PHYSICS KNOWLEDGEBASE

2020

# THERMAL EXPANSION


TEACHERS OF PHYSICS

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11/8/2020

**1.** Define temperature and give its **SI** unit.

- ✓ ***It is the degree of hotness or coldness of a body***
- ✓ ***SI unit is Kelvin***

**2.** Distinguish between **heat** and **temperature**

- ✓ ***Temperature is the degree of hotness or coldness of a body while Heat is a form of energy that flows from hot to cold object.***

**3.** Convert **-40.3$^{o}$C** to Kelvin

- ✓ ***-40.3 + 273 = 232.7***

## EXPANSION IN SOLIDS

**1.** State and explain **two** application of expansion and contraction of solids

- ✓ ***Telephone wires - they are loosely fixed to allow for contraction. During cold weather they contract and when it is warm, they expand.***
- ✓ ***Steam pipes - pipes carrying steam from boilers are fitted with loops or expansion joints. They allow the pipes to expand and contract easily.***
- ✓ ***Rivets - metals plates are joined together by rivets. They are fitted when hot and then hammered flat. On cooling it contacts pulling the two metals firmly together.***
- ✓ ***Bimetallic strip - it is applied in the thermostat to control room temperature through.***

**2.** State **two** quantities on which expansion on heating of a metal depends.

- ✓ ***nature of the material.***
- ✓ ***Temperature difference.***

**3.** In a ball and ring experiment, the ball goes through the rings at room temperature. When it is heated it does not go through the ring, but when left on the ring for some time, it goes through. Explain this observation

- ✓ ***When the ball is heated it expands and that is why it does not go through the ring.***
- ✓ ***When it is left for some time it cools and contracts.***
- ✓ ***At the same time the temperature of the ring increases and it expands so that the ball goes through.***

**4.** State the reason why electricity transmission cables are left sagging between the posts.

- ✓ ***To allow room for contraction when it is cold***

**5.** Give a reason why a concrete beam reinforced with steel does not crack when subjected to changes in temperature.

- ✓ ***They have the same linear expansion rate.***

**6.** Explain why a glass container with thick glass walls is more likely to crack than one with a thin wall when a very hot liquid is poured into them.

- ✓ ***Due to non uniform expansion between the inner and the outer parts of the glass. The inner part expands more than the outer one.***

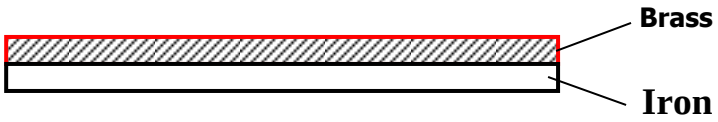
**7.** In an attempt to prepare a cup of tea, a student placed boiling water into a glass tumbler. The glass tumbler broke into pieces. Explain this observation.

- ✓ ***The inner parts of the tumbler are heated first and expand then the outer parts are heated later. This creates uneven expansion rates.***

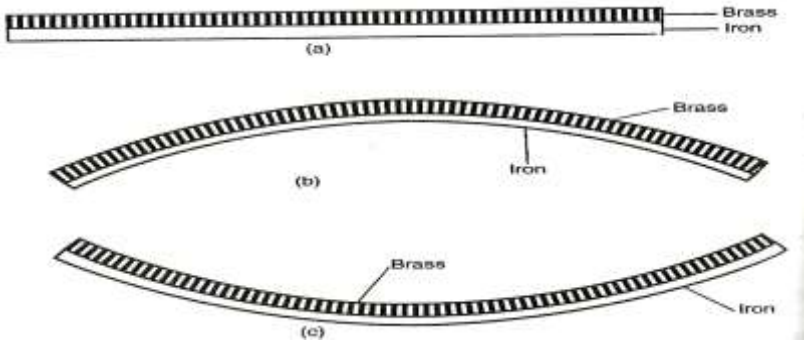
**8.** A piece of iron is heated. Explain what happens to its density.

- ✓ ***It expands hence increase in volume which in turn leads to decrease in density***

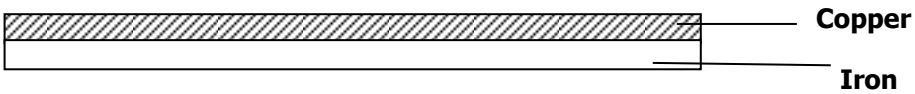
**9.** The diagram below shows a bimetallic strip at room temperature



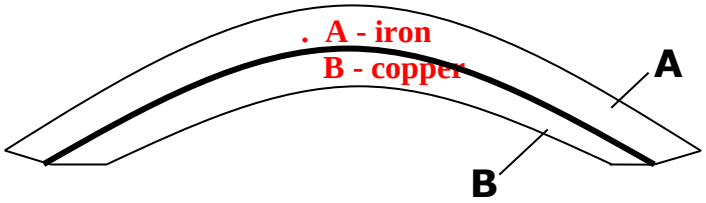
Sketch a diagram to show the appearance of the bimetallic strip when heated.



