Chapter 5. Heat Calorimetry

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Solution 1
Thermal energy is energy that is powered by a heat source. For e.g.: an electric heater generates thermal energy that can be used to warm a cold room in the winter.

Solution 2
Yes, heat is a form of energy.

Solution 3
Temperature is a physical property that quantitatively expresses the common notions of hot and cold. It is the degree of hotness or coldness of a body or environment.

Solution 4

Heat	Temperature
1. It is a form of energy in motion.	1. It is the degree of hotness or coldness of a body.
2. It is the cause of temperature. It is the heat that causes a change in the temperature of a body.	2. It is the effect of heat.
3. It does not determine the direction of flow of heat.	3. It determines the direction of flow of heat. It always flows from a body at a higher temperature to a body at a lower temperature.
4. It is measured in joule or calorie.	4. It is measured on the Celsius (°C), Fahrenheit (°F) or the Kelvin (K) scale.

Solution 5
The SI unit of heat energy is joule (J).

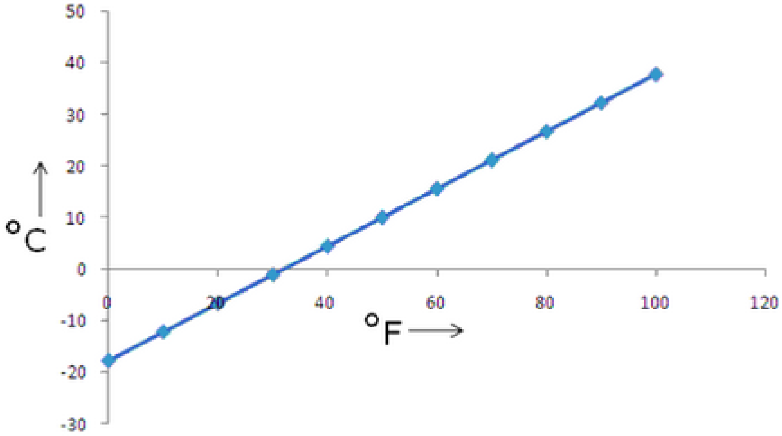
Solution 6
1 joule is the amount of heat required to raise the temperature of 1 kg of a substance, that has specific heat capacity 1J/kgK, through $1^{o}C$.

Solution 7
1 J = 4.2 cal. So, 1 joule is bigger than 1 calorie.

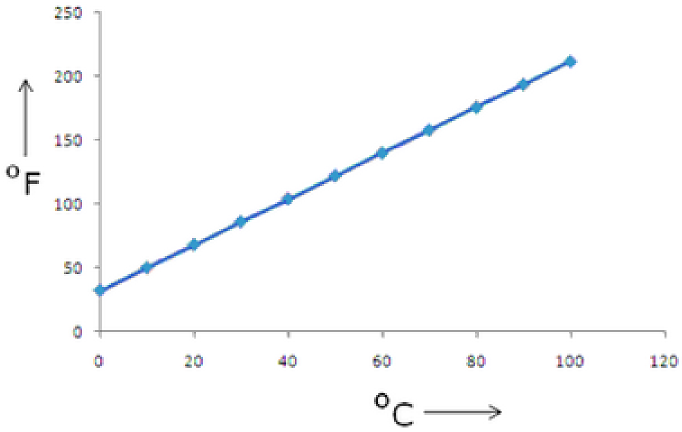
Solution 8
A thermometer is used to measure temperature.

Solution 9

(i)



(ii)



Solution 10

Temperature is the physical quantity that measures the degree of hotness.

Solution 11

Its energy increases on heating.

Solution 12

Gas molecules have very weak or no bonds at all and the spaces between gas molecules are very large. So, the molecules of a gas move about freely.

Solution 13

Two scales for measuring temperature arei. Celsius scaleii. Fahrenheit scale

Solution 14

'Liquid-in-glass' kind of thermometer is commonly used.

Solution 15

Doctor's thermometer is also called Clinical thermometer.

Solution 16

Melting point of ice:

On Celsius scale: $0^{o}C$

On Fahrenheit scale: $F = \frac{9}{5}C + 32$

$= 0 + 32 = 32^{o}F$

Solution 17

Celsius scale and Fahrenheit scale are two commonly used scales of temperature because the former is based on the freezing point of water as $0^{o}C$ and boiling point of water as $100^{o}C$. The same points on the Fahrenheit scale are $32^{o}F$ and $212^{o}F$.

Solution 18

The normal body temperature of a healthy person is 37oC.

Solution 19

$C = \frac{5}{9}(F - 32)$

Solution 20

Lower fixed point = 32oF Upper fixed point = 212oF

Solution 21

In Celsius scale, melting point of ice and boiling point of water are referred as "lower fixed point" and "upper fixed point" respectively. The temperature difference between the reference points is divided into 100 divisions and each division is called "one degree Celsius" (1oC). Thus, the melting point of ice is taken as 0oC and the boiling point as 100oC.

Solution 22

$F = \frac{9}{5}C + 32$

$= \frac{9}{5} \times 20 + 32 = 68^{o}F$

$\Rightarrow 20^{o}C \equiv 68^{o}F$

$68^{o}F > 20^{o}F$

or, $20^{o}C > 20^{o}F$

$20^{o}C$ represents a greater temperature rise.

