BGE S1-S3

Science

Biology • Chemistry Physics • Topical science

Third and Fourth Levels

Giuliana Iafrate
Barry McBride
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Contents

PHYSICS

TOPICAL SCIENCE

0.1 Get the most from this book

Science is a way for us to gain knowledge about how and why things happen in the way that they do. We do this by using our senses to observe the world around us and by doing experiments to investigate how things work.

This book covers the BGE Benchmarks for Sciences at Third and Fourth Levels, and is divided into Biology, Chemistry and Physics units. It also includes an introduction to the basic skills required to succeed in science and ends with a Topical Science unit containing ideas for research.

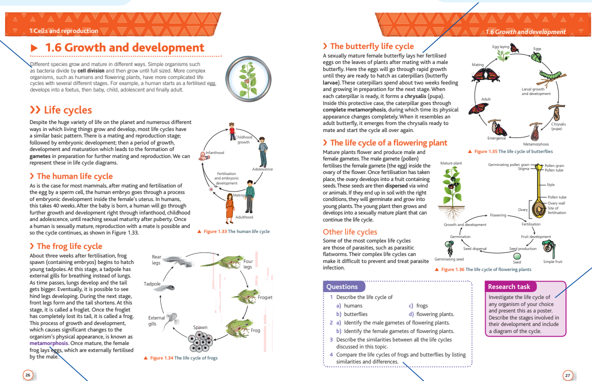
It is enjoyable and easy to read, delivering concepts and theories in a 'straight-to-the-point' manner, using clear and simple language. It is full of helpful hints and contains proven methods of delivering difficult concepts in a style that you can relate to and understand. This book has been designed both as a classroom aid and for your own personal study.

Learn the facts, demonstrate your understanding and build your skills

To get the most from this book, read it carefully and at a steady pace to give yourself time to understand the concepts and theories:

Each lesson starts with an introduction to the topic.

The information you require to understand the topic is presented in each lesson. These contain key points and clear explanations of concepts.



Research tasks give opportunities for further investigation on key areas of interest.

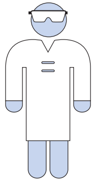
Highlighted glossary terms throughout, corresponding to a glossary at the end of the book, with definitions of key words and terms to help build your science vocabulary.

Work through the questions at the end of each lesson to test your knowledge and understanding of the topic.

0.2 Safety first!

Science is an amazing subject that can open up a world of discovery. However, science classrooms can be dangerous places, which is why there are strict safety rules that must be followed to ensure you and your classmates can work safely in your science lab.

Science safety rules aim to prevent accidents, so it is important that everyone follows all the safety rules shown below.



▲ **Figure 0.1** Science safety rules

Science safety rules

1. Only enter the science lab when a teacher tells you to.
2. Don't eat, drink or chew gum in the science lab.
3. Follow all instructions given to you by your teacher.
4. Always behave in a safe and orderly manner.
5. When doing experiments:
   - always wear your safety goggles
   - remain standing throughout
   - make sure that long hair is tied back
   - let the teacher know if anything is spilled or broken.

Figure 0.2 shows a science classroom where the students are not following the safety rules and are putting themselves and their classmates at risk.

▲ **Figure 0.2** Identify the dangers

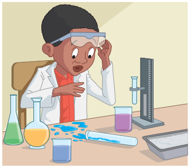
Safety first!

1 Use Figure 0.2 to help you to complete the following tasks:

a) Draw up a table listing all the safety rules being broken by each student.

b) Make a list of any other safety issues that must be addressed in this science classroom to make it safe for all.

2 Think about the following scenarios:

Scenario 1	Scenario 2
 Omar was sitting at his desk measuring out chemicals. He accidently spilled some chemicals onto his hand; he took his goggles off to look at his hand to make sure it was okay.	 Meera was using a Bunsen burner to heat a volume of water to its boiling point in a beaker. Her long hair was loose and when she turned around it caught fire as it came into contact with the Bunsen burner.
Scenario 3	**Scenario 4**
 Ethan was performing an experiment but was running out of time. To save time he placed the glassware and the chemicals he had been using into the sink rather than putting them back where he got them from.	 Catherine was not paying attention when the teacher was explaining how the experiment should be performed. The teacher left the room to collect some extra equipment, but Catherine started the experiment before the teacher had returned to class.

