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).

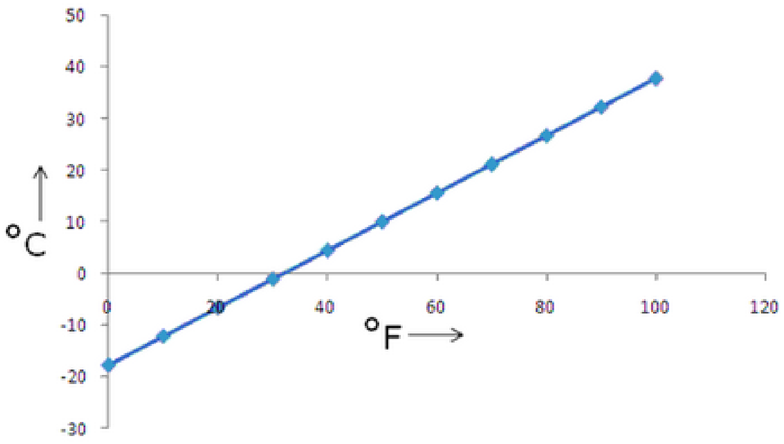
Solution 6
1 joule is the amount of heat required to raise the temperature of 1 kg of a substance, that has specific heat capacity 1J/kgK, through $1^{0}C$.

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

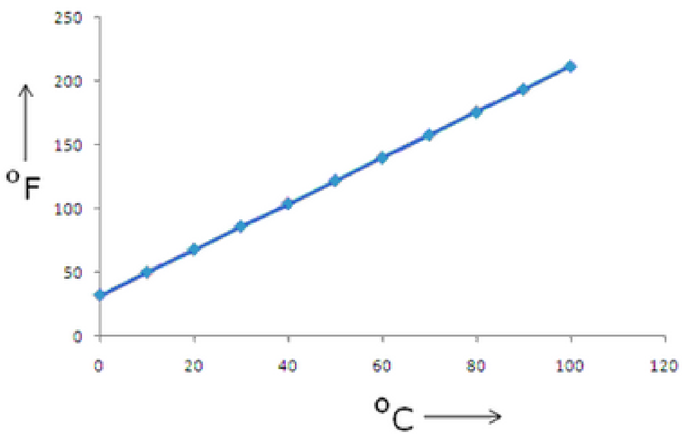
Solution 8
A thermometer is used to measure temperature.

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^oC

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

$= 0 + 32 = 32^oF$

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^oC and boiling point of water as 100^oC. The same points on the Fahrenheit scale are 32^oF and 212^oF.

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

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

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

$\Rightarrow 20^oC \equiv 68^oF$

$68^oF > 20^oF$

or, $20^oC > 20^oF$

20^oC 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

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

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

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

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

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

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 x C x ΔT

Q = 0.5 x 4200 x 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).