Solution 23

$$F = \frac{9}{5}C + 32$$
$$= \frac{9}{5} \times (-40) + 32 = -40^{o}F$$
$$\Rightarrow -40^{o}C \equiv -40^{o}F$$

Solution 24

$$C = \frac{5}{9}(F - 32)$$
$$= \frac{5}{9}(212 - 32)$$
$$= 100^{o}C$$
$$\Rightarrow 212^{o}F \equiv 100^{o}C$$

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Solution 25

(a) $C = (K - 273)$
$$= (0 - 273)$$
$$= -273^{o}C$$
$$\Rightarrow 0\,K \equiv -273^{o}C$$

(b) $F = \frac{9}{5}C + 32$
$$= \frac{9}{5}(-273) + 32$$
$$= -459.4^{o}F$$
$$\Rightarrow 0\,K \equiv -459.4^{o}F$$

Solution 26

Absolute zero is the temperature at which volume or pressure of an ideal gas becomes nil. It is 0 degrees on the Kelvin scale, which translates to -273oC (or -459.4oF).

Solution 27

$$K = (C + 273)$$
$$= (20 + 273)$$
$$= 293\,K$$
$$\Rightarrow 20\,^{o}C \equiv 293K$$

The corresponding temperature of the body on the Kelvin scale is 293 K.

Solution 28

$$F = \frac{9}{5}C + 32$$
$$= \frac{9}{5} \times 37 + 32$$
$$= 98.6^{\circ}F$$
$$37^{\circ}C \equiv 98.6^{\circ}F$$

Solution 29

SI unit of:i. Amount of heat ? jouleii. Heat Capacity ? joule per Kelviniii. Specific Heat Capacity ? joule per kilogram per Kelvin.

Solution 30

30. Let C be the specific heat capacity of water.

Let final temperature of the mixture be θ°C.

Heat energy lost by hot water = Heat energy gained by cold water

$2 \times C \times (80-\theta) = 8 \times C \times (\theta-25)$

or, $2(80-\theta) = 8(\theta-25)$

or, $80-\theta = 4\theta-100$

or, $5\theta = 180$

$\theta = 36$

So, the final temperature of water will be 36°C.

Solution 31

Let m be the mass of liquid A.

Assuming that there is no heat loss,

Heat energy given by A = Heat energy taken by B

or, $m \times 0.84 \times (40-32) = 100 \times 2.1 \times (32-20)$

or, $m = \frac{100 \times 2.1 \times 12}{0.84 \times 8} = 375\text{ g}$

Solution 32

Specific heat capacity of water is 4200 Jkg-1K-1.

Solution 33

This means that 4200 J of heat is required to raise the temperature of 1kg of water by 1K.

Solution 34

(i) In cooling ? Water is used in the cooling systems of automobiles and other engines. (ii) As heat reservoir – In cold countries, water is used as a reservoir for wine and juice to avoid their freezing. The reason is that water can provide more heat to the bottles due to its high specific heat capacity. Hence, they do not cool down further to freeze.

Solution 35

A calorimeter is a device used to measure the quantity of heat transferred to or from an object. It is made of copper because:i. Copper is a good conductor of heat so it attains the temperature of its contents in a very short time.ii. It has low specific heat (390 Jkg-1K-1). Therefore, it will take only a very little part of the heat energy given out in the experiment.

Solution 36

(i) Given: Heat Capacity, mC = 966 J/°C

Heat energy required, Q = m x C x change in temperature

= 966 x 15 = 14490 J

(ii) Q = m x C x T

$$\text{Specific heat capacity, } C = \frac{Q}{m\ \Delta T}$$

$$= \frac{14490}{2 \times 15} = 483\,\text{J kg}^{-1}\,{}^{\circ}\text{C}^{-1}$$

Solution 37

Farmers fill their fields with water on a cold winter night to protect the crops from frost. In the absence of water, if on a cold night the temperature of the surroundings fall below 00C, then the veins of the plants shall freeze. Due to anomalous expansion of water, ice shall occupy more volume than water. As a result of this expansion, veins shall burst and crops shall be destroyed. But water sprinkled on the crops shall not allow the temperature of the veins to fall below 00C.

Solution 38

Let the initial temperature of cold water be t and the final temperature of the mixture be θ.

Rise in temperature of cold water, (θ-t) =15°C.

Heat gained by cold water = Heat given out by hot water

or, 600 x C x 15 = 300 x C x (50-θ)

$$\text{or, } \theta = 50 - \frac{600 \times 15}{300} = 20^{\circ}\text{C}$$

θ-t =15°C

t = 20 -15 = 5°C

Solution 39

Heat capacity of a body is the quantity of heat required to raise its temperature by 1oC. It depends upon the mass and the nature of the body.Units: J/oC or calorie/oC

Solution 40

Specific heat capacity is the amount of heat required to raise the temperature of 1 kg of the substance by 1oC. Units: j/kgK or calorie/g oC

Solution 41

Change in temperature of lemon squash = 30-5 = 25°C

Heat lost by lemon squash, $Q = m \times C \times \Delta T$

$Q = 0.5 \times 4200 \times 25 = 52500$

Rate at which heat is removed is 30 Js^{-1}

$$\frac{Q}{t} = 30Js^{-1}$$
$$\frac{52500\,J}{t} = 30Js^{-1}$$
$$t = \frac{52500\,J}{30Js^{-1}}$$
$$= 1750\,sec = 29.2\,min$$

Solution 42

The given solid is weighed and then heated by placing it in a beaker containing boiling water. The steady temperature of the solid is noted. A calorimeter with stirrer is weighed. The calorimeter is then filled with water and weighed again. Thus, the mass of water used is calculated. Initial temperature of water is noted. Solid is then transferred into calorimeter. The contents are stirred and final temperature is noted.

