SENIOR THREE SELF STUDY WORK
WEEK 1
DAY 1
TOPIC: EXPANSION AND CONTRACTION

Expansion is the increase in size or an object when it gets hotter.

While contraction is the decrease in size of an object when it becomes colder.

(a) Expansion of solids

All solids expand when heat is applied to them. However, they do so in varying amounts.

Some solids expand very little while others expand greatly.

Expansion in solids can be investigated by using the following experiments.

(i) The ball and ring.
(ii) The bar and gauge

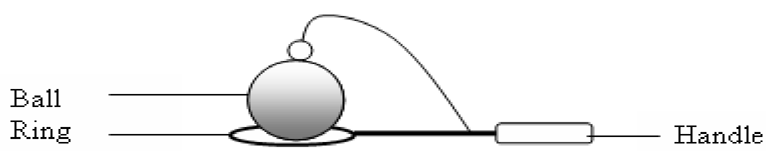
Experiments to investigate the effect of heat on solids

Ball and ring experiment

Apparatus/Requirements A ball and ring, source of heat

Procedure Part I

Pass the ball through the ring when cool as shown in figure 15.1 below.



Observation: The ball passes through the ring easily.

Part II

- Heat the ball on a Bunsen burner for some time.
- Try to pass it through the hole again.

Observation: The ball does not pass through.

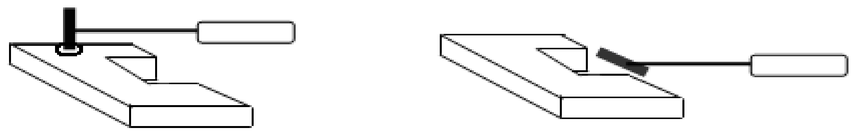
Explanation: When the ball is heated, it expands i.e. the size becomes bigger. As such, it cannot pass through the ring.

The bar and gauge experiment

Apparatus/Requirements A bar and gauge, source of heat

Procedure: Part I

- Pass one end of the bar through the hole on the gauge.
- Remove the bar and fix it in between the ends of the gauge as shown below.



(a) *Figure 15.2* (b)

Observation: The head of the bar passes through the hole and also fits in the gauge easily.

Part II

- Heat the bar on a Bunsen burner flame for some time.
- Try to pass it through the hole and also try to fix it in the gauge.

0bservation:

The head of the bar does not pass through the hole and does not fit in the gauge.

Allow the bar and the ball to cool and repeat the above procedures of passing the ball through the ring and fixing the bar in the hole and the gauge respectively.

Results: When the ball and the bar cool:

(i) The ball passes easily.
(ii) The bar fits in the gauge easily.

Explanation

When the bar is heated, it expands both sideways and length ways (i.e. the size becomes bigger and longer). As such, it cannot pass through the hole and fit in the gauge.

Note*:* The gauge shows that the bar has increased in length, which is called linear expansion. The ring shows that the diameter of the ball has increased in all directions. The expansion in area of a solid is known as superficial expansion and the expansion in volume is called cubical expansion.

Applications of expansion in solids

(a)Bimetallic strip A bimetallic strip is a strip made of two different metals welded or riveted together. When cold the double strip is straight as shown in the figure below.

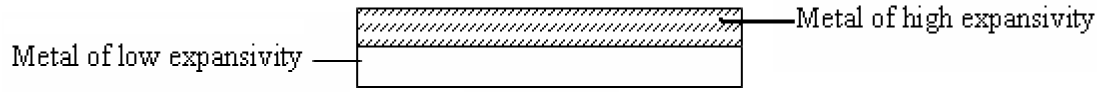


Figure 15.3

(b) Effect of heat on bimetallic strip

When a bimetallic strip is heated, the metals expand with the metal of higher expansivity expanding more than the one of low expansivity. The strip bends to form a curve with the metal of high expnasivity on the inside as shown in figure below.

Figure 15.4

Examples of a bimetallic strip are;

Brass and iron

- Brass having higher expansivity than iron.

Aluminium and iron

- Aluminium having higher than iron.

(c) Uses of expansion in bimetallic strip

Bimetallic strip is used as electrical switches, in thermostats and many other mechanical switching devices.

ACTIVITY 1

1. State which metal would be on the outside and inside if the two bimetalic strips in the example above is heated.

2a) Define the following terms.
(i) Expansion
(ii) Contraction of a material.
b) Describe an experiment to demonstrate expansion and contraction in solids. (c)
c)State any one application of expansion in solids.

DAY 2

Thermostat

A Thermostat is a device that automatically regulates the temperature of a system by maintaining it constant or varying it over a specific range.

A bimetal thermostat uses a special strip of metal to open and close a circuit as temperature fluctuates. Two metals with different expansion rates are bonded to make the strip. The thermostat is arranged so that when the metals are hot, the strip bends upward (toward the metal with the lower expansion rate) and disconnects the circuit. In this particular case, the thermostat will activate a heater when the circuit is closed and electricity is flowing.

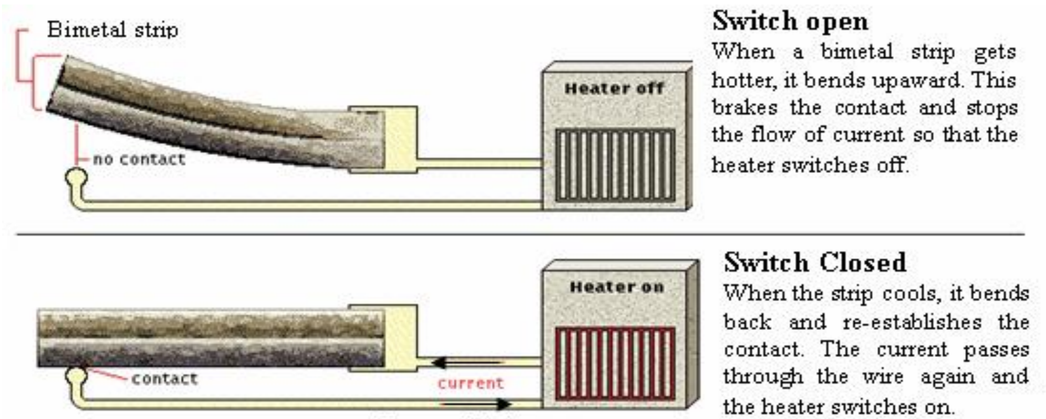


Figure 15.4

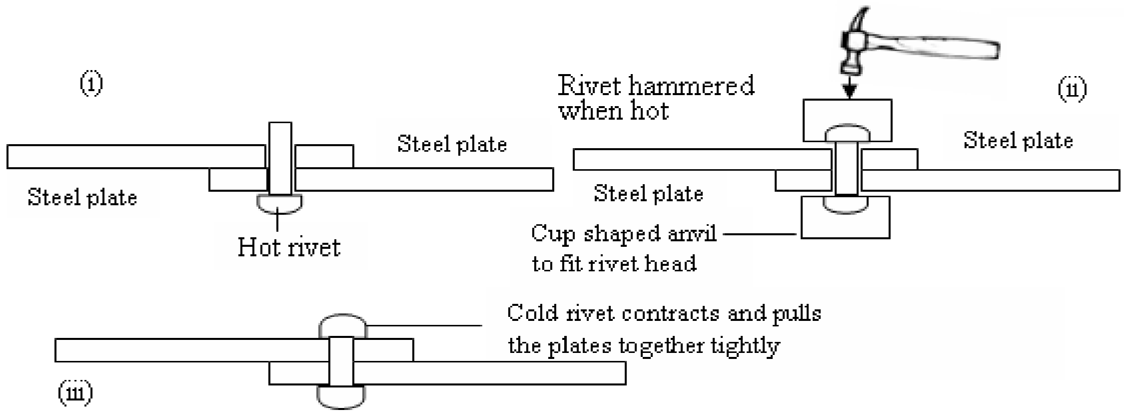
Note: Increasingly, the use of bimetallic strip for this purpose is being replaced by electronic circuits with no moving parts.

(a) Tight fitting of

(i) Riveting

Expansion and contraction is used in riveting to get a tight joint of two or more metal plates.

- A hot rivet (expanded) is pushed through a hole in the two plates or rods
- to be joined.
- The end of the hot rivet is hammered to form another.



Results: As the rivet cools it contracts and pulls the two plates more tightly.

(ii) Steel tyres onto cart and train wheels

The steel tyre is designed to just fit when it is red hot. As it cools down, it tightens and grips on the wheel.

(iii) Wheel and axles

The same method is also used in fitting wheels on to axles.

(b) Steel bridges

Girder bridges made of steel. During cold weather the bridge contracts and becomes shorter. And during hot weather, it expands and becomes longer. In order to allow for expansion and contraction, one end of the bridge is fixed and the other end is placed on rollers as shown in figure 15.6 below. This enhances the *to* and *fro* movement during expansion and contraction.

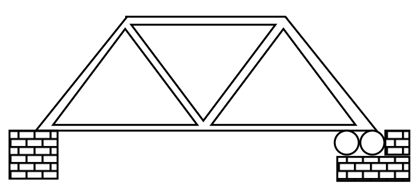


Figure 15.6

(c) Railway lines

Railway tracks have been bent and seriously damaged due to expansion during very hot days where the gap allowed for expansion was too small. Now to allow room for expansion and contraction, fairly large gaps are left between the sections of rails. And the sections are held together by fish plates fixed by bolts in oval shaped holes

(d) Pipelines

Pipelines carry steam, liquids and gases from one point to another. The pipes contract when cold and expand when hot. To avoid breakage of the pipes due to the force of expansion and contraction, the pipes are fixed fitted with loops or expansion joints. The joints and loops allow the pipes to expand and contract when steam passes through and when it cools down.

(e) Electricity and telephone lines

During cold weather especially at night hours, telephone wires contract and when it is hot during the days, they expand. During cold weather (from evening up to early morning hours) electricity/telephone wires contract. The wires become shorter and taut. And during the hot afternoon hours, the wires become longer and slack.

To avoid the wires from cutting, they are fixed loosely to allow contraction and expansion.

Linear expansivity

The change in the length of a substance during expansion is called *linear expansion*. And the measure of the tendency of a particular material to expand is called its *expansivity*.

The lengthways expansivity of a material is called its *linear expansivity* and is given by the symbol α(alpha).

Formula of linear expansivity

Definition:

Linear expansivity is defined as: *The increase in length of a unit length of a material for a degree rise in temperature*.

I.e. $$\text{Linear Expansivity} = \frac{Linear\ \ Expansion}{Original\ \ length\ \text{x}\ temperature\ \ rise}$$

S.I Unit of Linear expansivity

The S.I unit of linear expansivity is a derived unit.

$$= \frac{m}{m\ x\ °C}$$

$= °C^{-1}$ or K^{-1}

By re arranging the formula for linear expansion we obtain a formula which can be used
to calculate expansion of things like bridges and railway lines.

Linear expansion = Linear expansivity**x** ***Original length*** **x** ***temperaturerise***

Factors which determine linear expansivity

The linear expansion or change in length $\Delta l$of a material depends on three things:

(a) The length of the material, l.

(b) The change (rise) in temperature

(c) The linear expansivity of the material

EXAMPLE

1. Calculate the linear expansion of Aluminium cable 50 m between two electric poles when the temperature rises by 40°C. The linear expansivity of Aluminium is 2.6×10^{-5}/°C

Solution Δl= ?$\alpha = 2.6 \times 10^{-5}/^{o}C$, l = 50m

$$\Delta l = \alpha\, l \Delta\theta$$

$$= 2.6 \times 10^{-5} \times 50 \text{ m} \times 40\ °C$$

$$= 5.2 \times 10^{-2} \text{ m}$$

The Aluminium will increase in length by 5.2×10^{-2} m or 0.052 m or 5.2 cm.

