25. Calorimetry

Short Answer

1. Question

Is heat a conserved quantity?

Answer

No, heat is not a conserved quantity.

A conserved quantity remains the same before and after the physical event.

Heat is a form of energy, and energy can neither be created nor be destroyed, but can transform from one form to another.

Best example is a thermocouple, where heat energy is transformed into electrical output due to adjoining two dissimilar metals.

From 1st principle of thermodynamics, only the total energy before or after transformation remains constant.

2. Question

The calorie is defined as 1 cal = 4.186 joule. Why not as 1 cal = 4J to make the conversions easy?

Answer

Calorie is defined as amount of heat required to raise Temperature of one gram of water by one degree (Celsius).

Since heat is a form of energy, hence it’s required to give 4.185 J of work to 1 gram of water to raise its temperature by 1 Degree Celsius.

If we round off 4.185J to 4J, there will be a change of 0.185J of Work and hence our calculations will go wrong.

3. Question

A calorimeter is kept in a wooden box to insulate it thermally from the surroundings. Why is it necessary?

Answer

Calorimeter is an apparatus used for measuring the amount of heat involved in a chemical reaction or other process.

A calorimeter is kept inside a good heat insulator

If it's not kept inside the wooden box which acts as insulating Jacket, the heat will be lost to the surrounding through Conduction and this can lead to discrepancy in the desired results.

4. Question

In a calorimeter, the heat given by the hot object is assumed to be equal to the heat taken by the cold object. Does it mean that heat of the two objects taken together remains constant?

Answer

Yes, heat of the two objects taken together remains constant.

Since the heat given by the hot object is assumed to be equal to the head taken by the cold object, hence no heat is lost to the surroundings which means the heat of the two object (system) taken together remains constant.

5. Question

In Regnault's apparatus for measuring specific heat capacity of a solid, there is an inlet and an outlet in the steam chamber. The inlet is near the top and the outlet is near the bottom. Why is it better than the opposite choice where the inlet is near the bottom and the outlet is near the top?

Answer

Regnault's apparatus is an excellent apparatus to measure the amount of heat energy required to change the temperature of a solid body by a known amount.

In Regnault's apparatus the inlet is near the top and the outlet is near the bottom as steam enters at inlet and leaves in liquid phase at outlet.

When the steam enters at inlet, it loses heat, in which a part of steam condenses back to water.

On the other hand, the part of hot steam after losing heat gets denser and moves down towards the bottom.

So outlet must be in bottom as liquid lies below the steam.

6. Question

When a solid melts or a liquid boils, the temperature does not increase even when heat is supplied. Where does the energy go?

Answer

When heat is supplied to melt solid or boil liquid, the heat energy is used in breaking the bond forces between the molecules of the solid or liquid to bring them apart until phase gets changed.

Hence the heat energy supplied to molecules is utilized as kinetic energy to overcome the molecular forces keeping the temperature constant.

This is what we call Latent Heat.

7. Question

What is the specific heat capacity of

(a) Melting ice

(b) Boiling water?

Answer

The specific heat capacity of a body is defined as the amount of heat required to raise temperature of unit mass of a substance by one unit

(a) The specific heat capacity of melting ice is 0.50cal/g-^{0}C or 2093 J/kg-K.

(b) The specific heat capacity of boiling water is 0.46 cal/g-^{0}C or 1926 J/kg-K.

8. Question

A person's skin is more severely burnt when put in contact with 1g of steam at 100°C than when put in contact with 1g of water at 100°C. Explain.

Answer

Steam carries with it the heat of vaporization of the water.

At the same temperature, steam and boiling water don't contain the same amount of energy.

The internal energy of Steam at 100 ^{0}C is greater than boiling water at same temperature.

Hence steam burns more severely than water even though both are at same temperature.

9. Question

The atmospheric temperature in the cities on sea-coast change very little. Explain.

Answer

Coastal areas will generally have more moderate temperatures than inland areas because of the heat capacity of the ocean.

Water has a higher heat capacity than soil and rock; hence it takes time to Heat Ocean rather than soil or rocks.

And because of sea retains the head more when the heat exchange takes place between land and sea.

10. Question

Should a thermometer bulb have large heat capacity or small heat capacity?

Answer

Thermometer is a device to measure temperature of a body which consists of heat and specific heat of the body.

If it has lower heat capacity, it may expand substantially at high temperatures which lead to false readings.