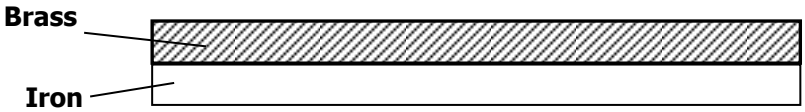

**10.** The figure below shows a bimetallic strip made of copper and iron at room temperature.




If copper expands more than Iron, identify **A** and **B** in the bimetallic strip if it is placed in a refrigerator whose temperature is **(- 70 °c )**



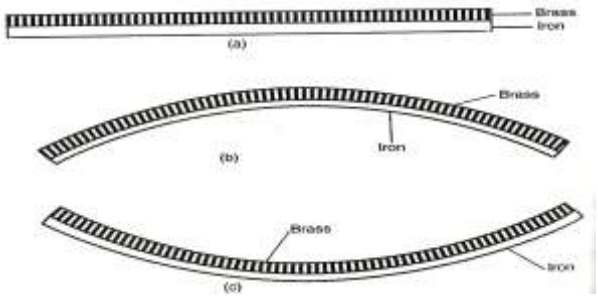

**11.** Figure below shows a bimetallic strip at room temperature.



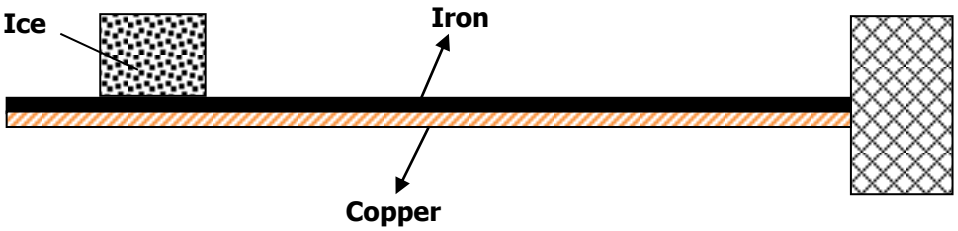

Draw the shape of the strip:

(i) When it is heated to **$80^0$C**.

(ii) When it is cooled to **$-10^0$C**.



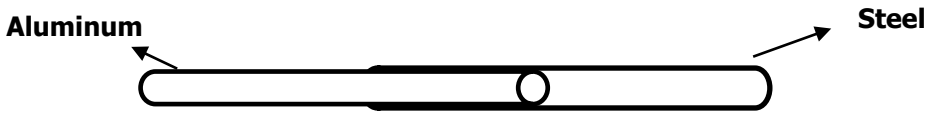
**12.** A cube of ice rests on a bimetallic strip at room temperature. The strip is made of iron and copper




State and explain what happens to the bimetallic strip.

✓ ***The ice will cool the bimetallic strip and copper will contract more than iron due to its low expansivity rate hence bending downwards.***

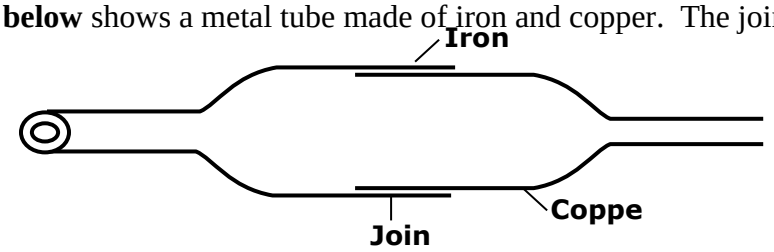
**13.** The figure below shows an aluminum tube tightly stuck in a steel tube.




Explain how the two tubes can be separated by applying a temperature change at the junction given that aluminium expands more than steel for the same temperature rise.

- ✓ ***Lowering the temperature at the junction. Aluminium will contract at a higher rate than steel hence becoming smaller. This will make it easy to separate.***

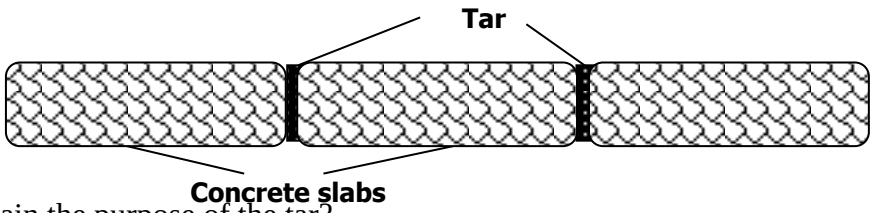
**14.** The diagram **below** shows a metal tube made of iron and copper. The joint is tight at room temperature.




