The City School

North Nazimabad Boys Campus

Class 10

Note the Date for Assessment : 10th March 2015

Based on the Thermal Physics (complete)

For Class 10 (all Sections)

Topic:Thermal Physics

(Important notes)

TEMPERATURE!

Introduction:

Heat refers to the amount of thermal energy that is transferred from a hotter to a colder region. Temperature is something different.

Definition:

So, what is the difference then? Temperature is the degree of hotness or coldness of a room, a bowl of soup or that of ice cream. Temperature is measured using the instrument thermometer with which we all are familiar.

Task: Google how a thermometer is made.

Thermometer:

An appropriate substance is chosen e.g. mercury because it varies continuously with changes in temperature, then two fixed points are chosen called the upper and the lower fixed point and lastly a scale is calibrated within the two fixed points. Also, you should all know how the two fixed points are marked, it is by placing the thermometer bulb in melting ice and on steam respectively for the lower and upper fixed points.

Now, suppose you have a thermometer with the upper and lower fixed points marked on it but it is not calibrated, and you also know where a certain point is whose temperature you have to find. You know the lengths of all three points. And the question is to find the temperature of the unknown temperature. All you have to do in such a question is insert the values of the known lengths. Here:

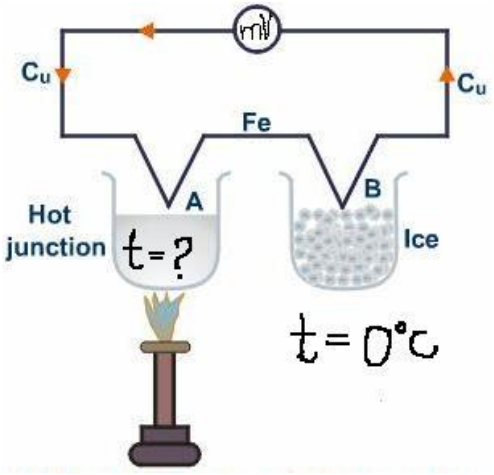
$°C = (l_θ - l_0) / (l_{100} - l_0) \times 100$

where °C is the unknown temperature, $l_θ$ is the length of the unknown temperature, l_{100} is the length of the 100°C (the upper fixed point) and l_0 is the length of the lower fixed point i.e. 0°C.

Try solving this question using the formula to see if you actually got it.

Q1. In an unmarked mercury thermometer, it was found that the length l_0 was 5 cm and the length l_{100} was 25cm. What is the temperature when $l_θ$ is **(a)** 14 cm, **(b)** 3 cm?

Thermocouple Thermometer:



Okay so a thermocouple is shown above, it basically consists of two wires made of different metals such as iron and copper as shown above. The ends of wires are joined together to form junctions. The unknown temperature labelled above is then calculated using the reading on the voltmeter (mV in the diagram).
How does this happen? Hmm..well, the two different temperatures causes a small voltage to be produced, greater the difference, greater is the voltage.
Task: Google the advantages of using thermocouple thermometer.

THERMAL PROPERTIES OF MATTER!

Introduction:

Definition:

First of all, what is **Heat capacity**? It is the amount of thermal energy required to raise the temperature of a body by 1K or 1°C. The symbol for heat capacity is C. The units for heat capacity are $J\ K^{-1}$ or $J°C^{-1}$. In symbols, we can express it as:

$$C = E / \Delta T$$

where E is thermal energy in Joule (J) and ΔT is the change in temperature in K or °C.

Q1. 100g of water requires 12 600 J of thermal energy to raise the temperature from 30°C to 60°C. Find the heat capacity of 100g of water.

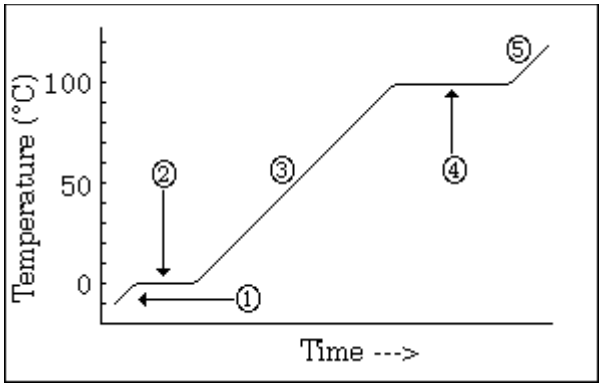
Specific Heat Capacity: It is the heat capacity per unit mass, that is, it is the amount of heat energy required to raise the temperature of 1 kg of a substance by 1K or 1°C.
The symbol for specific heat capacity is c. The symbols for specific heat capacity are $J\ kg^{-1}\ K^{-1}$ or $J\ kg^{-1}\ °C^{-1}$. In symbols, it is given by:

$$c = C / m = (E / \Delta T) / m$$

where m is mass in kg.

