

6. Heat Transfer

- Heat is a form of energy. When two bodies are in contact heat flows from body at higher temperature to body at lower temperature till the lower temperature of both is same.
- When a body is heated, its molecules move faster about their means position and kinetic energy increases and with fall in temperature their K.E. decreases.
- When a substance is heated
 - (i) It expands i.e. a change in size takes place
 - (ii) Change in temperature takes place.
 - (iii) Change in state takes place.
- **CHANGE OF STATE** : “The process of change from one state to another at a constant temperature is called change of state.”
- Solid on heating changes into LIQUID. LIQUID on absorbing heat changes to VAPOURS some SOLIDS on heating DIRECTLY change in vapours called SUBLIMATION. Substance is called SUBLIMATE.
SOLIDIFICATION on cooling when a vapours change into SOLID. GAS OR VAPOURS on cooling $\xrightarrow{\text{Condensation}}$ changes to LIQUID also called LIQUIFACTION.
- MELTING: Change of solid into liquid at constant temperature. FUSION \Rightarrow FREEZING is change of LIQUID into SOLID at constant temperature and change of solid into liquid at a constant _ temperature is called FUSION.
- EVAPORATION: “Change liquid to gas at ALLTEMPERATURES” It is surface phenomenon. “
- VAPOURIZATION : “Change of liquid into vapours at fixed temperature”.
- METING POINT: “Is the temperature at which a solid starts melting and remains constant till the whole of solid melts.”
M.P. is same as freezing point.
M.P. of ice is 0°C or freezing point, of water is 0°C .
- BOILING POINT: “Is the temperature of a liquid at which it start, boiling i.e. change into vapours or gaseous state.”
B .P. of pure water is 100°C .
- ABSOLUTE ZERO: “The temperature at which molecular motion completely ceases.”
- FACTORS EFFECTING THE RATE OF EVAPORATION :
 - (i) Temperature: Increases with increase in temperature
 - (ii) S.A.: Increases with increase in S.A.
 - (iii) BLOWING AIR—Renewal of air increases evaporation.
 - (iv) NATURE—Some liquids like spirit, alcohol, petrol evaporate easily.
- EVAPOURATION \rightarrow produces coolness, BOILING produces Hotness.
- LINEAR EXPANSION: When a solid rod (metal) is heated change in length takes place, which depends upon
 - (i) original length (L_0)
 - (ii) Increase in temperature
 - (iii) Material of rod.Let L_0 be the original length at 0°C , when heated to $T^{\circ}\text{C}$ final length becomes L
Increase in length ($L_t - L_0$) a $L_0 (T - 0)$

Or

Coefficient of linear expansion α which depends upon material of rod.

$$L_t - L_0 = L_0 \alpha T$$

$$\alpha = \frac{L_t - L_0}{L_0 T} = \text{increase in length} / \text{original length} \times \text{Rise in temperature}$$

- When a metal plate is heated, change in area takes place and the expansion is called SUPERFICIAL expansion.
- When a solid of volume v_0 is heated change in volume called cubical expansion takes place.
- $\alpha : \beta : \gamma = 1 : 2 : 3$

Test your self

A. Objective Questions

1. Write true or false for each statement

(a) Evaporation is rapid on a wet day.

Answer. False.

(b) Evaporation takes place only from the surface of liquid.

Answer. True.

(c) All molecules of a liquid take part in the process of evaporation.

Answer. False.

(d) Temperature of a liquid rises during boiling or vaporization

Answer. False.

(e) All molecules of a liquid take part in boiling.

Answer. True.

(f) Boiling is a rapid phenomenon.

Answer. True.

(g) All solids expand by the same amount when heated to the same rise in temperature.

Answer. False.

(h) Telephone wires are kept tight between the two poles in winter.

Answer. True.

(i) Equal volumes of different liquids expand by the different amount when they are heated to the same rise in temperature.

Answer. True.

(j) Solids expand the least and gases expand the most on being heated.

Answer. True.

(k) A mercury thermometer makes use of the property of expansion of liquids on heating.

Answer. True.

(l) Kerosene contracts on heating.

Answer. False.

