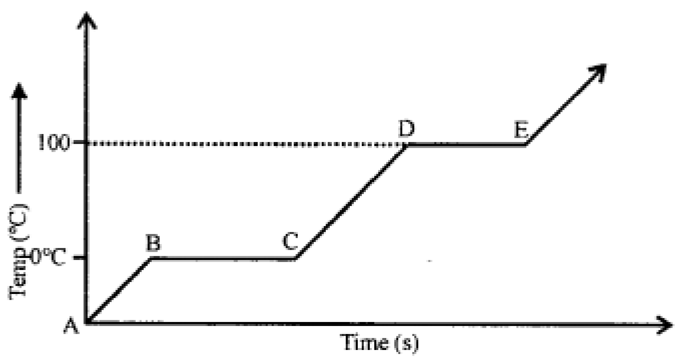
(a) (*i*) Heat liberated by a body = mass × sp. heat capacity × fall in temperature

$$= m \times C \times \theta_{fall}$$

(*ii*) The rise in temperature on kelvin scale will be 25 K.

(*iii*) The average kinetic energy of the molecules remains same.

(b)



(c) Heat absorbed by ice to form water at 0°C = 40 g × 336 Jg^{-1} = 13440 J.

Heat absorbed by water at 0° to attain temperature of 10°C

$= mC\theta_R$

$= 40 \text{ g} \times 4.2 \text{ Jg}^{-1}\,°\text{C}^{-1} \times 10°\text{C} = 1680 \text{ J}.$

∴ Total heat absorbed = (13440 + 1680) J = 15120 J

Heat given out by water at 60°C = $mC\theta_F$

$= m \times 4.2 \text{ Jg}^{-1}\,°\text{C}^{-1} \times 50°\text{C} = 210\, m \text{ J g}^{-1}$

Now, Heat given out = Heat absorbed

∴ $210\, m \text{ Jg}^{-1} = 15120 \text{ J}$

$$\therefore\ m = \frac{15120}{210} \text{ g} = 72 \text{ g}.$$

2013

Question 18.

(a) Define the term 'Heat capacity' and state its S.I. unit

(b) How much heat energy is released when 5 g of water at 20°C changes to ice at 0° C?
[Specific heat capacity of water = 4.2 Jg^{-1} $°C^{-1}$; Specific latent heat of fusion of ice – 336 g^{-1}]

Answer:

(a) **Heat capacity :** The amount of heat energy required to raise the temperature of a given mass of a substance through 1 K (or 1°C) is called its heat capacity.

S.I. unit of heat capacity is JK^{-1}.

(b) Heat energy released in cooling water to 0°C

$$= mc\theta_f = 5 \times 4.2 \times 20 = 420J$$

Heat energy released in freezing water = mL = 5 × 336
= 1680 J

∴ Total heat energy released = (1680 + 420) J = 2100 J

Question 19.

(a) (i) It is observed that the temperature of the surrounding starts falling when the ice in a frozen lake starts melting. Give a reason for the observation.

(ii) How is the heat capacity of the body related to its specific heat capacity ?

(b) (i) Why does a bottle of soft drink cool faster when surrounded by ice cubes than by ice cold water, both at 0° C ?

(ii) A certain amount of heat Q will warm 1 g of material X by 3°C and 1 g of material Y by 4°C. Which material has a higher specific heat capacity.

(c) A calorimeter of mass 50 g and specific heat capacity 0.42 J g^{-1} $°C^{-1}$ contains some mass of water at 20°C. A metal piece of mass 20 g at 100 °C is dropped into the calorimeter. After stirring, the final temperature of the mixture is found to be 22°C. Find the mass of water used in the calorimeter.

[specific heat capacity of the metal piece = 0.3 Jg^{-1} $°C^{-1}$]

[specific heat capacity of water = 4.2 Jg^{-1} $°C^{-1}$] (4)

Answer:

(a) (i) Every kilogram of ice at 0°C on melting to form water at 0°C needs 336×10^3 J of heat energy as its specific latent heat is 336×10^3J. This heat energy is supplied by the surrounding of the lake, which in turn results in the fall in temperature.

(ii) Specific heat capacity of a body = $\frac{\text{Heat capacity of the body}}{\text{Mass of the body}}$

(b) (i) Every gram of ice surrounding the soft drink extracts out 336 J of heat energy from it and the temperature of surrounding the soft drink remains at 0°C. However, in case of cold water, it will extract out only 4.2 J of heat energy per gram. Furthermore, the temperature of surrounding water starts rising. Thus, soft-drink bottle cools better in case of ice.

(ii) Material X has higher specific heat capacity compared to material Y.

It is because for the mass amount of heat its temperature rises less than Y.

(c) Let mass of water = 'm'

Final temp. $\theta = 22°C$

Heat lost by metal piece = $20 \times 0.3 \times (100 - 22) = 6 \times 78$
$= 468$ J

Heat gained by Calorimeter + water

$= [(50 \times 0.42) + (m \times 4.2)]\ (22 - 20)$

$= (21 + 4.2\ m)^2$

$\therefore\ 42 + 8.4\ m = 468$

$8.4\ m = 426$

$m = \frac{4260}{84} = 50.7g$

Question 20.
50 g of metal piece at 27 °C requires 2400 J of heat energy so as to attain a temperature of327 °C. Calculate the specific heat capacity of the metal.