Melting and Solidification:

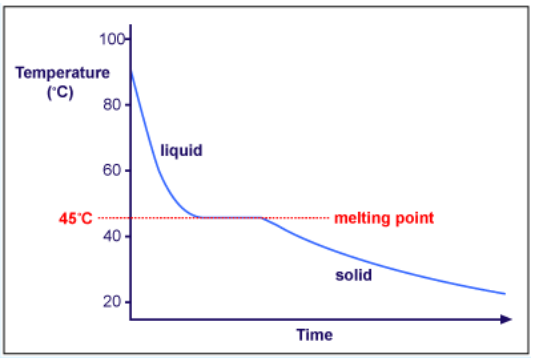
We all know that when a solid changes to liquid upon heating, this change of state is called melting. For a pure substance, melting occurs at a definite or constant temperature. This temperature is called the melting point.



In this diagram, a typical graph of temperature against time is shown.
This graph will be seen, a lot! So let's discuss what's happening at each step. This is basically the heating curve of ice. At 1, the temperature of the solid ice on heating rises from - 10°C to 0 °C as shown by the portion 1. of the curve. There is a change in temperature.
At 2, the temperature remains steady at 0°C as the ice melts. Now this is important! On the graph, it can be seen from the straight line. This happens in spite of thermal energy being absorbed. There is no change in temperature. So where did the absorbed thermal energy go? This can be explained by using the kinetic model of matter, which we have already studied in the previous tutorial on kinetic model of matter. The thermal energy that is absorbed is used to break the attraction between the water molecules.

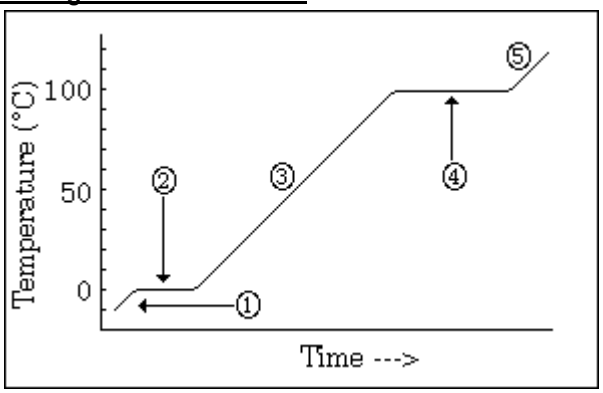
The heat that is absorbed without a change in temperature, like in 2, is called the latent heat of fusion of a substance. We will study this later in this tutorial.

Before further discussing the graph, let us learn what solidification is. It's simply the reverse of melting, that is, when a liquid changes into solid. Yeah, its called freezing as well. A pure substance freezes at a temperature equal to its melting point. The difference is, during freezing, energy is removed and during melting, energy is absorbed.



Okay the diagram above shows the cooling curve, how can we tell? The temperature is falling. The melting point is the same as freezing point, in this case its 45°C.

Boiling and Condensation:



Okay now look at this graph again. What is happening at 3? The water is boiling. Boiling is the process where a liquid is changed into gas by heating. The particular temperature at which it occurs is the boiling point.

At 3, when all the ice has melted, the temperature of the liquid water rises from 0°C to 100°C as shown. There is a change in temperature as the thermal energy is absorbed by the water.

At 4, the graph shows that the temperature remains steady at 100°C.The fixed or constant temperature 100°C is the boiling point of water. During the change in state from water to vapours, there is no change in temperature even though the thermal energy is being absorbed. Why? The reason for this is the same as that in melting, the thermal energy absorbed is used for breaking the forces of attraction between water molecules.

Latent Heat:

It is not as difficult as it sounds! Latent heat is the energy absorbed or released during a change of state. There is no temperature change as all the thermal energy is used to make (in freezing) or break (in boiling) the intermolecular bonds. There are two types of latent heat: latent heat of fusion and latent heat of vaporization.