Hence thermometer bulbs should have large heat capacity.

Objective I

1. Question

The specific heat capacity of a body depends on

A. the heat given

B. the temperature raised

C. the mass of the body

D. the material of the body

Answer

The specific heat capacity of a body is defined as the amount of heat required to raise temperature of unit mass of a substance by one unit.

Now, heat capacity of a body varies due to variations in its molecular structure and hence the material of the body.

2. Question

Water equivalent of a body is measured in

A. kg

B. calorie

C. kelvin

D. m3

Answer

Water equivalent of a body is defined as quantity of heat that raises the temperature of some substance by some amount, simultaneously raise the same temperature of a certain mass of water.

Mass of an object is measure in Kg so water equivalent has a unit of mass in Kg.

Hence its measured in Kg

3. Question

When a hot liquid is mixed with a cold liquid, the temperature of the mixture

A. first decreases then become constant

B. first increases then become constant

C. continuously increases

D. is undefined for some time and then becomes nearly constant.

Answer

When hot liquid is mixed with cold one, the molecules of the hot and cold liquid exchange heat and hence temperature is undefined.

When they share heat, the systems reach equilibrium.

Hence first the result is undefined and then reaches equilibrium.

4. Question

Which of the following pairs represent units of the same physical quantity?

A. Kelvin and joule

B. Kelvin and calorie

C. Newton and calorie

D. Joule and calorie

Answer

Calories the unit for amount of heat needed to raise the temperature of 1 g of water from 14.5^{0} to 15.5^{0} at the pressure of 1 atm

Heat is a form of energy and Joule is the unit of energy.

Hence these two units represent same physical quantity.

5. Question

Which of the following pairs of physical quantities may be represented in the same unit?

A. Heat and temperature

B. Temperature and mole

C. Heat and work

D. Specific heat and heat

Answer

Heat is a form of energy and work is force applied to a distance.

Now, work done to raise/fall temperature of a body is nothing but heat required to control the temperature, hence both physical quantities can be represented in the same unit.

6. Question

Two bodies at different temperatures are mixed in a calorimeter. Which of the following quantities remains conserved?

A. Sum of the temperatures of the two bodies

B. Total heat of the two bodies

C. Total internal energy of the two bodies

D. Internal energy of each body

Answer

When two bodies of different temperatures are missed in a calorimeter, the heat gets exchanged between the molecules of the system, but no heat is exchanged in the surrounding in a calorimeter.

Thus, the total internal energy of the bodies remains conserved as external work done is zero.

7. Question

The mechanical equivalent of heat

A. has the same dimension as heat

B. has the same dimension as work

C. has the same dimension as energy

D. is dimensionless

Answer

The net work done is equal to the change in kinetic energy,

Mechanical energy can be converted to heat and vice – versa.

If the mechanical work done *(W)* by an object produces the same temperature change as heat *(H),* then

Mechanical equivalent of heat (J)

= Amount of Work (W) / units of Heat (Q).

We know unit of work and heat is the same, hence it's dimensionless.

Objective II

1. Question

The heat capacity of a body depends on

A. the heat given

B. the temperature raised

C. the mass of the body

D. the material of the body

Answer

We know

$$C = \frac{\Delta Q}{M}\Delta T$$

C=heat capacity

ΔQ=heat given

ΔT=change in temperature

As heat capacity is the heat given to the body to raise its temperature by unit degrees.

Heat capacity depends on the material of the body and mass of it.

2. Question

The ratio of specific heat capacity to molar heat capacity of a body

A. is a universal constant

B. depends on the mass of the body

C. depends on the molecular weight of the body

D. is dimensionless

Answer

$$S = \Delta Q/m\Delta T$$

$$C = \Delta Q/n\Delta T$$

n=m/M

s=specific heat capacity

C=molar heat capacity

ΔQ=heat exchange

ΔT=temperature change

m=mass of body

M=molecular mass of body

n=moles of mody

$$\frac{S}{c} = 1/M$$

so;

ratio of S and c will depend on the molecular weight of the body.

3. Question

If heat is supplied to a solid, its temperature.

A. must increase

B. may increase

C. may remain constant

D. may decrease

Answer

Heat transferred, $\Delta Q = mC\Delta T$

Where,

ΔT=tempeature change

M=mass

C=heat capacity

Thus, form the above relation, we found that the heat capacity of an object is directly dependent on the temperature difference.