Mass of calorimeter with stirrer = m_1 g
Specific heat capacity of calorimeter = C_1 (given)
Mass of water taken = m_2 g
Specific heat capacity of water = C_2 (given)
Mass of solid = m_3 g
Specific heat capacity of the solid (to be determined) = C_3
Initial temperature of the solid = x°C
Initial temperature of water +Calorimeter = y°C
Final temperature of the mixture = z°C
Heat lost by the solid = Heat gained by the calorimeter and water

$$m_3C_3(x-z) = m_1C_1(z-y) + m_2C_2(z-y)$$
$$= (m_1C_1 + m_2C_2)(z-y)$$
$$C_3 = \frac{(m_1C_1 + m_2C_2)(z-y)}{m_3(x-z)}$$

i.e. the specific heat capacity of the solid is calculated.

Solution 43

The specific heat capacity of water (4200 J Kg-1 K-1) is about five times as that of sand. Due to which water takes long time to get heated up and equally long time to get cooled. Thus, large temperature difference between the land and the sea causes formation of land and sea breezes.

Solution 44

Principle of Calorimetry: When a hot body is mixed or kept in contact with a cold body, there is a transfer of heat from hot body to cold body such thatTotal heat gained by colder body = Total heat lost by the hot body,if there is no loss of heat to the surroundings.

Solution 45

Water is used as an effective coolant since it has a high value of specific heat capacity (4200 J kg-1K-1).

Chaper 5. Heat Change Of State

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Solution 1
Specific heat is the amount of heat required to raise the temperature of 1 kg of the substance through $1^{o}C$.It is not same as heat capacity.

Solution 2
SI unit of specific heat is J $kg^{-1}K^{-1}$.

Solution 3
Specific Heat.

Solution 4
Principle of Calorimetry:When a hot body is mixed or kept in contact with a cold body, there is a transfer of heat from hot body to cold body such thatTotal heat gained by colder body = Total heat lost by the hot body,if there is no loss of heat to the surroundings.

Solution 5
Thermal capacity of a body is the quantity of heat required to raise its temperature by $1^{o}C$.

Solution 6
The product of mass and specific heat is known as heat capacity.

Solution 7
No, specific heat does not depend on temperature. It is constant for a substance.

Solution 8
Copper road becomes warmer than an aluminium rod of the same mass because copper has lower heat capacity than aluminium.

Solution 9

The amount of heat required to raise the temperature of a body by $1^{\circ}C$ is called Heat capacity.

Solution 10

Heat capacity has units $J/^{\circ}C$.

Solution 11

Specific heat of water is 4200 J $kg^{-1}K^{-1}$

Solution 12

The substances like water which have high heat capacity warm up more slowly than substances like iron which have low heat capacity.

Solution 13

Latent heat is the quantity of heat absorbed or released by a substance undergoing a change of state, such as ice changing to water or water to steam, at constant temperature.

Solution 14

SI unit of latent heat is J/kg.

Solution 15

It means that 1 g of ice at $0^{\circ}C$ absorbs 336 J of heat energy to convert into water at $0^{\circ}C$.

Solution 16

When a liquid is solidified, it may either expand or contract. As water freezes to form ice it expands and increases in volume by 10 per cent.

Solution 17

The melting point of ice decreases on addition of impurities in it.

Solution 18

The melting point of substances which contract on melting (like ice) decreases by the increase in pressure.

Solution 19

Regelation is the phenomenon of melting under pressure and freezing again when the pressure is reduced.

Solution 20

The amount of heat required to change a liquid at its boiling point to vapour at the same temperature is called its latent heat of vaporization.

Solution 21

The boiling point of a liquid increases with the increase in pressure and decreases with the decrease in pressure.

Solution 22

The latent heat of fusion of ice is the amount of heat energy required to change ice at $0^{o}C$ into water at the same temperature.

Solution 23

The latent heat of vaporization of steam is the amount of heat energy required to change water at $100^{o}C$ to steam at the same temperature.

Solution 24

The physical quantity which does not change during change of state is temperature of the body.

Solution 25

1 kg of ice at $0^{o}C$ absorbs 336000 J of heat energy to convert into water at $0^{o}C$.

Therefore,1 kg of water at $0^{o}C$ has 336000 J heat energy more than 1 kg ice at $0^{o}C$. So, ice appears colder than water.

Solution 26

Steam causes more severe burns than water at $100^{o}C$ because every gram of steam gives out 2260 J of heat energy while condensing. This much quantity of heat is additional to the heat contained in 1 g of boiling water.

Solution 27

The unit of heat capacity in CGS system is calorie/^{o}C.

Solution 28

1 cal g-1 oC-1 = 239 J kg-1 oC-1

Solution 29

This means that 0.2 cal g-1 oC-1 of heat is required to raise the temperature of 1g of the body by 1oC.

Solution 30

m = 100 gC = 0.04 cal g^{-1} ^{o}C^{-1}Heat capacity = m x C = 4 cal ^{o}C^{-1}

Solution 31

Heat capacity = mass x specific heat capacity

Solution 32

No, specific heat does not depend on mass of a substance. It is constant for a substance.

Solution 33

Specific heat of water in SI units is 4200 J kg-1 K-1.Solution 34
Ammonia has the maximum value of specific heat.

Solution 35

Heat gained or lost by a substance depends on the mass of the substance and the nature of the substance.