Expansion in liquids

All liquids like solids expand with varying amounts. Some expand more than others.

To demonstrate expansion of water

Apparatus: A round bottom flask, capillary tube, source of heat, a cork and a liquid.

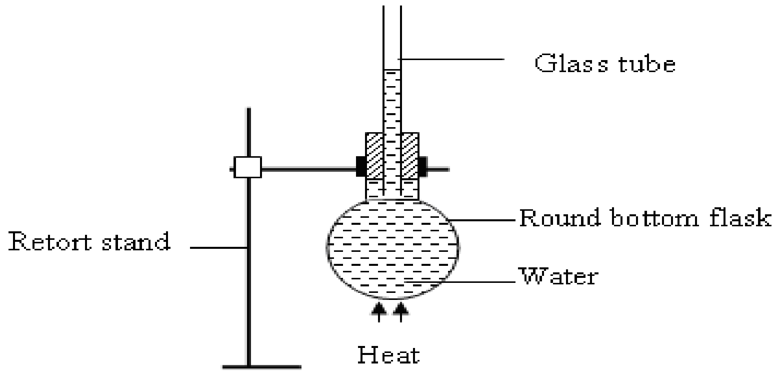
Procedure

- Fill a round bottom flask up to the brim with liquid (e.g. water).

- Insert a capillary tube through a cork and cork the flask.

- Mark the level of liquid in the glass tube.

- Set up the apparatus as shown in figure 15.7 below.



Figur 15.7

- Heat the flask as you observe the level of the water in the tube.

Observation: First the level of the water falls and then starts to rise again.

Explanation

(i) The fall of water level

The initial fall of water level is due to the expansion of the glass flask, which gets heated first and expands. The expansion of the flask results to increased volume of the flask. So water moves in to fill the extra volume.

(ii) The rise of water level

Finally, the heat reaches the water and starts to expand, thus rising up the glass tube.

Note that: Water expands faster than glass.

Comparison of expansion of different liquids.

Expansion in different liquids can be compared by filling the liquids in different flasks of the same size and type.

To compare the expansion of different liquids e.g. water, alcohol, methylated spirit, ether, benzene

Apparatus: Four identical flasks, trough, water, stirrer, source of heat

Procedure

- Fill the flasks with the liquids to the same height/level and then place them in water in a trough as shown in figure below.
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- .

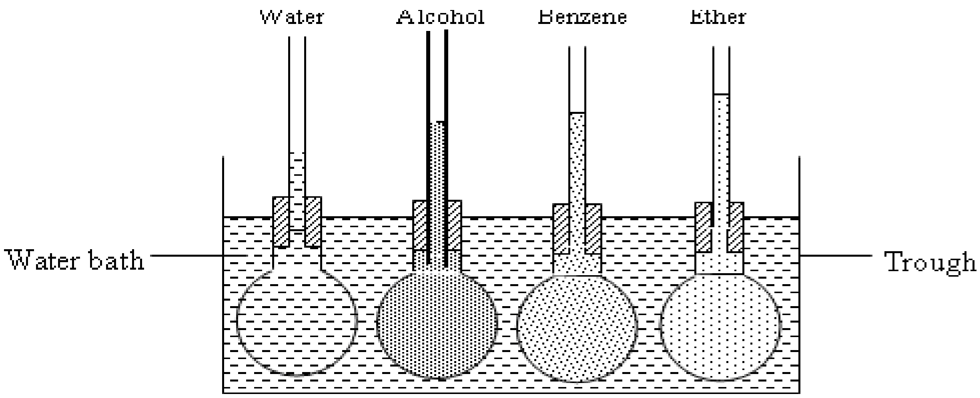


Figure 15.8

- Heat the water bath while stirring.
- Observe the levels of the liquids in the flasks

Observation: The levels of the liquids in the tubes first fall and then rise by different amounts as the heating continues.

Result: The result shows that ether expands most followed by benzene while water being the least.

Conclusion: The above observation shows that some liquids expand more than others for a given rise in temperature.

The expansion of water

Most liquids contract steadily as they cool, and contract further on reaching their freezing point. Water contracts as it cools down from 100°C to 4°C. However, between 4°C and 0°C, water behaves unusually in that it expands as it gets cooler with its minimum volume at 4°C. This behavior of water is described as anomalous (irregular). When water freezes its volume increases by about 8%, which is a much larger increase in volume than occurs between 4°C and 0°C.

The change in volume/density of water with temperature as shown in the figures

(a) and (b) .

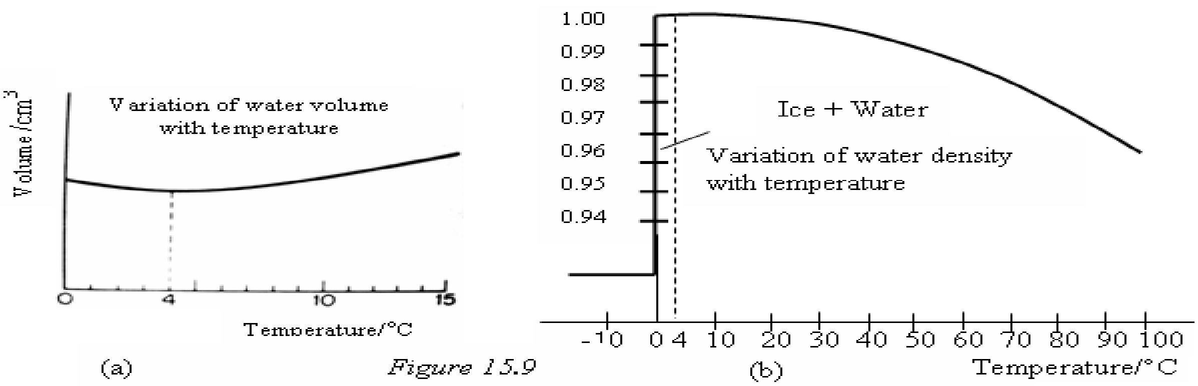


Figure 15.9

The importance of the anomalous expansion of water

When a pond is freezing over, density of water at 4°C remains at the bottom of the pond.

The less dense (but lower temperature) water, between 3°C and 0°C, floats in layers above it. The water on the surface is frozen, but floats because it is less dense than the water below it. The different density layers stop convection currents spreading the heat.

Ice is a bad conductor of heat so that the layer of ice on the top of a pool acts like an insulating blanket and slows further loss of heat from the water below.

Aquatic animals and plants make use of this phenomenon, by living in the liquid layer when the water freezes over in the winter.

Expansion in gases

Experiment to show expansion in gases

Apparatus: A round bottom flask fitted with glass tube, water, trough and source of heat from Bunsen burner.

Procedure

- Fill a trough with clean water.
- Pass a glass tube through a cork and invert the cork into a round bottom flask.
- Dip the tube in the water in the trough.
- Heat the flask by directing a Bunsen burner flame to it for a short time.
- Observe the water level in the tube.
- Allow the flask to cool while the tube is still in the water. Observe what happens.

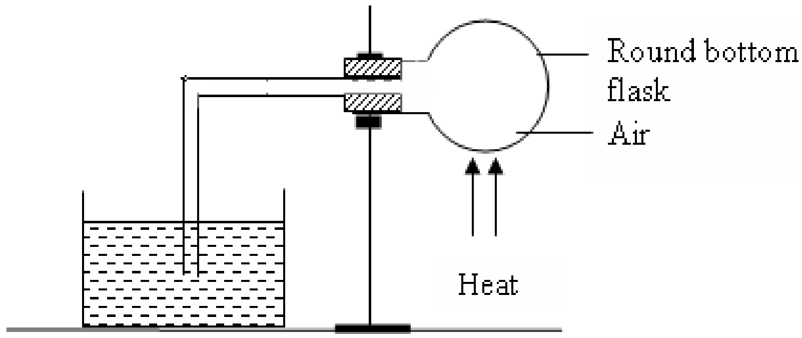


Figure 15.10

Observation:

When the flask is hot, the level of the water in the glass tube falls and air bubbles are released.

On cooling, the water level rises up the glass tube.

Explanation

- When the flask is heated the air inside expands. This forces some air out of the flask. Thus bubbles of air are seen as the air escapes.
- As the air in the flask cools, it contracts creating more space and reducing the pressure, then the atmospheric pressure acting on the surface of the water pushes water into the glass tube.

ACTIVITY 2

1. (a) Define linear expansivity of a material.
   (b) Calculate the linear expansion of concrete bridge of span 100m when the temperature rises by 20°C. The linear expansivity of concrete is $1.2 \times 10^{-5}/^{o}C$

2. (a) Describe an experiments to show expansion in Liquids.
   (b) Explain the anomalous behaviour of water and give its importance to aquatic animals.

3. (a) State:
   (i) Any two thermometric liquids you know.
   (ii) The properties of a thermometric liquid.
   (iii) Advantages of mercury over alcohol as used a thermometer.

(d) Define the following terms.

(i) Lower fixed point.

(ii) Upper fixed points.

(c) Describe how the fixed points of a thermometer are determined in the laboratory.

4. The interval between the ice and steam points on a thermometer is 192 mm. Find the temperature when the length of the mercury thread is 67.2 mm from the ice point.

5. The distance between the lower and upper fixed points on the Celsius scale in unmarked mercury-in-glass thermometer is 25 cm. If the mercury level is 5 cm below the upper fixed, calculate the temperature value.

6. Convert the following temperature readings to Celsius scale.

   (a) 750 K (b) 400 K (c) 973 K

7. Convert the following temperature readings to Kelvin scale.

   (a) 340 ℃ (b) 130℃ (c) 20℃

8. (a) Name any two physical properties, which change with temperature. (b) Explain why gaps are left between rails in a railway line.

   (c) Why do gases expand much more than solids for the same temperature change?

   (d) Name one application of a bimetallic strip.

   (e) Mention any three reasons for not using water as a thermometric liquid.

9. Figure 15.13 shows strips of copper and iron bonded together.

Figure 15.13

   (a) Redraw the diagram to show what happens when the strip is heated.

   (b) Why does the change you have shown in (a) take place?

DAY 3

TOPIC: HEAT CAPACITY

Heat:

The term heat is used to describe the energy transferred through the heating process. Its unit is ***joules***

Heat capacity

The ***heat capacity*** of a substance is the quantity of heat required to rise its temperature by 1°C or 1K.

- Its symbol is *C* and its unit is Joule per degree Celsius (*J/°C*) or Joule per Kelvin (*J/K*)
- *Heat capacity = mass x specific heat capacity*
- In symbols: $C = mc$

Specific heat capacity

Specific heat capacity is the quantity of heat required to raise the temperature of 1kg by 1°C or 1K.

- Its symbol is c.
- Its unit is joule per kilogram degree Celsius (*J/Kg°C*) or joule per kilogram Kelvin *(J/KgK) or* $(JKg^{-1}\,K^{-1})$.
- When the temperature of a substance rises; heat gained =mass × specific heat capacity × temperature rises,

In symbols:

$Q_{gained} = m.c\,(\theta_2 - \theta_1) = m.c.\theta$

Where temperature rises (θ) is ($\theta_2 - \theta_1$), final temperature minus initial temperature.

Example-1:

Find the amount of heat required to raise the temperature of 2kg of iron from 20°C to 70°C (specific heat capacity of iron is 460J/kg°C)

Solution:

Mass, m = 2kg

Initial temperature, θ_1 = 20°C

Final temperature, θ_2 = 70°C

Temperature rises, $\theta = \theta_2 - \theta_1$

70 - 20 = 50°C

Specific heat capacity of iron, $c = 460J/kg°C$

Heat gained, Q = ?