Hence, we can say that the when the heat is applied to the solid, temperature of the solid can be zero or positive so the temp will remain constant or will increase when heat is supplied

4. Question

The temperature of a solid object is observed to be constant during a period. In this period.

A. heat may have been supplied to the body

B. heat may have been extracted from the body

C. no heat is supplied to the body

D. no heat is extracted from the body

Answer

Heat change, $\Delta Q=mC\Delta T$

Where,

ΔT=tempeature change

M=mass

C=heat capacity

Since the temperature is constant,

$\Delta Q=0$,

The heat supplied might have been supplied to the body was used in the breaking the bond of the molecules, changing the state of the solid.

Thus, the temperature of the solid remains constant. In the period of heat may have been supplied to the body and heat may have been extracted from the body.

5. Question

The temperature of an object is observed to rise in a period. In this period.

A. heat is certainly supplied to it

B. heat is certainly not supplied to it

C. heat may have been supplied to it

D. work may have been done on it.

Answer

Formula used:

$\Delta Q=mC\Delta T$

ΔQ=heat exchange

ΔT=tempeature 4change

M=mass

C=heat capacity

If the temperature of an object rises in a period, then there are two possibilities. The heat may have been supplied to it, leading to an increase of the internal energy of the object, increasing the temperature of the body.

The second possibility is that some work has been done on it, again leading to an increase of the internal energy of the body.

Thus, the temperature can be increased by supplying heat or by doing work on an object.

6. Question

Heat and work are equivalent. This means,

A. when we supply heat to a body we do work on it

B. when we do work on a body we supply heat to it

C. the temperature of a body can be increased by doing work in it.

D. a body kept at rest may be set into motion along a line supplying heat to it.

Answer

According the statement “heat and work are equivalent”, heat supplied to the body increases its temperature. Similarly, work done on the body also increases its temperature.

$\Delta Q = mC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

When heat is supplied to a body, we do not do work on it.

When we do work on an object, it does not mean we are supplying heat to the body.

Work done can be converted to temperature but increasing temperature cannot do work on an object

Exercises

1. Question

An aluminum vessel of mass 0.5 kg contains 0.2 kg of water at 20°C. A block of iron of mass 0.2 kg at 100°C is gently put into the water. Find the equilibrium temperature of the mixture. Specific heat capacities of aluminum, iron and water are 910 J kg^{-1} K^{-1}; 470 J kg^{-1} and 4200 J kg^{-1} K^{-1} respectively.

Answer

Given;

Mass of aluminium=0.5kg

mass of water=0.2kg

Mass of iron=0.2kg

temperature of aluminium vessel and water=20^0c

Temp of iron=100^0c

heat capacity of aluminium=910 J/kg-k

heat capacity of iron=470J/kg-k

heat capacity of water=4200J/kg-k

Formula used:

ΔQ=mCΔT

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

let the dinal temperature of the mixture be T;

so;

$$\textit{Heat gain by aluminum and water} = 0.5 \times 910(T-293) + 0.2 \times 4200(T-293)$$

$$\textit{Heat lost by iron} = 0.2 \times 470 \times 373 - T)$$

as

heat gain by aluminum and water=heat loss by iron

$$0.5 \times 910(T-293) + 0.2 \times 4200(T-293) = 0.2 \times 470 \times (373 - T)$$

$$(T-293)(0.5 \times 910 + 0.2 \times 4200) = 0.2 \times 470 \times (373 - T)$$

$$1389T = 414497$$

T=298.41^{0}k

2. Question

A piece of iron of mass 100 g is kept inside a furnace for a long time and then put in a calorimeter of water equivalent 10g containing 240 g of water at 20°C. The mixture attains an equilibrium temperature of 60°C. Find the temperature of the furnace. Specific heat capacity of iron = 470 J kg^{-1} °C^{-} .

Answer

Given:

Mass of iron=100g

water equivalent of calorimeter=10g

Mas of water =240g

temp of surface=0^0c

S_{iron}=470J/kg-k

Formula Used:

ΔQ=mCΔT

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat gained by water = heat lost by iron

So

$$\frac{10}{1000} \times 470 \times (T - 60) = \frac{250}{1000} \times 4200 \times (60 - 40)$$

$$47T = 44820$$

T=953.61^{0}C

3. Question

The temperatures of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C, and when B and C are mixed, it is 23°C. What will be the temperature when A and C are mixed?