2. Fill in the blanks

(a) Boiling occurs at a **fixed temperature**.

(b) Evaporation takes place at **all temperature**.

(c) The molecules of liquid **absorb** heat from surroundings in evaporation.

(d) Heat is **absorbed** during boiling.

(e) Cooling is produced in **evaporation**.

(f) A longer rod expands **more** than a shorter rod on being heated to the same temperature.

(g) Liquids expand **more** than the solids.

(h) Gases expand **more** than the liquids.

(i) Alcohol expands **more** than water.

(j) Iron expands **less** than copper.

3. Match the following

Column A	Column B
(a) Blowing air increases	(i) increase in inter-molecular separation
(b) Increase in pressure increases	(ii) pendulum of a clock
(c) Thermal expansion	(iii) cooking utensils
(d) Invar	(iv) boiling point
(e) Pyrex glass	(v) evaporation

Column A	Column B
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(e) Pyrex glass	(iii) cooking utensils

4. Select the correct alternative

(a) In evaporation

1. all molecules of liquid begin to escape out
2. **only the molecules at the surface escape out**
3. the temperature of liquid rises by absorbing heat from surroundings.
4. the molecules get attracted within the liquid.

(b) The rate of evaporation of a liquid increases when :

1. temperature of liquid falls

2. liquid is poured in a vessel of less surface area
3. **air is blown above the surface of liquid**
4. humidity increases.

(c) During boiling or vaporization

1. **all molecules take part**
2. temperature rises
3. no heat is absorbed
4. the average kinetic energy of molecules increases.

(d) The boiling point of a liquid is increased by

1. increasing the volume of liquid
2. **increasing the pressure, on liquid**
3. adding ice to the liquid
4. decreasing pressure on liquid.

(e) Two rods A and B of the same metal, but of length 1 m and 2 m respectively, are heated from 0°C to 100°C . Then

1. both the rods A and B elongate the same
2. the rod A elongates more than the rod B
3. **the rod B elongates more than the rod A**
4. the rod A elongates, but the rod B contracts.

(f) Two rods A and B of the same metal, same length, but one solid and the other hollow, are heated to the same rise in temperature.

Then

1. the solid rod A expands more than the hollow rod B
2. the hollow rod B expands more than the solid rod A
3. the hollow rod B contracts, but the solid rod A expands
4. **both the rods A and B expand the same.**

(g) A given volume of alcohol and the same volume of water are heated from the room temperature to the same temperature then.

1. alcohol contracts, but water expands
2. water contracts, but alcohol expands
3. water expands more than alcohol
4. **alcohol expands more than water.**

(h) The increase in length of a metal rod depends on

1. the initial length of the rod only
2. the rise in temperature only
3. the material of rod only
4. **all the above three factors.**

(i) The correct statement is

1. Iron rims are cooled before they are placed on the cart wheels.
2. A glass stopper gets tighten on warming the neck of the bottle.
3. Telephone wires sag in winter, but become tight in summer.
4. **A little space is left between two rails on a railway track.**

B. Short/Long Answer Questions

Question 1.

What is matter ? What is it composed of

Answer:

MATTER: Anything around us is a matter.

“Anything that has mass, occupies volume and can be felt by our senses.”

It is composed of ‘molecules’.

Question 2.

Name the three states of matter and distinguish them on the basis of their (i) volume, and (ii) shape

Answer:

THREE STATES OF MATTER:

(i) SOLID (ii) LIQUID (iii) GASEOUS

DISTINCTION BETWEEN THREE STATES ON THE BASES OF .

(i) VOLUME:

SOLIDS : have least volume.

LIQUIDS: have definite volume.

GASES: have maximum volume.

(ii) SHAPE:

SOLIDS: Have definite shape.

LIQUIDS : Have no definite shape.

GASES : Have no definite shape.

Question 3.

Distinguish between liquid and vapour (or gas) states of matter on the basis of following factors

- (a) Arrangement of molecules
- (b) Inter-molecular separation
- (c) Inter-molecular force, and
- (d) Kinetic energy of molecules

Answer:

Ans. DISTINCTION BETWEEN LIQUID AND VAPOUR ON THE BASES OF:

	LIQUID	VAPOUR
(a) Arrangement of molecules	Closely packed	Very losely packed
(b) Inter molecular separation	Least	Maximum
(c) Inter molecular force	Maximum	Least
(d) Kinetic energy of molecules	Least	Maximum

Question 4.