$Q_{gained} = m.c.\,\theta$

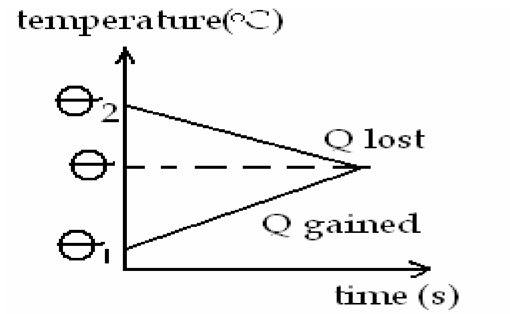
$= 2x460x50$

46000 *joules*

Calorimeter and method of mixtures

The term calorimeter means the science of heat measurements and any piece of apparatus with which heat measurements may be made is called a **calorimeter.** In this method hot substances are mixed with cold substances until they reach the same temperature. Assuming that no heat is lost to the surroundings then. The following equation is used;

heat gained by cold substances = heat lost by hot substances



- Where θ is the temperature of the mixture.

  θ_1 is the temperature of cold substance

  θ_2 is the temperature of hot substance

  m_1 is the mass of cold substance

  m_2 is the temperature of hot substance

  c_1 is the specific heat capacity of cold substances

  c_2 is the specific heat capacity of hot substances

- $Q_{gained} = Q_{lost}$

  $m_1.c_1.(\theta - \theta_1) = m_2.c_2.(\theta_2 - \theta)$

- During the experiment, heat can be lost by conduction, convection, radiation and evaporation. Heat lost by radiation can be reduced by:
- Using a bright polished calorimeter.
- By insulating the calorimeter with a poor conductor such as cotton wool. Heat lost by convection and radiation can be reduced by covering the container with a lid. Heat lost by conduction can be reduced by insulating the calorimeter. This process is called **Lagging.**

ACTIVITY 3

1.A 15kg of water at 20°C is added to 5kg of water at 40°C; find the temperature of the mixture?

2. 600g of water at 50°C is to be cooled to 25 °C by addition of cold water at 10°C how much cold water is to be added?

3. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.
What is meant by the above statement?

4. A 100g quantity of water at 24 ^{0}C is added to 50g of water at 36 ^{0}C. The temperature of the mixture is

5. The amount of heat required to raise the temperature of 0.5kg of iron from 25 ^{0}C to 50 ^{0}C is (specific heat capacity of iron is 460 joules kg^{-1} K^{-1})

6. A block of lead of mass 1000g hits a hard surface without rebounding with a velocity of 23 ms^{-1}. if the temperature rises from 25 ^{0}C to27 ^{0}C. Calculate the specific heat capacity of lead.

7. 450g of water at 60 ^{0}C is to be cooled to be 35 ^{0}C by addition of cold water at 20 ^{0}C. How much cold water is to be added?

8. When 1kg of a certain liquid is heated for 10s, its temperature rises by 25 ^{0}C. If the power supplied is 1000 watts, find the specific heat capacity of the liquid.

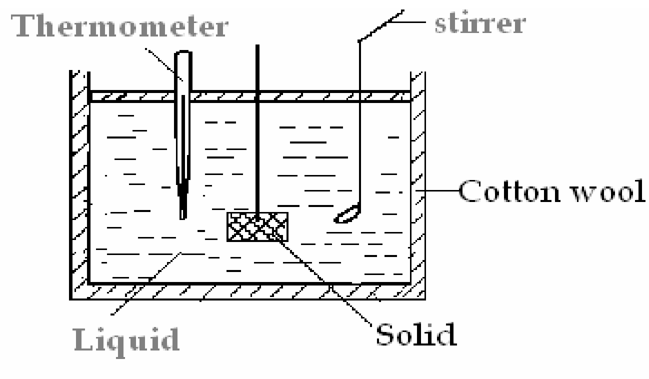
9. An electric heater is rated 240V, 400W. If the efficiency of the heater is 80% find the amount of energy wasted per second.

10. Calculate the specific heat capacity of paraffin if 22000 J of heat are required to raise the temperature of 2.0 kg of paraffin to 30 ^{0}C from 20 ^{0}C.

DAY 4

Measuring of specific heat capacity of liquid by method of mixture

If a solid of known mass m_2 is heated in water to a known temperature say θ_2. Then it is transferred very quickly into a liquid of mass m_1 which is at a temperature θ_1. The mixture is stirred gently until a common temperature θ is reached as in figure below.



Assuming that no heat is lost to the surrounding then

heat lost by solid = Heat gained by liquid + Heat gained by the calorimeter

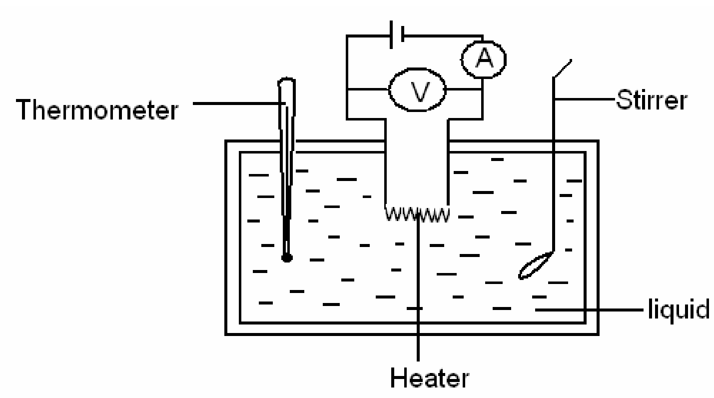
$m_2.c_1\ (\theta_2 - \theta) = m_1c_2\ (\theta - \theta1) + m_3.c_3\ (\theta - \theta_1)$

$= (m_2.c_2 + m_3.c_3)\ (\theta - \theta_1)$

If other terms are known, then c_1 can be calculated. Where m_3 and c_3 are mass and specific heat capacity of the calorimeter, c_1 and c_2 are specific heat capacity of the liquid and solid respectively.

Measuring of specific heat capacity of liquid by electrical method

In this method a liquid is in a well lagged calorimeter is electrically heated when current flows through a heater which is completely immersed in it as shown in the fig below.



The temperature of the liquid before current flows though the heater (θ_1) and at the end of the experiment ($\boldsymbol{\theta_2}$) is recorded.

The current I in the circuit and potential difference V across the heater must remain constant throughout the time (t) over which the temperature changes are recorded.

Assuming no heat lost to the surrounding then

electrical energy supplied = heat gained by the liquid and the calorimeter.

Electrical energy supplied = VIt

$$= P \times t$$

$$VIt = m_1.c_1 (\theta_2 - \theta_1) + m_2.c_2 (\theta_2 - \theta_1)$$

$$VIt = (m_1.c_1 + m_2c_2)(\theta_2 - \theta_1)$$

m_1 = mass of the liquid

m_2 = mass of the calorimeter

c_1 = specific heat capacity of liquid

c_2 = specific heat capacity of calorimeter

θ_1 = original temperature

θ_2 = temperature after heating.

Note: *If heat gained by the calorimeter is negligible, it does not need to induce in the formula*

ACTIVITY 4

1.

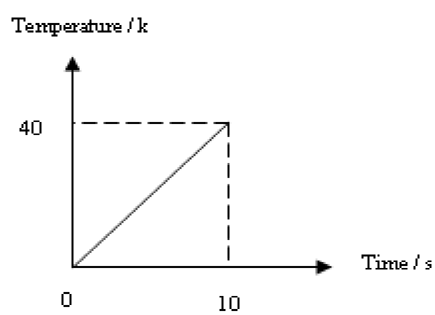
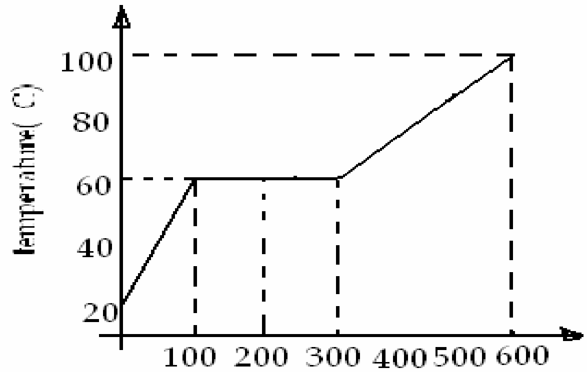


Figure above shows a graph of the temperature rise with time when a body of mass 4kg is heated using a 2000W heater. Find its specific heat capacity in $Jkg^{-1}K^{-1}$.

2. a) Define specific heat capacity of a substance and state its S.I units

b) The amount of heat required to raise the temperature of a 0.5kg mass from -5^0C to 15^0C is (specific heat capacity of salt solution is 4000 J $kg^{-1}K^{-1}$)

3. When 100W heater is used to heat 1kg of solid wax, the temperature of the wax is observed to change with time as shown below.



Find the specific latent heat of fusion of the wax

4. A heater with a power rating of 100W is placed in 0.5kg of ice at 0 ^{o}C. How long will it take the heater to melt all the ice? (Specific latent heat of fusion of ice = 3.34×10^5 Jkg^{-1})

5. How much heat is required to raise the temperature of 20g of water from 30 ^{0}C to 60 ^{0}C?

6. An electric heater is immersed in 0.05kg of oil in a calorimeter of negligible heat capacity. The temperature of the oil rose from 20 ^{0}C to 50 ^{0}C in 100 s. If the specific heat capacity of the oil is 2000 j kg^{-1}, calculate the power supplied by the heater, assuming that there is no heat loss

7. Calculate the time required for a kettle taking 10 A from a 240 V supply, to heat 5kg of water through 80 ^{0}C, assuming no heat is lost.

DAY 5

LATENT HEAT

When a solid is heated, its temperature rises until its melting point is reached when it begins to melt. The solid melts as more heat is absorbed by the solid but the temperature remains unchanged until the entire solid has melted then the temperature rises again. When a liquid cools its temperature also remains constant at freezing point. At this temperature liquid gives off heat energy and changes into solid. This phenomenon always occurs during a change of state of substance without change of temperature at melting point is called **Latent heat of fusion.** Latent means hidden or concealed.

Specific Latent heat of fusion of a substance is the quantity of heat required to change unit mass from solid to liquid at constant temperature.

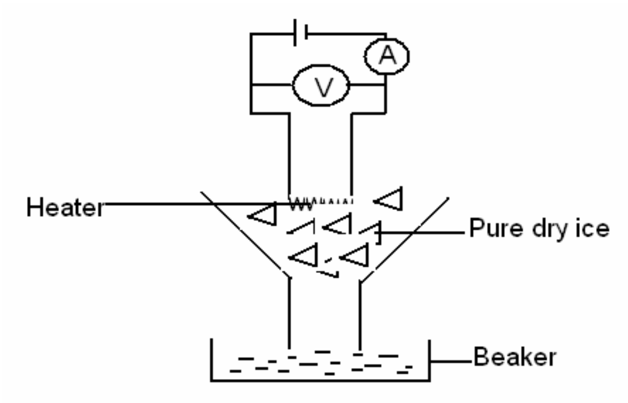
The specific latent heat of vaporization of a substance is the quantity of heat required to change unit mass from liquid to vapor at constant temperature.

$$Q = m.L$$

Where *L is* specific latent heat and its unit is J/kg

Example-: Calculate the heat required to convert 2kg of water at 100°C to steam (specific latent heat of vaporization of water = 2.26 × 10^{6} **J**/kg**)**

An experiment to determine specific latent heat of fusion of ice



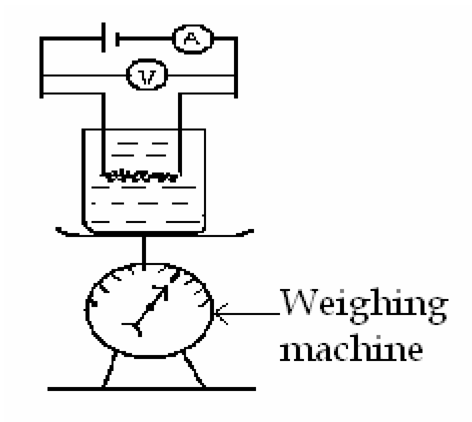
- The circuit in which the battery, ammeter and heater are in series and voltmeter is parallel to the heater is connected as shown.
- The heater is completely immersed in pure dry ice (assuming no heat is lost to the surrounding).
- The switch is closed and a stop clock is stated at the same time. The mass 'm' of water collected in a known time, t, is noted, by weighing the beaker before and after the experiment.
- The voltmeter and ammeter readings V and I respectively are noted.

$$mL = VIt$$

$$L = \frac{VIt}{m}$$

Where: *L is the specific latent heat of fusion of ice*.