Explain how you would separate the two by changing the temperature given that copper expands more than iron for some change in temperature. (2mks

- ✓ ***Lowering the temperature. Copper will contract at a higher rate hence it will become smaller than the iron. It becomes easy to separate.***

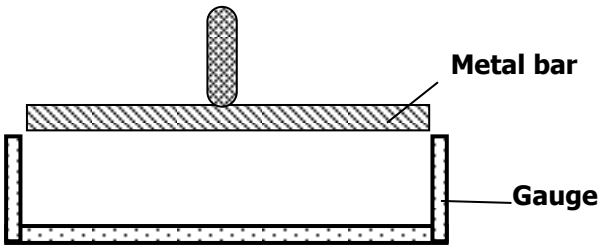
**15.** The figure below shows concrete road made of concrete slabs and gaps filled with tar.




State and explain the purpose of the tar?

- ✓ ***To allow room for expansion and contraction - when temperatures rise concrete slabs increase in length and when temperatures decrease they decrease in length.***

**16.** The figure below shows a metal bar that fits exactly in to the gauge at room temp. The metal bar is heated and then fitted into the gauge.



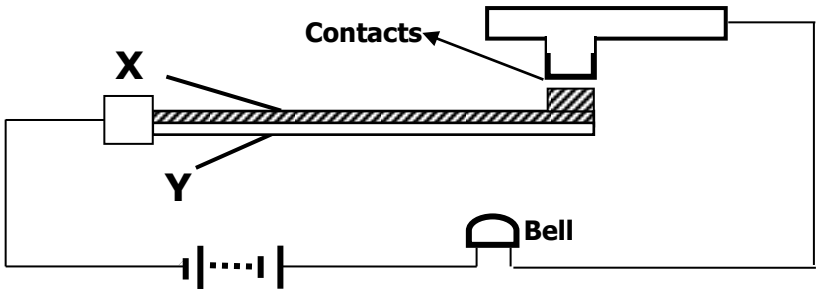

State and explain the observations made.

- ✓ ***When the bar is heated, it does not fit into the gauge. This is because the bar expands when heated.***

**17.** State and explain **two** applications of expansion and contraction of solids.

- ✓ ***Steam pipes - pipes carrying steam from boilers are fitted with loops or expansion joints. They allow the pipes to expand and contract easily***
- ✓ ***Rivets - metals plates are joined together by rivets. They are fitted when hot and then hammered flat. On cooling it contacts pulling the two metals firmly together***
- ✓ ***Bimetallic strip - it is applied in the thermostat to control room temperature through it***

**18.** The diagram below shows a model of fire alarm based on bimetallic strip. The strip is made of brass and iron.



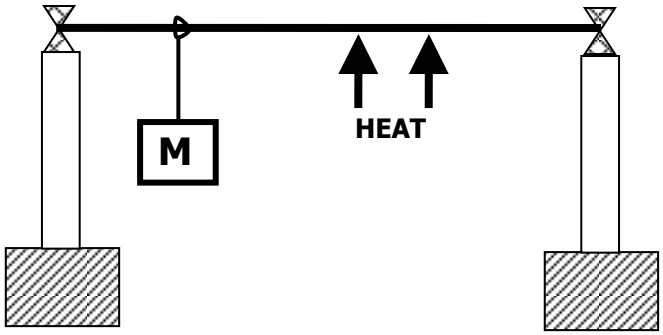

(i) Label the metal **X** and **Y**

- ✓ *X - iron*
- ✓ *Y - brass*

(ii) Describe how the fire alarm works.

- ✓ ***When fire breaks out, the temperatures around the bimetal rises and causes the bimetal strip to expand.***
- ✓ ***Brass expands more than iron and thus the strip bends upwards making contact with the contact.***
- ✓ ***This completes the circuit, current flows and thus the electric bell rings alerting one that there is fire.***

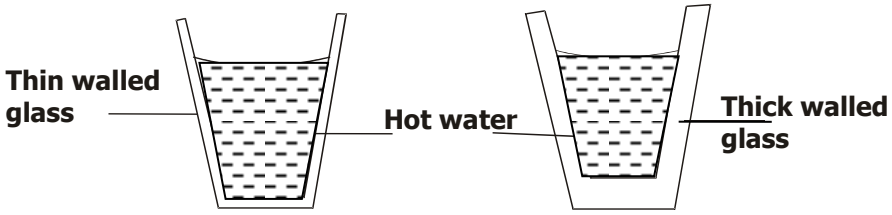
**19.** The mass M was suspended from a tight copper wire using a rider as shown. The copper wire was then heated.




**State** and **explain** what was observed on the position of M as the wire was heated for some time.

- ✓ ***The mass would slide towards the heating point because the when the copper is heated it expands and by gravity the mass moves towards the centre of the wire as it expands and increase in length.***

**20.** Figure below shows two glasses of different thickness.




Hot water was poured in both glasses. What is likely to be observed and why?