Solution 36

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. The sun's heat warms the surface water a lot more than the deep ocean water, and this temperature difference creates heat energy. Thus, oceans are known as storehouse of heat energy. Just a small portion of the heat trapped in the ocean could power the world.

Solution 37

Water has a high specific heat capacity. So, water extracts much heat without much rise in temperature. By allowing water to flow in radiator pipes of the vehicles, heat energy form such parts is removed. Hence, it is used as a cooling agent in the radiators of automobiles.

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Solution 38

A change of state is a change in the object from a solid to liquid or from a solid to gas or from liquid to solid. Ice changing into water is an example of a change in state.

Solution 39

Heat energy is absorbed during melting of ice.

Solution 40

Heat energy is released during freezing of ice.

Solution 41

Temperature remains constant when ice melts at 0oC.

Solution 42

The molecules in a solid are held by strong intermolecular bonds. For the solid to melt, these bonds have to be broken. Since energy is needed to break the intermolecular bonds, the thermal energy supplied at the melting point is used to do the work to break the intermolecular bonds between the molecules of the solid. Once the intermolecular bonds are broken, the molecules can then move out of their fixed positions. Hence it can then be said that the solid has melted, which is the change of state from solid to liquid. This explains why temperature remains constant during the melting phases.

Solution 43

Whenever a substance goes through a phase change (like boiling), the energy goes into breaking up the interactions between molecules, and so the temperature stays constant until all the interactions are broken. Once whole of the substance has boiled, then any added heat will act to raise them temperature again.

Solution 44

Atmosphere is usually warm during snowfall because each kilogram of ice on melting absorbs 336000 J of heat from atmosphere.

Solution 45

Latent heat of fusion of ice, L=336 J/g Mass of ice, m=2gAmount of heat required convert 2g of ice at 0oC into water at 0oC = m x L = 2 x 336 = 672 J

Solution 46

Latent heat of vapourisation of water, L=540 cal/gMass of water, m=100gAmount of heat required convert 100g of water at 100oC into steam at 100oC = m x L = 100 x 540 = 54 kJ

Solution 47

Ice melts under pressure. So, when the steel blades of the skates pressed on the ice, the ice melts. The water formed makes the skates slide easily over the ice, reducing friction. So, when we are skating on ice, we are skating on a thin film of water, which acts like lubricating oil. Nothing such happens in case of glass.

Solution 48

Bottled drinks are cooled more effectively when surrounded by lumps of ice than by cold water at 0oC because ice appears colder than water at 0oC.

Solution 49

Parts AB and CD correspond to the substance existing in two states.

Solution 50

(e) The first time when temperature is constant represents change of state from solid to liquid and the second time temperature is constant represents change of state from liquid to vapour.

Solution 51

(a)Boiling point of substance is 150oC (because the part BC represents condensation where the vapour changes into liquid without the change in temperature.
(b)DE represents freezing of the substance where the liquid changes into solid at a constant temperature of 100oC.
(c)Melting point is the temperature of the region DE where liquid changes into solid i.e., 100oC.

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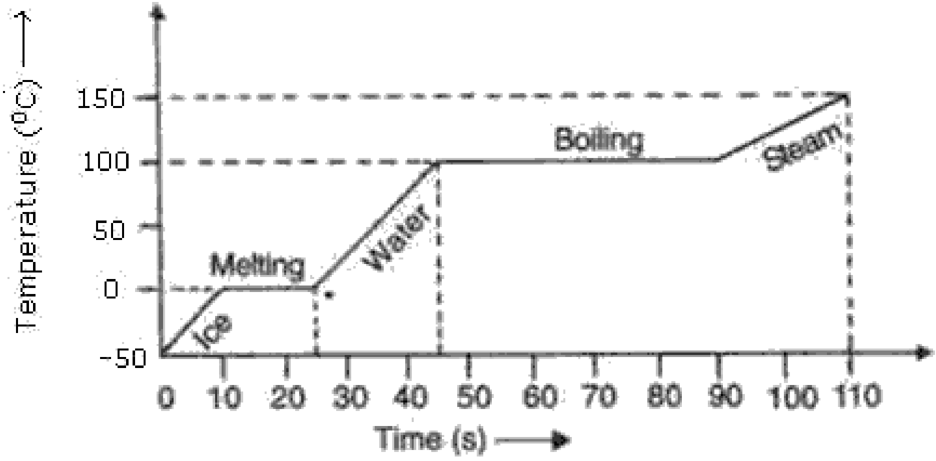
Solution 52



Solution 53

i.AB represents the change of state from solid to liquid i.e., AB represents melting of ice at 0oC.ii.CD represents the change of state from liquid to vapour i.e., CD represents boiling of water at 100oC.iii.The ice initially is in solid state at -10oC. On heating, its temperature rises to 0oC. It then takes some heat at 0oC to melt in water at 0oC which is its latent heat.

Chapter 5. Heat

Solution 1

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(a)J/kg ^oC(b)2000 / (4 x 3) J/kg ^oC(c)AB and CD(d)Latent heat is emitted(e)The first time when temperature is constant represents change of state from solid to liquid and the second time temperature is constant represents change of state from liquid to vapour.