Determination of specific latent of vaporization



- The liquid is poured in a beaker and the mass (m_1) of the beaker is noted.
- The beaker is placed on top of a weighing balance.
- A heater is connected in series with an ammeter and parallel with a voltmeter.
- The heater is totally immersed in the liquid.
- The heater is switched on and left until the liquid boils thoroughly and the time t, is noted.
- Boiling is allowed to continue for some time and time t_2 is noted again.
- The reading of the weighing balance (m_2) is noted, when sufficient liquid has vaporized.

Time taken for vaporization, $t = t_2 - t_1$

Difference in weight balance, $m = m_1 - m_2$

Ammeter reading $= I$

Voltmeter reading $= V$

$$mL = VIt$$

$$L = \frac{VIt}{m}$$

L can be calculated from expression.

ACTIVITY 5

1.(a) What is meant by specific latent heat of vaporisation?

(b) State two factors, which affect boiling points of water.

(c) Calculate the heat required to convert 0.8 kg of water at 100 ^{0}C to steam.

[Specific latent heat of vaporization of water = 2.26 x 10^6 j/kg]

2. (a) What is meant by latent heat of vaporization?

(b) With the aid of a labeled diagram, describe how a refrigerator works.

3. **(**a) What is meant by specific heat capacity of a substance? And state its SI unit

(b) When a block of iron of mass 2 kg absorbs 19 kJ of heat, its temperature rises by 10^{o}C. Find the specific heat capacity of the iron.

5. **(**a) Define the term specific latent heat of vaporization.

(b) Describe an experiment to determine the specific latent heat of vaporization of steam.

6. (a) Define the term specific latent heat of fusion.

(b) A copper can of mass 0.2kg contains 0.20kg of water at 10 ^{0}C. The can and its contents are placed in a refrigerator. Calculate the quantity of heat given out if the temperature of the can and its contents falls to –2 ^{0}C. ($c_{copper} = 400\ J\ kg^{-1}\ K^{-1}$, $c_{ice} = 2100\ J\ kg^{-1}\ K^{-1}$, $L_{fusion} = 340000\ J\ kg^{-1}$)

7. An immersion heater rated 1000 W, 250 V supplies heat to 80kg of liquid in a tank. If the temperature of the liquid rises by 40 ^{0}C in 48 minutes, what is the specific heat capacity of the liquid?

8. Distinguish between specific heat capacity and specific latent heat of a substance.

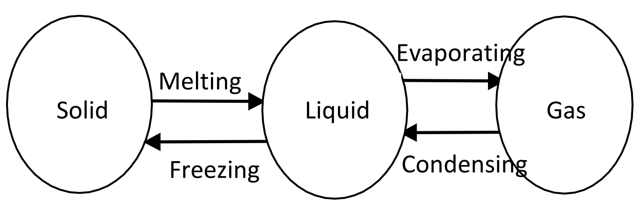
9. A copper block of mass 250g is heated to a temperature of 145 ^{0}C and then dropped into a copper calorimeter of mass 250g, which contains 250 cm^3 of water at 20 ^{0}C.

(i) Calculate the maximum temperature attained by the water (specific heat capacity of copper = 400 J kg^{-1}K^{-1})

(ii) Sketch a graph to show the variation of water with time.

DAY 6

EFFECTS OF HEAT ON MATTER:



When a solid is heated it changes to a liquid at its **melting point**.

Definition:

Melting point is a constant temperature at which a solid change to a liquid.

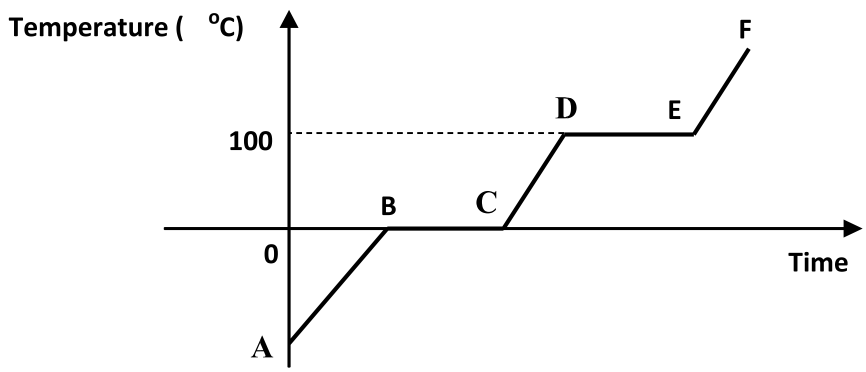
When a liquid is cooled it changes to a solid at its freezing point.

Definition:

Freezing point is a constant temperature at which a liquid changes to a solid.

When a liquid is heated it changes to a gas (vapour) at its boiling point.
Definition:
Boiling point is the constant temperature at which a liquid changes into a gas. When a liquid is cooled it condenses and changes to a liquid.

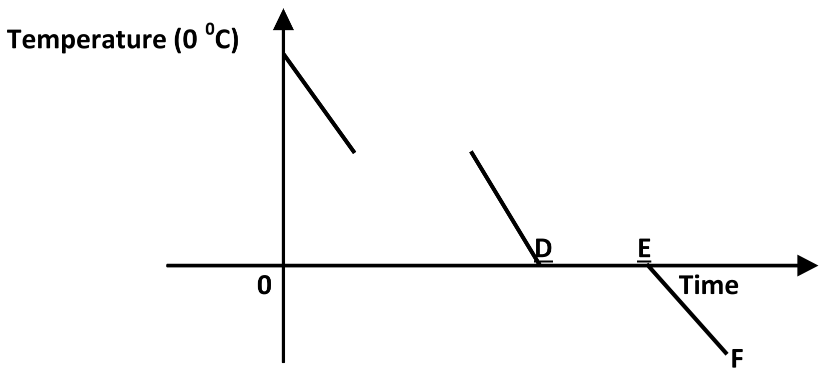
HEATING AND COOLING CURVES (graphs of temperature against time)
<u>The heating curve when ice below its melting point is heated</u>.



<u>Explanation of the shape of graph</u>.
AB: temperature of ice is increasing from A to its melting point 0℃ o
BC: ice is changing to water at 0 C
CD : the temperature of water is increasing from $0℃\ to\ boiling\ point\ 100℃$
DE: water is changing to steam at 100 C **EF:** temperature of steam is increasing

<u>The states of water along different regions are</u> ;
AB – solid state (ice)
BC – solid state and liquid state (water + ice)
CD – liquid state (water)
DE – liquid state and gaseous state (water + vapour)
EF – gaseous state (steam or vapour)

100 <u>B C</u>



<u>The cooling curve when water above its boiling point is</u>

<u>Explanation of shape of the graph</u>

AB: temperature of steam is decreasing from to boiling point 100℃. o

BC: steam is changing to water at 100 C

CD : the temperature of water is decreasing from 100℃ to freezing point 0℃ o

DE: water is changing to ice at 0 C

EF: temperature of ice is decreasing

<u>The states of water along different regions are</u>;

EF – solid state (ice)

DE – solid state and liquid state (water + ice)

CD – liquid state (water)

BC – liquid state and gaseous state (water + vapour)

AB – gaseous state (steam or vapour)

ACTIVITY 6

Where necessary assume the following

Specific heat capacity of water	= 4200Jkg^{-1}K^{-1}
Specific heat capacity of copper	= 400 Jkg^{-1}K^{-1}
Specific heat capacity of iron	= 450 Jkg^{-1}K^{-1}
Specific heat capacity of aluminium	= 880 Jkg^{-1}K^{-1}
Specific heat capacity of ice	= 2100 Jkg^{-1}K^{-1}
Specific latent heat of fusion of ice	= 336,000 Jkg^{-1}

Specific latent heat of vaporization of water = 2,250,000 Jkg^{-1}

1. How much heat is required to raise the temperature of 50g of Aluminium from

100^oC to 120^oC?

2. If 98,000J of heat are needed to raise the temperature of 2kg of a substance from 51 C to 65 C. What is the specific heat capacity of a substance?

3. An electric fire has a power of 1,800W. When used to heat a liquid of 5kg, it takes 6 minutes to o raise the temperature by 90 C. What is the specific heat capacity of the liquid?

4. A 30g block of copper is heated from -20^oC to 180^oC. How much heat does it absorb during heating?

5. How much heat energy is needed to melt 0.01kg of ice at 0 C? **Ans: 3360J**

6. How much heat energy is needed to change 0.2kg of ice at 0 C into steam at 100 C?

7. An electric heater marked 225,000W keeps water boiling at 100 C. What mass of water evaporates in a second?

8. An electric heater was used to heat 2kg of water from 20 C to 50 C in 25 minutes. If the voltage across the heater was 24V, what was the current through the heater?

9. 5kg of ice cubes are removed from the freezing compartment of a refrigerator into a home freezer. The refrigerators freezing compartment is kept at -40 C the home freezer is kept at -17 C. How much heat does the freezer's cooling system remove from the ice cubes?

10. What is the heat capacity of 5.5kg of Aluminium?

10.. 2kg of ice at $-5°C$ was heated up to steam at $100°C$.
Sketch a temperature time graph curve for the ice up to steam
Find the heat at each section of the graph drawn. (S.H.C of ice = 2000 J $kg^{-1}K^{-1}$,S.H.C of water = 4200 J $kg^{-1}K^{-1}$,S.L.H. of fusion of ice = $3.36x10^5$Jkg-1 , S.L.H. of vaporization of water = $2.26x10^6$Jkg)

DAY 6

GAS LAWS

Gas laws describe the behavior of gases when subjected to physical factors such as pressure and temperature.

These laws express the relationships between pressure (P), volume (V) and temperature (T) of a fixed mass of a gas.

There are three gas laws namely;

- Boyle's law.
- Pressure law.
- Charles' law.