- ✓ ***The thick-walled glass broke while the thin walled glass didn't break.***
- ✓ ***The temperature difference between the outer and inner surface was more for the thick-walled glass.***

## EXPANSION IN LIQUIDS AND GASES

**1.** State one application of expansion in gases

- ✓ ***Bursting of car tyres when left in the sun for long time***

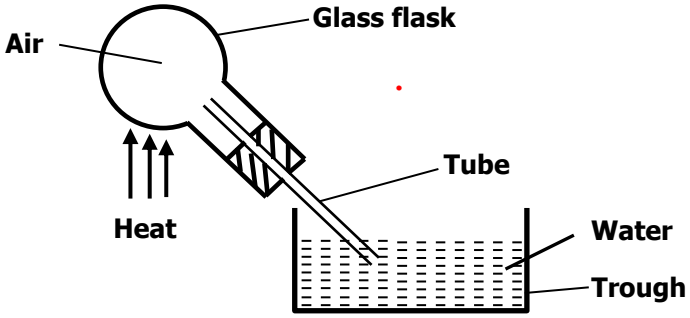
**2.** When a thermometer is immersed in ice cold water, the mercury thread is observed to rise before dropping steadily in the capillary tube. Explain.

- ✓ ***The initial fall of the level of the mercury is due to the expansion of the glass stem which gets heated first.***
- ✓ ***The mercury starts expanding when the heat finally reaches it and it rises up the capillary tube.***

**3.** A bottle of soda always has a space between the cap and the top of the liquid. Explain.

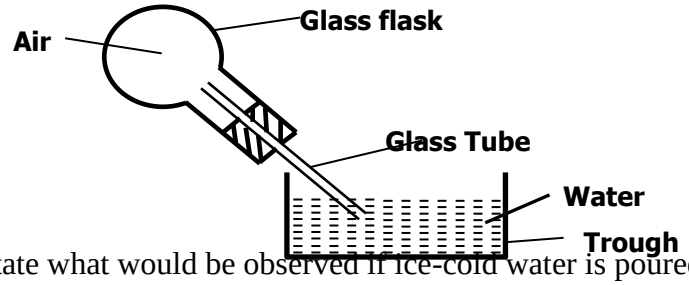
✓ ***To allow for expansion of the liquid when the temperatures goes up***

In the set up shown below, it is observed that the level of the water in the tube initially rises before starting to drop. Explain this observation.




✓ ***To allow for expansion of the liquid when the temperatures go up***

**4.** The diagram below shows a flask fitted with a glass tube dipped into a beaker containing water at room temperature. The cork fixing the glass tube is tight.



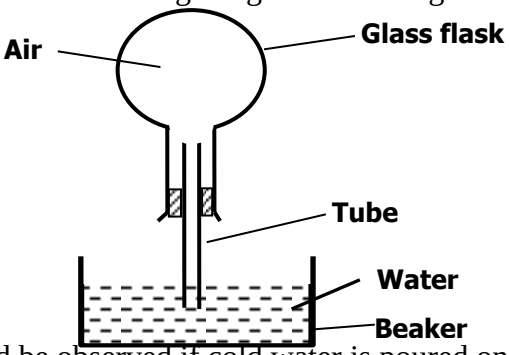

(i) State what would be observed if ice-cold water is poured on to the flask

✓ ***Water level in the glass tube dropped first then rose again***

(ii) Give a reason for the observation in (i) above

✓ ***when the ice-cold water is poured on the flask the air inside contracts creating pressure difference.***

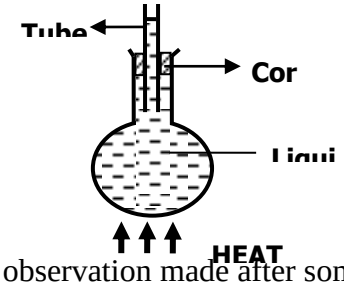
**5.** The diagram below shows a flask fitted with a glass tube dipped into a beaker containing water at room temperature. The cork fixing the glass tube is tight.




State with reason what would be observed if cold water is poured on to the flask.

✓ ***When the ice-cold water is poured on the flask the air inside contracts creating pressure difference.***

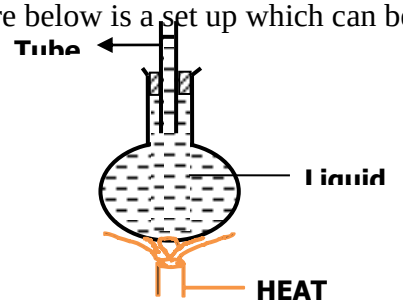
**6.** The figure below shows a set up used to study expansion of liquids




State and explain the observation made after some time

✓ **The water rises up the tube due to contraction of the air in the glass flask.**

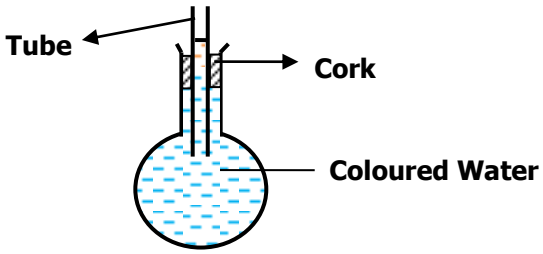
**7.** The system in the figure below is a set up which can be used to illustrate expansion of liquids.