Answer

Given:

Temp of A=12° c

Temp of B=19° c

Temp of C=28° c

Formula used:

ΔQ=MCΔT

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Now;

When A and B are mixed

M_A(16-12)=M_B(19-16)

M_B=4M_A/3

Also;

When B and C are mixed

M_B(23-19)=M_c(28-23)

M_B=5M_c/4

So when A and C are mixed let the final temperature be T

M_A(T-12)=M_c(28-T)

$\frac{3}{4}M_B(T-12)=\frac{4}{5}M_B(28-T)$

15T-180=448-16T

T=20.3° C

4. Question

Four 2 cm × 2 cm × 2 cm cubes of ice are taken out from a refrigerator and are put in 200 ml of a drink at 10°C.

(a) Find the temperature of the drink when thermal equilibrium is attained in it.

(b) If the ice cubes do not melt completely, find the amount melted. Assume that no heat is lost to the outside of the drink and that the container has negligible heat capacity. Density of ice = 900 kg m^{-3}, density of the drink = 4200 J kg^{-1} K^{-1}, latent heat of fusion of ice = 3.4 × 10^5 J kg^{-1}.

Answer

(a)**Given:**Number of ice cubes = 4Volume of each ice cube = (2 × 2 × 2) = 8 cm^3Density of ice = 900 kg m^{-3}Total mass of ice, m_i = (4×8 ×10^{-6} ×900) = 288×10^{-4} kgLatent heat of fusion of ice, L_i = 3.4 × 10^5 J kg^{-1}Density of the drink = 1000 kg m^{-3}Volume of the drink = 200 mlMass of the drink = (200×10^{-6})×1000 kg

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Let us first check the heat released when temperature of 200 ml changes from $10^{o}C$ to $0^{o}C$.$H_w = (200 \times 10^{-6}) \times 1000 \times 4200 \times (10-0) = 8400$ J

Heat required to change four 8 cm^3 ice cubes into water $(H_i) = m_i L_i = (288 \times 10^{-4}) \times (3.4 \times 10^5) = 9792$ J

Since the heat required for melting the four cubes of the ice is greater than the heat released by water ($H_i > H_w$), some ice will remain solid and there will be equilibrium betweenice and water. **Thus, the thermal equilibrium will be attained at 0^{o} C.**

(b)

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Equilibrium temperature of the cube and the drink = 0°CLet M be the mass of melted ice.Heat released when temperature of 200 ml changes from 10C to 0C is given by$H_w = (200 \times 10^{-6}) \times 1000 \times 4200 \times (10-0) = 8400$ J

Thus,$M \times (3.4 \times 10^5) = 8400$ J

Therefore,**M = 0.0247 Kg = 25 g**

5. Question

Indian style of cooling drinking water is to keep it in a pitcher having porous walls. Water comes to the outer surface very slowly and evaporates. Most of the energy needed for evaporation is taken from the water itself and the water is cooled down. Assume that a pitcher contains 10 kg of water and 0.2 g of water comes out per second. Assuming no backward heat transfer from the atmosphere to the water, calculate the time in which the temperature decreases by 5°C. Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$ and latent heat of vaporization of water = 2.27 × 10^6 J kg^{-1}.

Answer

Given

Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$

latent heat of vaporization of water = 2.27×10^6 J kg^{-1}.

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat lost per second from the atmosphere = Heat gained by the water

$0.2\times 10^{-3}\times 2.27\times 10^{6}=4200\times(10-0.2\times 10^{-3})\times \Delta T$

$\Delta T=0.01080974°$ C

Therefore time required for 5° change=5/0.01080974=462.5 seconds=7.7 minutes

6. Question

A cube of iron (density = 8000 kg m^{-3}, specific heat capacity = 470 J kg^{-1} K^{-1}) is heated to a high temperature and is placed on a large block of ice at 0°C. The cube melts the ice below it, displaces the water and sinks. In the final equilibrium position, its upper surface just goes inside the ice. Calculate the initial temperature of the cube. Neglect any loss of heat outside the ice and the cube. The density of ice = 900 kg m^{-3} and the latent heat of fusion of ice = 3.36×10^5 J kg^{-1}.

Answer

Given:

iron (density = 8000 kg m^{-3}, specific heat capacity = 470 J kg^{-1} K^{-1})

density of ice = 900 kg m^{-3}

latent heat of fusion of ice = 3.36×10^5 J kg^{-1}.

