lower secondary science 9 workbook answers

Mathematics: Analysis and Approaches SL (Cambridge High School (Milton))

Unit 1 Photosynthesis and the carbon cycle

Topic 1.1 Photosynthesis

Exercise 1.1A How light level affects photosynthesis

The type of plant; the mass of the plant; the temperature

Apparatus	Amount of light	Volume of gas collected in cm^3
A	high	18.3
B	low	7.2
C	none	0.5

Plants photosynthesise faster when they have more light.

Exercise 1.1B The effect of different colours of light on the rate of photosynthesis

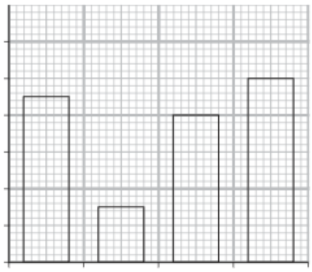
The colour of the light / cellophane.

The number of bubbles produced in one minute.

Any three from: the light intensity (strength); the type of water the water plant was in; the quantity of water plant; the type of water plant; the temperature.

For example:

Colour of light	Number of bubbles per minute			
	1st try	2nd try	3rd try	mean



Accept any valid conclusion that can be made from these results, for example: plants photosynthesise fastest in white light; photosynthesis happens faster in blue light than in green light.

Exercise 1.1C Turning an idea into a hypothesis that can be tested

Accept any answer that:

- is in the form of a clearly phrased hypothesis
- relates to the effect of carbon dioxide on the rate of photosynthesis of an aquatic plant
- can be tested by experiment.

For example, a possible hypothesis could be:

Water plants give off more bubbles per minute when they are given more carbon dioxide.

Look for:

- a clear statement of the independent variable and dependent variable
- at least two other variables that will be controlled
- a clearly explained method, with enough detail that someone else could follow it, including a labelled diagram of the apparatus
- a clear description of how the independent variable will be changed
- a clear description of how and when results will be collected
- a results chart, with headings and units (but no results)
- a prediction based on scientific understanding.

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Topic 1.2 More about photosynthesis

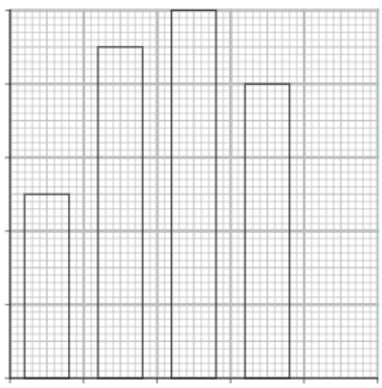
Exercise 1.2A Duckweed experiment

A 0, B 1, C 2, D 3, E 4

quantity of fertiliser

number of duckweed plants, volume of water, temperature, light intensity

Dish	Number of grains of fertiliser	Number of plants at end of experiment



Duckweed plants grew and reproduced faster in the dishes with 1 or 2 grains of fertiliser than with no fertiliser.

This shows that adding fertiliser causes the duckweed plants to grow and reproduce faster.

However, fewer plants grew and reproduced when 3 grains of fertiliser were added than when 2 were added, and all the plants died when 4 grains were added.

Use three sets of dishes for each quantity of fertiliser.

(The other two choices would be different experiments and would not test Sofia's original idea, which was that giving duckweed plants extra nitrate fertiliser helps them to grow and reproduce faster.)

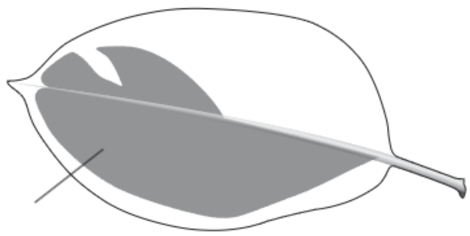
Exercise 1.2B Testing a variegated leaf for starch

chlorophyll

Chlorophyll absorbs energy from sunlight. Without chlorophyll, the leaf cells will not be able to photosynthesise and make glucose. Without glucose, they will not be able to make starch.

This is to break down the cell membranes in the leaf, allowing the iodine solution to get to the starch.

This is to remove the chlorophyll from the leaf, making it easier to see any colour changes when iodine solution is added.



starch

Exercise 1.2C Floating discs experiment

oxygen

The stomata (little holes in the epidermis) are on the underside of leaves. The oxygen is made by the cells inside the leaf, from where it diffuses out through the stomata.

The more bubbles of oxygen produced, the more quickly the leaf disc will rise; the bubbles of gas collecting under the leaf make it float upwards. A mention of the gas bubbles attached to the leaf making it less dense would show a very good level of understanding.

For example: Leaves photosynthesise more quickly in bright light than in dim light or leaves make more oxygen in bright light than in dim light.

Light intensity/brightness

3 (bright light) and 44 (dim light) should be circled.

Mean for bright light = 12.75, 12.8 or 13.
Mean for dim light = 70.75, 70.8 or 71.

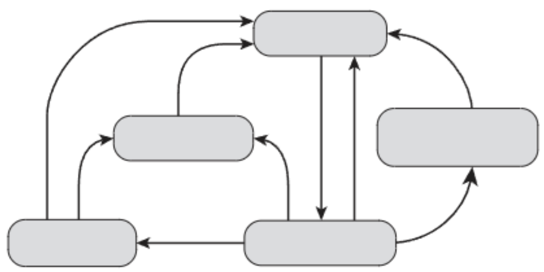
There were a lot of variables that the girls could not control, however hard they tried. For example: the bubbles of oxygen might not come out of every part of each leaf evenly, so some of the leaf discs would tip over and rise to the surface more quickly or more slowly; some of the discs might hit the sides of the beaker, which would make them rise more slowly; it would be difficult to decide exactly when to start the timer, and when to stop it.

The conclusion should be a response to the hypothesis that the learner stated in the answer to question 4. For example: Leaf discs photosynthesise more quickly in bright light than in dim light.

Leaves use light as their energy source for photosynthesis, so they photosynthesise more quickly in bright light than in dim light. This means that they make oxygen more quickly. Oxygen bubbles collect more quickly on the undersides of the leaf discs in bright light, so the discs rise to the surface more quickly.

Topic 1.3 The carbon cycle

Exercise 1.3 Completing a carbon cycle diagram



So that the gases in the tube could not mix with the air. This allowed Arun to see how the processes happening inside the tubes changed the concentration of carbon dioxide in the tube.

Any two from: temperature, volume of indicator, time the apparatus was left for.

Tube	Contents	Colour of indicator at start	Colour of indicator after two hours

In tube A, the plant photosynthesised and respired, but it photosynthesised more than it respired. The animal respired. Overall, about the same quantity of carbon dioxide was taken in for photosynthesis as was given out by respiration. The quantity of carbon dioxide in the tube did not change.

In tube B, the animal respired, giving out carbon dioxide. There was a high concentration of carbon dioxide in the tube.

In tube C, the plant photosynthesised and respired, but it photosynthesised more than it respired. More carbon dioxide was taken in than was given out. So there was almost no carbon dioxide left in the tube.

In tube D, there was no respiration or photosynthesis. The quantity of carbon dioxide in the tube did not change.

Look for these ideas:

- The only process that removes carbon dioxide from the atmosphere is photosynthesis.
- Respiration and combustion add carbon dioxide to the atmosphere.
- If there was no photosynthesis, then carbon dioxide would build up in the atmosphere.

Topic 1.4 Climate change

Exercise 1.4 Interpreting graphs about climate change

There is more carbon dioxide in the atmosphere now than there used to be: Graph C.

Sea level is steadily rising: Graph A.

Sea ice in the Arctic is present for fewer months in the year now, and there is less of it: Graph B.

Sea level is rising. Sea level has risen by 230 mm since 1880.

Sea ice covered a smaller area in 2017–2018 than between 1979 and 2016.

Sea ice appeared later and disappeared earlier in 2017–2018.

