CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

Unit 1
Experimental techniques

In this unit you will come to understand the general principles behind various experimental techniques. Experimental investigation is a very important aspect of Physical Science.

This unit is divided into five sections:

A	Appropriate apparatus
B	Paper chromatography
C	Melting and boiling points
D	Methods of purification
E	Separation of petroleum into fractions

When you have studied this unit you should be able to:

- name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders
- describe paper chromatography (including the use of locating agents) and interpret simple chromatograms
- indicate that mixtures melt and boil over a range of temperatures
- identify pure substances by distinctive melting and boiling points
- describe methods of purification by the use of a suitable solvent, filtration, crystallisation, re-crystallisation and distillation (including use of a fractionating column)
- describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation
- name the uses of the fractions: petrol fraction as fuel in cars; paraffin fraction for oil stoves and aircraft fuel; diesel fraction for fuel in diesel engines; lubricating fraction for lubricants; making waxes and polishes and bitumen for making roads.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

A Appropriate apparatus

Time

Stop clocks and stop watches measure intervals of time in units called seconds and minutes.

There are many different kinds of stop clocks. The two mains sorts are dial, or analogue, stop clocks and digital stop clocks.

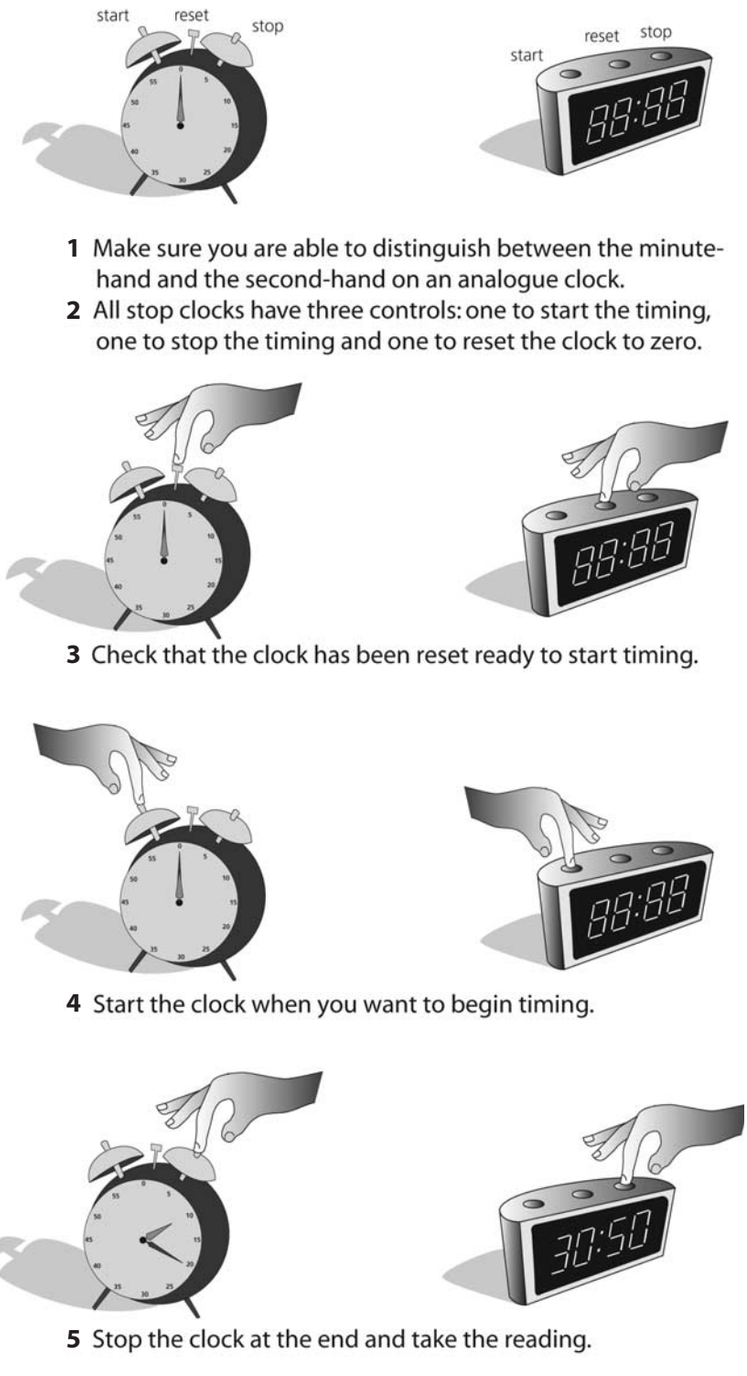


Figure 1.1 Two methods of measuring time (dial and digital)