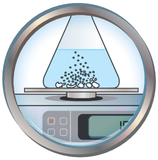
▲ Figure 0.3

Copy and complete the sentences below by listing the rules being broken by each student and say what they can do to improve their safety in the science classroom.

- Omar is not acting safely because …
- Meera is not acting safely because …
- Ethan is not acting safely because …
- Catherine is not acting safely because …

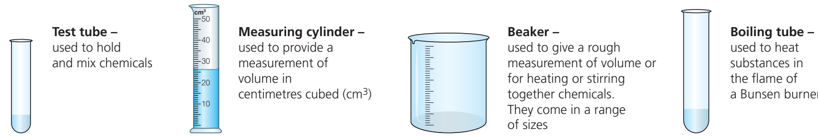
3 Create a 'Science Safety Rules' poster for your science classroom. The poster should be bright and colourful, clearly listing the five science safety rules.

0.3 Equipment in the science classroom



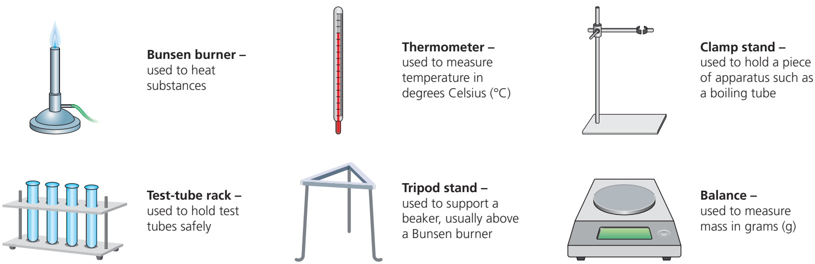
The science classroom will have equipment that you may not have used before. It is important to learn where the equipment is stored in your science classroom, what it is used for and how to use it correctly.

Let's start with glassware. Many types of glassware are used in the science lab; we will cover some of the basic equipment here.



▲ **Figure 0.4** Basic science glassware

There are other pieces of equipment that we also must learn to use safely to be able to perform experiments.

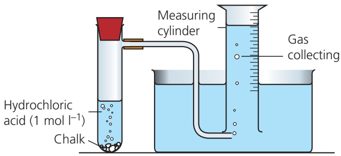


▲ **Figure 0.5** Science equipment

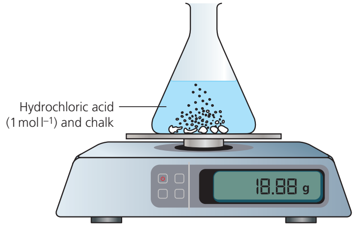
Designing experiments

When designing an experiment, safety should always be the top priority and you should always show your science teacher your plan before carrying out any experiment.

Most commonly, experiments are designed to measure a change in something, for example the change in **mass** or **volume**, the rate of reaction or the level of activity. The data that is collected can be analysed and a **conclusion** can be drawn, for example 'as the temperature increased, the volume of gas produced increased'.



▲ **Figure 0.6** Measuring volume of gas produced



▲ **Figure 0.7** Measuring loss of mass

The design of the experiment should take into account what will be measured. Ask yourself 'what data shall I collect?' and 'what equipment is available to me?'

Will you collect a gas? You could measure the volume of gas produced by a reaction over a period of time.

Will you measure loss of mass? You could measure the change in mass as a reaction proceeds.

Equipment in the science classroom

1 Using Figures 0.4 and 0.5 to help you, copy and complete the diagram shown in Figure 0.8 by labelling all the pieces of apparatus used. The first one has been done for you.