What is evaporation ? Explain it on the basis of molecular motion.

Answer:

EVAPORATION : "The change of liquid into its vapours at all temperature from its surface is called evaporation."

EXPLANATION OF EVAPORATION on the bases of molecular motion:

Molecules of liquid have more spaces, less molecular force of attraction and more K.E. than molecules of solids and can move through out the liquid.

While moving they can not escape the surface as they are being pulled inside by other molecules as there are no molecules above the surface. But when some molecules acquire sufficient K.E. (Threshold velocity), they over come the ATTRACTIVE FORCES of other molecules and escape into the open space above the liquid. These escaping molecules form the vapour of the liquid and the process called Evaporation continues till all the liquid evaporates.

Question 5.

Do all the molecules of a liquid take part in evaporation ? If not, explain your answer.

Answer:

No, all the molecules of the liquid do not take part in evaporation only those molecules near the surface of liquid which acquire sufficient Kinetic energy (Threshold velocity) escape as they over come attractive forces of other molecules. Then other molecules come to the surface of the liquid and acquire more K.E. and escape the surface. This continues till all the liquid evaporates.

Question 6.

No heat is supplied to a liquid during evaporation. How does then the liquid change into its vapours ?

Answer:

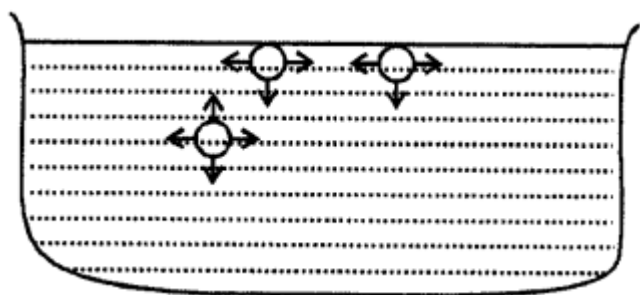
Though no heat is supplied to the liquid but molecules near the surface of the liquid acquire sufficient kinetic energy by collisions with other liquid molecules and with this K.E. they overcome the attractive forces of other molecules and change into vapours.

Question 7.

Comment on the statement 'evaporation is a surface phenomenon'.

Answer:

Change of liquid into vapours at all temperatures from the surface is called evaporation. Evaporation takes place at surface in those molecules which are at surface and have sufficient K.E. to overcome attractive force due to inner surrounding molecules.



Question 8.

Why is cooling produced when a liquid evaporates ?

Answer:

For changing liquid into vapours heat is needed this heat is taken from the container or surroundings and temperature of container or body itself fall and cooling is produced.

Question 9.

Give reason for the increase in rate of evaporation of a liquid when

- (a) air is blown above the liquid
- (b) surface area of liquid is increased
- (c) temperature of liquid is increased.

Answer:

(a) BLOWING AIR ON LIQUID SURFACE INCREASES RATE OF EVAPORATION :

Blowing air takes away with it the molecules of liquid escaping out of the surface. To take their place, other molecules escape out from the surface of liquid.

(b) SURFACE AREA INCREASES THE RATE OF EVAPORATION: On increasing the area of the surface, number of molecules escaping out from the surface increases.

(c) INCREASE IN TEMPERATURE INCREASES THE RATE OF EVAPORATION:

Increase in temperature increases K.E.

(K.E = $\frac{1}{2} Mv^2$). More and more molecules come to the surface of liquid hence the rate of evaporation will increase with increase in temperature.

Question 10.

What is boiling ? Explain it on the basis of molecular motion?

Answer:

BOILING: "The change of liquid to vapours on heating at a constant temperature is called BOILING"

$K.E = \frac{1}{2} Mv^2$: more the speed of molecules more is the kinetic energy. Heating of the liquid increases the average K.E. of liquid molecules and molecules acquire sufficient K.E. needed to overcome the force of attraction of other molecules. These molecules start leaving the liquid not only at the surface but also near the walls of the containing vessel and bubbles are seen on the walls of vessel. This causes the agitation in the whole of the liquid and this is called boiling.