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

Temperature

We use thermometers to measure how hot or how cold things are in units called degrees Celsius. The symbol °C is used.

Safety precautions

- Never stir vigorously with a thermometer.
- Never put an ordinary thermometer to a flame.
- Never leave a thermometer in a place where it can roll off easily.

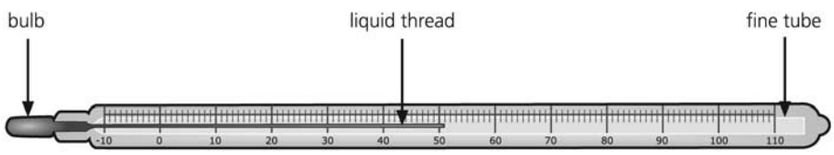


Figure 1.2 Thermometers are used to measure temperature

Mass

Balances measure mass in units called grams. The symbol used for mass is g. There are many kinds of balances. The two main types are digital balances and lever arm balances. All balances work best on firm, level surfaces.

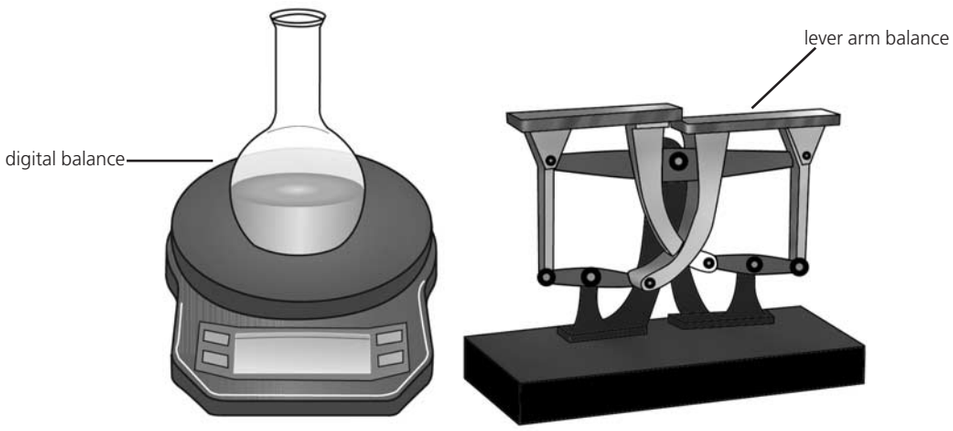


Figure 1.3 Instruments used to measure mass

Safety precautions

You need to take great care to measure mass accurately. Here are some precautions:

- Put things carefully on the pan. Never drop things onto the pan.
- Never weigh hot objects.
- Be careful not to weigh extra drips or bits of a substance.
- Avoid any vibrations – even breathing on the pan will affect the reading.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

Volume

A measuring cylinder is used to measure the volume of liquids. The units used are millimetres (mm) or centimetres cubed (cm^3).