2 Copy and complete the diagram shown in Figure 0.9 by labelling all the pieces of apparatus used.

3 Copy and complete the following sentences by adding the correct piece of apparatus.

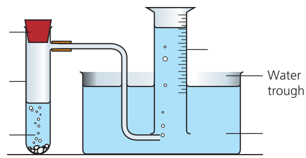
a) A ______________ ______________ is used to mix or hold chemicals.

b) When measuring temperature, a ______________ is used.

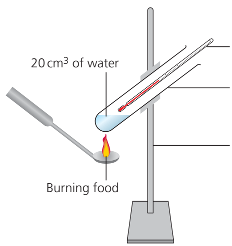
c) A ______________ ______________ is used to safely hold a boiling tube that is being heated by a ______________ ______________.

4 As part of an experiment, a student has to heat 100 cm^3 of water to 80 °C using a Bunsen burner.

Draw a labelled diagram of the student's apparatus.



▲ **Figure 0.8** Collecting a gas



▲ **Figure 0.9** Burning food

0.4 Measuring

We use measurements all the time in daily life. For example, on the drive to school the 30 mph shown on the car dashboard is a measurement of speed; at lunchtime the 500 cm^3 found on the side of your bottle of water is a measurement of volume and the mass of crisps in a standard bag is around 25 g.

Measurements are also important when carrying out experiments. As in everyday life, **all** measurements must be accompanied by a **unit**.

30 mph	500 cm^3	25 g
Value: 30	Value: 500	Value: 25
Unit: miles per hour (mph)	Unit: centimetres cubed (cm^3)	Unit: grams (g)

The **unit** of a measurement is as important as the **value**, because the number is meaningless without the unit. Look again at the everyday examples at the start of this section – would these measurements still be useful if they told you that you are driving at '30' or that there is '500' in your bottle of water? Units are important!

In science we use a variety of units for our measurements and it is important to learn them all.

Volume

Volume is mainly measured using two units, cm^3 (centimetres cubed) or l (litres).

1 litre = 1000 cm^3

The volume shown on the measuring cylinder in Figure 0.10 is 80 cm^3. This can be converted into litres by dividing by 1000:

$$\frac{80}{1000} = 0.08\,l$$

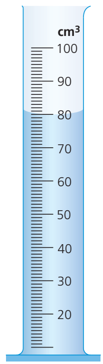


Figure 0.10 Measuring 80 cm^3 of a liquid

When reading the volume from the measuring cylinder, it is important to read it at eye level from the bottom of the meniscus (the little dip at the surface of the liquid).

Mass

Mass is measured using two units, g (grams) or kg (kilograms).

1 kg = 1000 g

The mass shown on the balance in Figure 0.11 is 196.7 g. This can be converted into kilograms by dividing by 1000:

$$\frac{196.7}{1000} = 0.1967\,kg$$

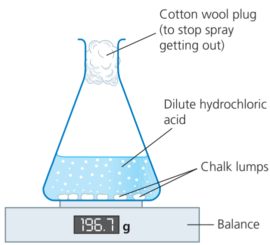


Figure 0.11 A balance being used to measure change in mass during a chemical reaction

Time

Time is mainly measured using s (seconds) or min (minutes).

1 minute = 60 seconds

The time shown on the stopwatch in Figure 0.12 is 01:10 (1 minute 10 seconds). This can be converted into seconds by adding the 10 seconds to 60 seconds (1 minute):

60 + 10 = 70 seconds

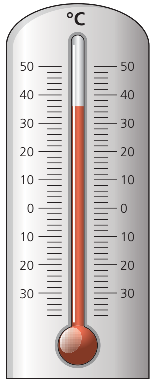
▲ **Figure 0.12** The stopwatch timed 1 minute 10 seconds

Temperature

Temperature is usually measured in °C (degrees Celsius), although there are some other units which you will come across as you progress through secondary school.

The temperature shown on the thermometer in Figure 0.13 is 36 °C.