You would need to collect data for more years after 2017–2018 to see if this is a trend or just a one-o□ result for this period.

For example: We can correlate an increase in burning fossil fuels with the rise in carbon dioxide concentration.

In the northern hemisphere there is more light and higher temperatures in summer than in winter. Plants photosynthesise more in summer, using more carbon dioxide. So carbon dioxide concentration falls in summer and rises in winter when plants cannot photosynthesise as much.

Unit 2 Properties of materials

Topic 2.1 Atomic structure and the Periodic Table

Exercise 2.1 Atomic structure

12

14

aluminium

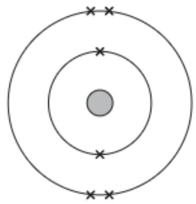
neon

Atomic number = 5; Mass number = 11; Number of protons = 5; Number of neutrons = 6; Number of electrons = 5

6

6

6



Element	Atomic number	Mass number	Protons	Neutrons	Electrons	Electronic structure
			15	16	15	2,8,5
			20	20	20	2,8,8

The atomic number increases by 1 every time you move along to the next element in the Periodic Table.

The mass number increases in most cases (except between argon and potassium where the mass number decreases by 1) but the increase is not by a fixed number each time.

calcium and argon

Accept helium, nitrogen, oxygen or neon.

Element	Potassium
	19
	39
	19
	20
	19
	2, 8, 8, 1

Topic 2.2 Trends in groups within the Periodic Table

Exercise 2.2A Elements in the same group

The number of protons increases.

The mass number increases.

Atomic number = 11; Mass number = 23; Number of protons = 11; Number of neutrons = 12; Number of electrons = 11

2, 8, 1

They have the same number of electrons (one) in the outer shell and both have 2 in the inner shell and both have 2 in the inner shell.

Atomic number = 19; Mass number = 39; Number of protons = 19; Number of neutrons = 20; Number of electrons = 19

2, 8, 8, 1

All three atoms have one electron in the outer shell, and two in the inner shell.

The atoms get larger / there are more electron shells as you go down the group. The atoms have a larger mass / more protons and neutrons as you go down the group.

Exercise 2.2B Trends in groups in the Periodic Table

A group in the Periodic Table is a column of elements.

Watch out for any confusion in understanding that −7 °C is a higher temperature than −220 °C.

The trends are:

- the melting points increase as you go down the group
- the boiling points increase as you go down the group
- the elements become less reactive as you go down the group.

The melting point of iodine will be higher than that of bromine.

Iodine is a solid at room temperature. This is because the melting point of iodine is likely to be more greater than room temperature (around 22 °C). The table shows very large changes in melting points between the elements in the group.

The melting point of bromine is −7 °C so the melting point of iodine would be expected to be much higher than that.

Iodine would have a much lower boiling point than astatine. (The trend in the group is that the further down you go, the more the boiling point increases.)

Astatine is less reactive than iodine as it is below iodine in Group 7.

Exercise 2.2C Comparing the trends in Groups 1 and 7

The melting point decreases.

The melting point increases. This is the opposite of what happens in Group 1. (Watch out for any confusion in understanding that −7 °C is a higher temperature than −220 °C.)

In Group 1, the boiling point decreases as the atomic number increases, whereas in Group 7, the boiling point increases as the atomic number increases.

In Group 1, the least reactive element is the one with the smallest atom; the most reactive is the one with the largest atom. In Group 7, the least reactive element is the one with the largest atom; the most reactive is the one with the smallest atom.

Rubidium, Group 1: Students should predict that:

- it will be more reactive than the other elements shown (as it has a larger atom)
- it will have a lower melting point
- it will have a lower boiling point

Iodine, Group 7: Students should predict that:

- it will be less reactive than the other elements shown (as it has a larger atom)
- it will have a higher melting point
- it will have a higher boiling point.

Topic 2.3 Why elements react to form compounds

Exercise 2.3A Atoms and ions

The outer shell of the atom should be labelled as the highest energy level.

Diagram should have a nucleus, and one shell with two electrons.

Li^+

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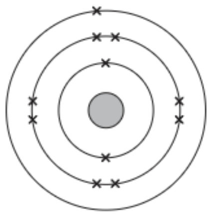
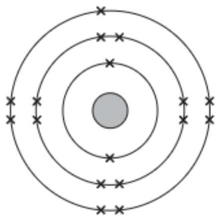
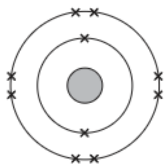
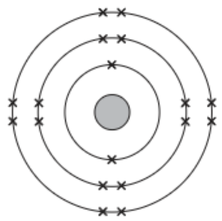
Diagram should have two shells, with electron structure 2,8 and a nucleus.

F^-

Exercise 2.3B Why do ions form?

sodium: atomic number 11 mass number 23	chlorine: atomic number 17 mass number 35
sodium atom:  The learners must place the electron crosses in the correct shells but they can be anywhere in those shells.	chlorine atom:  The learners must place the electron crosses in the correct shells but they can be anywhere in those shells.
sodium ion:  The learners must place the electron crosses in the correct shells but they can be anywhere in those shells.	chlorine ion:  The learners must place the electron crosses in the correct shells but they can be anywhere in those shells.

The electrons are held in place by the electrostatic forces between the protons and the electrons.

Ions are formed because the outer shells of the atoms are not full and that makes the atom less stable. The atoms can form full shells by losing or gaining electrons.

Exercise 2.3C Forming ionic compounds

Calcium diagram should have a nucleus, shells, with electron structure .

Chlorine diagram should have a nucleus, shells, with electron structure .

Diagrams must be labelled.

Calcium diagram should have a nucleus, shells, with electron structure .

Chlorine diagram should have a nucleus, shells, with electron structure .

Diagrams must be labelled; learners may mark the chlorine ion as negatively charged and the calcium ion as positively charged.

The calcium atom has two electrons in its highest energy shell. For the calcium atom to become more stable these two electrons must be lost. Chlorine has seven electrons in its highest energy level so only needs one electron to fill this shell. Two atoms of chlorine are needed to use the two electrons lost from the calcium atom so the formula for calcium chloride is $CaCl_2$ because two atoms of chlorine are needed for every one atom of calcium.

Topic 2.4 Simple and giant structures

Exercise 2.4A Ionic or covalent bonds

Ionic bonding, because the particles are packed closely together in a lattice pattern.

Arrows should indicate the points where the large atom and the four small atoms in each molecule join. The label should read 'strong forces within each molecule'.

Substance B

Substance A

Ionic

covalent

Any correct example, such as graphite or silicon dioxide.

Exercise 2.4B Properties of ionic and covalent substances

Its melting and boiling points are high.

a gas

potassium chloride, calcium chloride and magnesium oxide

ammonia and bromine

Water; because it has a boiling point of 100 °C and a melting point of 0 °C.

bromine

Magnesium oxide has high melting and boiling points because it is an ionic compound. The ions have strong forces holding them together in a lattice pattern. This means that a lot of energy is needed to overcome these forces and make the magnesium oxide melt or boil.

Ammonia has low melting and boiling points because, although the forces inside the molecules are strong, the forces between the molecules are weak and less energy is needed to overcome these intermolecular forces and make the ammonia melt or boil.

Exercise 2.4C Giant structures of carbon

diamond (left) and graphite (right)

The atoms of carbon in graphite are arranged in layers. The bonds between the carbon atoms in the layers are strong (each carbon atom bonds with three other atoms) but the bonds between the layers are weak. This means that the layers can slide over one another and the surface is soft and comes away. For example, when you write with a graphite pencil.

The atoms of carbon in diamond are arranged in a rigid, giant three-dimensional structure or lattice. This means that there are strong bonds throughout the whole structure and this is what makes diamond so hard.

Unit 3 Forces and energy

Topic 3.1 Density

Exercise 3.1A Comparing densities

gas

B

R

The density of the material should be less than that of water / less than 1.0 g/cm^3.