Question 11.

Why does bubbles appear when a liquid is heated ?

Answer:

When liquid is heated formation of vapours takes place which appear in the form of bubbles.

Question 12.

What is the change in average kinetic energy of molecules of a liquid during boiling at its boiling point ?

Answer:

AVERAGE KINETIC ENERGY is the measure of temperature of body. When temperature of body increases the average kinetic energy increases and when Average Kinetic energy decreases there is decrease of body temperature and hence at boiling point average Kinetic energy increases.

Question 13.

How is the heat energy supplied to a liquid used during boiling at a fixed temperature ?

Answer:

When heat is supplied, temperature of liquid rises continuously till the water starts boiling at 100°C. Once the water starts boiling, its temperature does not rise further, although heat is still being supplied. This heat is being used to change each and every water molecule into vapour.

Question 14.

Name two ways of change of liquid state to the vapour state and distinguish them.

Answer:

Two ways of change of liquid state to vapour state are:

- (i) Evaporation
- (ii) Boiling.

DIFFERENCE BETWEEN EVAPORATION AND BOILING:

BOILING	EVAPORATION
(i) Heat is supplied.	Heat is absorbed.
(ii) Fast process.	Slow process.
(iii) Starts from bottom.	Starts from surface <i>i.e.</i> surface phenomenon
(iv) Sound is produced.	Silent process
(v) Heating effect	Cooling effect
(vi) Takes place at a fixed temperature called boiling point.	Takes place at all temperatures.

Question 15.

What do you understand by thermal expansion of a substance ?

Answer:

The expansion of a substance on heating is called the thermal expansion of the substance.

Question 16.

Give two examples of the substances which expand on heating.

Answer:

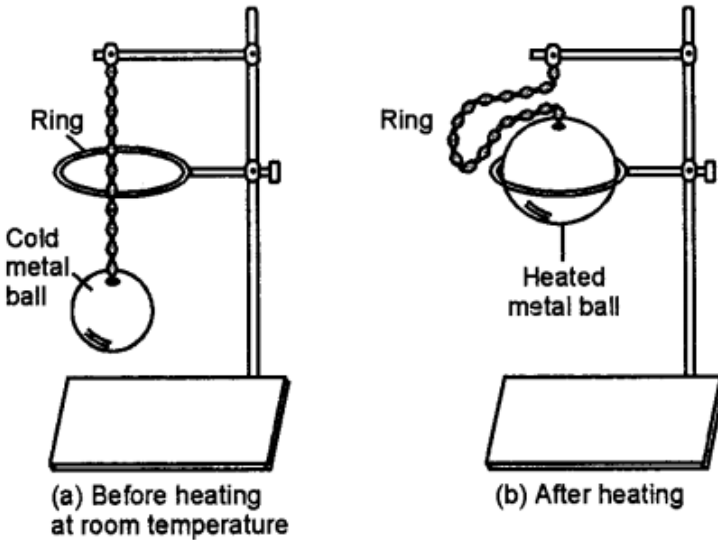
Iron, water expand on heating.

Question 17.

Describe an experiment to demonstrate the thermal expansion in solids.

Answer:

Experiment: [Gravesand's ball and ring experiment]



Take metallic ball and ring so that ball can pass through ring easily. Now heat the ball. We see that heated ball cannot pass through the same ring. This is because on heating the ball increases in size. Now on cooling the ball again it can pass through the ring. This experiment shows that solids expand on heating and contract on cooling.

Question 18.

State three factors on which depend the linear expansion of a metal rod on heating.

Answer:

Factors on which increase in length of a rod depend when heated are:

- (1) Length of rod L . Increase in length is directly proportional to original length.
- (2) Temperature of rod. It is directly proportional to increase in temperature.
- (3) Nature of material of rod.

If L_1 is original length of rod at t_1 °C and on heating to t_2 °C its length becomes L_2 .