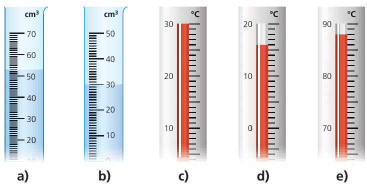
To read the value on a thermometer accurately, the reading must be taken at eye level.



▲ **Figure 0.13** The thermometer reads 36 °C

Measuring

1 Record the measurements and units shown on the pieces of apparatus in Figure 0.14.



▲ **Figure 0.14**

2 Copy and complete Table 0.1 by converting the masses shown into the other unit.

Mass in grams (g)	Mass in kilograms (kg)
500	
250	
	0.6
	2
750	
	1.5

▲ **Table 0.1**

3 Copy and complete Table 0.2 by converting the volumes shown into the other unit.

Volume in centimetres cubed (cm^3)	Volume in litres (l)
100	
1000	
	0.5
	3
10	
	2.5

▲ **Table 0.2**

4 Name the pieces of equipment that can be used to measure:

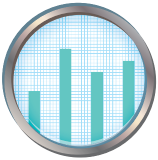
a) volume

b) mass

c) temperature

d) length

e) time.



▶ 0.5 The results are in!

When you perform an experiment, it is important to record your results carefully, so that you can study them and draw a conclusion. The recorded results may also be transformed into a bar chart or line graph, which allows you to analyse them further and helps you to communicate your results to others.

›› Handling data

When performing experiments you may record measurements such as temperature, mass or volume. The most efficient way of recording measurements is in a table, like Table 0.3.

All table lines should be drawn with a ruler. Use clear headings and units for measurements.

The table has been drawn with a ruler.

This table has clear headings and the units are shown.

Metal	Voltage (V)
copper	1.0
magnesium	0.0
zinc	0.2
lead	0.5
silver	1.5

▲ Table 0.3

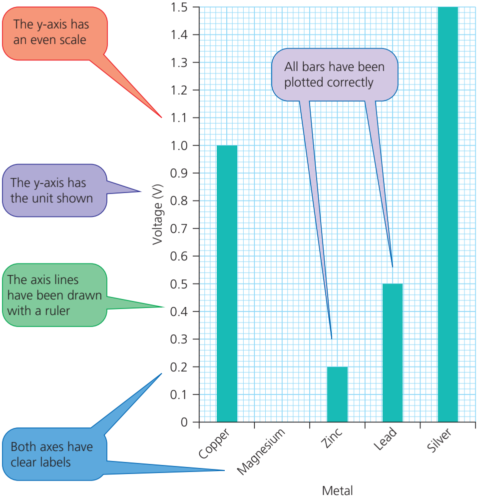
All numbers are recorded clearly.

› Graphs and charts

A very effective way of analysing results is by drawing them as a graph or chart. Graphs and charts must be drawn following a set of rules which are easy to remember using this simple mnemonic.

S CALE	Your graph must have an even scale so that the numbers follow a regular pattern such as 0, 1, 2, 3, 4 … **or** 0, 5, 10, 15, 20 … **or** 0, 10, 20, 30 …
L ABELS	Both axes must be clearly labelled.
U NITS	Units must be shown if required.
R ULER	Draw your axis lines with a ruler.
P OINTS	All points must be plotted accurately.

It's important to note that graphs are completed slightly differently in Biology, however. In Biology, all points must be joined point to point using a ruler. Ask a Biology teacher to show you how to do this.



The results shown in Table 0.3 have been drawn as a bar chart (Figure 0.15).

Figure 0.15 A bar chart of the results in Table 0.3

The results shown in Table 0.4 are for a reaction between acid and chalk. The student recorded the volume of gas produced at regular time intervals.

Time (s)	Volume of CO_2 produced (cm^3)
0	0
30	28
60	39
90	46
120	51
150	55
180	58
210	60
240	61
270	62
300	62

Table 0.4

The results shown in Table 0.4 have been drawn as a line graph (Figure 0.16).