State one way of modifying the apparatus so that the rise in level for a particular temperature change is increased

- ✓ ***Using a glass flask with thin wall to increase the sensitivity***

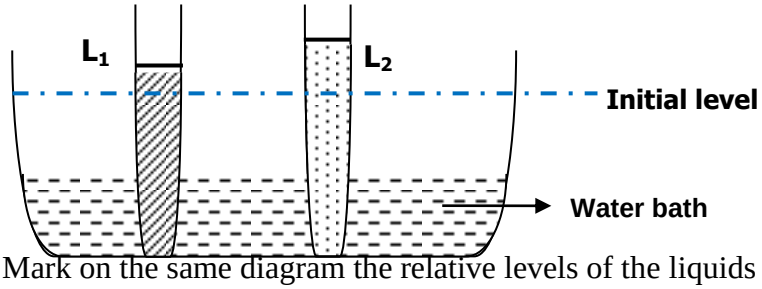
**8.** A round – bottom flask is filled with coloured water as shown in the diagram below.




When the flask is placed in ice cold water the level on water rose and then fell.
Explain this observation.

- ✓ **The flask contracts first reducing in volume and after sometime the coloured water also contracts reducing in volume hence the drop.**

**9.** The figure below shows the levels attained by two liquids $\mathbf{L_1}$ and $\mathbf{L_2}$ after the temperature has been raised. The liquids were initially at the same levels as shown. The tubes are identical and closed at the lower end



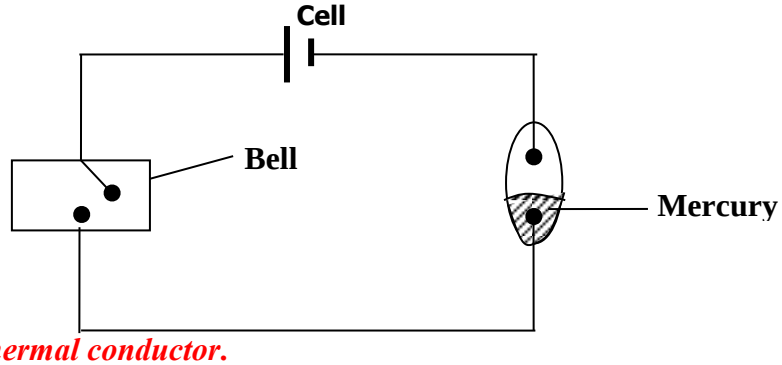

**(i)** Mark on the same diagram the relative levels of the liquids when the temperature is lowered below the initial value

- ✓ ***$L_2$ would be lower than $L_1$***

**(ii)** Give a reason for your answer

- ✓ ***$L_1$ seems denser than $L_2$ thus expands and contracts less compared to $L_2$.***

**10.** The diagram below shows circuit of a fire alarm. When fire breaks it rings the bell to alert people that there is fire. Name two properties of mercury that makes it suitable to be used.




- ✓ ***It's a good thermal conductor.***
- ✓ ***Expands regularly.***

## ANOMALOUS BEHAVIOUR

**1.** Give any two evidence of the unusual expansion of water.

- ✓ ***Floating of ice on water bodies the temperatures go down***
- ✓ ***Weathering of rocks***

**2.** Describe ONE advantage and ONE Disadvantage of anomalous behavior of water.

- ***Advantage;***
- ✓ ***Weathering of rocks***
- ***It enables aquatic life to survive in liquid layers below the ice when the temperatures are low.***
- ***Disadvantages;***
- ✓ ***Icebergs pose a great danger to ship as navigators cannot see the submerged part.***
- ✓ ***It leads to bursting of water pipes.***

**3.** State one biological importance of anomalous expansion of water

- ✓ ***It enables aquatic life to survive in liquid layers below the ice when the temperatures are low.***

Aquatic animals are observed to survive in frozen ponds. Explain this observation.

- ✓ ***Floating ice which is a poor conductor of heat acts as a shield against heat loss from the water below it.***

**4.** A certain substance contracts when heated at a certain temperature and expands when cooled at the same temperature.

(i) Name the substance

- ✓ ***water***

(ii) State **one** disadvantage of this behaviour.

- ✓ l***ce berg cause sea and ocean accident.***
- ✓ ***Bursting of water pipe during cold seasons.***

**5.** State why it is necessary to leave an air space in a closed glass bottle of water when it is to be kept in a refrigerator.