Boyle's law :

It states that the volume of a fixed mass of a gas is inversely proportional to its pressure at constant temperature.

$$\boldsymbol{Pressure \propto \frac{1}{Volume}}$$

$$\boldsymbol{P \propto \frac{1}{V}}$$

$$\boldsymbol{P = K\frac{1}{V}}$$

$$\boldsymbol{PV = K}$$

$\textit{Where K is constant of proportionality}$

If the volume of gas changes from V_1 to V_2 and its pressure changes from P_1 to P_2.

n

Where $P_1 - initial\ pressure$

$P_2 - final\ pressure$

$V_1 - initial\ volume$

$V_2 - final\ volume$

Examples:

1.The volume of a fixed mass of a gas at constant temperature is 250cm when the pressure is 720mmHg. Find the pressure when the volume is increased to 600cm.

$$\boldsymbol{P_1 = 720mmHg, V_1 = 250cm^3,\ P_2 = ?, V_2 = 600cm^3}$$

$$\boldsymbol{P_1V_1 = P_2V_2}$$

$$\boldsymbol{720 \times 250 = P_2 \times 600}$$

$$\boldsymbol{\frac{720 \times 250}{600} = P_2}$$

$$\boldsymbol{P_2 = 300mmHg}$$

2. The volume of a fixed mass of a gas at constant temperature is 2.0 x 10^{-5} m^3

when the 64pressure is 7.2 x 10 Pa, find the pressure when the volume is increased to 6.0 x 10^{-4} m^3 .

$$\boldsymbol{P_1 = 7.2 \times 10^6 Pa,\ V_1 = 2.0 \times 10^{-5} m^3,\ P_2 = ?, V_2 = 6.0 \times 10^{-4} m^3}$$

$$\boldsymbol{P_1V_1 = P_2V_2}$$

$$\boldsymbol{7.2 \times 10 \quad \times 2.0 \times 10^{-} \quad = P_2 \times 6.0 \times 10^{-} \quad {}^{6}}$$

$$\boldsymbol{\frac{7.2 \times 10^6 \times 2.0 \times 10^{-5}}{6.0 \times 10^{-4}} = P_2}$$

$$\boldsymbol{P_2 = 2.4 \times 10^{-4}}$$

ACTIVITY 6

1. The volume of a fixed mass of a gas at constant temperature is $4cm^3$ when the pressure is 6 atmospheres, find the volume when the pressure is increased to 12 atmospheres.
2. The pressure of a fixed mass of a gas is 5 atmospheres when its volume is $200cm^3$. Find the pressure when the volume is
   i) halved
   ii) doubled

2. a) i) State Boyle"s law ii) With the aid of a labeled diagram describe the experiment to show the relationship between the volume and the temperature of a fixed mass of a gas at atmospheric pressure.

b) A cylinder with a movable piston contains $0.1m^3$ of air at a temperature of 27^oC. Calculate the volume of the gas if it is cooled to -33^oC at constant pressure.

c) Define the term specific heat capacity

d) A copper block of mass 200g is heated to a temperature of 145^oC and then dropped into a well lagged copper calorimeter of mass 250g which contains $300cm^3$ of water at 25^oC i) Calculate the maximum temperature attained by the water

ii) Sketch a graph to show the variation of temperature of water with time

(b) Explain the following observations;

(i) A woolen carpet feels warmer to a bare foot than a bare cement. *(02marks)*

(ii) House ventilators are placed on the upper side of a room. *(02marks)*

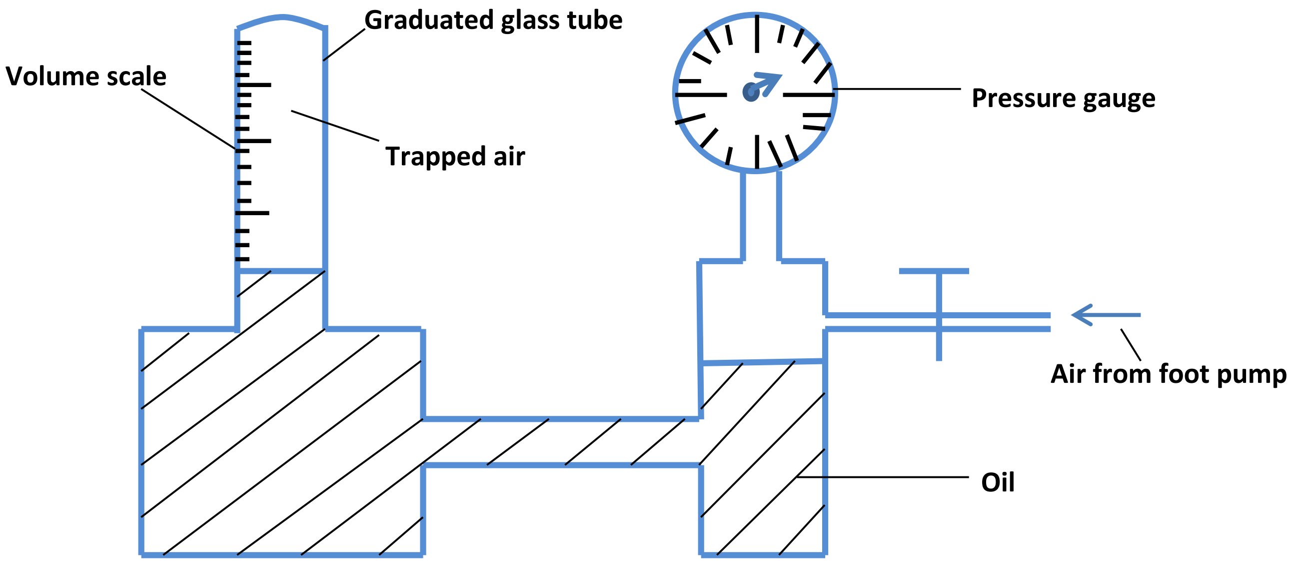
(c) An electric heater of **50Whatts** is used to heat a metal block of mass **5kg** in **10** minutes, a temperature rise of **12^0c** is produced. Calculate;

(i) The quantity of heat produced.

(ii) The specific heat capacity of the metal. *(03marks)*

DAY_7

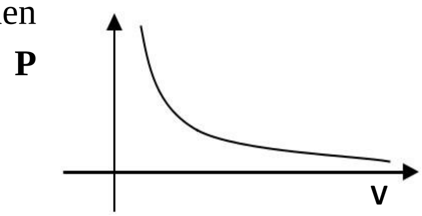
Experiment to verify Boyle's law



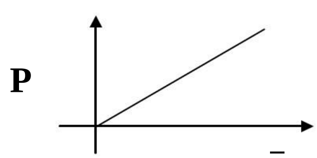
- Trap air above oil in the graduated glass tube.
- Read the initial volume, V and pressure, P of trapped air.
- Increase the pressure of trapped air by using a foot pump connected to a pressure gauge as shown above.
- Allow the air to cool to room temperature.
- Read and record the new values of V and P.
- Increase the pressure again to get different values of V and P.
- Record your results in a suitable table including values of $\frac{1}{V}$

P	V	$\frac{1}{V}$

- A graph of P against V is then plotted.



A graph of P against is $\frac{1}{V}$ also plotted.



From the above graphs it shows that pressure is inversely proportional to volume which is Boyle's law.

Pressure law (Gay Lussac law):

It states that the pressure of a fixed mass of a gas is directly proportional to its absolute temperature at constant volume.

$$\boldsymbol{Pressure \propto Absolute\ temperature}$$
$$\boldsymbol{P \propto T}$$
$$\boldsymbol{P = KT}$$
$$\boldsymbol{\frac{P}{T} = K}$$
$$Where\ \boldsymbol{K}\ is\ constant\ of\ proportionality.$$

If the temperature of gas changes from T_1 to T_2 and its pressure changes from P_1 to P_2.

$$Then,\quad \boldsymbol{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$

Where $T_1 - initial\ temperature$
$final$

$T_2 - \quad temperature$
$P_1 = initial\ pressure$
$P_2 = final\ pressure$

Definition:

Absolute temperature is the temperature at which the volume of a gas reduces to zero. Or **Absolute temperature** the temperature at which the molecules of a gas have the lowest kinetic energy

N.B: The temperature must always be in kelvins.

Examples:

1. The pressure of a fixed mass of a gas at 127 ^{0}C is 600mmHg. Calculate its pressure at o constant volume if the temperature reduces to 27 ^{0}C.

$$\boldsymbol{P_1 = 600mmHg, P_2 = ?,}$$
$$\boldsymbol{T_1 = 127℃ = 127 + 273 = 400K,\quad T_2 = 27℃ = 27 + 273 = 300K}$$
$$\boldsymbol{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$
$$\boldsymbol{\frac{600}{400} = \frac{P_2}{300}}$$
$$\boldsymbol{P_2 = 450mmHg}$$

2. The pressure of a gas is $75Nm^{-2}$ at -73℃. What is its pressure when a gas is heated up to

127℃.

$$\boldsymbol{P_1 = 75Nm^{-2}, P_2 = ?, T_1 = -73℃ = -73 + 273 = 200K,\ T_2 = 127℃ = 127 + 273 = 400K}$$
$$\boldsymbol{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$
$$\boldsymbol{\frac{75}{200} = \frac{P_2}{400}}$$
$$\boldsymbol{P_2 = 150Nm^{-2}}$$

ACTIVITY 7

1.A sealed flask contains a gas at a temperature of 27°C and a pressure of 90 kPa. If the temperature rises to 127°C. What will be the new pressure?

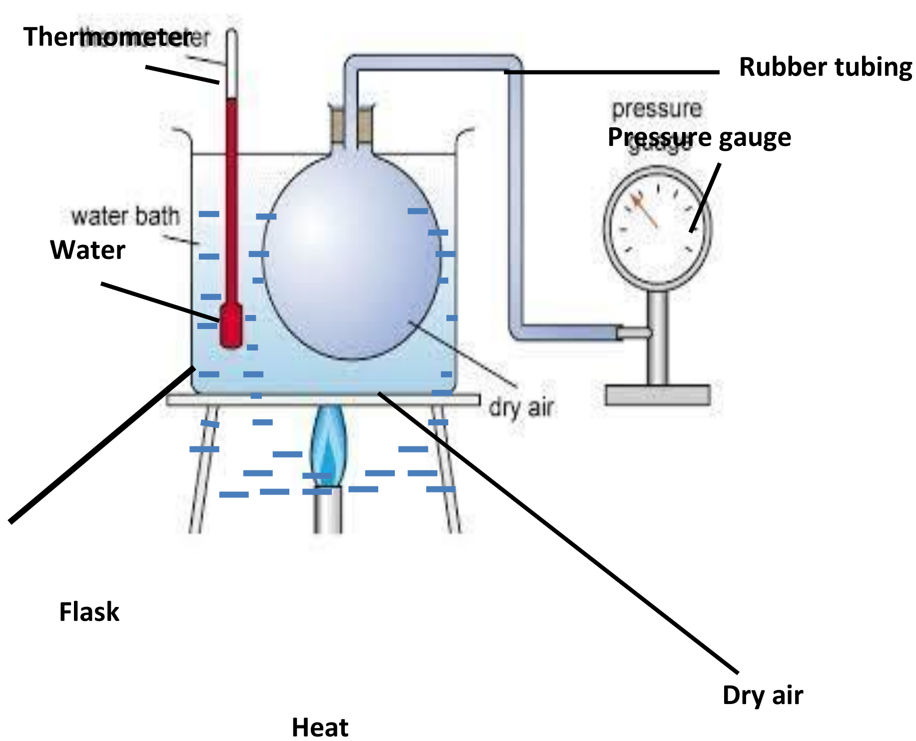
2, In an experiment 500cm of a gas was collected at a temperature of 97 C and a pressure of 3.7 x 10 Pa. Find the volume of the gas if the pressure changes to 6.0 x 10 Pa at a temperature of 27 C.