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Solution 2

(a)Heat capacity of a body is the quantity of heat required to raise its temperature by 1^oC. It depends upon the mass and the nature of the body.Units: J/^oC or calorie/^oC(b)Change in temperature = (50-30) = 20^oC Amount of heat required, Q = m x C x ?T = 0.5 x 4200 x 20 = 42000 J

Solution 3

(a)This means that 390 J of heat is required to raise the temperature of 1kg of copper by 1^oC.(b)Change in temperature = (100-30) = 70^oC = 70 KAmount of heat given out, Q = m x C x T = 0.6 x 900 x 70 = 37800 J

Solution 4

a) Principle of Calorimeter:

When a hot body is mixed or kept in contact with a cold body, there is a transfer of heat from hot body to cold body such that

Total heat gained by colder body = Total heat lost by the hot body,

if there is no loss of heat to the surroundings.

One calorie is the quantity of heat required to raise the temperature of 1 g of water by 1°C.

1 calorie = 4.186 joule

One kilocalorie is the quantity of heat required to raise the temperature of 1 kg of water by 1°C.

1 kcal = 4.186×10^3 joule

b) Let the final temperature of the mixture be θ°C.

Heat lost by hot water = Heat gained by cold water

$0.4 \times C \times (80 - \theta) = 1 \times C \times (\theta - 20)$

or, $32 - 0.4\theta = \theta - 20$

or, $\theta = 37.14°C$

c) m = 360 g = 0.36 kg

Change in temperature, ΔT = (100-40)°C = 60°C = 60 K

Amount of heat required, $Q = m \times C \times \Delta T$

$= 0.36 \times 4200 \times 60 = 90720$ J

Time taken = 5 min = 300 sec

Rate of heat supplied $= \frac{Q}{t} = \frac{90720}{300} = 302.4$ J/s

Solution 5

Let the specific heat of the solid be C.

Heat lost by solid = Heat gained by water

0.08 x C x (80-30) = 0.4 x 4200 x (30-10)

$$\text{or}, C = \frac{0.4 \times 4200 \times 20}{0.08 \times 50} = 8400\,\text{J}\,\text{kg}^{-1}\text{K}^{-1}$$

Solution 6

Let the mass of water be m.

Heat lost by mercury = Heat gained by water

0.2 x 140 x (100-25) = m x 4200 x (25-20)

$$\text{or}, m = \frac{0.2 \times 140 \times 75}{4200 \times 5} = 0.1\,\text{kg} = 100\,\text{g}$$

Solution 7

Specific heat of copper = 390 J $kg^{-1}K^{-1}$

Let the initial temperature of copper be t.

Heat lost by copper = Heat gained by water

1 x 390 x (t-40) = 2 x 4200 x (40-15)

$$\text{or}, t - 40 = \frac{2 \times 4200 \times 25}{390} = 538.46$$

$$\text{or}, t = 578.46°\text{C}$$

Solution 8

Heat lost by metal = Heat gained by calorimeter and oil

$m_3C_3(x-z) = m_1C_1(z-y) + m_2C_2(z-y)$

where, m_1C_1=32 J/°C

m_2=100 g

y=30 °C

m_3=80 g

C_3=0.12 J/g°C

x=90°C

z=35°C

$$\Rightarrow 80 \times 0.12 \times (90-35) = 32 \times (35-30) + 100 \times C_2 \times (35-30)$$

$$\Rightarrow 528 = 160 + 500C_2$$

$$\Rightarrow C_2 = 0.736\,\text{J}/\text{g}°\text{C}$$

Solution 9

a)

i. Latent heat is the amount of hidden heat supplied to or extracted from the substance to change its state without any change of temperature.

ii. Latent heat of fusion of ice is the amount heat absorbed by ice at 0°C to convert into water at 0°C.

b) Amount of heat required to convert ice from -10°C to 0 °C = m x C x θ

= 40 x 2.1 x 10 = 840 J

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

= 40 x 330 = 13200 J

Amount of heat required to convert water from 0°C to 20 °C = = 40 x 4.2 x 20 = 3360 J

Total heat required during the process = 17400 J

Solution 10

a)

i. Specific latent heat is the amount of heat required to change the state of unit mass of a substance without change in temperature.

ii. Specific latent heat of fusion is the amount of heat required to change unit mass of a solid at its melting point into liquid at the same temperature.

b) It means that 1 kg of water at 100°C absorbs 2268 J of heat energy to convert into steam at 100°C.

c) Amount of heat given out while converting water from 50°C to 0 °C = m x C x θ

= 100 x 4.2 x 50 = 21000 J

Amount of heat given out while converting water at 0°C to ice at 0 °C = mL

= 100 x 330 = 33000 J

Amount of heat given out while converting ice from 0°C to -50 °C = = 100 x 2.1 x 5 = 10500 J