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat lost by iron= Heat gained by ice

$8000\times$ Volume$\times$ $470\times$ T=$900\times$ Volume $\times$ 3.36×10^5

T=80.42° C

7. Question

1 kg of ice at 0°C is mixed with 1 kg of steam at 100°C. What will be the composition of the system when thermal equilibrium is reached? Latent heat of fusion of ice = 3.36×10^5 J kg^{-1} and latent heat of vaporization of water = 2.26×10^6 J kg^{-1}.

Answer

Given

Latent heat of fusion of ice = 3.36×10^5 J kg^{-1}

latent heat of vaporization of water = 2.26×10^6 J kg^{-1}

Formula used:

$\Delta Q=MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat lost 1 kg of steam= Heat gained by 1 kg of ice

$3.36\times 10^5+1\times 1000\times T=2.26\times 10^6+1\times 1000\times (100-T)$

This equation gives T>100 therefore we come to know steam is still present.

So making the temp of the mixture to be 100° C

$3.36\times 10^5+1\times 4200\times 100=M\times 2.26\times 10^6$

M=0.3345kg

So mass of steam turned water=0.3345kg

So

Mass of water in mixture=1+0.3345=1.3345kg

Mass of steam left=1-0.3345=0.665kg

8. Question

Calculate the time required to heat 20 kg of water from 10°C to 35°C using an immersion heater rated 1000 W. Assume that 80% of the power input is used to heat the water. Specific heat capacity of water = 4200 J kg^{-1} K^{-1}.

Answer

Given:

heat capacity of water = 4200 J kg^{-1} K^{-1}.

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat given by heater = heat taken by water

$0.8\times 1000\times t=20\times 4200\times (35-10)$

t=2625 s=43.75 minutes

9. Question

On a winter day the temperature of the tap water is 20°C whereas the room temperature is 5°C. Water is stored in a tank of capacity 0.5 m^3 for household use. If it were possible to use the heat liberated by the water to lift a 10 kg mass vertically, how high can it be lifted as the water comes to the room temperature? Take g = 10 m s^{-2}.

Answer

Given:

Temperature of tap water=20^0C

Room temp=5^0C

Volume of tank=$0.5m^3$

Mass to lift=10kg

Formula used:

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Heat liberated by water =work done to lift

$0.5\times 1000\times 4200\times (20-5)=10\times 10\times$ height

Height=315000m=315km

10. Question

A bullet of mass 20g enters into a fixed wooden block with a speed of 40 m s^{-1} and stops in it. Find the change in internal energy during the process.

Answer

Given:

Mass of bullet=20g

Initial speed = 40m/s

Formula used:

Kinetic energy =1/2 mv^2

Change in kinetic energy=change in internal energy

16J =change in internal internal energy

11. Question

A 50 kg man is running at a speed of 18 km h^{-1}. If all the kinetic energy of the man can be 9used to increase the temperature of water from 20°C to 30°C, how much water can be heated with this energy?

Answer

Given:

Speed of man:5m/s

$\Delta T=10^0C$

Mass of man=50kg

Formula used:

Kinetic energy =1/2 mv^2

$\Delta Q = MC\Delta T$

ΔQ=heat exchange

ΔT=tempeature change

M=mass

C=heat capacity

Kinetic energy of person = heat absorbed by the water

$625 = M \times 4200 \times (30-20)$

M=0.01488kg

12. Question

A brick weighing 4.0 kg is dropped into a 1.0 m deep river from a height of 2.0 m. Assuming that 80% of the gravitational potential energy is finally converted into thermal energy, find this thermal energy in calorie.

Answer

given:

mass=4kg

height=3m

Formula used:

Potential energi=mgh

M=mass

g=9.8m/s

h=height

so

potential energy=$4\times 10\times 3=120$J

energi converted to thermal energy=$0.8\times 120=96$J

thermal energi in calories=96/4.2=22.8 cal

13. Question

A van of mass 1500 kg travelling at a speed of 54 km h^{-1} is stopped in 10 s. Assuming that all the mechanical energy lost appears as thermal energy in the brake mechanism, find the average rate of production of thermal energy in cal s^{-1}.

Answer

Given:

Mass of van=1500kg

Speed=15m/s

Time taken to stop=10s

Formula used:

Mechanical energy=kinetic energi=1/2mv^2

M=mass

V=velocity

So

Kinetic energy=1/2× 1500×225=168750J

Average rate of production of thermal energi=energy produced /time

=168750/10 J/s

=4017.8 cal/s

14. Question

A block of mass 100g slides on a rough horizontal surface. If the speed of the block decreases from 10 m s^{-1} to 5 m s^{-1}, find the thermal energy developed in the process.