3. a) With the aid of a labeled diagram, describe the experiment to show the relationship between temperature and pressure a fixed mass of a gas at constant volume.

b) A gas of volume $1000cm^3$ at a pressure of 4.0×10^5 Pa and temperature of 17^oC is heated to 89.5^oC at constant pressure. Find the new volume of the gas.

c) A balloon is filled with $50cm^3$ of hydrogen and tied to the ground. The balloon alone and the container it carries have a mass of 2kg. If the densities of hydrogen and air are $9.0 \times 10^{-2}kgm^{-3}$ and $1.29kgm^{-3}$ respectively, how much load can the balloon lift when released

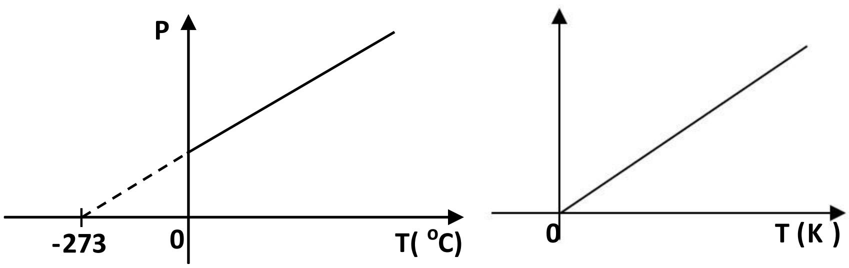
<u>Experiment to verify Pressure law</u>



- The apparatus is set up as shown above.
- The flask containing dry air is placed in a metal can with water such that water is almost to the top of its neck.
- The can is heated from the bottom while stirring.
- Pressure, P is then recorded for different values of temperatures.
- The results are recorded in a suitable table

P	**T(^{0}C)**	**T(K)**

- A graph of P against temperature is then plotted.



P

- From the above graphs it shows that pressure is directly proportional to the temperature which is pressure law.

NOTE: The temperature -273 C (0K) is called **absolute zero temperature.**

Charles' law:

It states that the volume of a fixed mass of a gas is directly proportional to its absolute temperature at constant pressure.

$$\boldsymbol{Volume \propto Absolute\ temperature}$$

$$\boldsymbol{V \propto T}$$

$$\boldsymbol{V = KT}$$

$$\boldsymbol{\frac{V}{T} = K}$$

$$Where\ \boldsymbol{K}\ is\ constant\ of\ proportionality.$$

If the temperature of gas changes from T_1 to T_2 and its volume changes from V_1 to V_2.

$$\boxed{Then, \quad \boldsymbol{\frac{V_1}{T_1} = \frac{V_2}{T_2}}}$$

Where $T_1 - initial\ temperature$

$T_2 - final\ temperature$

$V_1 = initial\ volume$

$V_2 = final\ volume$

Example:

1. The volume of a fixed mass of a gas at 127^0 C is $300cm^3$. Calculate its volume at constant pressure if the temperature reduces to 27^0 C.

$$\frac{1}{T_1} = \frac{2}{T_2}$$

$$\frac{300}{(127+273)} = \frac{V_2}{(27+273)} \rightarrow \frac{300}{400} = \frac{V_2}{300}$$

$$V_2 = 225cm^3$$

2. The volume of a fixed mass of a gas at 17^0 C is 5.0 x 10^{-4} m. Calculate its temperature at constant pressure if the volume reduces to 2.0 x 10^0 m

$$V_1 = 5.0 \times 10^{-4}m^3, V_2 = 2.0 \times 10^{-4}m^3,$$

$$T_1 = 17℃ = 17 + 273 = 290K, \quad T_2 = ?$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{5.0 \times 10^{-4}}{290} = \frac{2.0 \times 10^{-4}}{T_2}$$

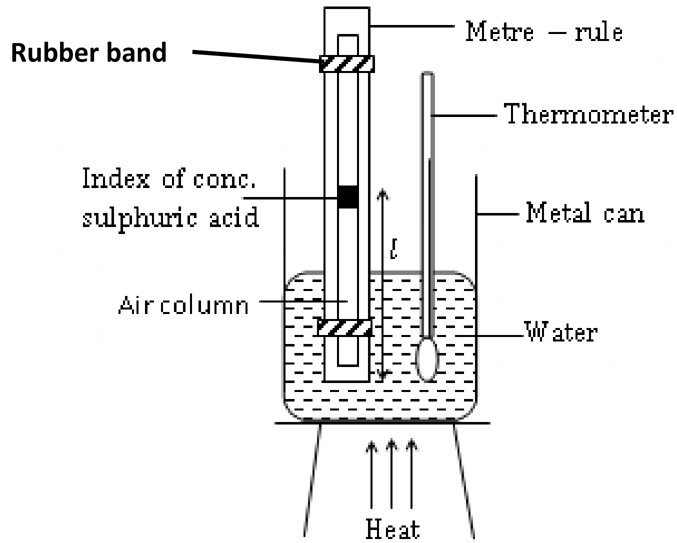
$$\frac{2 \times 290}{5} = T_2$$

$$T_2 = 116K$$

ACTIVITY 7

3. The volume of a fixed mass of a gas at 27^0 C is $400cm^3$. Calculate its volume at constant pressure if the temperature reduces to -123 C.
4. The temperature of a fixed mass of a gas is 27℃. If the volume is halved, find its new temperature.

Experiment to verify Charles' law:



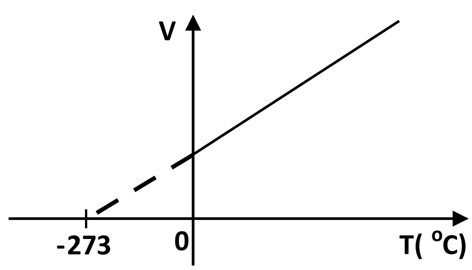
- Trap dry air using the index of concentrated sulphuric acid in a capillary tube.
- Tie the tube on the metre rule using a rubber band.
- Place the tied tube in a metal can containing water.
- Heat the water slowly while stirring gently.
- Read and record the length, L of the trapped air column and the temperature, T from the thermometer.
- Repeat procedures to obtain other values of L for different temperature values.
- Record the results in a suitable table.

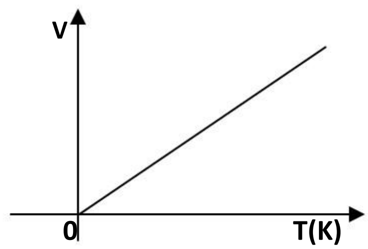
L(cm)	T(^{0}C)	V

But L is proportional to volume,

V so V=L

Plot a graph of volume V against temperature T.





- From the above graphs it shows that volume is directly proportional to the absolute temperature which is Charles's law.

DAY 8 **Equation of state for an ideal gas:**

This is sometimes referred to as ideal gas equation. It combines the three gas laws. Combining the three gas laws, we get;

$$\frac{PV}{T} = K$$

Therefore if the volume of the gas changes from $V_1 \ to\ V_2$, its pressure changes from $P_1 \ to\ P_2$ and its temperature from $T_1 \ to\ T_2$

$$Then, \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

NOTE:

At standard temperature and pressure (**s.t.p**)

- Standard absolute temperature= $273K$
- Standard pressure $= 76cmHg \ or\ 760mmHg\ or\ 1.01 \times 10^5 Pa$

Examples:

1. A bicycle pump contains $50cm^3$ of air at $17°C$ and a pressure of 1 atmosphere. Find the pressure when it is compressed to $10cm^3$ and its temperature rises to 27^0

$$P_1 = 1\ atm, P_2 = ?, V_1 = 50cm\ , V_2 = 10cm\ ?$$
$$T_1 = 17°C = 17 + 273 = 290K, \qquad T_2 = 27°C = 27 + 273 = 300K$$
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
$$\frac{1 \times 50}{290} = \frac{P_2 \times 10}{300}$$
$$P_2 = \frac{50 \times 300}{290 \times 10}$$
$$P_2 = 5.17\ atm$$

2. In an experiment 58cm of a gas was collected at a temperature of 17 C and a pressure of 8.0 x 10^4 Pa. Find the volume the gas at s.t.p.

$$P_1 = 8.0 \times 10^4 Pa, \qquad At\ s.t.p, P_2 = 1.01 \times 10^5 Pa, V_1 = 58cm^3, V_2 = ?$$
$$T_1 = 17°C = 17 + 273 = 290K, \qquad At\ stp, T_2 = 273K$$
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
$$\frac{8.0 \times 10^4 \times 58}{290} = \frac{1.01 \times 10^5 \times V_2}{273}$$
$$V_2 = \frac{8 \times 273 \times 58}{290 \times 1.01 \times 10}$$
$$V_2 = 43.25cm^3$$

Kinetic theory of Gas laws:

Recall; Kinetic theory of matter states that matter is made up of small particles called molecules that are in a continuous random motion and possess energy.

Question: **Explain what causes gas pressure**.

Increase in temperature, increases the speed of molecules and hence with the walls of the container thus creating pressure.

N.B: This explains why the pressure of a car tyre increases on a hot day.

Boyle's law:

For a fixed mass of a gas;

When the volume of the fixed mass of a gas is reduced at constant temperature the speed of the gas molecules increases hence the rate of collision with the walls of the container increases thus the pressure of the gas increases.

However, increasing the volume of a gas reduces the pressure since the speed of the molecules of the gas reduces hence reducing on the rate of collision with the walls of the container.

Charles' law:

For a fixed mass of a gas;

When the temperature of the fixed mass of a gas is increased at constant pressure, the speed of the molecules of a gas increases and the rate of collision with the walls of a container increases thus increasing the volume of gas.

Pressure law:

For a fixed mass of a gas;

When the temperature of the fixed mass of a gas is increased at constant volume, the speed of the molecules of a gas increases and the rate of collision with the walls of a container increases hence the pressure of the gas increases.

ACTIVITY 8

1.The volume of hydrogen at 273℃ is 10 cm^3 at a pressure of 152 cmHg. What is its volume at s.t.p.?

2.a) State the kinetic theory of matter

b) i) State the law of volume and temperature

ii) The volume of a fixed mass of a gas at a given pressure is 1.5m^3 at 300K. at what temperature will the volume of the gas be at the same pressure

c) Describe an experiment to determine the fixed points of a thermometer

i) Mention any three reasons for not using water as a thermometric liquid

iii) When a Celsius thermometer is in a boiling liquid, the mercury thread rises above the lower fixed point by 19.5cm. Find the temperature of boiling liquid if the fundamental interval is 25cm

VAPOURS

Vapour is the gaseous state of a substance below its critical temperature.
Critical temperature is the minimum temperature above which the gas cannot be changed back to a liquid.

There are two types of vapours namely;
- Saturated vapour
- Unsaturated vapour

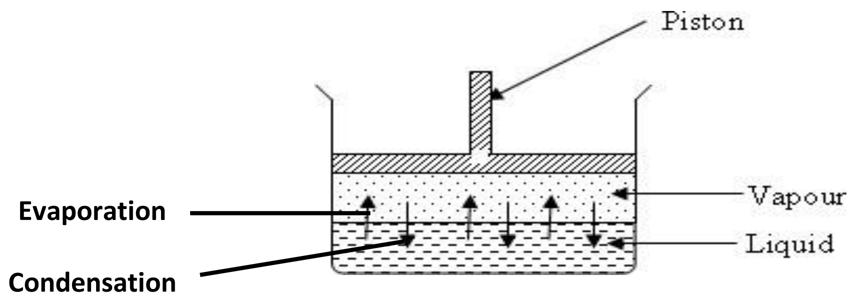
SATURATED VAPOUR

This is the vapour that is in dynamic equilibrium with its own liquid.
i.e. $rate\ of\ evaporation = rate\ of\ condensation$

Saturated vapour pressure;

This is the pressure exerted by a vapour that is in dynamic equilibrium with its own liquid.

Explanation of occurrence of saturated vapour pressure (s.v.p) using kinetic theory



Consider a liquid enclosed in a container with a piston.
When a liquid in a closed container is heated, some of the liquid molecules get enough kinetic energy and break the intermolecular forces and escape from the surface of the liquid and occupy the space just above it and become vapour molecules. This process is called evaporation.
These vapour molecules collide with the walls of the container hence creating vapour pressure.
When these molecules bounce off from the walls of the container, they strike the liquid surface and re-enter the liquid. This process is called condensation.
A state of dynamic equilibrium is attained i.e. (rate of evaporation = rate of condensation) and this point, vapour is said to be saturated and exerting saturated vapour pressure.
Definition: Vapour pressure is the pressure exerted on the walls of the container by the vapour molecules.