∴ Increase in length of rod = $(L_2 - L_1)$

and increase in temperature $(t_2 - t_1)$

∴ $[L_2 - L_1] \propto L_1(t_2 - t_1)$

But the increase in length of rod does not depend on whether the rod is solid or hollow.

Question 19.

Two iron rods – one 10 m long and the other 5 m long, are heated to the same rise in temperature. Which will expand more ?

Answer:

$L_t - L_0 \propto L_0$

∴ The rod having greater length will expand more when rods are heated to the same temperature.

∴ Rod with 10 m length will expand more.

Question 20.

Two identical rods of copper are heated to different temperatures — one by 5°C and the other by 10°C. Which rod will expand more ?

Answer:

Two rods with same length and material are heated to different temperature.

$$L - L_0 \propto \Delta t$$

∴ Rod with higher temperature i. e. at 10°C will expand more.

Question 21.

One rod of copper and another identical rod of iron are heated to the same rise in temperature. Which rod will expand more? Give reason.

Answer:

When two identical rods (same length) are of different material and heated to same rise in temperature, the copper rod will expand more than iron, since expansion depends on nature of material.

(Coefficient of linear expansion of copper 17×10^{-6} per °C > iron 13×10^{-6} per °C)

Question 22.

Two identical rods—one hollow and the other solid, are heated to the same rise in temperature. Which will expand more ?

Answer:

When two identical rods are heated to the same range of temperature, solid rod will expand more.

v More heat is present in solid rod.

Question 23.

In the ball and ring experiment, if the ball after heating is left to cool on the ring for some time, the ball again passes through the ring. Explain the reason.

Answer:

On heating the ball expands and increases in size and cannot pass the ring when left on it. As the ball cools, it contracts, size becomes less than ring and passes the ring.

Question 24.

Explain the following:

- (a) The telephone wires break in winter.
- (b) Iron rims are heated before they are fixed on the wooden wheels.
- (c) The gaps are left between the successive rails on a railway track.
- (d) A glass stopper stuck in the neck of a bottle can be removed by pouring hot water on the neck of the bottle.
- (e) A cement floor is laid in small pieces with gaps in between.

Answer:

(a) Metals expand on heating (in summer) and contract on cooling (in winter). Therefore while putting up the wires between two poles, care is taken that they are kept tight while laying them in winter as they sag in summer due to expansion.

(b) Iron rims are made slightly smaller in diameter than the wooden wheel and on heating wheel expands and can easily slip over the wooden wheel and on cooling the rim contracts and MAKES A TIGHT FIT OVER the wooden wheel.

- (c) In summer due to considerable rise in temperature, the gaps allow for the expansion of rails, otherwise the rail will bend side ways.
- (d) By pouring hot water on the neck of the bottle, the neck expands and stuck glass stopper can easily be removed.
- (e) In summer when temperature rises small pieces of cement expand and to allow expansion gaps are left between small pieces.

Question 25.

Why is one end of a steel girder in a bridge kept on rollers instead of fixing it in pillar ?

Answer:

In summer when temperature increases considerably the bridge made of metal expands and rollers slide to allow for expansion otherwise the bridge may break the pillar.

Question 26.

A metal plate is heated. State three factors on which the increase in its area will depend.

Answer:

THREE FACTORS ARE:

- (i) Original area of plate A_0 .
- (ii) Rise in temperature t .
- (iii) Nature of material of plate.

Question 27.

A cubical metal solid block is heated. How will its volume change ?

Answer:

When a solid is heated, it expands in all directions. The volume of a cube also increases.

Let V_0 be the volume of cube of side L_0 at 0°C . i.e. $V_0 = L_0^3 - V$

When temperature increases to $t^\circ\text{C}$ each side increases to V_t

$$\therefore V_t = L_t^3$$

$$\text{Increase in volume} = (V_t - V_0) [L_t^3 - L_0^3]$$

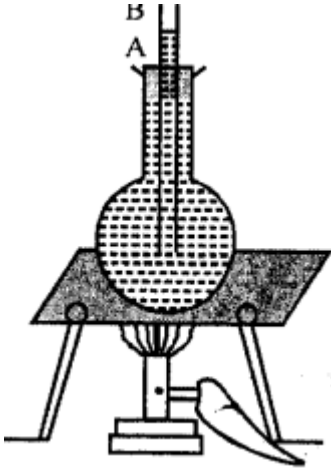
$$\text{Increase in temperature} = (t - 0)^\circ\text{C} = t^\circ\text{C}$$

Question 28.