Total heat required during the process = 64500 J

Solution 11

Heat given out by steam = Heat taken by ice

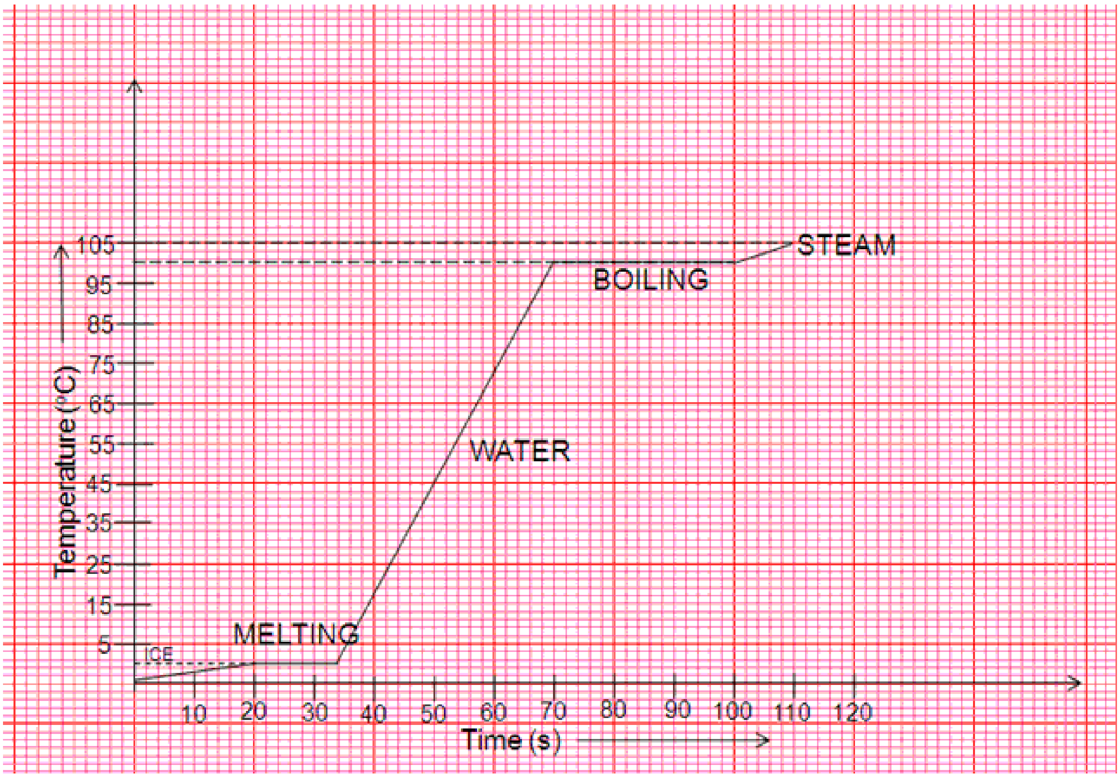
$m_1L_v + m_1 \times C \times \Delta T = m_2L_f$

$(1000 \times 2268) + (1000 \times 4.2 \times 100) = m_2 \times 336$

$$m_2 = \frac{2688000}{336} = 8000\ g$$

8000 g of ice melts.

Solution 12



Solution 13

Let the final temperature of the mixture be t.

Heat gained by ice = Heat lost by water

$m_1L + m_1 \times C \times (t-0) = m_2 \times C \times (30-t)$

$(200 \times 336) + (200 \times 4.2 \times t) = 2000 \times 4.2 \times (30-t)$

$336 + 4.2t = 42(30-t)$

$t = 20°C$

Solution 14

(a) Melting point is 80°C

(b) Boiling point is 200°C.

(c) In 5 min, change in temperature = 50°C

$\frac{Q}{t} = 100\ J/s$

Heat supplied in 5 min, Q = 100 × 30 = 3000 J

$Q = mC_s\Delta T$

$C_s = \frac{Q}{m\Delta T} = \frac{3000}{100\times 50} = 0.6\ J/g\,°C$

(d) From 5 min to 18 min, heat supplied, Q=780× 100= 78000 J

Q=mL

78000= 100× L

L=780 J/g

(e) From 18 min to 40 min, change in temperature = 120°C

$\frac{Q}{t} = 100 J/s$

Heat supplied in 22 min, Q = 100 × 1320 = 132000 J

$Q = mC_L\Delta T$

$C_L = \frac{Q}{m\Delta T} = \frac{132000}{100\times 120} = 11 J/g\,°C$

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Solution 15

Let the final temperature of the mixture be t.

Heat lost by lead = Heat gained by water

$m_1L + m_1 \times C_L \times (327\text{-}t) = m_2 \times C_w \times (t\text{-}20)$

1 x 27000 + 1 x 130 x (327-t) = 1 x 4200 x (t-20)

27000 + 42510 -130t = 4200t – 84000

153510 = 4330t

t=35.45°C

So, the final temperature of water is 35.45°C.

Solution 16

Let the mass of steam be m.

Heat lost by (steam at 100°C to condense into water at 100°C + 100°C water to convert into 40°C water = Heat gained by water to raise the temperature to 40 °C

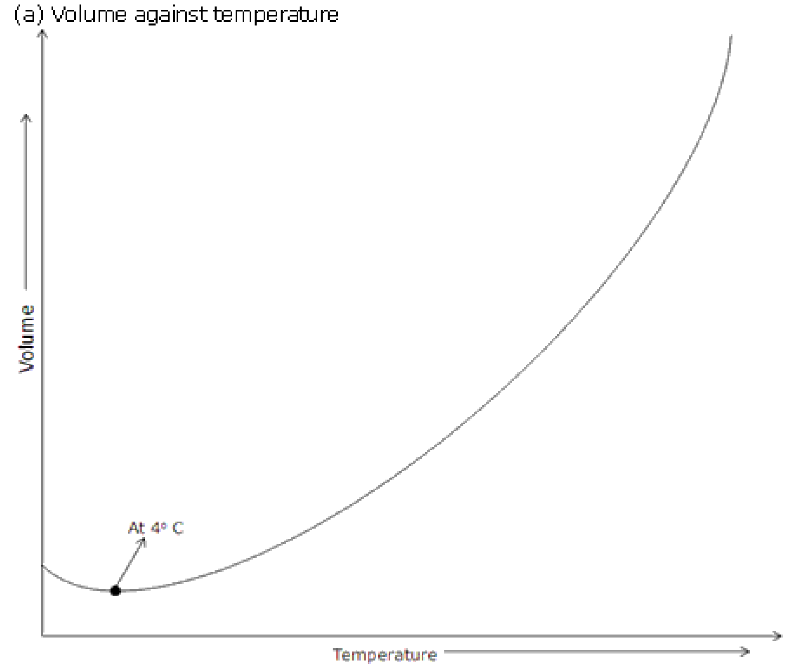
m x 2268 + m x 4.2 x (100-40) = 120 x 4.2 x (40-20)

