(For Counsellor's use only)

Grade . . . . Name . . . .

Evaluated by . . . . Enrolment Number . . . . .

EXPERIMENT 14

PHASE CHANGE

14.1 Introduction
Objective
14.2. Appartus
14.3 Study Metarial
Kinetic Theory and Phase Change
Evaporation causes cooling
First Order Phase Change
Transition Temperature
14.4 Precautions
14.5 The Experiment
Melting of the sold
Measurement of Temperature
Cooling Curve
Calculation
Observation
14.6 Conclusion

14.1 INTRODUCTION

It is well known that matter around us exists in solid, liquid and gaseous **(vapour)** forms. It **is also** well known that **under suitable conditions** the same substance (such as water) can exist as ice (solid), water (liquid) and steam **(vapour/gas).** In scientific language **these** are referred to as solid phase, liquid phase and gaseous phase, **respectively. A** change from one phase to another is usually accompanied by a cbang in volume and some absorption **or liberation** of **heat.**

SAQ:
When you go to a **doctor** for an "injection", before injecting the needle the doctor wipes an area of **your skin** with a **ball** of **cotton** soaked in spirit. Write down how you had felt in that region **soon** after wiping.

....

....

....

In hot summer you order for a glass of "sharbat". You ask for a good quantity of ice to be added to get a really cool "sharbat". Write down what you had noticed on the surface of the glass.

....

....

....

OBJECTIVES

After performing the experiment you should be able to

* Infer that then is a transfer of heat without any change in **temperature,** during a phase change.
* Estimate the amount of heat given out when a liquid freezes into a solid.
* Understand and interpret cooling curves.
* Verify that there is a change in volume during phase changes.
* x **Correlate** the experiment with other phase changes that you come acrossevery day,

14.2 APPARATUS

Glass test tube
Bunsen burner or a spirit **lamp**
Water bath
Stand and clamp
Thermistor
Resistance (ohm) meter, or LCR bridge.
Clock or **stop** watch
Spring **balance** or **rough balance**

14.3 STUDY MATERIAL

14.3.1 KINETIC THEORY AND PHASE CHANGE

The kinetic theory of matter tells us that matter exists as molecules, and molecules are in constant motion. In **the case** of solids the moleculesare almost fixed around certain locations and the motion **in** such cases is one of vibration only. When the solid is heated (more energy is supplied) the vibrations become more and more energetic and the molecules are no longer tied to fixed locations. They move randomly within the body of the material and we get the liquid phase which is defined bye surface. When the liquid is heated the molecules gain more and more energy and are able to overcome the pull of the other **molecules** near the **surface** and **evaportion** sets in. The molecules get into the vapour phase. Likewise when a **liquid is** to be frozen the kinetic energy of the molecules is to be reduced. **This is** done by removing some energy from the liquid. **The** same is true for condensations of vapour.

The energy needed for the phasechange at a **given temperature** is knownas the latent heat. Since **the mean distance** between the molecules changes, the volume also changes during a phase change.

14.3.2 EVAPORATION CAUSES COOLING

The average kinetic energy of the molecules is a measure of the temperature of the material. When there is evaporation it is the energetic n~olecules that are able to overcome the pull of the other molecules at the surface of the liquid. Thus evaporation reduces'the average kinetic energy of the molecules left behind in the liquid and the result is "evaporation causes cooling".

143.3 FIRST ORDER PHASE CHANGE

The phase change of the type described above with changes in volume, and absorption **or** liberation of heat (change in entropy) is known as **a** first order phase **change.**

14.3.4 TRANSITION TEMPERATURE

The melting of a solid (fusion) or the boiling of a liquid takes place at certain temperatures known as the melting point **(m.p)** or "boiling point" **(b.p). These** temperatures are also known as the transition temperatures for the respective phase changes.

14.4. PRECAUTIONS

You will be using napthalene as the solid for this experiment. Make sure you don't inhale the vapour of napthalene directly. It is unpleasent and may be harmful.

While melting **napthalene** to avoid overheating. It is suggested that you heat the test tube containing napthalene by keeping it in hot water in a water bath, Do not **heat the test tube** directly as the liquid napthalene may catch fire and sometimes the test tube may crack.

14.5 THE EXPERIMENT

14.5.1 MELTING

Find the weight of the empty **test-tube** and record it here.

Weight of empty test-tube = m_1 = ... Kg

Nowtakeabout **15 or 20 grams of napthalene bits, and** find theirweight. Record the weight here.