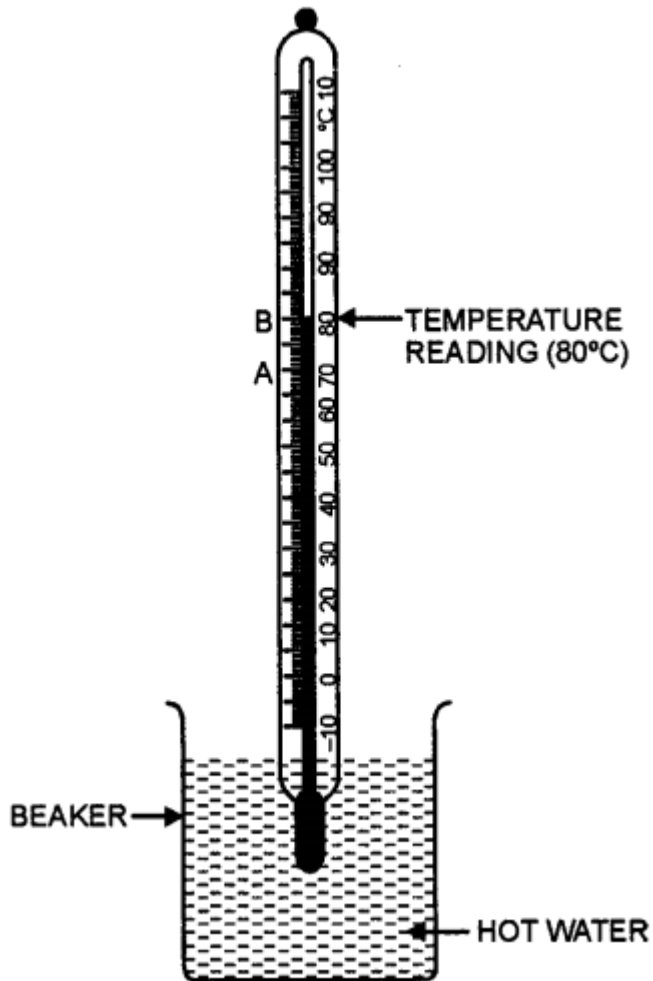
Describe an experiment to show that liquids expand on heating.

Answer:

Experiment. Take round bottomed flask filled with water. Close its mouth with air-tight cork having delivery tube through it. Mark the level of water. Let it be at A. Now heat the flask. As water gets heated in flask, the level of water in the tube rises from A to B. This proves that liquids expand on heating.



OR Experiment : Take a laboratory Celsius thermometer. Suspend it with the help of a stand. Note the level of mercury thread in it. Let it be at A. Now take hot water in a beaker and as shown, set up the arrangement. The mercury thread rises to B by gaining temperature. This shows that liquids expand on heating.



Question 29.

State one application of thermal expansion of liquids.

Answer:

APPLICATION OF THERMAL EXPANSION OF LIQUIDS : An important application is mercury thermometer or alcohol thermometer.

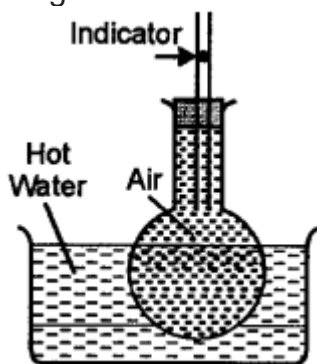
When the bulb of the thermometer is kept in contact with a hot body the mercury expand and the level of mercury rises in the capillary tube.

Question 30.

Describe an experiment to show that air expands on heating.

Answer:

Take a glass flask bottomed flask. Close its mouth with a cork having capillary tube containing indicator visible in the tube as shown. Make it air tight. Place the flask in hot water. After few minutes, we see the indicator moving up. This happens because air inside the flask expands with rise in temperature. This proves that gases expand on heating.