m(2268 + 252) = 10080

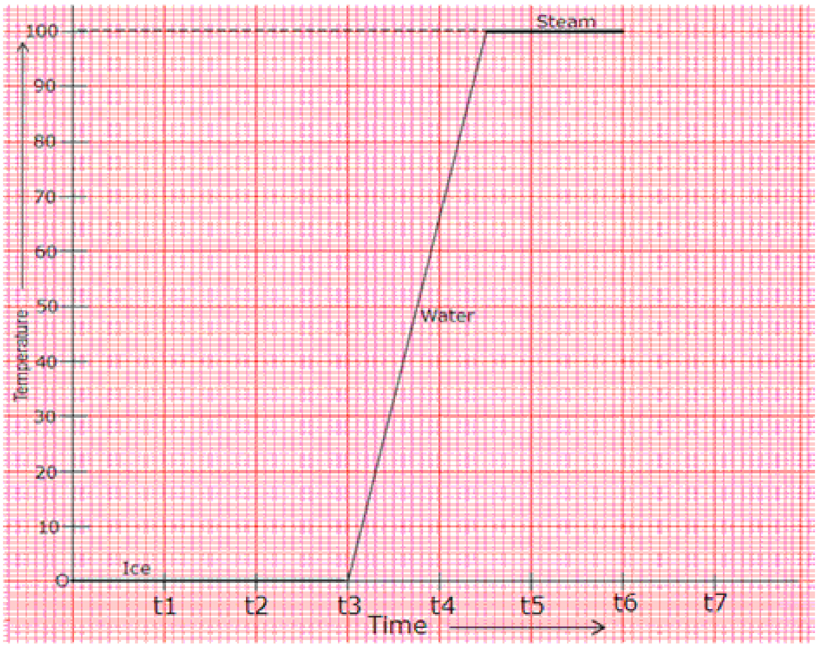
m = 4 g

Solution 17

(a) Volume against temperature



(b) Temperature against time



Solution 18

(a) Ice melts under pressure. So, when the steel blades of the skates pressed on the ice, the ice melts. The water formed makes the skates slide easily over the ice, reducing friction. So, when we are skating on ice, we are skating on a thin film of water, which acts like lubricating oil. Nothing such happens in case of glass.

(b) Sand improves the friction between car tyres and the road, so cars don't skid on icy surfaces. Salt is spread so as to decrease the melting point of ice. Ice on the roads melt, making the roads less slippery.

(c) Steam burn is worse than a hot water burn because 1 g of steam gives out 540 calories of additional heat.

(d) Lumps of ice cool better than cold water because each gram of ice requires additional 80 calories of heat to get converted into water. Hence, cooling capacity of lumps of ice is more than cold water.

Solution 19

(a) Mass of water in the bucket = Density x Volume

= 1000 kg/m³ x 0.01 m³ = 10 kg

Let the mass of water that came out from the tap be m.

Heat lost by hot water = Heat gained by cold water

10 x 4200 x (80-50) = m x 4200 x (50-25)

300 = 25m

m=12 kg

12 kg of water came out of tap in 20 sec.

So, the rate at which cold water came out of the tap is $\frac{12}{20} = 0.6 kg/s = 600 g/s$

(b) In the above calculation we assumed that there is no loss of heat to the surroundings

Solution 20

Q = 650 J

m = 0.25 kg

ΔT = (35-15) = 20°C

Q = m x C x T

$$C = \frac{Q}{m \times \Delta T} = \frac{650}{0.25 \times 20} = 130 J/kg^{\circ}C$$

Solution 21

Mass of calorimeter, m_1 = 57.5 g

Specific heat capacity of calorimeter, C_1 = 0.4 J/g°C

Mass of water taken, m_2 = 60 g

Specific heat capacity of water, C_2 = 4.2 J/g°C

Mass of iron nails, m_3 = 55 g

Specific heat capacity of iron = C_3

Initial temperature of iron nails, x = 100°C

Initial temperature of calorimeter + water, y = 12°C

Final temperature of the mixture, z = 20°C

Heat lost by iron nails = Heat gained by calorimeter and water

$m_3C_3(x-z) = m_1C_1(z-y) + m_2C_2(z-y)$

$$C_3 = \frac{(m_1C_1 + m_2C_2)(z-y)}{m_3(x-z)}$$

$$= \frac{(57.5 \times 0.4 + 60 \times 4.2)(20-12)}{55 \times (100-20)} = 0.5 J/g^{\circ}C$$

Solution 22

Let the final temperature of the mixture be t.

Heat lost by lead = Heat gained by water

$m_1L + m_1 \times C_L \times (327-t) = m_2 \times C_w \times (t-20)$

1 x 27000 + 1 x 130 x (327-t) = 1 x 4200 x (t-20)

27000 + 42510 -130t = 4200t – 84000

153510 = 4330t

t=35.45°C

So, the final temperature of water is 35.45°C.