- ✓ ***To give room for the extra volume attained when the water freezes since its expands of freezing.***

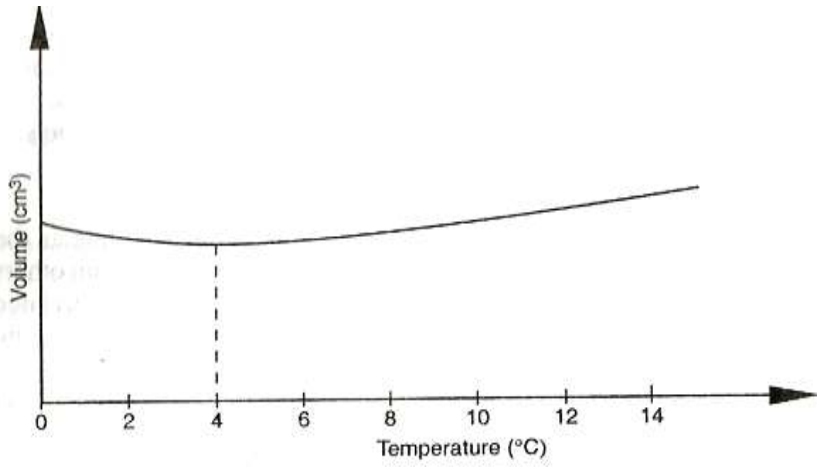
**6.** Explain why water in a pond may freeze on the surface only but not deep inside the pond.

- ✓ ***Due to anomalous expansion of water.***

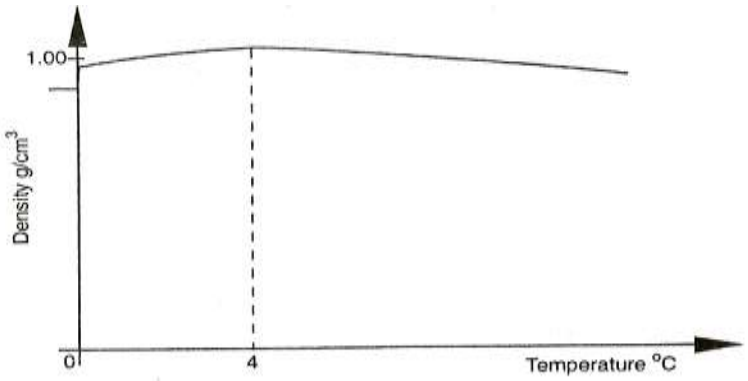
**7.** Explain why fish can survive under water when the surface is already frozen.

- ✓ ***Because the water below the frozen surface has a higher temperature.***

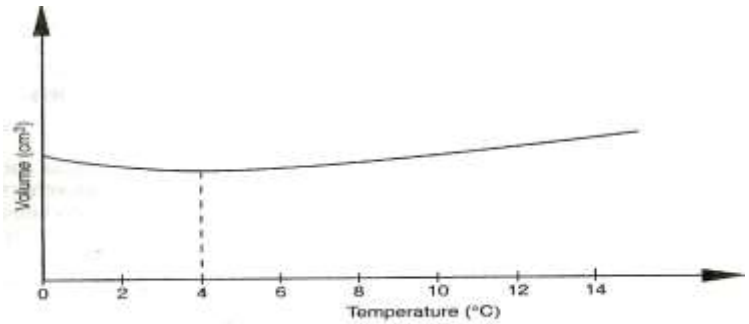
**8.** (i) Sketch the graph of volume against temperature of water between $0^0$c to $10^0$c



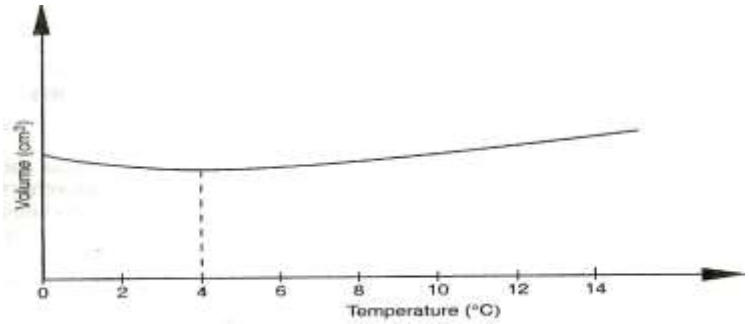
**9.** (i) Sketch the graph of density against temperature of water between $0^0$c to $10^0$c .




**10.** Sketch on the set of axis below a graph of **ma** Temperature vater against **temperature** from -**5$^0$C** to **10$^0$C**.




**11.** Sketch on the set of axis below a graph of **volume** of water against **temperature** from **-5$^0$C** to **10$^0$C**.




State and explain one factor that enhances accuracy in a thermometer.