NOTE:

Gas laws only apply to a fixed/constant mass of a gas.

Therefore, saturated vapours do not obey ideal gas laws because their masses change due to condensation or evaporation as the conditions change.

It should be noted that saturated vapor occurs for a very short time and at a constant temperature (boiling point).

UNSATURATED VAPOUR

This is the vapour that is not in dynamic equilibrium with its own liquid.

i.e. $rate\ of\ evaporation \neq rate\ of\ condensation$

Unsaturated vapour pressure:

This is the pressure exerted by a vapour that is not in dynamic equilibrium with its own liquid**.**

Differences between saturated vapour and unsaturated vapour

Saturated vapour	**Unsaturated vapour**
• It doesn't obey gas laws. • It is the vapour in dynamic equilibrium with its own liquid. • Exists at a fixed temperature.	• It obeys gas laws. • It is the vapour that is not in dynamic equilibrium with its own liquid. • Exists at any temperature.

Other terms;

Super saturated vapour:

This is the vapour whose rate of evaporation is greater than the rate of evaporation.

Ideal gas:

This is a gas whose intermolecular forces are negligible.

Real gas:

This is a gas whose intermolecular forces are not negligible.

Dew point:

This is the temperature at which atmospheric air is saturated with water vapour.

OR

This is the temperature at which water vapour condenses to liquid water (dew) **Note**;

Fog or cloudy film forms on windscreens of cars because the dew point of water vapour has been exceeded.

EVAPORATION:

This is the process by which a liquid changes into gas (vapour).

OR

This is the escape of molecules of a liquid from its surface.

Evaporation takes place only at the surface of the liquid.

It takes place at all temperatures but it is greatest when the liquid is at its boiling point.

Explanation of evaporation according to kinetic theory:

(How evaporation causes cooling)

According to kinetic theory, molecules of a liquid are in a state of continuous random motion and their speed depend on the temperature of the liquid.

Faster moving molecules with the most kinetic energy reach the liquid surface and weaken the intermolecular forces of attraction and then escape from the surface of liquid causing evaporation.

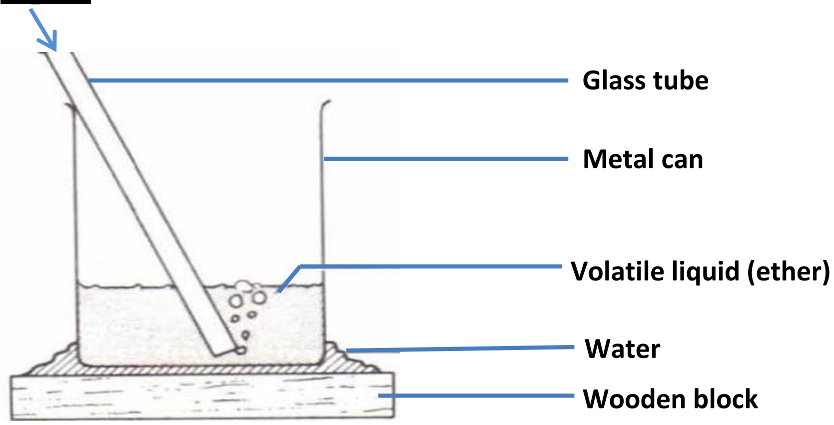
The slow moving molecules with the lowest kinetic energy remain in the liquid thus cooling the liquid.

Recall: Temperature decreases with decrease in speed of molecules. Since some molecules have low speeds, so they are cold.

Applications of cooling as a result of evaporation:

- Panting of dogs.
- Making of ice by evaporation of a volatile liquid.
  - Refrigerators.

<u>Experiment to make ice by evaporation of a volatile liquid</u>: Air



<u>Procedures</u>:

- Place a metal can filled with ether (volatile liquid) on a film of water on top of a wooden block.
- Blow air through the glass tube.

<u>Observation</u>:

- It is observed that the water under the can turns into ice i.e. it freezes.

<u>Explanation</u>:

Ether will evaporate when it gets necessary heat from water and blowing in air increases the rate of evaporation.

Since water is supplying heat to ether, it loses heat thus its temperature decreases hence water freezes to ice.

<u>Definition</u>:

Volatile liquid is a liquid with a low boiling point.

<u>Factors that affect the rate of evaporation</u>:

Rate of evaporation indicates the number of molecules that escape from liquid surface per second.

The following factors affect the rate of evaporation;

(i) <u>Surface area</u>:

Increasing the surface area increases the rate of evaporation because a large surface exposes many energetic molecules to escape while small surface exposes fewer molecules to escape.

• This explains why a plate cools porridge faster than a cup since the plate is wider than the cup.

(ii) **<u>Temperature</u>:**

Increasing temperature increases the rate of evaporation and decreasing the temperature decreases the rate of evaporation. At high temperature, more molecules will move faster to escape from the liquid surface but at low temperature fewer molecules move faster to escape from the liquid surface.

(iii) **<u>Wind (air currents)</u>:**

The rate of evaporation increases if there is too much wind/air blowing because wind blows away molecules which have already escaped from the liquid so they can't return back to the liquid.

This explains why a person can cool porridge while blowing air through it.

(iv) **<u>Pressure</u>:**

Reducing pressure of air above the liquid surface (atmospheric pressure) increases the rate of evaporation since low pressure is exerted on the liquid surface.

(v) **<u>Intermolecular forces of a liquid</u>**:

The stronger the intermolecular forces, the slower the rate of evaporation since molecules will need much heat to break these forces.

ACTIVITY 8

1 a i) Describe an experiment to show that evaporation produces cooling.

ii) Explain why evaporation produces cooling.

iii) State one application of cooling by evaporation.

b) State the factors that determine the rate of evaporation.

4. a) i) What is a saturated vapour

ii) Explain why the boiling point of a liquid depends on altitude.

3. (a) What is meant by saturated vapor pressure?

(b) Explain what may happen when one is to cook food from a very high altitude.

4.. a) What is meant by latent heat of evaporation

b) With the aid of a labeled diagram describe how a refrigerator works

c) The cooling system of a refrigerator extracts 0.7kW of heat. How long will it take to convert 500g of water at 20^oC into ice?

d) Explain how evaporation takes place

19. a) What is meant by conduction

b) Draw a labeled diagram of a vacuum flask and explain how it is able to keep a liquid hot a long time

c) With the aid of a labeled diagram describe an experiment to determine the upper fixed points of an un-calibrated thermometer

d) Explain the following observation a bare cement floor feels colder than a carpeted one

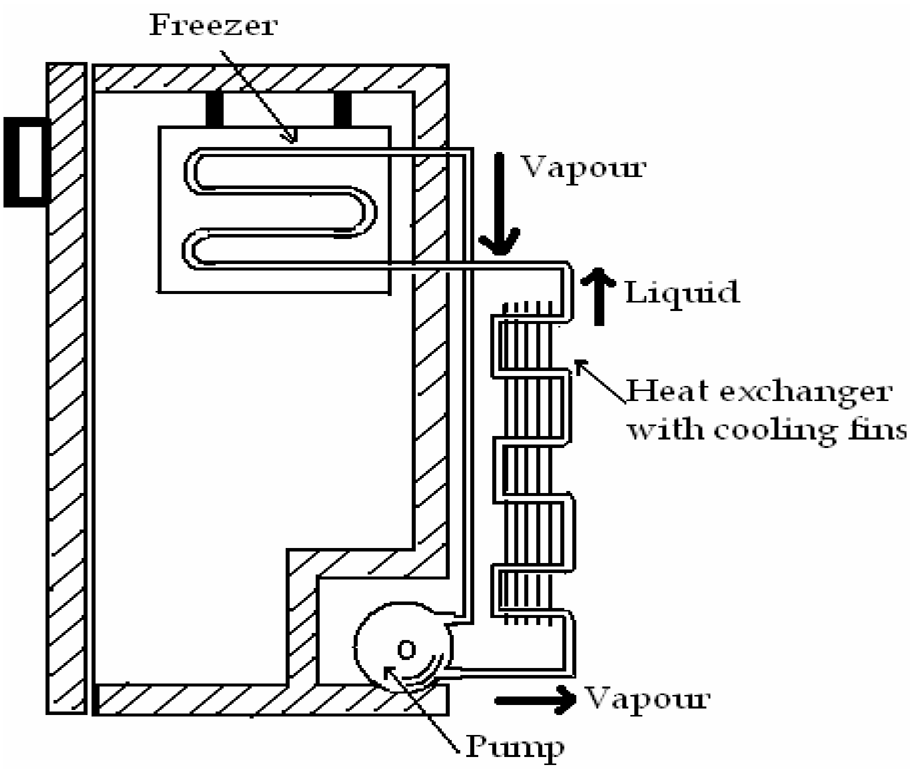
DAY 9

<u>REFRIGERATOR</u>:

This is a cooling device which transfers heat from objects in it to the surrounding. It is used in preservation of;

- Food in homes and supermarkets
- Blood in hospitals
- Medicines in hospitals and pharmaceuticals.

In a refrigerator, heat is taken in at one point and given out at another point by a volatile liquid or refrigerant.



<u>Mode of operation</u>:

- The copper tube contains a volatile liquid which enters the evaporator pipes in the freezer.
- The volatile liquid gets latent heat from the refrigerator contents thus evaporating to vapour.
- This causes cooling of the contents since they lose heat.
- The vapour formed is compressed into the condenser tube and turns into a liquid thus giving out latent heat.

- The heat given out is lost to the surrounding through the cooling fins by convection and radiation.
- The liquid returns to the freezer and the process continues.

<u>FUNCTIONS OF THE PARTS</u>:

(a) **<u>Compressor pump</u>:**

This removes the vapour formed in the freezer and forces the vapour to the condenser tube.

(b) **<u>Condenser tube (Heat exchanger)</u>:**

This where vapour is turned into a liquid giving out latent heat of vaporization to the surrounding air.

(c) **<u>Cooling fins</u>:**

These are painted black so that they can give out heat to the surrounding air. Black colours are good emitters of heat.

(d) **<u>Evaporator pipe</u>:**

This absorbs heat from the refrigerator contents and gives it to the volatile liquid so as to evaporate.

BOILING:

Definition:

Boiling is a process which occurs when atmospheric pressure is equal to saturated vapour pressure.

OR

Boiling is a process by which a liquid changes to vapour at its boiling point. Boiling occurs at a fixed temperature called <u>boiling point</u> and it takes throughout the liquid. Boiling involves formation of bubbles.

<u>Differences between boiling and evaporation</u>

Boiling	**Evaporation**
• It occurs at a fixed temperature. • It takes place throughout the liquid. • Doesn't cause cooling. • Involves formation of bubbles.	• It occurs at any temperature. • It takes place at the liquid. • Causes cooling. • Doesn't involve formation of bubbles.

FACTORS THAT AFFECT BOILING POINT OF A LIQUID

(i) **Pressure:**

The lower the atmospheric pressure, the lower the boiling point (temperature needed to boil a liquid). But if pressure is increased, the boiling point also increases.

This is because if the atmospheric pressure is decreased, then the liquid will boil more easily since it will take less time for its satu   rated vapour pressure to equal to atmospheric pressure.

This explains why;

- Cooking takes longer at higher altitudes.
- In a pressure cooker, food cooks more quickly.
  During cooking we cover our saucepans.

(ii) **Impurities:**

Addition of impurities like salt raises the boiling point of a liquid.

Salts in a water will cause water molecules to be more attracted to the salts thus a higher temperature is required to break the forces of attraction between water molecules thus increasing the boiling point of water.

This explains local salt **"kisula"** is added to beans so as they boil easily.

