Test Answers

Answer01

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in an aluminium calorimeter. Crushed dried ice was added to the water. The following results were obtained:

Mass of calorimeter = 77.2 g  
Mass of water = 92.5 g  
Initial temperature of water = 29.4 °C  
Temperature of ice = 0 °C   
Mass of ice = 19.2 g  
Final temperature of water = 13.2 °C

Room temperature was 21 °C. What was the advantage of having the room temperature approximately halfway between the initial temperature of the water and the final temperature of the water?

Describe how the mass of the ice was found.

Calculate a value for the specific latent heat of fusion of ice. The specific heat capacity of aluminium is 790 J kg-1 K-1  and the specific heat capacity of water is 4180 J kg-1 K-1.

The accepted value for the specific latent heat of fusion of ice is 3.3 × 105 J kg-1. Suggest two reasons why your answer is not this value.

Answer:

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in an aluminium calorimeter. Crushed dried ice was added to the water. The following results were obtained:  
Mass of calorimeter = 77.2 g  
Mass of water = 92.5 g  
Initial temperature of water = 29.4 °C  
Temperature of ice = 0 °C   
Mass of ice = 19.2 g  
Final temperature of water = 13.2 °C

The advantage of having the room temperature approximately halfway between the initial temperature of the water and the final temperature of the water was so that the heat lost by the calorimeter and its contents to the surroundings (when their temperature is above room temperature) is equal to the heat gained by the calorimeter and its contents (when their temperature is below room temperature). i.e. the heat lost to surroundings is approximately equal to the heat gained.

The mass of the ice was found by subtracting the mass of the calorimeter with the added warm water from the final mass of the calorimeter and its contents of original warm water + water from melted ice.

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| *Heat Gained = Heat Lost* | | | | | | |
| *Heat gained by ice melting* | *+* | *Heat gained by resulting water rising to final temperature* | *=* | *Heat lost by calorimeter cooling to final temperature* | *+* | *Heat lost by warm water cooling to final temperature* |
| *micelice* | *+* | *micecwDqice* | *=* | *mcalccalDqw* | *+* | *mwcwDqw* |
| *0.192 x l* | *+* | *0.192 x 4180 x 13.2* | *=* | *0.772 x 790 x 16.2* | *+* | *0.925 x 4180 x 16.2* |

Solving for l gives l = 3.2 × 105 J kg-1

"Suggest two reasons why your answer is not this value."

Any two of the following:

* thermometer not sensitive enough
* lack of insulation
* lack of stirring
* heat loss/gain to surroundings
* too long for ice to melt
* inside of calorimeter tarnished
* splashing
* heat capacity of thermometer

Answer02

A car of mass 1800 kg and moving at 25 m s-1 is brought to rest by the application of disc brakes. Find the average increase in temperature of the brakes if each of the four brakes has a mass of 4.5 kg. Take the specific heat capacity of the brake material to be 680 J kg-1 K-1, and assume that all the kinetic energy is changed into heat energy in the brakes.

Answer: Kinetic energy = ½ mv2 = 0.5 × 1800 × 625 = 5.625 × 105 J  
Four brakes, each of mass 4.5 kg, gives a total mass of 18 kg.  
Heat gained by brakes = mcDq = 18 × 680 × Dq  
Assuming all the kinetic energy is converted to heat energy  
18 × 680 × Dq = 5.625 × 105  
Dq = 46 K

Answer03

The temperature of 100 g of water was raised from 20 °C to 40 °C in 10 minutes by a heating coil of resistance 5.0 ohms and carrying a current of 2.0 A. Given that the specific heat capacity of water is 4.2 x 103 J kg-1 K-1, calculate the amount of energy lost to the surroundings.

Answer: Energy supplied  =  I2 Rt = 22 × 5 × 600 = 12 × 103  
Energy used = mcDq = 0.1 × 4.2 × 103 × 20 = 8.4 × 103  
Energy lost to surroundings = 12 × 103 - 8.4 × 103  = 3.6 × 103 J

Answer04

Water is being pumped through a central heating system at a rate of 1.15 m3 per hour. The temperature of the water leaving the boiler is 58.0 °C and the temperature of the water returning is 48.0 °C. Calculate the power output of the boiler. Assume heat losses to the surroundings to be negligible. Take the density of water to be 1.0 × 103 kg m-3 and the specific heat capacity of water to be 4.2 × 103 J kg-1 K-1.

Answer:   
Change in temperature of water = 58 - 48 = 10 K  
Heat lost = mcDq  
Density = mass / volume => Mass = density × volume  
So, heat lost per hour = 1 × 103 × 1.15 × 4.2 × 103 × 10 = 4.83 × 107 joule per hour  
Power = energy supplied / time = 4.83 × 107 / 3.6 × 103 = 13.4 kW

Answer05

A copper calorimeter of mass 180 g contains 450 g of water and 50 g of ice, all at 0 °C. Dry steam is passed into the calorimeter until a certain temperature, q, is reached. The mass of the calorimeter and its contents at the end of the experiment increased by 25 g.   
If no heat was lost to the surroundings, find the final temperature, q.  
Take the specific heat capacities of water and copper to be  
4200 J kg-1 K -1 and 390 J kg-1 K-1, respectively.  
Take the specific latent heat of fusion of ice to be 3.36 × 10 5 J kg-1 and the specific latent heat of vaporisation of water to be 2.26 × 106 J kg-1.