✓ ***Narrowing the capillary bore to ensure there is change in volume for even slight change in temperature.***

**THERMOMETERS**

**1.** Explain how sensitivity of clinical thermometer can be improved.

✓ ***By using a thinner walled bulb.***

**2.** Explain the function of the following features in a thermometer.

**(a)** Capillary bore

**Functions of parts of thermometer**

✓ ***To allow for expansion and contraction of the thermometric liquid***

**(b)** Thick Stem

✓ ***It serves as a magnifying glass for easy reading of the scale.***

**(c)** Thin Bulb

✓ ***It holds the thermometric liquid and also acts as athin glass wall for effective heat transmission.***

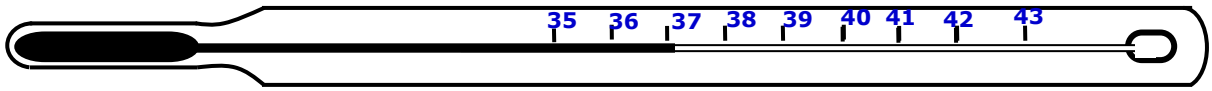
**3.** State the two special feature of a clinical thermometer.

- ✓ *Constriction*
- ✓ *It has a short scale of 35°-43°c*

**4.** Why is it that boiling is not used for sterilization of clinical thermometer?

✓ *The temperature of boiling water is far above the maximum temperature that the thermometer can measure, hence it can burst.*

**5.** The figure below shows a thermometer used by a doctor to determine the temperature of a patient. Why is it difficult to work with this thermometer?




✓ *It has no constriction to prevent flow back hence inaccuracy in temperature reading.*

**6.** The Figure below shows a clinical thermometer which is not graduated.


**(i)** Name the parts indicated with letters: **X** and **Y.**

- ✓ *x- bulb*
- ✓ *Y- constriction*

**(ii)** What is the function of the part labelled **Y**.

✓ *to prevent flow back of the thermometric liquid before temperature is read*

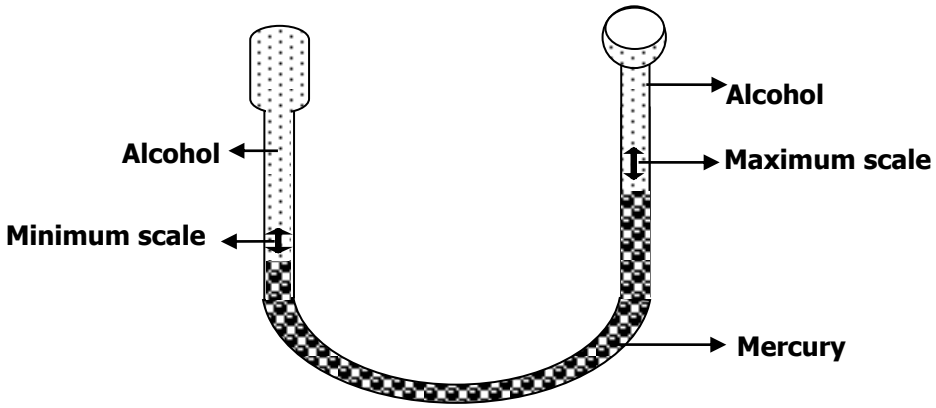
**(iii)** State the appropriate scale range in degrees Celsius of the thermometer.

✓ *35°-43°c*

**7.** Why must the tube of the thermometer be made of thin glass?

✓ *To increase sensitivity of the thermometer.*

**8.** The figure shows a six's maximum and minimum thermometer.




(i) State the thermometric liquid of the thermometer.

✓ *mercury and alcohol*

(ii) State any one feature which makes the thermometers suitable for its function.

✓ *It can measure both maximum and minimum temperature recorded*

**9.** State the reason for thin walled bulb in a liquid in glass thermometer.

✓ *To increase sensitivity.*

**10.** Explain how the thin bore in a liquid-in-glass thermometer improves sensitivity of the thermometer.

✓ *A small change in temperature would translate larger change on lenghth thus easy to make the reading.*

**11.** Explain the purpose of the constriction in a clinical thermometer.

✓ *To prevent flow back during temperature reading.*

**12.** State three properties of a good thermometric liquid

✓ *Easily visible.*

- ✓ *Expand and contract uniformly and by a large amount over a small range of temperature.*
- ✓ *Have a wide temperature range between boiling and freezing.*
- ✓ *Should not wet the glass.*

**13.** State two advantage of mercury over alcohol as a thermometric liquid.

- ✓ *Have a wide temperature range compared to alcohol and its a good thermal conductor and also doesn't wet glass*

**14.** Why is it that boiling is not used for sterilization of clinical thermometer?

- ✓ *The temperature of boiling water is far above the maximum temperature that the thermometer can measure, hence it can burst.*