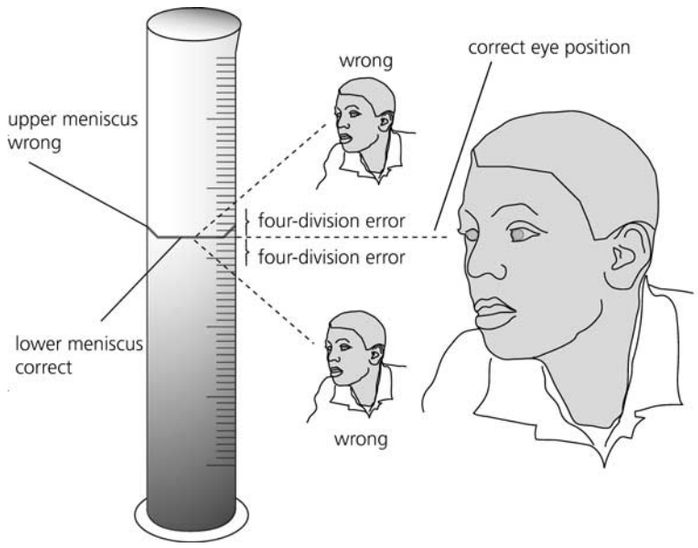


Figure 1.4 How to measure volume as accurately as possible

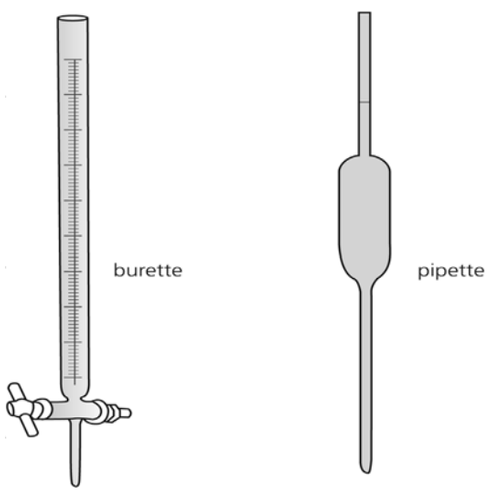


Figure 1.5 Instruments used to measure volume

Safety precautions

You need to take great care when you are trying to measure volume accurately. Here are some hints

- Stand the measuring cylinder on a firm, level surface before taking a reading.
- Read the scale at the bottom of the curved surface of the liquid. The curved surface is called a meniscus. Your eye should be level with the middle of the meniscus.
- Avoid placing very hot liquids in glass measuring cylinders.

Burettes and **pipettes** are also used to measure volume. Pipettes, which are available in different sizes, give a very accurate reading of volume. Burettes are used particularly for titrations to determine the volume of acid or alkali used.

© Cambridge University Press www.cambridge.org

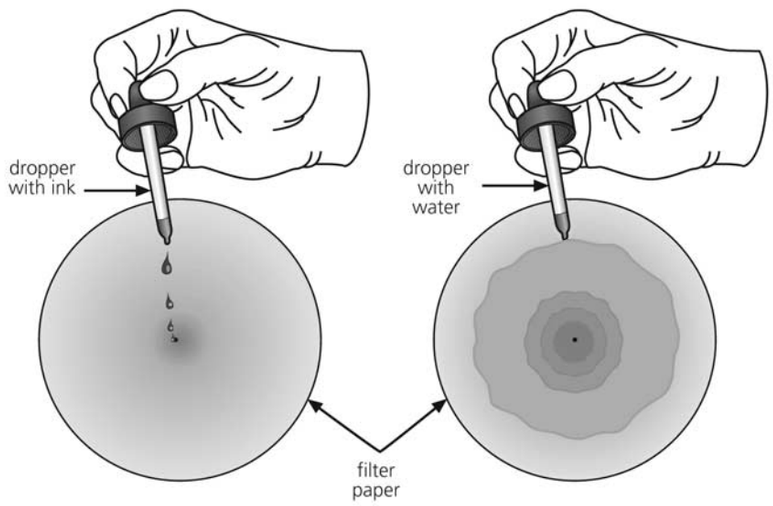
CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

B Paper chromatography

Paper chromatography is used to separate a mixture of dyes. Filter paper and a suitable solvent are used in the process. The solvent used is either water, propanone or any other organic solvent. The filter paper used has very small pores. The solvent moves up the paper as a result of capillary action. The different dyes placed in the mixture being tested have different solubilities. The dye with the greatest solubility in the solvent moves the greatest distance up the paper.

A simple experiment using filter paper and black ink shows the principle behind paper chromatography. A small drop of black ink is placed onto a circle of filter paper as shown below and allowed to dry. A drop of water is then added to the same spot. The ink slowly spreads out into different coloured rings (red, yellow, blue and green). This shows that black ink contains different dyes – each with different solubilities.