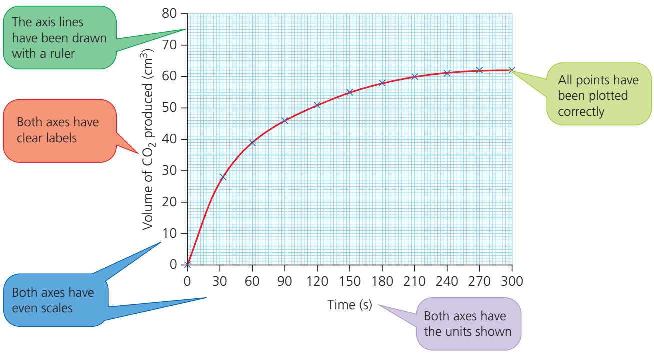


Figure 0.16 A line graph of the results in Table 0.4

Drawing a conclusion

The results of an experiment should be used to draw a conclusion. A conclusion summarises how the results answer the experiment's aim. For example, using the bar chart in Figure 0.15 it can be concluded that: 'silver metal produced the highest voltage' or 'the type of metal used affects the voltage produced'.

The results are in!

1 The results of a student survey on favourite sports to watch on TV were recorded in Table 0.5.

Draw a bar chart of the results.

Sport	Number of students
football	15
cricket	1
rugby	7
American football	2
Formula 1 racing	5

Table 0.5

2 The bar chart in Figure 0.17 shows the amount of energy used per day by different people.

Use the information in the bar chart to answer the following questions:

a) Which people require the most amount of energy per day?

b) Which people require 12 000 kJ per day?

c) List the three categories of people that require less than 10 000 kJ of energy per day.

d) How many categories of people are represented in the bar chart?

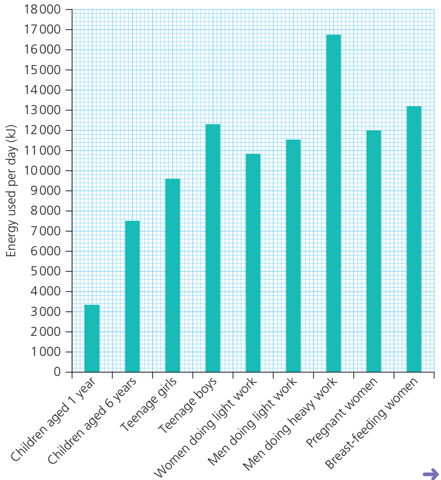


Figure 0.17

3 a) Draw line graphs of the information about cigarette smoking and about growth of seedlings shown in Tables 0.6 and 0.7.

i)

Number smoked per day	0	5	10	15	20	25	30
Deaths (×1000)	3	10	23	35	41	43	45

▲ Table 0.6 Smoking and deaths

ii)

Time (days)	0	7	14	21	28	35	42
Height (cm)	12	17	24	36	56	88	100

▲ Table 0.7 Time and plant growth

b) Use the results to draw conclusions linking:

i) the number of cigarettes smoked per day to deaths

ii) time (number of days) to height of seedlings.

4 The line graph in Figure 0.18 shows the effect that force has on the extension of an elastic band.

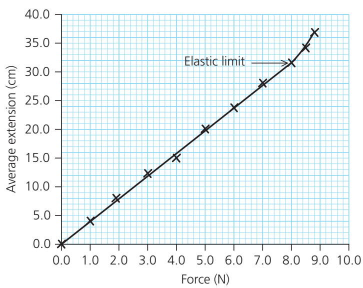
Use the line graph to answer the following questions.

a) State the extension of the elastic, in cm, when it reaches the elastic limit.

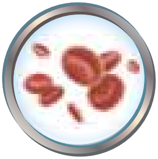
b) What force is required to stretch the elastic to its limit?

c) What force must be used to stretch the elastic by 20.0 cm?

d) What was the maximum value of the elastic stretch recorded?



◄ Figure 0.18 Graph showing force against elastic extension



1.1 Cells

Cells are the building blocks of all living things. There are hundreds of different types of cells in animals and plants, each with its own amazing job to do.