Weight of **napthalene** = m_2 = ... Kg

Pour the napthelene bits into the test-tube. Melt **it by** keeping the test tube immersed in **hot water** in a waterbath. Napathelene will melt intoa clearliquid. You would noticethat **the napthalene melts** even **before** the water boils! When you see entirely clear liquid within the **test-tube,** remove the test tube from the bath and wipe the outside of the tube dry using a piece of cloth. Clamp the test-tube **near the** top (above the level of the liquid napthalene) so that **air** can circulate freely around **the** tube for cooling.

14.5.2 MEASUREMENT OF TEMPERATURE

Lower the given thermistor half-way down inside the molten liquid (without touching the wall of the test-tube)and measure **its resistance using an LCR bridge** orohm-meter. You would have performed an **experiment** for calibrating a thermistor. If not, you may get from your Instructor a calibration **graph** connecting the **temperature** and resistance of the given **thermistor.**

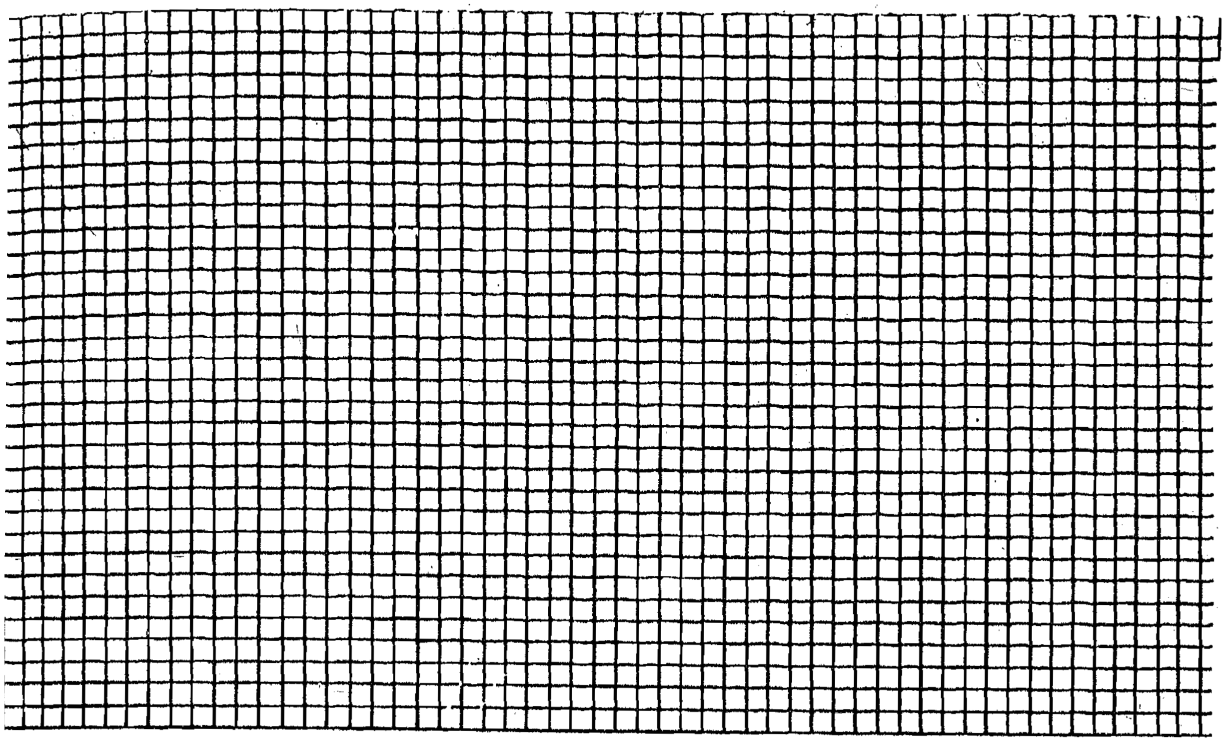
14.5.3 COOLING CURVE

Measure the resistance of the thermistor at regular intervals of time (say every 30 seconds) until the liquid gets frozen into a solid and the solid also gets cooled to about room temperature. Enter your values into Table 1.

TABLE 1

Time (minutes)	Resistance (ohms)	Temperature from calib.

Draw a graph connecting the time (x-axis) and temperature (Y-axis). This graph is known as the cooling curve.



14.5.4 CALCULATION

The graph will look something like the example in Fig. 14.1.