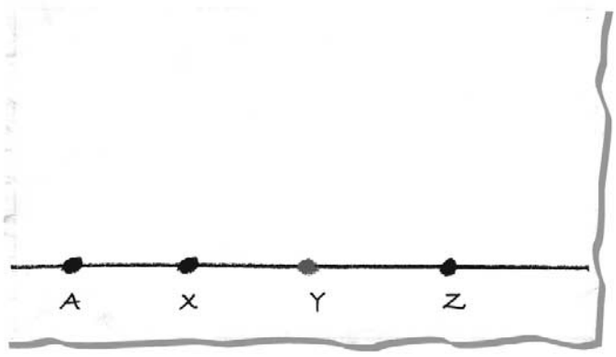
The filter paper with the resultant coloured rings (above) is called the chromatogram. The colour in the ring that is the furthest away from the centre is the most soluble in water. The colour nearest to the centre is the least soluble in water.

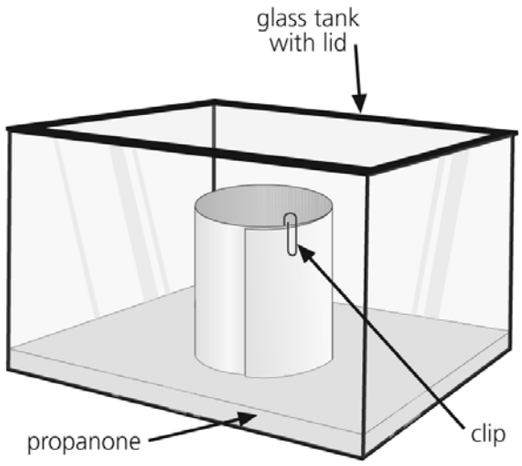
© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

Paper chromatography can also be used to identify which substances are present in a mixture. For example, if we think mixture A contains substances X, Y and Z (which are all soluble in propanone), but we do not know for certain, we could use this process to identify the substances present. The method would be carried out as shown below:





Dissolve a bit of each of the substances A, X, Y and Z in propanone to make a solution. Cut the filter paper into a rectangle. Draw a line in pencil at the bottom of the filter paper as shown above. Put a drop of each solution on the pencil line, marking them clearly. The spots must have a good distance between one another.

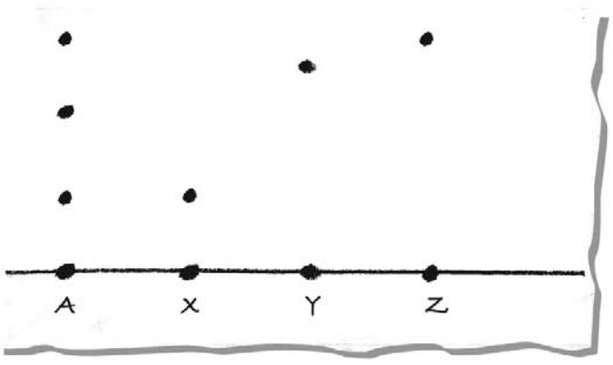
Roll the filter paper up and hold it with a paper clip as shown above. Let it stand in a glass tank into which you have placed a little of the propanone solution. Place the lid on the glass tank. The propanone will slowly rise up the paper, when it is near the top of the paper it can be removed.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

This is how the chromatogram would look after the separation.



A has separated into three spots. Two spots are the same height as the spots of X and Z. This means that A contains substances X and Z. A does not contain substance Y because not one of the dots of A correspond with same height of dots of Y.

Consider the following when doing paper chromatography:

- Ensure that the solvent level is below the pencil line, so that the solvent can move slowly up the paper.
- Use a pencil to draw the line, as lead does not dissolve in most solvents.
- If organic solvents are used, cover the container in which the chromatography is done to prevent evaporation.
- The chromatography should be stopped just before the solvent front reaches the top of the paper.