Answer:

$$Q = mC\,\Delta t$$

$$= 2400 = 50\,C \times (327 - 27)$$

$$50 \times 300\,C = 2400$$

$$\therefore\; C = \frac{2400}{50 \times 300} = 0.16\ J\ g^{-1}\ {}^{\circ}C^{-1}$$

Question 21.
(a) Heat energy is supplied at a constant rate to 100g of ice at 0 °C. The ice is converted into water at 0 °C in 2 minutes. How much time will be required to raise the temperature of water from 0 °C to 20 °C ?
[Given : sp. heat capacity of water – 4.2 J g^{-1} $°C^{-1}$] sp. latent heat of ice = 336 J g^{-1}. [4]
(b) Specific heat capacity of substance A is 3.8 J g^{-1} K^{-1}] whereas the Specific heat capacity of substance B is 0.4 J g^{-1} K^{-1}.

1. Which of the two is a good conductor of heat?
2. How is one led to the above conclusion?
3. If substances A and B are liquids then which one would be more useful in car radiators?

Answer:

(a) $m = 100g$, $t = 2$ minutes $= 2 \times 60$ sec.

Heat energy taken by ice at 0°C to convert to water at 0°C.

$$Q = mL = 100 \times 336 = 33600\ J$$

$$\therefore \ P = \frac{Q}{t} = \frac{33600}{2 \times 60} = 280 \text{ J/S}$$

The heat energy required to convert water at 0°C to 20°C.

$Q = mC\,\Delta t$

$= 100 \times 4.2 \times 20 = 8400$ J

$Q = P \times t$

$8400 = 280 \times t$

$$t = \frac{8400}{280}$$

$t = 30$ sec. = 0.5 min.

(b) (*i*) Substance B is a good conductor of heat.

(*ii*) Because specific capacity of B is less then that of A.

(*iii*) Substance A is more useful in car radiator. As substance which has higher sp. heat capacity will take longer time to evaporate and will work as coolant for longer time.

2015

Question 22.

(a) Rishi is surprised when he sees water boiling at 115 °C in a container. Give reasons as to why water can boil at the above temperature. [2]

Answer:

The water boils at the higher temperature because of the reasons given below :

1. The water used by Rishi might be impure. The boiling of a liquid increases with the addition of impurities.
2. Rishi might have used a container which creates a pressure within. The boiling point of a liquid increases with an increase in pressure.

(b) Which property of water makes it an effective coolant?

Answer:

The high specific heat capacity of water makes it an effective coolant.

Question 23.
(a)

1. Water in lakes and ponds do not freeze at once in cold countries. Give a reason is support of your answer.
2. What is the principle of Calorimetry?
3. Name the law on which this principle is based.
4. State the effect of an increase of impurities on the melting point of ice.

Answer:

1. The specific latent heat of fusion of ice is sufficiently high (=336 J g^{-1}), and so to freeze water, a large quantity of heat has to be withdrawn. Hence, it freezes slowly and thus keeps the surroundings moderate.
2. **Principle of calorimetry :** If no heat energy is exchanged with the surroundings, i.e. if the system is fully insulated, then the heat energy lost by the hot body is equal to the heat energy gained by the cold body.
3. The principle of calorimetry is based on the law of conservation of energy.
4. Increasing the impurities causes the melting point of ice to decrease.

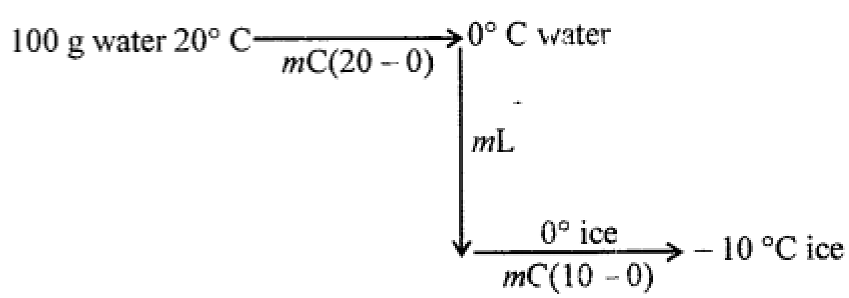
(b) A refrigerator converts 100 g of water at 20°C to ice at – 10°C in 35 minutes. Calculate the average rate of heat extraction in terms of watts.

Given: Specific heat capacity of ice = 2.1 J $g^{-1}.C^{-1}$

Specific heat capacity of water = 4.2 J $g^{-1}.C^{-1}$

Specific latent heat of fusion of ice = 336 J g^{-1} *[4]*

Answer:



Heat released by 100 g water 20 °C to change water 0°C

$= 100\ (4.2)\ (20 - 0) = 8400\ J$

Heat given out by 100 g water 0°C to change in ice 0°C = mL

$= 100 \times 336 = 33600\ J$

Heat given out by ice 0°C to change –10 °C ice

$mC\ (0 - (-10)] = 100 \times 2.1 \times 10 = 2100\ J$

Total heat given out = 8400 + 33600 + 2100 = 44100 J

$$\therefore \text{ Heat given out per sec} = \frac{441000}{(35\times60)s} = 2100$$

2016

Question 24.