Solution 23

For water:
m = 120 g = 0.12 kg
ΔT = 10 K
C = 4200 J/kgK
Q = m x C x ΔT
= 0.12 x 4200 x 10
=5040 J
For oil:
Q = 5040 J
m = 60 g = 0.06 kg
ΔT = 40 K

$$C = \frac{Q}{m \times \Delta T}$$

$$= \frac{5040}{0.06 \times 40} = 2100\ J/kgK$$

Solution 24

Mass of lead block, m = 250 g
Change in temperature,ΔT = 327°C – 27°C = 300°C =300 K
C = 0.13 J/gK
Amount of heat required to raise the temperature to 327°C,
Q = m x C x ΔT
= 250 x 0.13 x 300 = 9750 J

Amount of heat required to completely melt the block upto its melting point
Q = m x L
= 250 x 26 = 6500 J

Solution 25

Amount of heat required to convert ice into steam is as given below:

(ice from -10°C to 0°C) = 0.1 x 2100 x 10 = 2100 J
(ice at 0°C to water at 0°C) = 0.1 x 336000 = 33600 J
(water from 0°C to 100°C) = 0.1 x 4200 x 100 = 42000 J
(water at 100°C to steam at 100°C) = 0.1 x 2260000 = 226000 J

Total amount of heat required = 2100 + 33600 + 42000 + 226000 = 30370 J

Solution 26

Heat given out during the following three stages:

1. Cooling water from 20°C to 0°C = $mC_1\theta_1$ = 100 x 4.2 x 20 = 8400 J
2. Water at 0°C freezes to form ice at 0°C = m x L = 100 x 336 = 33600 J
3. Cooling of ice at 0°C to -10°C =$mC_2\theta_2$ = 100 x 2.1 x 10 = 2100 J

Total quantity of heat given out = 44100 J

$$\text{Rate of heat extraction in watts} = \frac{44100}{73.5 \times 60} = 10\,W$$

Solution 27

Let the specific latent heat of metal is L.
Mass of molten metal = 150 g = 150 x 10^{-3} kg
Q = m x L
75000 = 150 x 10^{-3} x L

$$L = \frac{75000}{150 \times 10^{-3}} = 5 \times 10^5\ J/kg$$

Additional heat given out by metal in cooling upto -50°C
Q = m x C x ΔT
= 150 x 10^{-3} x 200 x 850 = 25500 J

Solution 28

Let the latent heat of fusion of ice be L.
Heat gained by ice at -16°C to convert to 0°C = Heat given out by 4 g of water to at 0°C to freeze into ice at 0°C
(40 x 2.1 x -16) = 4 x L
1344 = 4L
L = 336 J/g

Solution 29

$$\frac{Q}{t} = 7000\,J/min$$
$$m = 5kg$$
$$\Delta T = 47 - 22 = 25°\,C$$
$$C = 4200\,J/kg°C$$
$$Q = m \times C \times T$$
$$= 5 \times 4200 \times 25 = 525000\,J$$
$$\text{Time taken} = \frac{525000}{7000} = 75\,min$$

Solution 30

Heat gained by ice at 0°C to convert to water at 0°C = Heat lost by water from 34°C to 0°C
17 x L = 40 x 4.25 x 34
17 L = 5780
L = 340 J/g

Solution 31

Heat gained by ice at 0°C to convert to water at 0°C = Heat lost by water to change the temperature from 35°C to 0°C
m x 336000 = 0.9 x 4200 x 35
m x 336000 = 132300
m = 0.39 kg

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Solution 32

Steam at 100^{0}C will produce more severe burns because every gram of steam gives out 2260 J of heat energy while condensing. This much amount of heat is additional to the heat contained in one gram of boiling water.

Solution 33

Ice cream appears colder to mouth than water at 0^{0}C because it can extract approximately 80 cal/g (latent heat of fusion of ice)more heat from as compared to water at 0 ^{0}C.

Solution 34

Although both ice cubes and iced water are at 0oC but ice cubes cool more quickly because each gram of ice requires additional 80 calories of heat to get converted into water at the same temperature, i.e., at 0^{0}C. Hence, the cooling capacity of ice cubes is more than that of iced water.

Solution 35

Q = 10125 J
m = 4.5 g
Q = m x L
10125 = 4.5 x L

$$L = \frac{10125}{4.5} = 2250\,J/g$$

Specific latent heat of steam is 2250 J/g.

Solution 36

(i) SI unit of heat is joule.
(ii) 1 cal = 4.2 J
(iii) Whenever mechanical work is done, heat is produced.
(iv) Two bodies in contact are said to be in thermal equilibrium, if they have the same temperature.
(v) The normal temperature of a human body is 37°C.
(vi) SI unit of specific heat is $Jkg^{-1}C^{-1}$.
(vii) The amount of heat required to change the state of a physical substance without any change of temperature is called latent heat of the substance.
(viii) Ice at 0°C is colder than water at 0°C.
(ix) Steam at 100°C is hotter than water at 100°C.
(x) Evaporation causes cooling.

Solution 37

1 gram of ice at 0^oC requires 80 calories of heat to get converted into 1 gram of water at 0^oC. So, water has more heat.

Solution 38

1 gram of water at 100^oC requires 540 calories of heat to get converted into 1 gram of steam at 100^oC. So, steam has more heat.

Solution 39

1 gram of ice at 0^oC requires additional 80 calories of heat to get converted into water at 0^oC. Then, heat is provided to raise the temperature to 10^oC. Therefore, ice requires more heat than water and the additional heat is known as 'Latent heat of fusion of ice'.

Solution 40

Pressure cooker increases the pressure and hence the boiling point increases. So, the boiling point becomes greater than 373kelvin.