When paper chromatography is used to separate non-coloured substances, a locating agent needs to be used. Locating agents such as amino acids are used to develop the colour. Sometimes the colour may only be seen if viewed using an ultra-violet light (UV light).

© Cambridge University Press www.cambridge.org

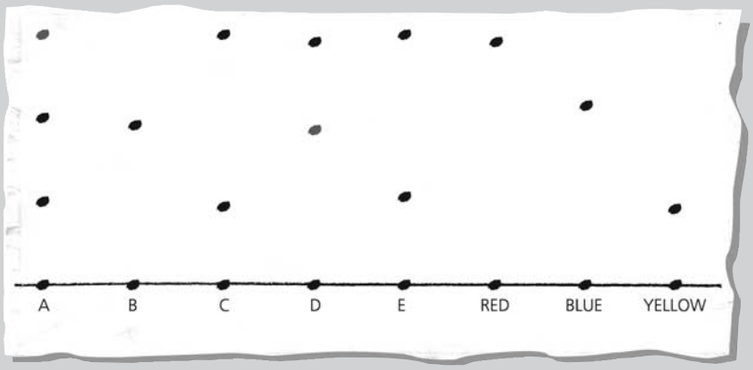
CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

ACTIVITY 1

Spend about 35 minutes on this activity.

1 Drops of eight different coloured substances were placed on a piece of filter paper, which was then placed in a covered glass tank containing a little propanone. Three of the substances were the basic colours, red, blue and yellow. The others were dyes, labelled A, B, C, D, and E. The resulting chromatogram is shown below:

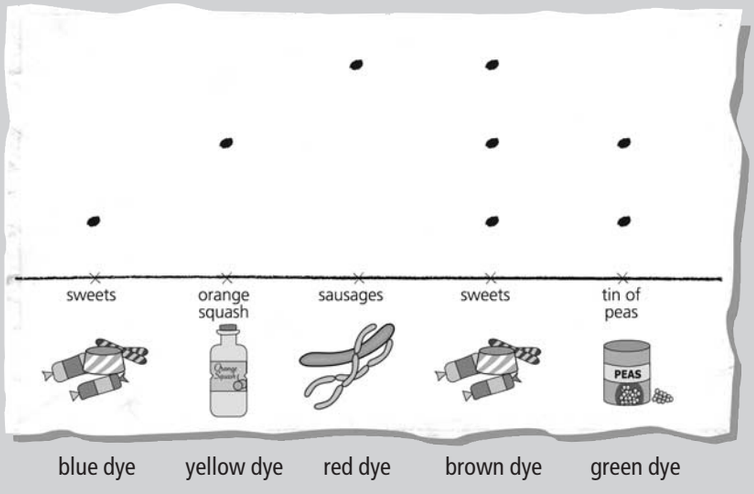


a Which dye contains only one basic colour?

b Which dye contains all three basic colours?

c Which basic colour is most soluble in propanone?

2 Paper chromatography can also be used to investigate the dyes used in food colourings. The results of an experiment are shown below:



a Which food colourings are made of only one coloured dye?

b How could you make the green dye?

c How could you make the brown dye?

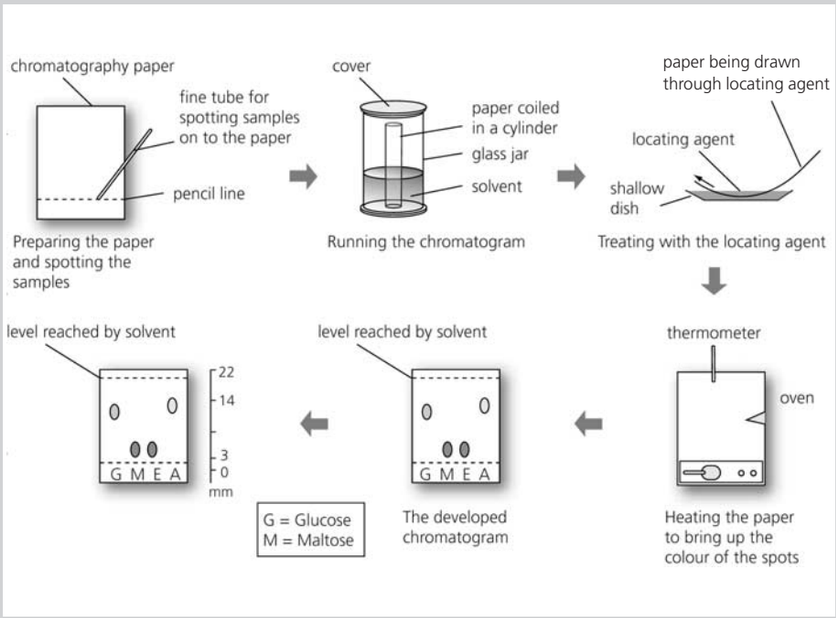
d Suggest one reason why manufacturers add colouring to foods.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