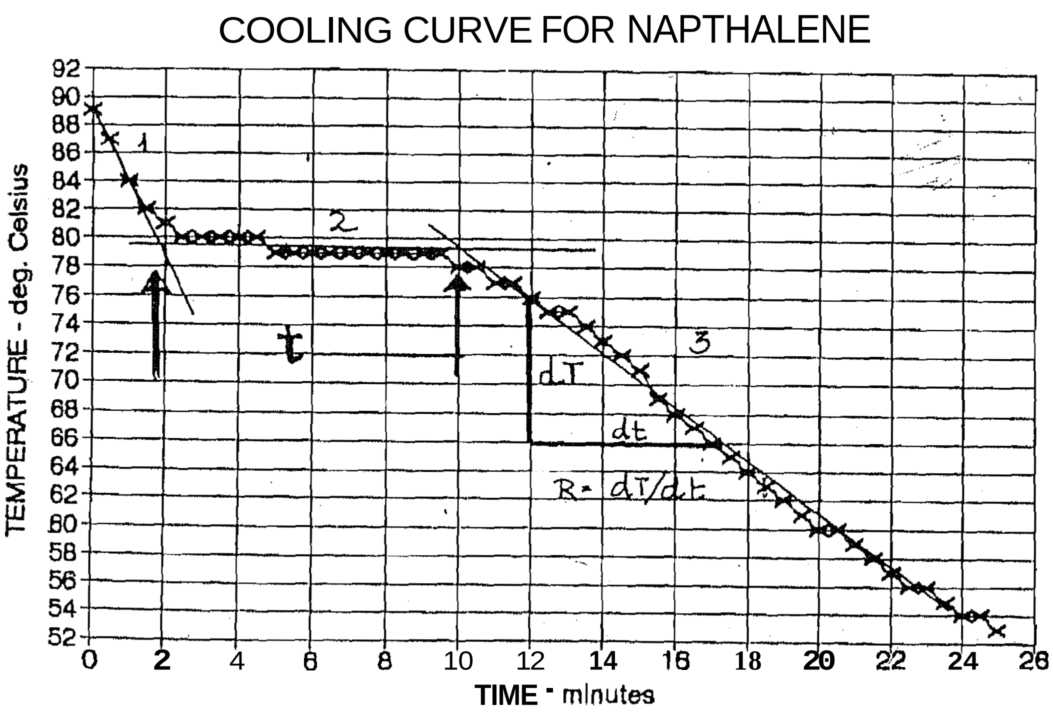


Fig.14.1

It has three distinct regions. (1)The cooling region for liquid. (2) The region during which the change of phase takes place. (3) The cooling region for the solid.

The region of the graph parallel to the time axis (x-axis) represents the time during which the phase change takes place. During this time the test-tube is giving away heat without any fall of temperature. Extend the Region 2. on either side of your graph, as shown in Fig.14.1. Extend the smooth cooling regions of your graph (Regions 1. and 3.) to meet the extended line, again as shown in the example. The duration represented by the interval AB is the time taken for the entire material to solidify. Record this here.

Time for phase change = t = ... sec.

Measure the rate of cooling in Region 3. (measure the slope dT/dt) and record it here.

Rate of cooling in Region 3. = dT/dt = ...deg/sec.

Now assume the specific heat of glass is

c_1 = 670 J/Kg,

and that of solid napthalene

c_2 = 1170 J/Kg.

From this you can calculate the latent heat of fusion of napthalene by noting that the heat loss during freezing time is the same as the heat loss of a solid cooling during that time. Write your calculated result here.

$m_2 * L = m_2 * c_2 * R * t + m_1 * c_1 * R * t$

Hence $L = c_2 * R * t + (m_1/m_2) * c_1 * R * t$ = ... J/Kg

14.5.5 OBSERVATION

Note the surface of the liquid inside the test tube during solidification. record your observations here.

....

....

....

Also give your inference from these observations, as follows.

The volume of the napthalene...
(increases/decreases) during solidification.

14.6 CONCLUSIONS

Have you met the objectives listed in 14.1?

Is the volume of a solid always less than the volume of the same material as a liquid? To help you ansewer, think whether the ice pieces in the "sharbat" float, or sink.

....

....

....

Will the slope of the time-vs-temperature curve depend on the quantity of solid taken in the test tube? Give reasons.

....

....

....

Suggest a suitable experiment for determining the latent heal of fusion of ice?

....

....

....

For preparing ice cream ice is not sufficient to cool the cream. A mixture of ice and salt is used. How docs it help?

....

....

....