Answer: Energy released when steam condenses at 100 °C is  
Q = ml = 0.025 × 2.26 × 106 = 5.65 × 104 J    (a)

Energy released when condensed steam cools from 100 °C to temperature q is  
Q  = mcDq = 0.025 × 4200 × (100 - q) = 1.05 × 104 - 105q  (b)

Energy absorbed by 50 g of ice on melting at 0 °C is  
Q = ml = 0.05 × 3.36 × 105 = 1.68 × 104 J    (c)

Energy absorbed by 500 g of water (the original 450 g of water and 50 g of melted ice) in warming from 0 °C to q  is  
Q = 0.5 × 4200 × q = 2100 q    (d)

Energy absorbed by 180 g of copper (the calorimeter) in warming from 0 °C to q°C is  
Q = mcDq = 0.18 × 390 × q = 70.2 q    (e)

Heat lost = heat gained  
(a) + (b) = (c) + (d) + (e)  
5.65 × 104 + 1.05 × 104 - 105 q = 1.68 × 104 + 2100 q + 70.2q  
5.02 × 104 = 2.275 × 103 q  
q  = 22 °C

Answer06

A refrigerator converts 1.3 kg of water at 20 °C into ice at -15 °C in 1 hour. Calculate the total heat removed and the effective power of the refrigerator. Take the specific latent heat of ice to be 3.4 × 105 J kg-1, the specific heat capacity of water to be   
4.2 × 103 J kg-1 K-1 and the specific heat capacity of ice to be 2.1 × 103 J kg-1 K-1.

Answer: Energy removed in cooling 1.3 kg water from 20 °C to 0 °C is  
Q = mcDq = 1.3 × 4.2 × 103 × 20 = 1.092 × 105 J

Energy removed in changing 1.3 kg of water at 0 °C to ice at 0 °C is  
Q = ml = 1.3 × 3.4 × 105 = 4.42 × 105 J

Energy removed in cooling 1.3 kg ice from 0 °C to -15 °C is  
Q = mcDq = 1.3 × 2.1 × 103 × 15 = 4.095 × 104 J

Total heat removed is  
Q = 1.092 × 105 + 4.42 × 105 + 4.095 × 104 = 5.922 × 105 J

Power = energy in joules / time in seconds  
= 5.922 × 105 / (60 × 60)  
= 164.5 W  
= 0.16 kW

Answer07

Given that the specific heat capacity of air is 1.0 × 103 J kg -1 K -1, calculate how much energy must be removed from a refrigerator containing 0.15 m3 of air to lower the temperature of the air from 20 °C to 4 °C (take density of air = 1.2 kg m-3 ).

Answer: Mass = density × volume  
= 1.2 × 0.15  
= 0.18 kg of air

Q = mcDq  
= 0.18 × 103 × (20 - 4)  
= 2880 J  
= 2.9 kJ

Answer08

Explain the term power. In a microwave oven, energy is absorbed by the water present in food and is converted to heat. An electrician tested the efficiency of a microwave oven, which had a power rating of 650 W, as follows. A plastic jug, of negligible heat capacity, containing 500cm3 of water at 20°C was placed in the oven. It was switched on at full power for two minutes. The electrician found that the temperature of the water had risen to 54°C.

Calculate the electrical energy supplied.  
Calculate the energy absorbed by the water. Hence determine the percentage efficiency of the microwave oven.  
Microwaves are continuously reflected off the walls of the oven. Interference occurs at points where the reflected microwaves meet. How might this interference affect the heating of food placed in the oven?  
Explain why a turntable can be used to ensure uniform heating of food in a microwave oven.  
Give another use for microwave radiation.

Answer: Power = rate at which work is done.   ( P = W/t)

P = W/t => W = P × t  
Since W = Q => Q = 650 × 120  
Q = 78 000 J Power input

"Calculate the energy absorbed by the water."

[As density of water =1 g cm-3 , 500 cm3 => 500g  = 0.5 kg = m ]

Q = mcDq  
Energy absorbed by water = 0.5 × 4200 × 34  
= 71 400 J Power output

"Hence determine the percentage efficiency of the microwave oven."

Solution  
(%) Efficiency = [useful power output]/[power input]  x 100  
=  71,400/78,000  ×  100 = 92%

"Microwaves are continuously reflected off the walls of the oven. Interference occurs at points where the reflected microwaves meet. How might this interference affect the heating of food placed in the oven?"

Solution  
It might result in areas of high and low heating - uneven cooking.

Using a turntable in a microwave oven to will make the peaks and troughs (due to interference ) hit different areas, resulting in a better spread of heat through the food.

Other uses for microwave radiation are: Broadcasting, telephone.

