Chapter 5. Heat: Thermal Expansion

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Solution 1:

- Coefficient of Linear expansion is equal to the change in length of a rod of length 1m when its temperature rises by 1°c.
- Coefficient of superficial expansion is equal to the change in area of a rod of area $1m^2$ when its temperature rises by 1°c.
- Coefficient of volume expansion is equal to the change in volume of a rod of volume $1m^3$ when its temperature rises by 1°c.

Solution 2:

If the Coefficient of Linear expansion is denoted by α

Coefficient of superficial expansion is denoted by β

And Coefficient of volume expansion is denoted by γ

Then the relation between α, β and γ is stated as

$\beta = 2\alpha$ and $\gamma = 3\alpha$

$\alpha : \beta : \gamma :: 1 : 2 : 3$

Solution 3:

A bimetallic strip consists of two metal strips- one with high coefficient of expansion and the other with low coefficient of expansion. Two different metals are used for regulating temperature in an electrical device as the strip bends due to different coefficient of expansion on excessive heating due to current, thus breaking electrical circuit until the strip cools down to a preset point. Two applications of bimetallic strip are thermostat in electric iron and in balance wheels.

- When boiling water is poured into a glass bottle, it generally cracks because on pouring hot water in the bottle the inner surface heats up and expands more as compared to its outer surface. This unequal expansion between the two surfaces causes a strain and the bottle cracks.
- Telephone wires sag in summer because due to heat of the sun, the wire expands and increases in length, thus they sag in summer.
- In cold countries water pipes burst in winter because the water has maximum density at 4°C and, due to anomalous expansion of water, it expands when the water is cooled to a temperature below 4°C
- Even when the water in the lakes is frozen, fishes can survive due to anomalous expansion of water, water has maximum density at 4°C and this dense water remains at the bottom of the lake and the upper layer of water is less dense and freezes but the temperature of each layer of water below increases by 1°C. Thus it is warmer in the lakes below the ice layer. This helps the fishes to survive.

Solution 4:

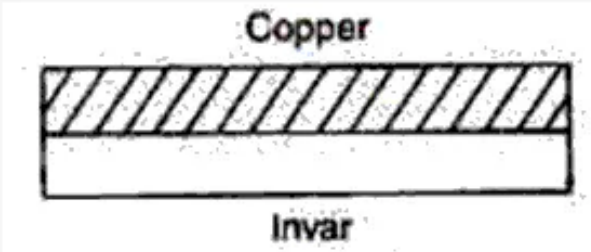


Diagram is to show how the given strip bends and cools. Due to heating the copper bends more than invar due to high coefficient of linear expansion of copper.

Solution 5:

Thermostat is a device for regulating temperature in electric circuits and it is made up of bimetallic strip. Two applications of thermostat are in electric iron and in refrigerators.

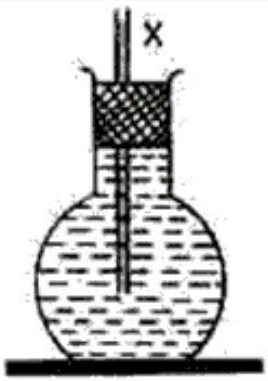
Solution 6:

When heated, water expands normally but behavior of water is unusual over a small range of temperature between 0 and 4°C. This is known as anomalous expansion of water.

Solution 7:

Anomalous expansion of water slows down the complete freezing of water in the lake.

Solution 8:



The level will rise above X when the flask is kept in hot water bath because the water in the flask will heat up and expand in volume thus raising the level of water in the tube above X

Solution 9:

- When boiling water is poured into a glass bottle, it generally cracks because on pouring hot water in the bottle the inner surface heats up and expands more as compared to its outer surface. This unequal expansion between the two surfaces causes a strain and the bottle cracks.
- Telephone wires sag in summer because due to heat of the sun, the wire expands and increases in length, thus they sag in summer.
- In cold countries water pipes burst in winter because the water has maximum density at 4°C and, due to anomalous expansion of water, it expands when the water is

cooled to a temperature below 4°C

- Even when the water in the lakes is frozen, fishes can survive due to anomalous expansion of water, water has maximum density at 4
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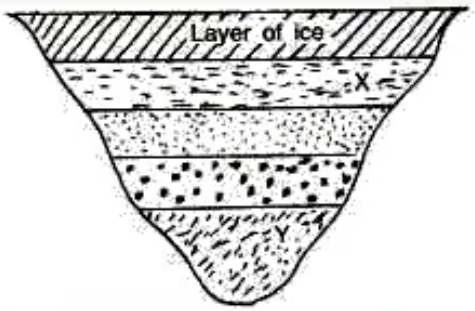
Solution 10:

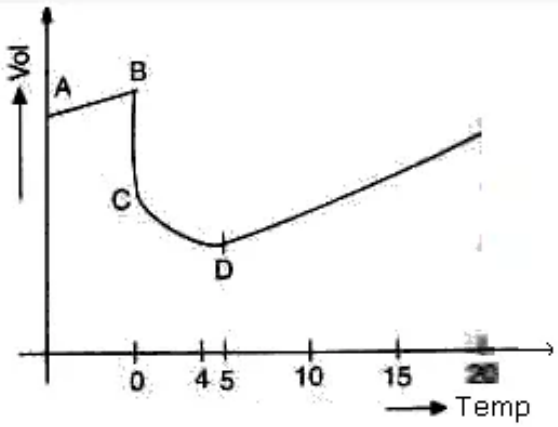


The layer at the top level is ice so its temperature is therefore 0°C and temperature at every layer of water below ice increases by 1°C

(i) At X = 1°C since it is the first layer below ice

(ii) At Y = 4°C since it is the fourth layer below ice

Solution 11:



(i) At BC temperature is constant because at 0° C all of the heat given is used in process of formation of water from ice and no part of heat is used in changing the temperature of ice.

(ii) At point D i.e. at 4°C the volume of water is minimum

(iii) At point D i.e. at 4°C, the density of water is maximum due to anomalous expansion of water in the temperature range of 0°C and 4°C as volume decreases, density of water increases

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Solution 12:

- Maximum
- Increases; decreases
- Coefficient; expansion
- Anomalous expansion of water
- Calorie
- Kelvin(K)

Solution 13:

We should heat the neck of the bottle because due to heating the neck will expand and loosen the stopper stuck in the neck. In this way, we can easily remove the stopper.

Solution 14:

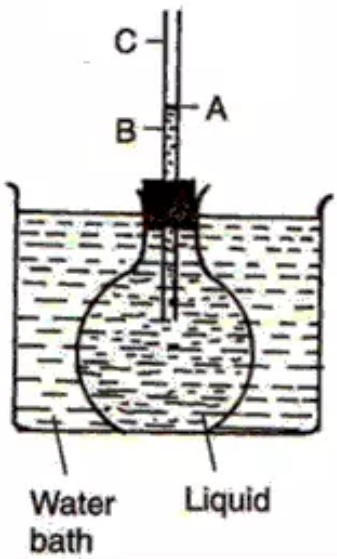
When a liquid is heated in a flask. Due to heat, the flask expands along with the liquid, thus providing more space for the liquid. Hence the level of the liquid falls. Thus this dropped level shows the apparent expansion of the liquid. The actual expansion of the liquid, when heated, is the real expansion.

Solution 15:

No, the both liquids i.e. mercury and alcohol will not have same volume on heating as they have different coefficient of expansions, thus they expand differently on heating at same temperature range. Alcohol expands more than mercury.

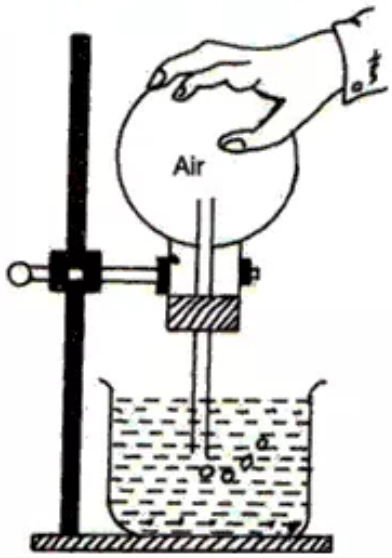
Solution 16:

Fill a round bottom flask with a coloured liquid up to the brim. Fit it with a one holed cork and pass a narrow glass tube through it. Mark the level of the liquid in the glass tube. Place the flask in a water bath and heat the bath. You will see that the level of liquid of water rises in the glass tube. This is due to the expansion of the liquid on heating.



Solution 17:

Take a round bottom flask which is filled with air and closed with a one holed rubber cork. A narrow capillary tube is passed through the cork and the flask is supported on a tripod in an inverted position as shown in the figure, so that the end of the capillary tube is under water. Now, heat the flask gently with a spirit lamp. You will observe bubbles coming out from the capillary tube. This shows that gases expand on heating.