The basic unit of life

Some organisms, such as amoeba, are made up of just one cell and are said to be **unicellular**. They are able to carry out all the processes for life in just one cell. However, **multicellular** organisms, such as most species of plants and animals, need many cells to survive.

Figure 1.1 An amoeba – a unicellular organism

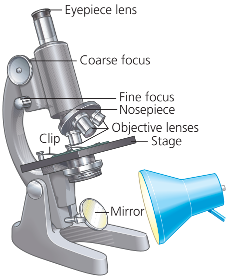


Figure 1.2 A microscope allows you to magnify and view cells

Take a ruler and find 1 mm. Now try to imagine dividing this 1000 times – this is how small cells are.

Cells are said to be **microscopic**, as they are so small they cannot be seen with the naked eye. To see cells, we need to use a microscope, as shown in Figure 1.2. Plant cells are usually bigger than animal cells, but are still microscopic.

Animal cells

When we look at an animal cell under the microscope, we see something similar to this human cheek cell. The tiny structures in cells are called **organelles**. Nearly all animal cells have at least three organelles: a **cell membrane**, a **nucleus** and **cytoplasm**.

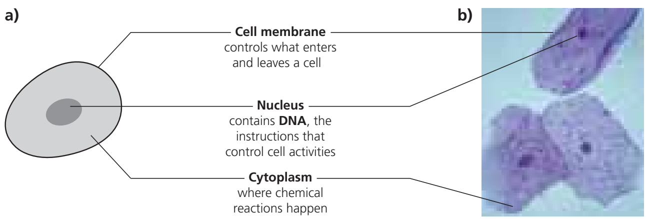
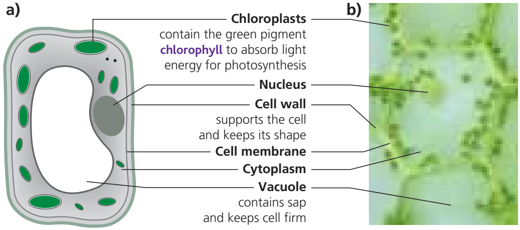


Figure 1.3 A diagram of a human cheek cell and real cheek cells as seen with a microscope

Plant cells

Plant cells also have a cell membrane, a nucleus and cytoplasm, and some additional organelles that are unique to plants. Plant cells have a **vacuole** to store water, a **cell wall** to provide support and **chloroplasts** to carry out **photosynthesis** in the green parts of the plant.



▲ Figure 1.4 A diagram of a plant cell and a real plant cell as seen under the microscope

Specialised cells

Multicellular organisms are made up of many different types of cell called **specialised cells**, each with its own specific job. Specialised cells have shapes and features that allow them to do their job. Figures 1.5 to 1.7 show three important specialised cells.

▲ Figure 1.5 Nerve cells can send messages all over the body and can be as long as you are tall. Their long extensions carry messages from your brain all the way to your toes

▲ Figure 1.6 The shape of a red blood cell allows it to absorb lots of oxygen to carry around the body

▲ Figure 1.7 A sperm cell has a tail to allow it to swim towards the female egg cell

Questions

1. Define the term *unicellular*. Give an example of a unicellular organism.
2. Define the term *multicellular*. Give an example of a multicellular organism.
3. State why a microscope is needed to view cells.
4. List the three organelles found in both animal and plant cells.
5. List the additional three organelles found in plant cells.
6. Create a table to include the functions of all of the organelles of animal and plant cells.
7. Define the term *specialised cell*. Give an example of a specialised cell.
8. Describe the feature of a sperm cell that allows it to do its job.
9. Explain the role of a red blood cell.
10. Cells are measured in micrometres (μm). There are 1000 μm in 1 mm. Calculate the size of a 0.03 mm cell in micrometres.

Research task

Prepare a fact file on one of the following specialised cells. Include a drawing and describe the special features.

- white blood cell
- human egg cell
- leaf mesophyll cell
- root hair cell