Question 31.

An empty glass bottle is fitted with a narrow tube at its mouth. The open end of the tube is kept in a beaker containing water. When the bottle is heated, bubbles of air are seen escaping into water. Explain the reason.

Answer:

When the bottle is heated, air in it expands and escapes the water in the form of bubbles.

Question 32.

Which of the following will expand more, when heated to the same temperature : (a) solid (b) liquid and (c) gas ?

Answer:

(c) Gas will expand more as the inter-molecular force of attraction in gas molecules is least and K.E. is maximum.

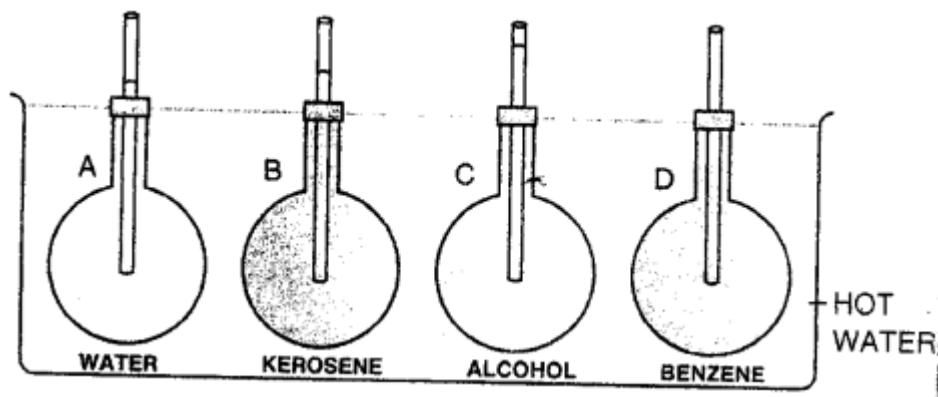
Question 33.

Describe an experiment to show that same volume of different liquids heated to same

rise in temperature expand by different amounts.

Answer:

CUBICAL EXPANSION OF DIFFERENT LIQUIDS IS DIFFERENT:



Experiment: Take four identical glass flasks each fitted with a narrow glass tube through a cork at its mouth. Fill flask A with water, B with kerosene, C with alcohol and D with Benzene. So that volume of each is same i.e. to the same level and their levels are visible above hot water bath. Put enough hot water in hot-water-bath. So that each flask is in the hot water. After some time we will see that different liquids rise to different levels. Water expands the least and benzene the most. This shows that different liquids of same volume expand by different amount.

Question 34.

100 ml of each of the following liquid is heated from 10°C to 50°C. Which will expand more : (a) water (b) benzene (c) alcohol ?

Answer:

100 ml. of each means same volume of each liquid heated 10°C to 50°C means same rise in temperature.

Hence, Benzene will expand more Water will expand least.

Question 35.

Water is heated from 0°C to 4°C. Will it expand ?

Answer:

Substances expand on heating.

But WATER—CONTRACTS with heated from 0°C to 4°C. After that i.e. above 4°C water starts expanding.

Question 36.

What do you mean by anomalous behaviour of water ?

Answer:

Substances when heated expand. Their density $[\frac{m}{v}]$ decrease. But in case of water: When water is heated from 0°C to 4°C it CONTRACT and density INCREASE, heating water above 4°C starts expanding and density of water decrease.

This means water has maximum density at 4°C. This is called anomalous behaviour of water.

Question 37.

How does the density of a substance (solid, liquid and gas) change on heating ?

Answer:

Density = Mass / Volume

In case of SOLIDS, when temperature is increased, increase in volume is very small and decrease in density is not appreciable. In case of LIQUIDS and GASES, as the temperature increases, volume increases by an appreciable amount and therefore decrease in their density is quite considerable.

Question 38.

An iron washer is heated. State the effect on its (i) mass, (ii) internal diameter, (iii) external diameter, and (iv) density.

Answer:

- (i) Mass remains same on heating.
- (ii) Internal diameter increases.
- (iii) External diameter increases.
- (iv) Density decreases.