Exercise 3.1B Understanding and calculating density

the mass of a certain volume of substance

(density =) $\frac{\text{mass}}{\text{volume}}$

density = $\frac{\text{mass}}{\text{volume}} = \frac{10}{10} = 1(.0)$ (g/cm^3)

density = $\frac{\text{mass}}{\text{volume}} = \frac{170}{20} = 8.5$ (g/cm^3)

density = $\frac{\text{mass}}{\text{volume}} = \frac{56}{100} = 0.56$ (g/cm^3)

$2 \times 2 \times 2 = 8$ cm^3

density = $\frac{\text{mass}}{\text{volume}} = \frac{71.2}{8} = 8.9$ (g/cm^3)

Exercise 3.1C Density, floating and sinking

polyethylene

polypropylene

cellulose acetate / polyvinyl chloride

density = $\frac{\text{mass}}{\text{volume}}$, so mass = density × volume = 1.0 × 250 = 250 g; so, the mass of the boat must be <u>less than</u> 250 g (accept values such as 249 g or 249.9 g)

The shape of the mild steel is designed so the ship is hollow / contains air; the average density of the mild steel and the air (and other materials) is less than 1.03 g/cm^3.

Topic 3.2 Heat and temperature

Exercise 3.2A Heat or temperature

100 °C is the   at which water boils.

25 000 J is the quantity of   needed to make cold water warmer.

22 °C is often described as room   .

The temperature of the coffee in each cup is different; the heat in the coffee in each cup is different.

The temperature of the soup in each bowl is the same; the heat in the soup in each bowl is different.

Exercise 3.2B Heat or temperature

°C or degrees Celsius

J or joules

heat – the total energy of particles in a substance.

temperature – the average energy of particles in a substance.

In a solid, the particles vibrate about positions.

When a solid is heated, the particles vibrate

.

When the temperature of a solid decreases, the particles vibrate .

Heat: the block with more mass has more particles, so it has more heat.
Temperature: the temperature of the two blocks is the same.

Exercise 3.2C Measuring heat and temperature

thermometer

joule meter

3000 J or 15 °C
repeat the experiment (not just repeat that reading as it cannot be done in isolation)

4500 J
10 000 J

Topic 3.3 Conservation of energy

Exercise 3.3A What does conservation of energy mean?

The quantity of energy will stay the same.

Energy input to the lamp equals energy output from the lamp.

100 J

3500 J

Exercise 3.3B The law of conservation of energy

Energy cannot be created or destroyed; energy can be changed from one form to another, (Statements can be in either order.)

The total of the light and thermal energy output must be equal to the quantity of electrical energy input.

She uses more energy for running and being active than when resting, so this extra energy must be supplied in her food.

100 − 65 = 35%

Exercise 3.3C Calculating energy changes

1000 − 850 = 150 J

1000 + 600 = 1600 J; 2400 − 1600 = 800 J

100 − 50 − 30 = 20%

Diagram should have the input labelled (on the left) as 100% electrical energy. There should be three output arrows labelled 50% thermal, 30% light, 20% sound. The thickness of each output arrow should be approximately in proportion to these percentages.

Topic 3.4 Moving from hot to cold

Exercise 3.4A Direction of thermal energy transfer 1

Thermal energy is transferred from a place of higher temperature to a place of temperature.

arrow pointing from flame to cooking pot

arrow pointing from heater towards air in room (arrow can point up or down, but must go from the heater to the air)

arrow pointing from foot to ice pack

Exercise 3.4B Direction of thermal energy transfer 2

Thermal energy will move from the object at higher temperature to the object at lower temperature.

Two arrows pointing into the centre block (10 °C): one from the left (20 °C) and one from the right (30 °C).

Curved line from top dashed line, starting at time 0, down to lower dashed line, then levelling o on the lower dashed line.

Exercise 3.4C Direction of thermal energy transfer 3

Thermal energy moves from her body to the air because her body is at a higher temperature than the air / surroundings.

Thermal energy moves from the air / surroundings into her body; the air is at a higher temperature than her body.

The temperature of the water will decrease; the ice is at a lower temperature than the water; thermal energy will move from the water to the ice.

The temperature of the coffee decreases; the temperature of the milk increases; the temperature of the coffee and the milk eventually become the same; the coffee is initially at a higher temperature than the milk; thermal energy flows from the coffee to the milk; the (overall) flow of thermal energy stops when the temperatures of the milk and the coffee are the same.

Topic 3.5 Ways of transferring thermal energy

Exercise 3.5A Describing thermal energy transfers

Thermal energy is transferred from the Sun to Earth by .

Thermal energy is transferred within metals by .

When warm air rises through cold air, this is called .

Neither nor can occur in a .

Conduction – particles vibrate more, collide with particles beside them, making these particles also vibrate more.

Convection – particles vibrate more, take up more space and decrease the density of the substance.

Radiation – type of wave that does not require particles to transfer thermal energy.

Exercise 3.5B Comparing thermal energy transfers

The particles in a solid are closer together; vibration of particles can be transferred to neighbouring particles more easily in a solid.

Convection requires particles to move; particles in liquids and gases can move; particles in solids are not free to move.

There are no particles in a vacuum; radiation does not require particles; conduction and convection both require particles.

Exercise 3.5C Variables affecting thermal energy transfer

Metal is a good conductor of heat; thermal energy is transferred to the contents quickly / easily.

Wood is a poor conductor of heat / wood is a good thermal insulator; the handle will not get hot / will not cause burns when held.

White is a good reflector of thermal radiation / white is a poor absorber of thermal radiation; the house will stay cool inside during hot sunny weather.

Wool is a poor conductor of heat / wool is a good thermal insulator; thermal energy will be transferred from the body to the surroundings more slowly through the wool.

The shiny metal reflects thermal radiation back to the food; plastic is a poor conductor of heat / plastic is a good thermal insulator; thermal energy will be transferred from the food in the box to the surroundings more slowly through the plastic.

Topic 3.6 Cooling by evaporation

Exercise 3.6A How evaporation works

when a liquid changes to a gas

(they can escape from the liquid and become gas).

Zara is correct; an example such as rain water evaporates from the ground, but the ground is not at 100 °C, or sweat evaporates from the skin, but the skin is not at 100 °C.

Exercise 3.6B Evaporation and cooling 1

Sweat evaporates, removing thermal energy from skin.

The average energy decreases; this is because the particles with the highest energy leave the liquid during the evaporation process.

The temperature decreases; this is because the average energy of the particles decreases and temperature is the average energy of the particles.

The fan makes air move; moving air speeds up evaporation; evaporation of sweat removes thermal energy from the skin; speeding up the evaporation speeds up the removal of thermal energy.

Exercise 3.6C Evaporation and cooling 2

The perfume feels colder; evaporation of a liquid removes thermal energy from the skin; speeding up the evaporation speeds up the removal of thermal energy.

Evaporation of sweat removes thermal energy from the skin; when evaporation stops (because of high humidity) then the removal of thermal energy stops / the cooling effect stops.

The water evaporates into the moving air; the water cools as it evaporates, lowering the temperature of the sponge; the air is now moving through a cooler sponge and thermal energy from the air is removed to the sponge / removed to the water to make it evaporate.

Unit 4 Maintaining life

Topic 4.1 Plants and water

Exercise 4.1A Water uptake by orange plant seedlings

Add up the total number of root hairs on all ten plants, then divide the total by 10.

Variety A plants had more root hairs per plant (920 compared with 800, i.e., 120 more root hairs per plant).