Answer

Given:

mass of block=0.1kg

Formula used:

kinetic energy=1/2mv^2

M=mass

V=velocity

Change in kinetic energy = thermal energy developed

$$\frac{0.1(100-25)}{2} = thermal\ energy$$

3.75J=thermal energy developed

15. Question

Two blocks of masses 10 kg and 20 kg moving at speeds of 10 m s^{-1} and 20 m s^{-1} respectively in opposite directions, approach each other and collide. If the collision is completely inelastic, find the thermal energy developed in the process.

Answer

Given:

Mass of blocks:10kg and 20kg

Speeds of blocks:10m/s and 20m/s

Formula used:

Momentum=mv

M=mass

V=velocity

Conserving momentum

Momentum initial=momentum final

10× 10-20×20=30× final velocity

Final velocity=10m/s

Thermal energy=change in kinetic energi

$$Thermal\ energy = \frac{1000 + 8000}{2} - \frac{3000}{2}$$

Thermal energy=3000J

16. Question

A ball is dropped on a floor from a height of 2.0 m. After the collision it rises up to a height of 1.5 m. Assume that 40% of the mechanical energy lost goes as thermal energy into the ball. Calculate the rise in the temperature of the ball in the collision. Heat capacity of the ball is 800 J K^{-1}.

Answer

Given:

Heat capacity of ball=800 J/K

Formula used:

Potential energy=mgh

M=mass

H=height

ΔQ=MCΔT

ΔQ=change in energi

ΔT=change in temperature

C=heat capacity

M=mass

So

Change in poteintial energy=0.5× g× M

Now;

Change in potential energy=change in energy

5M=MCΔT

5=800ΔT

0.0025^0C=ΔT

17. Question

A copper cube of mass 200 g slides down on a rough inclined plane of inclination 37° at a constant speed. Assume that any loss in mechanical energy goes into the copper block as thermal energy. Find the increase in the temperature of the block as it slides down through 60 cm. Specific heat capacity of copper = 420 J kg^{-1} K^{-1}.

Answer

Given:

Heat capacity of copper=420J/Kg/K

Formula used:

Potential energy=mgh

M=mass

H=height

ΔQ=MCΔT

ΔQ=change in energi

ΔT=change in temperature

C=heat capacity

M=mass

We know that loss in mechanical energy is due to frictional force which is equal to mgsinα

So

Loss in potential energy=thermal energy

0.2× g× .36=0.2× 420× ΔT

ΔT=0.00857

18. Question

A metal block of density 6000 kg m^{-3} and mass 1.2 kg is suspended through a spring of spring constant 200 N m^{-1}. The spring-block system is dipped in water kept in a vessel. The water has a mass of 260 g and the bock is at a height 40 cm above the bottom of the vessel. If the support to the spring is broken, what will be the rise in the temperature of the water. Specific heat capacity of the block is 250 J kg^{-1} K^{-1} and that of water is 4200 J kg^{-1} K^{-1}. Heat capacities of the vessel and the spring are negligible.

Answer

Given: Density of metal block, d= 6000 kg m^{-3}Mass of metal block, m = 1.2 kgSpring constant of the spring, k = 200 N m^{-1}

Volume of the block, V

=1.2/6000=2×10-4 m3

When the mass is dipped in water, it experiences a buoyant force and in the spring there is potential energy stored in it.

the net force on the block is zero before breaking of the support of the spring, then

balancing forceskx + Vρg = mg200x + (2 × 10^{-4})× (1000) × (10) = 12

=x=12-2200⇒x=10200=0.05 m

The mechanical energy of the block is transferred to both block and water. Let the rise in temperature of the block and the water be ΔT.

Applying conservation of energy, we get

$1/2kx^2+mgh-V\rho gh=m_1s_1\Delta T+m_2s_2\Delta T$

$=1/2\times200\times0.0025+1.2\times10\times40\times 10^{-2}- 2\times$ 10-4$\times1000\times10\times40\times10^{-2}$

=260× 1000×4200×ΔT+1.2×250×ΔT

=0.25+4.8-0.8=1092 ΔT+300ΔT

=1392 ΔT=4.25

=ΔT=4.251392=0.0030531

ΔT=3×10-3°