Latent heat of Fusion (L_f): Latent heat of fusion of a solid is the amount of thermal energy required to change it from solid to liquid state, or vice versa, without a change in temperature. The unit for this is Joule (J) as it the amount of energy.

Specific Latent heat of fusion (l_f): It is the amount of energy required to change 1 kg of a solid to liquid, or vice versa, without a change in temperature. It can also be qritten as:

$$L_f = l_f \times m$$

where m is mass in kg.

Q2. An ice-cream has a mass of 150 g. If the specific latent heat of fusion of ice is 340 000 J. Find the thermal energy required to melt the ice cream.

Latent Heat of Vaporisation (L_v): It is the thermal energy required to change a liquid from liquid to vapour state, or vice versa, without a change in temperature. The unit for this again is Joule (J).

Specific Latent Heat of Vaporisation (l_v): It is the amount of thermal energy required to change 1 kg of it from liquid to gaseous state, or vice versa, without a change in temperature.
It can also be written as:

$$L_v = l_v \times m$$

where m is mass in kg.
Evaporation:
We all know about evaporation, right? It is the change state from liquid to vapour, like boiling. So the, umm..what is the difference between the two? Actually evaporation can occur at any temperature while boiling occurs at a fixed temperature, that is, the boiling point. For instance, you hand out the wet clothes to let them dry. Is the temperature outside 100°C when the clothes dry? No no, of course not. The water evaporates, that means it occurred at any temperature, we don't know.
Here are all the differences between boiling and evaporation:

Boiling	Evaporation
Occurs at **fixed** temperature	Occurs at **any** temperature
Quick Process	Slow Process
Takes place **throughout** the liquid	Takes place only at the liquid **surfaces**.
Bubbles are formed in the liquid	**No bubbles** are formed in the liquid
Temperature **remains constant**	Temperature **may change**
Thermal energy supplied by **an energy source**	Thermal energy supplied by **the surroundings**

MCQs and Structured Questions

Submission Date Wednesday,11th March2015

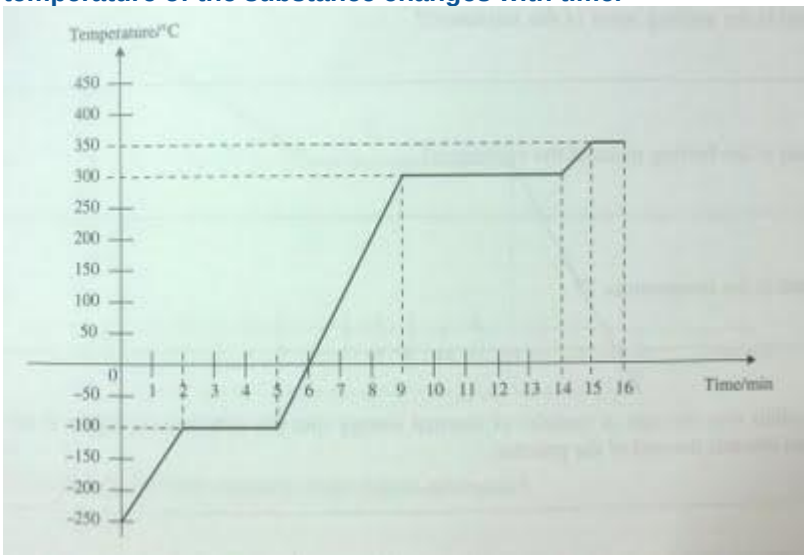
Topics ***Revision : Worksheet***

Thermal Physics and General Physics

Q1. A solid substance is placed in an oven which is set to temperature T. The graph illustrates how the temperature of the substance changes with time.

Structured Questions

1. A solid substance is placed in an oven which is set to temperature T. The graph illustrates how the temperature of the substance changes with time.