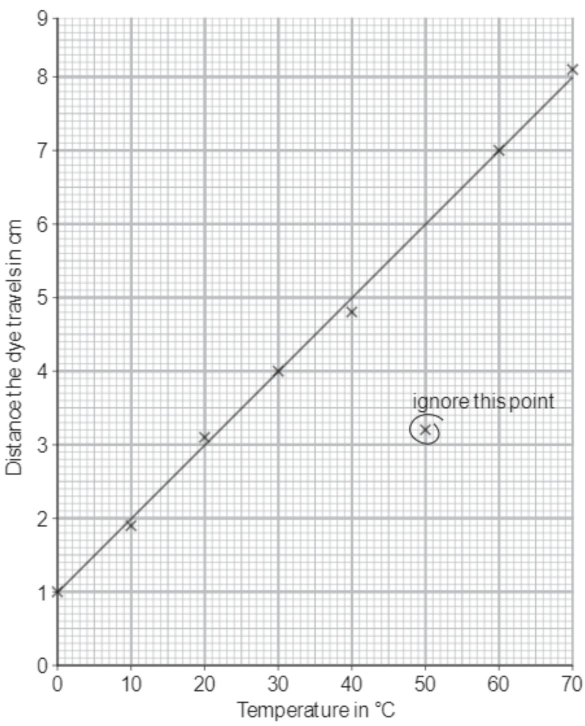
The mean length of the root hairs was greater than variety B (0.03 compared with 0.02, i.e. 0.01 mm longer).

The root hairs, therefore, had a greater surface area, so they could take up more water.

It moves across to the centre of the root into the xylem vessels. It then goes up the xylem into the leaves.

Exercise 4.1B Celery experiment

3.2 at 50 °C is the anomalous result.

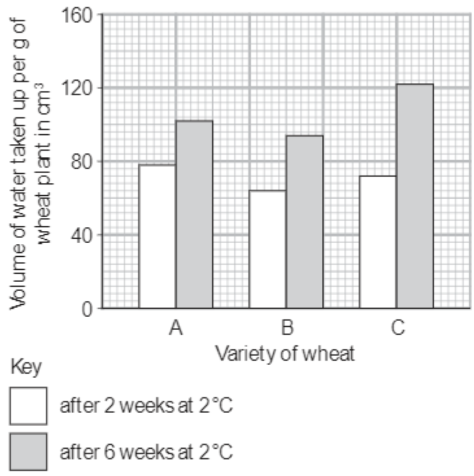


As temperature increases, the rate of transport of water in celery stalks increases.

Exercise 4.1C Interpreting data about water uptake

They want to be able to compare the ability of different varieties to take up water. The quantity of water taken up may also be affected by the size of the plants, and the plants might be different sizes. Calculating the volume taken up per gram makes it easier to compare the varieties; it controls a variable (the mass of the plant) and makes the comparison fair.

A bar chart is the best way to display these data.



After two weeks, variety A took up the most water, with variety C next and variety B taking up the lowest volume. Learners could also calculate the differences between the volumes.

All the plants had taken up a greater volume of water after six weeks. Now, instead of variety A taking up the most, it is variety C.

Variety C, because it takes up the most water over the longer period. This suggests that it might grow better and faster than the other varieties in the cold climate of Canada.

Topic 4.2 Transpiration

Exercise 4.2 How temperature affects water loss

She wanted to make sure that any water that was lost came from the plants and not from the soil.

The results table should have:

- clearly ruled columns and rows
- headings for the mass in the three different pots (either rows or columns), with the unit g
- headings for the 8 days, such as Day 1, Day 2 and so on; or Time in days
- the correct reading written in each cell in the table.

The anomalous result of 861 g for plant B should be circled.

The line graph should have:

- time in days on the -axis and mass in grams on the -axis
- suitable scales on both axes, using most of the graph paper and going up in even, sensible intervals
- each point plotted accurately, for each of the three pots
- three lines carefully drawn, either joined point-to-point or as a line of best fit, one for each pot
- each line labelled to show which pot it represents.

Plant B:
mass on day 1 = 893 g
mass on day 8 = 761 g
loss of mass over 7 days was 893 − 761 = 132 g
the mean loss of mass per day was
132 ÷ 7 = 19 g per day

Plant C:
mass on day 1 = 842 g
mass on day 8 = 618 g
loss of mass over 7 days was 842 − 618 = 224 g
the mean loss of mass per day was
224 ÷ 7 = 32 g per day

The results show that higher temperatures increase the rate of loss of mass. The loss in mass is due to water loss. Higher temperatures increase the rate at which water evaporates into the air spaces in the leaf. They also increase the rate at which water vapour diffuses out of the leaves into the air.

Topic 4.3 Excretion in humans

Exercise 4.3 Structure and function of the excretory system

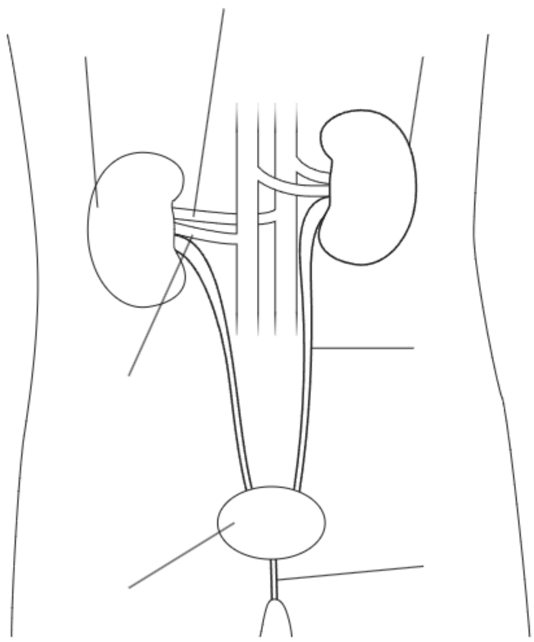
The are part of the excretory system.

This is also known as the system.

In the excretory system, a waste substance called is filtered out of the blood.

It dissolves in , forming a liquid called .

and



kidney: filters the blood, removing urea from it, and mixing the urea with water to produce urine

ureter: carries urine from the kidney to the bladder

bladder: stores urine

urethra: carries urine from the bladder to the outside of the body

Topic 4.4 Keeping a fetus healthy

Exercise 4.4A Length of pregnancy

The animals could be arranged in order of increasing or decreasing mean mass. For example:

Species	Mean mass of a female in kg	Mean length of pregnancy in days

There is no correlation.

Credit any use of figures that illustrates this answer. For example, wolves and chimpanzees both have a mean mass of 40 kg, but the length of pregnancy of a chimpanzee is more than three times longer than that of a wolf. Goats are much smaller than wolves, but have a longer pregnancy.

Also credit arguments that there is some degree of correlation. For example, the largest animal (elephant) has the longest pregnancy, and the smallest animal (rabbit) has the shortest.

There will be a lot of variation in the mass of the female animals in a species. Many different females would have been weighed and their masses recorded so that a mean could be calculated. Similarly, lengths of pregnancy will vary between individuals.

Exercise 4.4B Does caffeine affect birthweight?

The bar chart should have:

- full labels on each axis, using the full column headings from the table, i.e., 'caffeine intake per day in mg' on the -axis and 'mean birthweight in g' on the -axis
- a suitable, evenly spaced scale on the -axis, with a range that allows the bars to be plotted with some accuracy (e.g. from 3500 to 3700, in divisions of 25 or 50)
- each bar plotted reasonably accurately.

Some learners may appreciate that the intervals are not equal and may, therefore, construct a histogram in which the widths of the bars are in proportion to the interval widths. This is entirely correct.

Caffeine intake has no effect on mean birthweight.

Credit any use of supporting figures. Learners should also be encouraged to recognise that a difference of just a few grams is not significant when the total mass is more than 3000 g.

They could have actually measured the mother's intake of coffee, rather than asking them to fill in questionnaires (which the mothers might not have done correctly or accurately).

They could have used more mothers in their study.

They could have used a wider range of caffeine intake.

They could have split the levels of caffeine intake into smaller intervals, for example less than 49, from 50 to 99, from 100 to 149 and so on.

Exercise 4.4C Smoking and birthweight

2609 + 23 713 = 26 322

No, the number of babies born to mothers who did not smoke was 23 713, but the number born to mothers who smoked was 2609. This means that the number of mothers who smoked was much smaller than the number who did not smoke.