Solution 18:

A hot glass chimney often crack when a drop of water falls on it because the glass of the chimney expands due to constant heating by the flame of the chimney but as a cooler

water drop falls on the glass, the outer surface contracts more than the inner side of the glass. . This unequal contraction between the two surfaces causes a strain and the glass cracks.

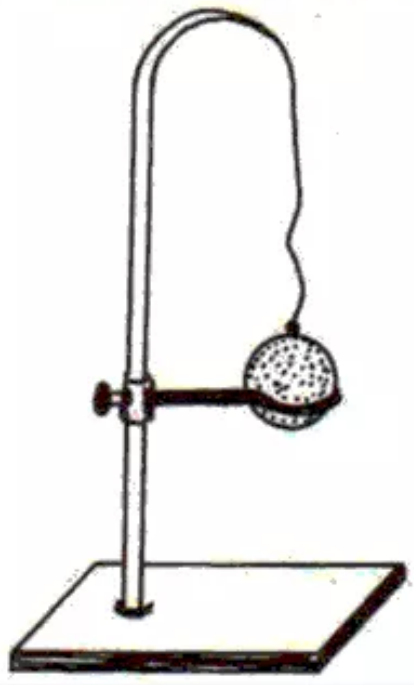
Solution 19:
No, we cannot fuse iron wire in glass rod because glass is bad conductor of heat and it does not allow heat to pass through it and iron wire would not be able to get sufficient heat to fuse.

Solution 20:
We should heat the neck of the bottle because due to heating the neck will expand and loosen the stopper stuck in the neck. In this way, we can easily remove the stopper from the bottle.

Solution 21:
Two substances that expand on heating are water and iron.

Solution 22:
Two substances that contract on heating are plastic and poly-ethene.

Solution 23:
Take a ball and ring apparatus as shown in figure. At room temperature, the ball can just pass through the ring. Now heat the ball over a flame and try to pass it through the ring. You will find that the ball when heated is not able to pass through the ring. The diameter of the ball increases when the ball is heated. This shows the expansion of solid on heating.



Solution 24:
The joints in metal pipes loosen in summers because the joints get more space to expand due to the heat in summers as compared to the pipes therefore the joints become loose in summers

Solution 25:
The increase in length of a rod depends on the following factors

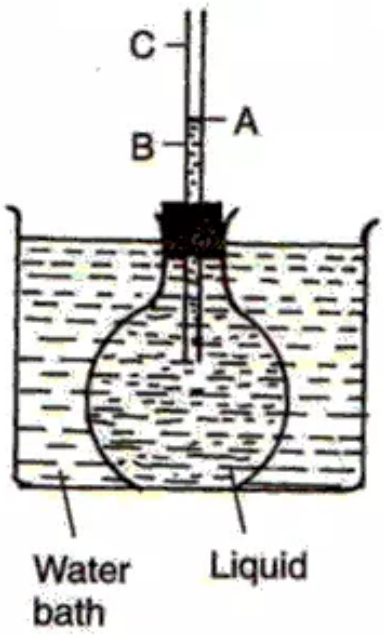
- material of the rod
- Original length of the rod
- Rise in temperature

Solution 26:
The given statement states that the change in length of the metal will be 0.000016 m when its temperature changes by 1°C.

Solution 27:
On heating the copper washer

- Its internal diameter will increase as the copper washer expands outwards
- Volume will increase as the size of the metal expands on heating
- Mass will remain the same as the mass does not change with change in temperature
- Density will decrease as the volume of the washer increases on heating and density is inversely proportional to volume
- External diameter will increase because the copper washer expands outwards

Solution 28:
Fill a round bottom flask with a coloured liquid up to the brim. Fit it with a one holed cork and pass a narrow glass tube through it. Mark the level of the liquid in the glass tube as A. Place the flask in a water bath and heat the bath. You will see that the level of liquid of water starts falling to level B and then it rises to level C. In this, AC is the apparent expansion and is due to expansion of the flask due to heating which provides more space for the liquid. Hence the level of liquid drops. As soon as the liquid also starts getting heated up, it expands and the level of liquid rises. BC is the real expansion. So the actual expansion of the water is sum of AC and AB



Solution 29:

At 4°C, water has the maximum density due to anomalous expansion.

Solution 30:

It can be seen from the graph that the volume of the water decrease from 0°C to 4°C and the volume is minimum at 4°C. After 4°C the volume increases with the increase in temperature.