3 The diagrams below show the main stages in an experiment using paper chromatography to identify the hydrolysis products of starch. Spots G and M on the paper are samples of pure glucose and pure maltose. Spot E is a sample of starch which has been hydrolysed using the enzyme in saliva. Spot A is a sample formed by hydrolysing starch with acid.



a What is the purpose of the locating agent?

b Why is no locating agent needed when inks or grass pigments are analysed by chromatography?

c Which sugar moves further up the paper – glucose or maltose?

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-68769-0 - NSSC Physical Science Module 3
Olatunde Ajayi
Excerpt
More information

C Melting and boiling points

Every substance has its own unique melting point (m.p.) and boiling point (b.p.). No two substances have the same m.p. and b.p., which is why these are useful measurements to identify a substance or to tell whether a substance is pure or not.

ACTIVITY 2

To find the melting point of pure ice.

Spend about 25 minutes on this activity.

Apparatus

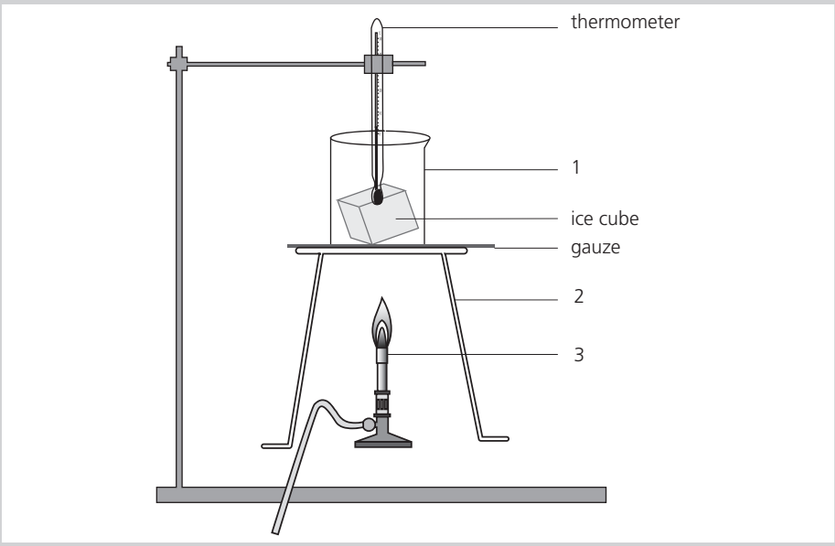
- beaker (or jam jar)
- thermometer
- ice cubes
- table salt.

Procedure

1 Place a few crushed ice cubes in a beaker.
2 Keep the thermometer in the ice cubes.
3 Observe the reading in the thermometer.
4 You should observe the ice slowly changing into water after some time. We call this change melting. You will also note that the thermometer indicated a temperature of 0 °C. This is called the melting point or the temperature at which a substance melts.
5 Next put a few small pieces of fresh ice into a beaker and sprinkle table salt on the ice.
6 Stir until the ice melts and then record the temperature.
7 You should see the thermometer showing -2 °C, which shows that salt is an impurity in water. Impurities lower the melting points of substances.

ACTIVITY 3

Spend about 10 minutes on this activity.



a Complete the labelling of the above diagram.

b What do you see when the ice cubes are gently warmed?

© Cambridge University Press www.cambridge.org