Yes, the evidence suggests that it did. The percentage of babies with low birthweight in 2004 to 2005 was 14.0 for mothers who smoked, and only 9.6 for mothers who did not smoke. So, although there were quite a lot of low birthweight babies born to mothers who did not smoke, the risk was less than for mothers who smoked.

In 2004 to 2005 there were 2609 babies born to mothers who smoked, but in 2006 to 2007 there were only 2109. This suggests that fewer mothers smoked during pregnancy.

These figures could also mean that fewer women had babies overall in 2006 to 2007, but the figures for mothers who did not smoke shows that this was not so, because these numbers increased. The total number of babies born in 2006 to 2007 is slightly greater than the number born in 2004 to 2005 (27 064 and 23 713 respectively).

Some learners might like to calculate the percentage of babies born to women who smoked and who did not smoke in each row:

For 2004 to 2005: Total number of babies = 26 322

Percentage of babies born to mothers who smoked = (2609 ÷ 26 322) × 100 = 9.9%

For 2006 to 2007: Total number of babies = 27 064

Percentage of babies born to mothers who smoked = (2109 ÷ 27 064) × 100 = 7.8%

Overall, there is correlation between smoking during pregnancy and an increased risk of having a baby with low birthweight. The data do support the idea that smoking increases the risk of low birthweight. However, they do not that smoking actually this effect. To be certain that it is smoking that causes the increased risk, we would need a lot more evidence from other studies. (That evidence does, of course, exist.)

Unit 5 Reactivity

Topic 5.1 Reactivity and displacement reactions

Exercise 5.1A Using the reactivity series

less vigorously

It does not react at all; give credit for silver reacts less / is less reactive than copper.

Zinc will react more quickly than iron with dilute acid.

No; there will be not be a displacement reaction because copper is less reactive than iron.

Silver or gold; give credit if another unreactive metal such as platinum is named.

iron, lead or copper

yes

no

no

yes

yes

magnesium + zinc chloride → magnesium chloride + zinc

Exercise 5.1B Displacement reactions

It tells you that zinc is more reactive than copper.

zinc + copper sulfate → zinc sulfate + copper

It tells you that zinc is less reactive than magnesium.

magnesium (most reactive), iron, copper (least reactive).

Sofia could place a small piece of the metal in each of the solutions. She will be able to observe the reactions with the solutions and if there is a reaction with copper sulfate she will know that the metal is more reactive than copper. If there is no reaction with zinc sulfate she will know that it is less reactive than zinc. By observing the reactions in all four of the solutions she will be able to work out which metal she has.

To distinguish between iron and zinc you could place a piece of each of the two metals in a solution of iron sulfate. The zinc would react but the iron would not. Credit the use of any iron salt.

Exercise 5.1C Displacing metals

Metal E is the most reactive because it has the most displacement reactions.

		Metal					
		A	B	C	D	E	F
Metal salt	A	✗	✓	✗	✓	✓	✓
	B	✗	✗	✗	✗	✓	✗
	C	✓	✓	✗	✓	✓	✓
	D	✗	✓	✗	✗	✓	✗
	E	✗	✗	✗	✗	✗	✗
	F	✗	✓	✗	✓	✓	✗

The metals that are more reactive than C, copper, and less reactive than D, zinc, are lead and iron. Iron is more reactive than lead, so and . The metals that are more reactive than D, zinc, are magnesium and aluminium. B is less reactive than E, so and . Learners should not suggest an alkali metal as these are too reactive in water to use in displacement reactions.

copper sulfate + iron → iron sulfate + copper

magnesium chloride + zinc → no reaction

iron sulfate + magnesium → magnesium sulfate + iron

zinc chloride + silver → no reaction

zinc chloride + iron → no reaction

Potassium is very reactive in water and if used in solutions of salts it would be very dangerous.

Topic 5.2 Using the reactivity series and displacement reactions

Exercise 5.2 Using the reactivity series

The metal is more reactive than iron and copper but less reactive than magnesium.

aluminium or zinc

Accept any metal above copper in the reactivity series such as iron, zinc or magnesium.
Accept any metal above zinc such as magnesium.

Zinc is more reactive than iron so the zinc combines with the chlorine in the iron chloride and forms zinc chloride and leaves iron metal.

zinc + iron chloride → zinc chloride + iron

Iron can be displaced by zinc because zinc is more reactive. Copper is even less reactive than iron so zinc will displace copper from a solution of copper chloride.

Zinc is less reactive than magnesium so it cannot displace magnesium from a solution of magnesium chloride.

Aluminium and iron oxide are mixed in a container over the rail that needs to be welded. This reaction produces so much heat energy that the displaced iron melts. The molten iron produced can be shaped and used to join the rails together. For the iron oxide and aluminium to react they have to be ignited and this is done using another exothermic reaction. (Credit naming the reaction between magnesium powder and barium nitrate, but it is the idea of using an exothermic reaction to start the main reaction that is needed here, rather than the details.)

This method is used because it produces enough energy to melt the iron, and is possible to do when the work has to be done away from an electricity supply.

aluminium + iron oxide → aluminium oxide + iron

carbon

Iron ore is heated in the blast furnace with carbon in the form of coke. The carbon displaces the iron from the iron oxide and molten iron is produced.

iron oxide + carbon → iron + carbon dioxide

It is above iron in the reactivity series. (Accept any more specific suggestion provided it is not above aluminium.)

Topic 5.3 Salts

Exercise 5.3A Which acid is used to make which salt?

Hydrochloric acid — HCl — chlorides
Sulfuric acid — H_2SO_4 — sulfates
Nitric acid — HNO_3 — nitrates

magnesium chloride: hydrochloric acid;
magnesium nitrate: nitric acid;
magnesium sulfate: sulfuric acid.

NaCl: sodium chloride;

$CuSO_4$: copper sulfate;

$CuCl_2$: copper chloride;

KNO_3: potassium nitrate

citrates

Exercise 5.3B Making salts

Place some zinc metal into dilute nitric acid. When it has stopped reacting, put your solution into an evaporating basin and heat it gently to evaporate o the water and produce crystals of zinc nitrate.

zinc + nitric acid → zinc nitrate + hydrogen

Silver is much less reactive than zinc and will not react with dilute sulfuric acid.

Potassium is far too reactive; there would be an explosive reaction if potassium metal were placed in dilute sulfuric acid.

It is important because harmful fumes will be given o from the acid.

copper oxide + sulfuric acid → copper sulfate + water

magnesium + nitric acid → magnesium nitrate + hydrogen

copper oxide + nitric acid → copper nitrate + water

zinc + hydrochloric acid → zinc chloride + hydrogen

zinc + sulfuric acid → zinc sulfate + hydrogen

Exercise 5.3C Practical steps for making salts

Copper chloride cannot be made by reacting copper with dilute sulfuric acid because, to make a chloride, you would need to use hydrochloric acid and copper is unreactive and does not react with any dilute acid.

The first step is to react copper oxide with sulfuric acid. Excess copper oxide is added to sulfuric acid in a beaker. This is heated gently and stirred constantly. When a colour change (to blue) is seen, you should stop heating. Safety precautions: wear safety glasses, as you are using acid; do not boil the acid mixture, as harmful fumes are given o.

The second step is to filter the mixture. The excess copper oxide is left in the filter paper and the filtrate is a solution of copper sulfate. No additional safety precautions need to be taken.

The third step is to evaporate the water from the copper sulfate solution by heating it gently in an evaporating basin. When small crystals form, or the solution starts to spit, stop heating and allow the rest of the water to evaporate slowly. Safety precautions: wear safety glasses and take care as the hot solution may spit and burn you.

Credit labelled diagrams that help to explain the above method.

Topic 5.4 Other ways of making salts

Exercise 5.4A Preparing copper chloride

The copper carbonate reacts with the acid and carbon dioxide gas is given o. Credit any mention of the formation of copper chloride or water.