QUESTION:

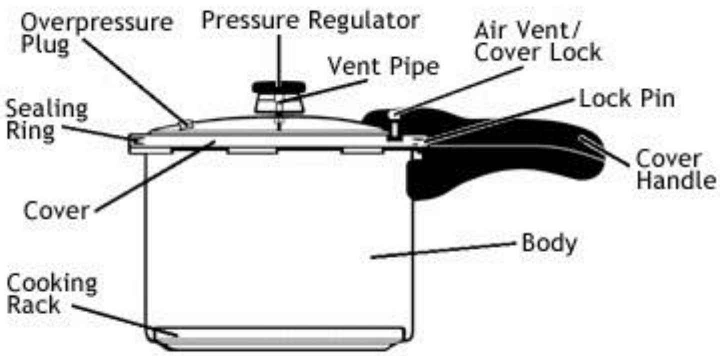
Why cooking takes a lot of time to boil at high altitudes.

This is because at high altitude, the atmospheric pressure is low therefore, the boiling point of water is also low. This causes water to boil faster before food is properly cooked.

Hence it takes a lot of time for saturated vapour pressure to equal to the atmospheric pressure.

PRESSURE COOKER:

Pressure cookers are useful in places where the atmospheric pressure is low e.g. at the top of a mountain because they raise the boiling point of a liquid thus reducing time for cooking.



How a pressure cooker works.

- A pressure cooker has a lid (cover) that prevents steam from escaping.
- As water inside is heated, steam accumulates thus an increase in steam pressure causing the boiling point of water to rise above 100^0C.

Thus food boils quickly thereby saving time and fuel.

FREEZING POINT AND MELTING POINT

Freezing is the process by which a liquid changes to a solid. Freezing occurs at constant temperature called freezing point.

Melting is the process by which a solid change to a liquid. Melting occurs at a constant temperature.

Freezing point is a constant temperature at which a substance changes from liquid state to solid state.

Melting point is a constant temperature at which a substance changes from solid state to liquid state.

Factors that affect freezing and melting points of a substance.

(i) **Pressure:**

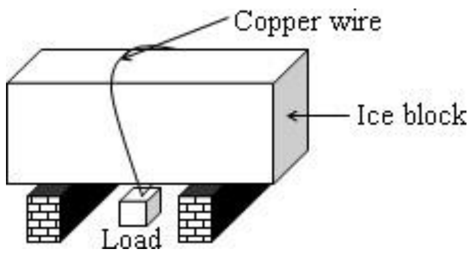
Increase in pressure lowers the melting/freezing point of a substance and vice versa

(ii) **Impurities:**

Addition of impurities lowers the melting/freezing points of a substance and vice versa.

- This explains why ice melts why ice melts quickly when salt is sprinkled on it.

<u>Effect of pressure on melting point of ice</u>.



When pressure is increased on the ice by the copper wire;

 The copper wire passes through the ice block since increased pressure by the copper wire lowers the melting point of ice. So it melts easily at a low temperature.

ACTIVITY 9

1. a) Define specific heat capacity

b) 0.05kg of water at 80^oC is mixed with 0.06kg of water at 10^oC contained in a vessel of heat capacity 28Jkg^{-1}. What is the final temperature of the mixture?

c) i) Define specific latent heat of fusion

ii) Describe a simple method to determine the specific latent heat of fusion of ice c) When 0.005kg of ice at 0^oC is added to 0.02kg of warm water at 30^oC the final temperature attained is 8^oC. Find the specific latent heat of fusion of ice.

2. a) i) Define heat capacity of a substance

ii) Describe an experiment to determine specific heat capacity of a substance by method of mixtures

iii) State the precautions necessary for accuracy during the experiment above

b) A well lagged copper calorimeter of mass 85g contains 80g of water at 60^oC. Dry ice at 0^oC is added to the calorimeter and after stirring the mixture attains a steady temperature of 20 ^oC. Find the mass of ice added

b) i) Define specific heat capacity.

ii) Describe an experiment to determine the specific heat capacity of a solid

c) A copper block of mass 250g is heated to a temperature of 145°C and then transferred to a cooper calorimeter of mass 250gwhich contains 250cm^{3}of water at 20°C

i) Calculate the maximum temperature attained by water

ii) Sketch the graph to show the variation of temperature with time

d) i) What is meant by the term temperature ii) Give two physical properties which change with temperature

5. a) Define the following terms as used in heat

i) Specific heat capacity ii) Latent heat of vaporization

b) Describe an experiment to determine the specific heat capacity of a liquid

c) Steam from boiling water is bubbled through 1.5kg of water at 20^{o}C. After this process, the mass of water was found to be 1.54 kg. What is the new temperature of water?

d) State four ways in which heat losses can be minimized in a calorimetry experiment

4. a) Define specific latent heat of fusion

b) Describe an experiment to determine the specific latent heat of fusion of ice

c) A copper block of mass 300g is heated to a temperature of 245^{o}C and then dropped into a well lagged copper calorimeter of mass 350g containing 400g of water at 35^{o}C.

Calculate the maximum temperature attained by the water.

d) i) What is meant by absolute zero temperature

ii) A sealed flask contains gas at a temperature of 27^{o}C and a pressure of 900Pa. if the temperature rises to 127^{o}C. What will be the new pressure?

5. a) i) Define temperature.

ii) The fundamental interval of a mercury-in-glass thermometer is 192mm. Find the temperature in degrees Celsius when mercury thread is 67.2mm long

b) With the aid of a labeled diagram describe the experiment to show the relationship between the volume and the pressure a fixed mass of a gas at constant temperature.

c) A copper block of mass 150g is heated to a temperature of 95^{o}C and then dropped into a well lagged copper calorimeter of mass 200g containing 250g of water at 15^{o}C. Calculate the maximum temperature attained by the water.

d) State any two differences between boiling and evaporation

6. a) Define specific latent heat of vaporization

b) A calorimeter of mass 35g and specific heat capacity $840Jkg^{-1}K^{-1}$ contains 143g of water at 7^oC. Dry steam at 100^oC is bubbled through water in the calorimeter until the temperature of the water rises to 29^oC. If the mass of steam which condenses is 5.6g,

i) Calculate heat gained by the water and calorimeter

ii) Obtain an expression for the heat lost by the steam in condensing at 100^oC and in cooling to 29^oC.

iii) Find the specific latent heat of vaporization of water

c) Explain in terms of molecules what is meant by a saturated vapour?

d) Describe briefly one application of vaporization

7. a) i) Describe the fixed points of a Celsius scale of temperature

ii) Give two advantages of mercury over alcohol as thermometric liquid iii) Convert -200^oC to Kelvin

b) Use the kinetic theory to explain the following

ii) Cooling by evaporation

iii) Why the temperature of a gas contained in a cylinder increases when it is compressed

c) Explain briefly the transfer of thermal energy by conduction in metals

d) A battery of e.m.f 12V and internal resistance 1Ω is connected for 3minutes across a heating coil of resistance 11Ω immersed in a liquid of mass 0.2kg and specific heat capacity $2.0 \times 10^3Jkg^{-1}K^{-1}$. Find the rise in temperature of the liquid. State clearly any assumptions made.

ACTIVITY 10

1.a) What is meant by conduction

b) Draw a labeled diagram of a thermos flask and explain how it is able to keep a liquid cold for a long time

c) With the aid of a diagram, describe how you would determine the upper fixed point of un -calibrated thermometer

d) Explain the following observations;

i) A bare cement floor feels colder than a carpeted one

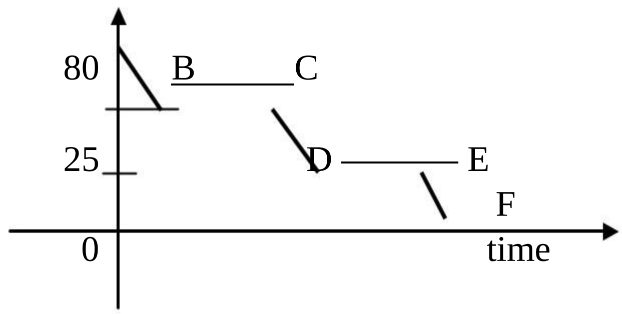
ii) A beam with a notch that is used for constructing a bridge lasts longer when the notch is on its top surface than when the notch is on its lower surface

2.a) Define the following terms

i) Specific heat capacity

ii) Specific latent heat of fusion

Temperature (^oC) A



b) The figure above shows a cooling curve of a liquid whose boiling point is 80^oC and freezing point is 25^oC.

i) Give the states over regions AB, BC, DE and
EF ii) What is happening over region BC?

iii) Use the kinetic theory to explain the differences in states over regions AB and EF

c) An iron rod of mass 0.8kg is pushed into an insulator solid substance through a distance of 2.3m against frictional force of 400N. The temperature of iron rises by
2.5^oC. Calculate the specific heat capacity of iron

d) i) Explain why when water in a saucepan is heated, the level first falls and then rises after some time

ii) The length of mercury thread of un-calibrated thermometer is 10cm when the bulb is in pure melting ice and rises to 20cm in steam. What is the reading of the thermometer when the mercury thread is 18cm?

4. a) Define specific latent heat of vaporization

b) Describe an experiment to determine specific latent heat of vaporization of steam

c) A copper calorimeter of heat capacity $60Jkg^{-1}$ contains 0.5kg of water at 20^oC. Dry steam at 100^0C is passed into the water in the calorimeter until the temperature of the water and the container reaches50^oC. Calculate the mass of steam condensed

d) i) What is meant by saturated vapour pressure ii) Explain what may happen when one is to cook food from a very high altitude

5. a) i) Define latent heat of fusion.

ii) Describe with the aid of a labeled diagram, an experiment to show the effect of increase in pressure on the melting point of ice

b) If the melting point of lead is 327^oC, find the amount of heat required to melt 200g of lead initially at 27^oC given that specific latent heat of fusion of lead is $2.5 \times 10^6 Jkg^{-1}$ and specific heat capacity of lead is $660Jkg^{-1}K^{-1}$.

c) What is meant by the terms?

i) Temperature ii)
Heat

d) State two physical properties which change with temperature.

6. a) Describe an experiment to determine the specific latent heat of fusion of ice
b) i) 2 kg of ice initially at -10°C is heated until it changes to steam at 100°C ii) Sketch the graph to show how temperature changes with time iii) Calculate the energy required at each end of the graph

7.a) Differentiate between conduction and convection

d) Describe an experiment which can be performed to show convection in a liquid

e) i) Draw a labeled diagram of a vacuum flask
ii) Explain how a vacuum flask minimizes heat losses

f) Why is a car radiator made of fins and painted black

6.a) i) Define latent of fusion ii) Describe with the aid of a labeled diagram, an experiment to show the effect of increase in pressure on the melting point of ice

e) What is meant by the terms?

i) Temperature
ii) Heat

f) The fundamental interval of mercury in glass is 192mm. find the temperature in degrees Celsius when the mercury thread is 67.2mm below the upper fixed point.

d) State two physical properties which change with temperature

8. (a) The cooling system of a refrigerator extracts 0.07kW of heat. How long will it take to convert 500g of water at 20 ^{0}C into ice? *($L_f = 0.336x10^6\ J\ kg^{-1}$)*
(b) Explain how evaporation takes place.

9. A copper container of heat capacity 60J $kg^{-1}\ K^{-1}$contains 0.5kg of water at 20^0C. Dry steam is passed into the water until the temperature of the container and water reaches 50^0C. Calculate the mass of steam condensed. ($L_v = 2.26 \times 10^6\ J\ kg^{-1}$)

10. Equal volumes of water at the same temperature are poured in a basin and in a jug. State, giving a reason, which water will evaporate faster.