Answer09

In an experiment to measure the specific heat capacity of a liquid, a quantity of liquid was heated in a copper calorimeter.   
The following measurements were obtained:  
Mass of calorimeter = 53.0 g  
Mass of calorimeter + liquid = 142.6 g  
Initial temperature of calorimeter + liquid = 16 °C  
Final temperature of calorimeter + liquid  = 21 °C  
Energy supplied = 1168 J

Using these measurements, calculate the value for the specific heat capacity of the liquid, given that the specific heat capacity of copper is 390 J kg-1 K-1  
Describe the apparatus that might have been used in addition to the calorimeter.  
Give two ways in which heat loss from the calorimeter might have been reduced in this experiment.  
Explain why using a larger mass of the liquid while supplying the same amount of energy might have produced a less accurate result.

*Answers:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Energy Supplied* | *=* | *Energy gained by liquid* | *+* | *Energy gained by calorimeter* |
| *Q* | *=* | *mliqcliqDqliq* | *+* | *mcalccalDqliq* |
| *1168* | *=* | *0.0896 x c x 5* | *+* | *0.053 x 390 x 5* |
| *1168* | *=* | *0.448 c* | *+* | *103.35* |
| *1064.65* | *=* | *0.448 c* |  |  |
| *=>cLiq* | *=* | *2.38 x 103 Jkg-1 K-1* |  |  |

*"Describe the apparatus that might have been used in addition to the calorimeter."*

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*"Give two ways in which heat loss from the calorimeter might have been reduced in this experiment."  
  
Solution*  
*Heat losses from the calorimeter might have been reduced by:*  
*a) placing the calorimeter in a beaker surrounded by plenty of cotton wool to insulate it*  
*b) using a cover or lid on the calorimeter*  
*c) cooling the calorimeter and liquid below room temperature before supplying the heat. This ensures that, on average, heat will neither be gained nor lost to the surroundings.*  
  
*"Explain why using a larger mass of the liquid while supplying the same amount of energy might have produced a less accurate result."  
  
Solution*  
*The use of a larger mass of liquid, while supplying the same amount of energy, would have produced a less accurate result. This is because a smaller rise in temperature would have resulted which would cause a greater percentage error in the results.*  
  
*In an experiment to measure the specific latent heat of vaporisation of water, steam was passed into cold water in a copper calorimeter.*  
  
*The following results were obtained:*  
*Mass of calorimeter = 105.2 g*  
*Mass of calorimeter + water = 228.8 g*  
*Temperature of the cold water = 18 °C*  
*Temperature of the steam = 100 °C*  
*Mass of calorimeter + water + steam = 231.2 g*  
*Final temperature of the water = 29 °C*  
  
*Given that the specific heat capacity of copper is 390 J kg-1 K-1 and that the specific heat capacity of water is 4180 J kg-1 K-1 calculate the specific latent heat of vaporisation of water.*  
  
*Draw a labelled diagram of the apparatus which could have been used in this experiment.*  
  
*Explain why passing more steam into the water might have improved the accuracy of the result.*  
  
*Explain, also, why cooling the water used in the calorimeter to below room temperature could have led to a more accurate result*.

*Solution*  
The use of a larger mass of liquid, while supplying the same amount of energy, would have produced a less accurate result. This is because a smaller rise in temperature would have resulted which would cause a greater percentage error in the results.

Answer 10

"In an experiment to measure the specific latent heat of vaporisation of water, steam was passed into cold water in a copper calorimeter.  
  
The following results were obtained:  
Mass of calorimeter = 105.2 g  
Mass of calorimeter + water = 228.8 g  
Temperature of the cold water = 18 °C  
Temperature of the steam = 100 °C    
Mass of calorimeter + water + steam = 231.2 g  
Final temperature of the water = 29 °C  
  
Given that the specific heat capacity of copper is 390 J kg-1 K-1 and that the specific heat capacity of water is 4180 J kg-1 K-1 calculate the specific latent heat of vaporisation of water."

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| --- | --- | --- |
| Energy lost by steam condensing and water cooling | = | Energy gained by water and calorimeter |
| msl + mscwDqs | = | mwcwDqw + mcccDqc |
| (2.4 x 10-3)l + (2.4 x 10-3)(4180)(71)(11) | = | (0.1236)(4180)(11) + (0.105)(390) |
| (2.4 x 10-3)l + 712.27 | = | 5683.13 + 450.45 |

Specific latent heat of vaporisation of liquid l = 2.26 × 106 J kg-1 = 2.26 MJ kg-1  
   
"Draw a labelled diagram of the apparatus which could have been used in this experiment."

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*"Explain why passing more steam into the water might have improved the accuracy of the result."  
  
Solution*  
*Greater mass of steam (or rise in temperature) would result in a smaller error.*  
  
*"Explain, also, why cooling the water used in the calorimeter to below room temperature could have led to a more accurate result."  
Solution*  
*This would ensure that the steam condenses quickly.*  
  
*Also the final temperature of the calorimeter would be minimised, resulting in less loss of heat to the surroundings and thus reduced experimental error.*