(unreacted) copper carbonate

A solution of copper chloride: credit 'a mixture of water and copper chloride'. (Learners should recognise that water and the salt are present.)

Place the filtrate in an evaporating basin and heat it to evaporate o the water and leave the crystals.

When the solution is being heated it tends to spit, and this can burn.

They should wear safety glasses to prevent damage to their eyes; take special care when close to the evaporating dish; turn o the heat when the solution begins spitting.

copper carbonate + hydrochloric acid → copper chloride + water + carbon dioxide

Exercise 5.4B Preparing potassium chloride

hydrochloric acid

The list should include: measuring cylinder, beaker (credit conical flask), hydrochloric acid, burette, stand, universal indicator solution, safety glasses.

Put on safety glasses. First add a drop of universal indicator solution to the potassium hydroxide in the beaker, which turns blue. Set up the burette and fill with acid. Add acid, a little at a time, to the potassium hydroxide, and swirl the beaker to mix the contents.

When they see the universal indicator solution turn from blue to green.

Add charcoal to the neutral solution to remove the colour. Then the solution should be filtered to remove the pieces of charcoal.

potassium hydroxide + hydrochloric acid → potassium chloride + water

$KOH + HCl \rightarrow KCl + H_2O$

Exercise 5.4C Mystery substances

carbon dioxide

hydrogen

salts

sulfuric acid

a solution of copper chloride (accept any chloride of a metal below iron on the reactivity series)

hydrochloric acid

zinc carbonate

iron

magnesium

zinc sulfate + sulfuric acid → zinc sulfate + carbon dioxide + water

iron + copper chloride → iron chloride + copper

(Accept another chloride as the reactant, provided it is below iron on the reactivity series.)

magnesium + hydrochloric acid → magnesium chloride + hydrogen

Topic 5.5 Rearranging atoms

Exercise 5.5A What happens to the atoms and the mass when chemicals react?

The magnesium atoms should be coloured green and oxygen atoms red.

The magnesium atoms should be coloured green, chlorine atoms yellow and hydrogen atoms left blank.

magnesium chloride

The answer to each of the four questions is 2.

yes

Oxygen atoms should be coloured red and the hydrogen atoms left blank.

The number of hydrogen atoms in the reactants is   the number of hydrogen atoms in the products.

The number of oxygen atoms in the reactants is   the number of oxygen atoms in the products.

24 g

80 g (Accept a figure less than 80 g with an explanation that some carbon dioxide will be lost to the atmosphere.)

Exercise 5.5B Before and after the reaction

calcium, chlorine, hydrogen, oxygen and carbon

The particle diagram should show a molecule of sulfur dioxide: a light circle representing the sulfur atom, touching two dark circles representing the oxygen atoms.
sulfur + oxygen → sulfur dioxide;
$S + O_2 \rightarrow SO_2$

magnesium, carbon and oxygen

carbon and oxygen

from the hydrochloric acid

from the hydrochloric acid

45 g

25 g of magnesium will be present in the magnesium sulfate

The term conservation of mass means that all of the atoms present at the start of a reaction are still there at the end. No elements are destroyed and no elements are created, so the mass of the products is the same as the mass of the reactants.

250 g

zinc + sulfuric acid → zinc sulfate + hydrogen

No, he has not made a mistake.

One of the products is hydrogen gas. Since Arun used a beaker without a lid, this gas has escaped into the air. This accounts for the apparent loss of mass.

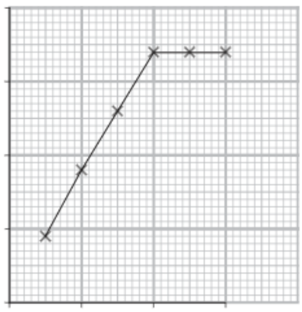
When scientists get an unexpected result in an experiment they should repeat the experiment several times to ensure the unexpected result is not a mistake.

Exercise 5.5C Investigating burning magnesium

The volume of oxygen used, the time taken to transfer the deflagrating spoon, the time taken to light the magnesium.

magnesium + oxygen → magnesium oxide

Credit: axes the correct way round and correctly labelled, including units; suitable choice of scale; points plotted accurately and joined appropriately.



The greater the mass of magnesium burned, the greater the mass of product formed. However, this is only true of masses of magnesium up to 2.0 g; above this the mass of the product does not change.

The mass of the product formed stays the same at these masses because the magnesium has used up all the (limited supply of) oxygen available. Some of the magnesium may not have been burnt.

There are a number of movements of things into and out of the gas jar, and so chances to spill magnesium or the product. Also, there is a good chance that some oxygen will be lost from the gas jar as the deflagrating spoon is transferred. The lighting of the magnesium would need to be done quickly. If some magnesium had not burned it would need to be separated from the product.

The burning magnesium should not be looked at directly. The deflagrating spoon will get hot so will need to cool down before the mass of the product can be measured.

Unit 6 Sound and space

6.1 Loudness and pitch of sound

Exercise 6.1A Comparing sound waves

A

A

D

C

B

C

Exercise 6.1B Drawing sound waves

Wave spacing should be the same; height of the peaks and the depth of the troughs should increase equal and opposite about the mid-line.

Wave spacing should decrease so there are more waves (still evenly spread) on the grid; height and depth should stay the same.

Wave spacing should increase so there are fewer waves (still evenly spread) on the grid; height and depth should decrease equal and opposite about the mid-line.

Exercise 6.1C Understanding sound waves

0.5 mm

250; unit Hz

loudness decreases, pitch increases

sound is higher pitched (accept one octave higher)

double the frequency / twice as fast / twice as many in the same period of time

double the frequency / twice as fast / twice as many in the same period of time

Topic 6.2 Interference of sound

Exercise 6.2A Reinforcing sound

The sound becomes louder.

D

The sound waves reinforce.

Exercise 6.2B Cancelling and reinforcing

The pitch .

The loudness .

Arun hears nothing / no sound.

A wave drawn with peaks aligned with the original wave; it must cross the mid-line at the same points as the original wave; it need not be the same amplitude as the original.

A wave drawn with peaks aligned to the troughs of the original wave; it must cross the mid-line at the same points as the original wave; it must be the same amplitude as the original.

Exercise 6.2C Interfering sound waves

They are equal.
They are equal.
They are equal.

Amplitudes are .
Frequencies are .

2500 Hz
2 mm

frequency 2500 Hz; amplitude 1 mm

Topic 6.3 Formation of the Moon

Exercise 6.3A How was the Moon formed?

D, B, A, C

A newly formed planet.

Both the Earth and the Moon.

Exercise 6.3B Describing the collision theory

A

An object of a similar size to Mars collided with Earth; the object has been called Theia. The impact caused a disc of dust and rock to form around Earth; the dust and rock eventually came together under gravity to form the Moon.

Exercise 6.3C Evidence for the collision theory

Any three from:

- The Moon is less dense than the Earth.
- Samples of rock from the Moon show that its surface was once molten.
- The Moon has a small iron core, similar to the Earth.
- There is evidence outside the Solar System of similar collisions causing rings of rock and dust.
- The collision theory fits with the theory of how the Solar System was formed.
- The composition of rocks on the Earth and the Moon are the same.

Any one from:

- The surface of the Earth does not appear ever to have been molten. A collision that formed the Moon would have caused the surface of the Earth to melt. The surface would have later solidified.
- Venus has no moon; collisions in the early years of the Solar System would have been common and scientists would have expected Venus to have a moon formed in the same way.
- The composition of rocks on the Moon would be expected to be more different to rocks on Earth. In fact, the composition of the Moon is more similar to Earth.

The composition of rocks on the Moon is very similar to that on Earth.

The composition of rocks on the Earth and the Moon are very similar.

A captured object would have formed separately from Earth / far away from Earth / at a different time than Earth; the composition of a captured object would probably be different from that of Earth.