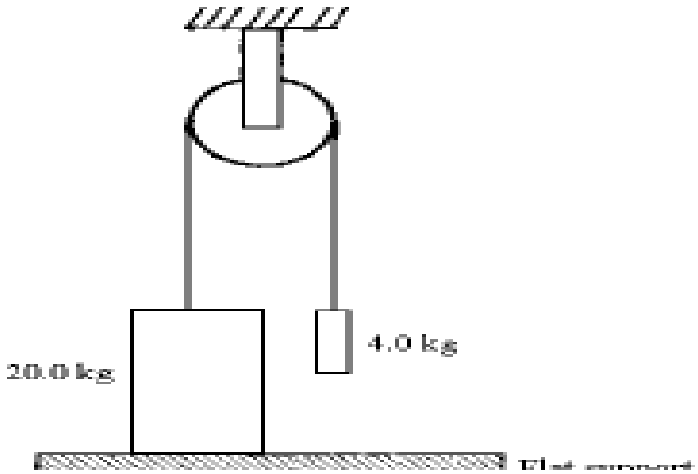
a. What is the state of the substance when the time is 1.0 min?
b. What is the state of the substance when the time is 4.0 min?
c. What is the state of the substance when the time is 8.0 min?
d. What is the state of the substance when the time is 9.0 min?
e. What is the state of the substance when the time is 13.0 min?
f. What is the state of the substance when the time is 14.0 min?
g. What is the state of the substance when the time is 15.0 min?
h. What is the melting point of the substance?
i. What is the boiling point of the substance?
j. What is the termperature T?
k. Explain why the rate of transfer of thermal energy into the substance is higher at the beginning than towards the end of the process?
l. Why is the temperature unchanged between the 15th and and the 16th minute?

Q2 A steady force of 6.0 N is applied horizontally to a body of mass 4.0 kg, which is initially at rest. In the 2.0 s during which the force is applied, the mass moves 3.0 m in the direction of the force. Assuming that there is no resistance to the motion, find a. the work done by the force b. the resulting kinetic energy of the body c. the resulting velocity of the body

Q3 An empty lift is counterbalanced by a heavy piece of metal. Some people of combined mass 350 kg enter the lift and operate it. The lift rises 50 m in 60 s. Calculate a. the work done in raising the people b. the power required to do this (take weight of 1kg to be 10N)

Q4 A spring has a length of 5.0cm when it has no load hanging on it. When a load of weight 30N is hung from it, its length becomes 11.0cm. How long will it be if the weight of the load is changed to 20N

Q5 Two masses, 20.0kg and 4.0kg, are connected to two ends of a rope that passes over a smooth pulley as shown in the diagram.



a. Mark and label on the diagram all the forces acting on the two masses.
b. The flat support is removed.
i. State the subsequent motion of the masses.
ii. Calculate the acceleration of the connected masses.

MCQs

1. When the temperature of a body increases, its
a. internal energy decreases
b. internal energy remains constant
c. internal energy increases
d. heat capacity increases

2. The internal energy of a body is measured in
a. kg
b. °C
c. J
d. JK-1

3. The heat capacity of a bottle of water is 2100 J°C-1. What is the amount of heat required to heat the water from 30°C to 50°C?
a. 2100J
b. 4200J
c. 42000J
d. 63000J

4. If the same amount of heat is supplied to 2 metal rods, A and B, rod B shows a smaller rise in temperature. Which of the following statements is true about the heat capacity of rods A and B?
a. The heat capacity of A is less than that of B
b. The heat capacity of B is less than that of A
c. The heat capacity of A is zero
d. The heat capacity of B is zero

5. The heat capacities of 10g of water and 1kg of water are in the ratio
a. 1 : 10
b. 10 : 1
c. 1 : 100
d. 100 : 1

6. 1 kg of substance X of specific heat capacity 2 kJkg-1°C-1 is heated from 30°C to 90°C. Assuming no heat loss, the heat required is
a. 7.5 kJ
b. 18 kJ
c. 80 kJ
d. 120 kJ

7. How much heat is required to raise the temperature of 20g of water from 10°C to 20°C if the specific heat capacity of water is 4.2 Jg-1°C-1?
a. 1.68 J
b. 84 J
c. 840 J

8. An object is moving due east at a constant speed of 5m/s before two equal and opposite forces of 10N each act on the object at the same time. The object will

a. move with higher speed in the same direction
b. move with lower speed in the same direction
c. continue to travel at the same speed in the same direction
d. change the direction of motion and travel in the opposite direction

9. A car is being driven up a slope at a constant speed. Which of the following describes the energy conversion of the system?
a. chemical into kinetic
b. chemical into potential
c. kinetic into potential
d. potential into kinetic

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c. kinetic into potential
d. potential into kinetic