**15.** Temperature scale in clinical thermometer ranges from **$35^0$C** to **$43^0$C.** Explain.

- ✓ *The normal human body temperature is 37°c.*

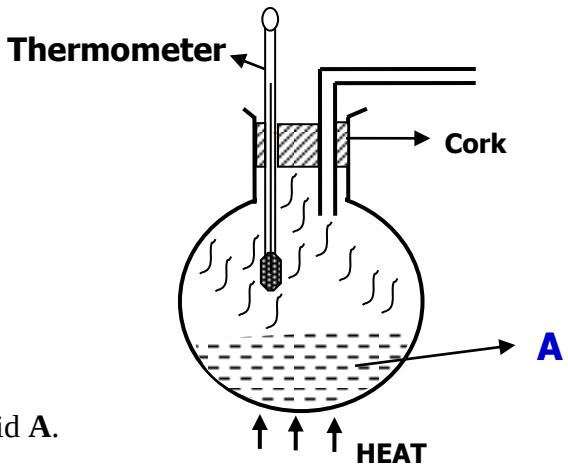
**16.** A mercury thermometer can be modified to measure small changes in temperature. State one possible modification

- ✓ *By narrowing the capillary bore as well as using a thin walled bulb.*

**17.** A clinical thermometer needs to be an **accurate maximum** thermometer. Explain briefly how these two basic requirements are achieved

- ✓ *By narrowing the capillary bore as well as using a thin walled bulb.*

**18.** The diagram below shows an arrangement used to determine the upper fixed point ofungraduated thermometer.




(i) Name liquid **A**.

- ✓ *Water*

(ii) Why is the bulb of thermometer not dipped in liquid A.

- ✓ *Because the temperature of the steam is not affected by impurities in water.*

**19.** When calibrating a liquid in glass thermometer, it is normally not advisable to dip the bulb in boiling water when getting the upper fixed point. Explain why it is so.

- ✓ *The temperature of the boiling water depends on presence of impurities and pressure hence may not be the actual boiling point.*

**20.** An uncalibrated thermometer is placed first in melting ice then in boiling water. The lengths of the liquid column are **22mm** and **79mm** respectively. What temperature in **$^0$C**would correspond to a length of **63mm**?

***$0^0$C – 22mm***
***$100^0$C – 79mm***
***Difference = 57mm***
***Difference in length for 63mm mark***
***= 63-22***
***=41mm***
***If 57mm is $100^0$C***
***Then 41mm is …?***
$\frac{4100}{57} = 71.93^0$C

**21.** When making the fixed points on a thermometer it is observed that at **0°C** the mercury thread is of length **2cm** and **8cm** at **100°C**. What temperature would correspond to a length of **6cm**.

***$0^0$C is 2cm***
***$100^0$C is 8cm***
***The difference in length is 6cm***
***What temperature corresponds to length difference =6 -2= 4cm.***
***Thus $100^0$C – 6cm***
***..?  - 4cm***
$\frac{400}{6} = 66.67^0C$

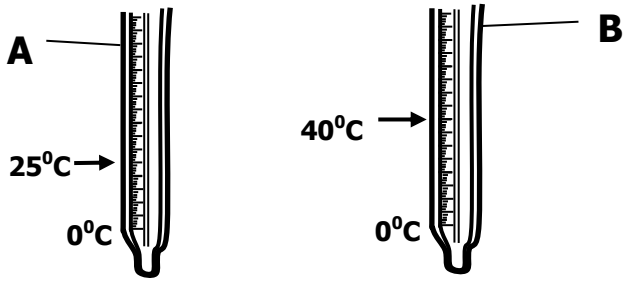
**22.** A faulty mercury thermometer reads **$40^o$C** and **$120^o$C** when placed in pure melting ice and steam from boiling water respectively. Determine the actual temperature when this thermometer reads **$50^o$C**.

***$100^0$C – $80^0$C difference***
***?  - $10^0$C  difference***
***Thus, $\frac{8000}{1000} = 12.5^0C$***
***80***

**23.** A faulty thermocouple thermometer reads **$20^0$c** when dipped in pure melting ice and **$80^0$c** when put in steam above pure boiling water. What would be the reading of the thermometer when used to measure the temperature of a sick person whose temperature is **42 $^0$C**

***$100^0$C – $60^0$C difference.***
***..?  - $22^0$C difference***
$\frac{220}{60} = 36.67^0C$

**24.** The diagram below shows two thermometers. **A** and **B**. Thermometer **A** is faulty and thermometer **B** shows correct readings. At room temperature the thermometers read **$25^0$C** and **$40^0$C** respectively as shown




The two thermometers were used to measure the temperature of a warm water reading. **B** recorded a temperature of **$65^0$C**. State the reading of thermometer **A** in the liquid whose temperature is being measured.

***65- 40 = $25^0$C difference***
***So, 25+ 25***
***= $50^0$C***