Topic 6.4 Nebulae

Exercise 6.4A What are nebulae?

asteroid, moon, star, nebula

All nebulae contain dust and gas. All nebulae are different shapes

hydrogen

Exercise 6.4B Types of nebula

emission nebula / supernova remnant

Horsehead (nebula) / Pleiades

emission nebula / supernova remnant

Newly formed stars would emit light; this type of nebula emits its own light.

Exercise 6.4C Stellar nurseries

A nebula / part of a nebula where stars are formed.

Dust and gas particles are pulled together by gravity. As the object grows, the force of gravity increases; the increasing force of gravity attracts more material. As the object grows larger the pressure inside increases; high pressure inside the object can start reactions that give out heat and light.

No stars were being formed at the very beginning of the universe; stars started being formed at a low rate when the universe was very young. The rate of star formation increased rapidly until about 2000 million years, then slowed until about 6000 million years, then the rate started to decrease; the rate is still decreasing today.

Topic 6.5 Tectonics

Exercise 6.5A Movement of tectonic plates

(labels from top to bottom): crust, mantle, outer core, inner core

curved arrows drawn in the mantle, coming up from the outer core toward the crust and curving down again toward the inner core.

crust

Slowly moved apart / moved into different positions due to the movement of tectonic plates; continental drift.

The following should be ticked: The same types of fossils have been found in different continents.

Volcanoes and earthquakes are more likely to happen in particular places.

The alignment of magnetic materials in rocks varies with the age of the rock.

Exercise 6.5B Tectonic plates

inner core, outer core, mantle, crust

mantle
Molten rock in the mantle gets heated from the core; heated material expands and becomes less dense and rises. Close to the crust, this material cools, becomes more dense and sinks again. Movement of molten rock across the top of the mantle pulls the tectonic plates along with it.

New rock forming in the middle of the ocean takes up more space; pushes the tectonic plates either side of the ridge away from the ridge, causing the continents to separate.

The ridge is a boundary between two tectonic plates. Volcanoes occur because magma / molten rock is being pushed up. Earthquakes occur because of the movement between the two adjacent tectonic plates.

Exercise 6.5C Evidence for tectonic plates

Irregularly shaped parts of the Earth's crust that can move relative to each other.

Convection currents in the mantle, caused by heating from the Earth's core, pull the tectonic plates from below.

Lack of evidence for movement / movement was too slow for people to see; no knowledge of what forces could drive the movement; people are slow to accept new ideas.

The North American continent is on a tectonic plate. The movement of the plate causes the movement of the continent. The movement is measured relative to surrounding plates / continents that move differently.
1 000 000 mm = 1 km

$$23\,\text{mm} = \frac{23}{1\,000\,000} = 0.000\,023\,\text{km}$$

speed is 0.000 023 km / year

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$= \frac{1}{0.000\,023}$$

= 43 500 years (or other methods using direct proportion to reach the same answer)

Small mammals could not swim between these continents (at their separation today) so the continents must have been joined / part of the same land mass / larger continent in the past; the continents have separated due to movement of tectonic plates.

The Earth's magnetic poles have reversed several times in the past. Newer rock is forming in the middle and the magnetite there will align with the current magnetic field direction. Rock is pushed outward, so older rocks are found further away from the middle. This shows that the tectonic plates are moving slowly apart, pushed by the newly forming rock and this has been continuing for millions of years.

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Unit 7 Genes and inheritance

Topic 7.1 Chromosomes, genes and DNA

Exercise 7.1 Chromosomes, genes and DNA

A: nucleus; B: cytoplasm

X written in the nucleus of each cell.

Look for a sentence that includes correct information about each term. Example sentences are:

Chromosomes are found in the nucleus of every cell / Chromosomes are made of DNA.

Genes are found on chromosomes / Genes contain information that is inherited from an organism's parents.

DNA is the substance that chromosomes and genes are made of.

The DNA in a cell contains instructions for making a cell and a whole organism. If any of these instructions are missing or damaged then the cell or the organism cannot be correctly formed. So when a cell divides it is essential that each of the new cells gets a full set of all the DNA in the parent cell.

Topic 7.2 Gametes and inheritance

Exercise 7.2 Egg cells and sperm cells

Egg cells and sperm cells are specialised cells called .

Egg cells are and sperm cells are .

All cells contain one X chromosome, but cells can contain an X chromosome or a Y chromosome.

A sperm cell can join with an egg cell in a process called .

For example:

Egg cell	Sperm cell

Accept any statement that makes clear what the difference is and that states a sensible reason for the difference. For example:

Sperm cells have a tail to swim to the egg cell, but egg cells do not need to swim.

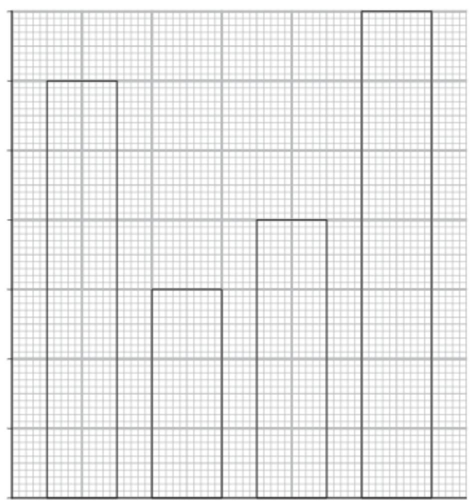
Sperm cells are elongated to make it easier for them to swim, but egg cells do not move so they can just be round.

Topic 7.3 Variation

Exercise 7.3A Recording variation

number of plants: 6, 3, 4, 7

20



variation

Exercise 7.3B Variation in holly leaves

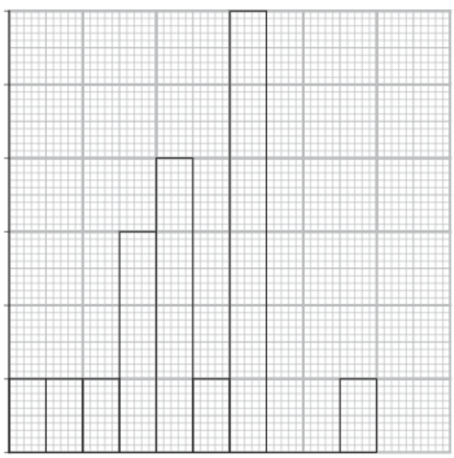
As some of the prickles are very small, allow some leeway in learners' answers. The numbers are:

17, 15, 14, 17, 15, 17, 17, 15, 16, 13, 14, 11, 14, 12, 17, 20, 15, 17

276 ÷ 18 = 15.3 prickles

Number of prickles					
Tally	|	|	|	|||	||||
Number of leaves					

Number of prickles					
Tally	|	卌 |			|
Number of leaves					



For example, length, width.

Exercise 7.3C Variation in pea pods

Number of peas, length, width.

Number of peas: 9, 9, 9, 11, 8, 7, 10, 6, 13, 7, 9, 12, 9, 10, 9, 9, 7, 11, 9, 8

and There are different possibilities for the choices of categories into which to group the results, so accept other groupings.

Number of peas				
Tally	||||	卌 卌	||||	||
Number of pods				

The frequency diagrams that learners draw will depend on the feature they have chosen, and the way that they have grouped the data.

Look for:

- the chosen feature on the -axis, with a clearly labelled scale including units
- the number of pods on the -axis, with a scale with equal intervals
- at least half of the graph grid used, preferably more
- bars carefully and neatly drawn (and touching if a histogram is drawn instead of a bar chart).

Topic 7.4 Natural selection

Exercise 7.4A Blue-tailed lizards

nucleus

inheritance

When the lizard sheds its tail the snake is more likely to be attracted to a blue tail than to a brown tail. So the blue tails are more likely to distract the snake from eating the lizard itself.

More parent lizards with blue tails survive, so they are the ones that reproduce. They pass on their genes for blue tails to their offspring.