(a) Calculate the mass of ice required to lower the tempera-ture of 300 g of water at 40°C to water 0°C.

[Specific latent heat of ice = 336 J, Specific heat capacity of water is 4.2 $Jg^{-1}\ °C^{-1}$]

(b) What do you understand by the following statements :

(i) The heat capacity of water is 60 JK^{-1}.

(ii) The specific heat capacity of lead is 130 $Jkg^{-1}\ K^{-1}$.

(c) State two factors on which heat absorbed by a body depends.

Answer:

(a) Let m be the mass of the ice to be added.

Heat energy required to melt to lower the temperature is = m × L

= m × 336

Heat energy imparted by the water in fall of its temperature from 40°C to 0°C = mass of the water × specific heat capacity × fall in temperature.

= 300 × 4.2 × 40°C

If there is no loss of heat,

m × 336 J/g = 300 g × 4.2 J/g°C × 40°C

$$\therefore\ m = \frac{300\times4.2\times40}{336}$$

$\therefore\ m = 150g$

(b) (i) Heat capacity is the amount of heat required to raise the temperature of a body by 1°C or 1 K. Thus, 60 JK^{-1} of energy is required to raise the temperature of the given body by 1 K.

(ii) Specific heat capacity is the amount of heat energy required to raise the temperature of unit mass of a substance through 1 °C or IK. Thus, 130 J Kg^{-1} K^{-1} of heat energy required to raise the temperature of unit mass of lead through 1 K.

(c) Heat absorbed by a body is directly proportional to :

1. its mass
2. Rise in temperature
3. Specific heat capacity

Question 25.

(a)

1. What is the principle of methods of mixtures ?
2. What is the other name given to it ?
3. Name the law on which this principle is based.

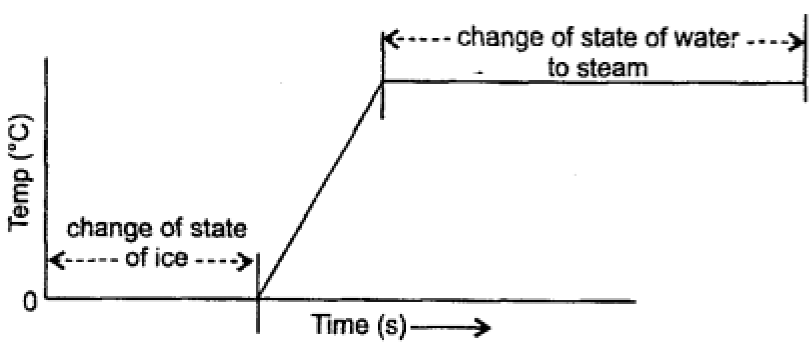
Answer:

1. The principle of method of mixture says that the heat lost by a hot body is equal to the heat gained by a cold body.
2. The other name given to the principle of mixture is the principle of calorimetry.
3. The principle of mixture is based on the law of conservation of energy.

(b) Some ice is heated at a constant rate and its temperature is recorded after every few seconds, till steam is formed at 100°C. Draw the temperature-time graph to represent the change. Label two phase changes in the graph.

Answer:

The figure for phase change is shown below :



(c) A copper vessel of mass 100 g contains 150 g of water at 50°C. How much ice is needed to cool it to 5°C ?

Given : Sp. heat capacity of copper = 0.4 J g^{-10} C^{-1}

Sp. heat capacity of water = 4.2 Jg^{-10} C^{-1}
Sp. latent heat of fusion of ice 336 Jg^{-10} C^{-1}

Answer:

Heat energy lost by the vessel and water contained in it in cooling the water from 50°C to 5°C is used in heating ice to melt it and then to raise its temperature from 0°C to 5°C.

Now, heat energy lost by the copper vessel is

$Q_C = m_C C_C \, \Delta t = 100 \times 0.4 \times (50 - 5) = 100 \times 0.4 \times 45$

$Q_C = 1800$ J

Similarly, heat energy lost by water is = 150 × 4.2 × 45

$Q_W = m_W C_W \Delta t = 150 \times 4.2 \times (50 - 5)$

$Q_W = 28350$ J

Hence, the total heat energy lost is

$Q_L = 1800 + 28350 = 30150$ J

Let m g of ice be used to cool water. So, heat gained by ice is

$Q_I = mL_{ice} + mc_W \Delta t$

$Q_I = 336\,m + m \times 4.2 \times 5 = 336m + 21m = 357$ m J

Therefore, from the principle of calorimetry, the mass of ice is

$Q_L = Q_I$

$\therefore$ $357m = 30150$

$$\therefore \; m = \frac{30150}{357} = 84.45 \text{ g}$$