Exercise 7.4B Camouflaged caterpillars

How many green caterpillars and how many yellow caterpillars Marcus picks up.

Repeat the experiment five times with the same caterpillars, using five different students to collect them.

D1, B2, A3, E4, C5

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Exercise 7.4C Woolly mammoths

Look for the following ideas somewhere in the answer:

- variation in the steppe mammoths – some have longer fur and longer tusks
- these were better adapted to survive when the climate got colder
- steppe mammoths with short fur and short tusks were less likely to survive
- most reproduction was done by individuals with long fur and long tusks
- genes for these characteristics were passed on to offspring
- over time, more mammoths in the population came to have long fur and long tusks.

Unit 8 Rates of reaction

Topic 8.1 Measuring the rate of reaction

Exercise 8.1A Showing the change in rate of reaction on a graph

between 0 and 100 seconds

between 250 and 350 seconds

35 cm^3 (allow 36 cm^3)

(66 − 53) cm^3 = 13 cm^3

Exercise 8.1B Changes in the rate of reaction

magnesium + hydrochloric acid → magnesium chloride + hydrogen

She did this to ensure her results were reliable.

Time in s	Volume of gas collected in cm^3			
	Attempt 1	Attempt 2	Attempt 3	Mean
				0
				30
				43
				55
				60
				60

Credit:

- use of pencil and ruler
- good use of whole graph paper grid
- suitable scales used
- points accurately plotted using small crosses
- appropriate line of best fit drawn.

The reaction ended after 80 seconds. We know this because no more hydrogen was produced after this time.

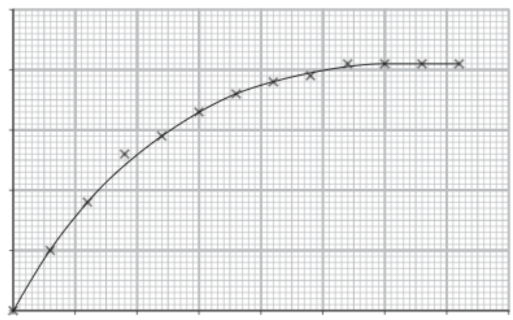
The reaction is fastest between seconds and seconds.

Exercise 8.1C Explaining observations

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

Credit the equation if it is not balanced.

Suggestions could include: the difficulty of assembling the apparatus, adding the acid and starting the stop clock all the same time; difficulty in reading the measuring cylinder accurately as bubbles are being given off; difficulty of reading the volume quickly and accurately at 30 second intervals. Accept any sensible suggestions. Ideas for overcoming these could be: to have one person in charge of the timing and one in charge of the assembling of the apparatus; being very organised with everything ready and then assembling as quickly as possible; one person watching the measuring cylinder and another calling out when a reading is needed.



Credit:

- use of pencil and ruler
- good use of whole grid
- suitable scales used
- points accurately plotted using small crosses
- appropriate line of best fit drawn.

The graph shows that the volume of hydrogen gas collected increases over the time of the experiment. However, more hydrogen is collected in the first 30 seconds than in all subsequent 30-second periods. The rate of reaction decreases over the time of the experiment and by 270 seconds the reaction is complete, as there is no further increase in the volume of hydrogen collected.

16 cm^3 per minute or 0.27 cm^3/s. Allow slight variations in this answer if the learners have read it correctly off their own graph.

6 cm^3 per minute or 0.1 cm^3/s. Allow slight variations in this answer if the learners have read it correctly off their own graph.

At the start of the reaction there are many particles of magnesium and hydrochloric acid. These must collide with each other with enough energy to react. As the particles react there are fewer left that are unreacted, so the chance of them colliding decreases and the rate of reaction decreases. When there are no more unreacted particles left, the reaction is complete.

Topic 8.2 Surface area and the rate of reaction

Exercise 8.2 Surface area and the rate of reaction

hydrogen

zinc + hydrochloric acid → zinc chloride + hydrogen

It is difficult to read the volume of gas on the measuring cylinder, especially if the changes are very small. You have to read it carefully as the cylinder is upside down. Credit other comments about the difficulty of getting the reactants mixed together and the apparatus assembled all at the same time.

the same

There should be a statement to the effect that the reaction starts off fairly quickly, then slows down. At 420 seconds, the reaction has not yet finished.

The line for the flat piece of zinc is steeper than the one for the lump of zinc and the line flattens out sooner than the one for the lump of zinc.

There is the same mass of zinc in both experiments but the reaction using the flat piece of zinc is faster than the one using the lump of zinc. This is because the flat piece of zinc has a larger surface area than the lump of zinc. When the reaction takes place, only the particles on the surface of the zinc can react with the acid as they are the only ones in contact with it. So the flat piece of zinc reacts more quickly.

The line should be to the left of the other lines. It should be steeper and reach the end of the reaction more rapidly. The final volume of gas produced should be the same as for the flat piece of zinc.

The zinc powder has a much greater surface area than the flat piece of zinc. There are more particles (on the surface of the zinc powder) exposed to the hydrochloric acid, so the reaction can take place more quickly. The reaction again slows as there are fewer particles left to react. The reaction is complete more quickly than with the flat piece of zinc. But because the masses of the flat piece of zinc and the zinc powder are the same, the total volume of hydrogen produced is the same.

Topic 8.3 Temperature and the rate of reaction

Exercise 8.3A Explaining changes in the rate of reaction

At the start of the reaction there are a lot of reactant particles. They move about and a large number of them are likely to collide with one another with enough energy to react.

As the reaction continues, some of the particles have reacted so there are fewer reactant particles left. There are fewer available particles to collide and react so the rate of reaction decreases.

When the temperature increases, some of the thermal energy is transferred to the particles. The particles with more energy move more quickly. This means that there will be more collisions in a period of time, so the rate of reaction will increase.

Exercise 8.3B Temperature and the rate of reaction

Credit any suitable metal such as magnesium or zinc and acids such as hydrochloric, sulfuric or nitric acid. Very reactive metals, such as potassium or sodium, should not be credited.

Wear safety glasses and there should be some comment about taking care when using hot acids.

The mass, surface area and type of metal; the volume, concentration and type of acid.

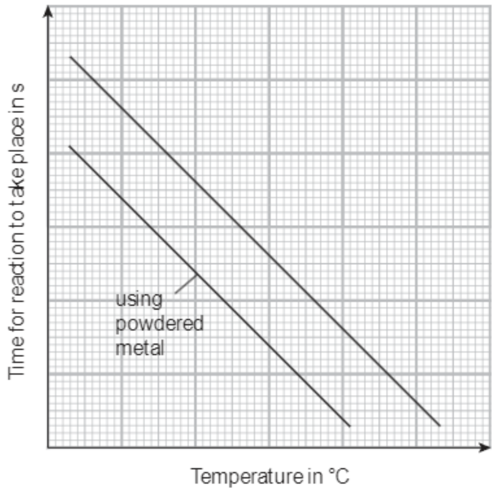
Because there will be no more bubbles of gas given off.

Table with these headers

Temperature in °C	Time in s			
	Attempt 1	Attempt 2	Attempt 3	Mean

Challenge

and



For a reaction to take place, the particles of the reactants must collide with enough energy. The particles of the acid are constantly moving. The higher the temperature, the more energy the particles have and they move more quickly. This means that there are likely to be more collisions that result in a reaction. The higher the temperature, the faster the reaction.

See graph in above. The results would show that the reaction times at all temperatures would be lower than when the first experiment was done. This is because the powdered metal has a greater surface area so more particles are available to react in a given time.

On the graph, credit any line that shows the results will be faster than those shown in answer on the graph above. The line should be to the left of the line shown above. The line should be to the left of the line in part and labelled

Topic 8.4 Concentration and the rate of reaction

Exercise 8.4A Concentration and the rate of reaction

There should be an explanation of mixing the acid with different volumes of water. Some reference to accuracy should be included, such as how to read the measuring cylinder correctly using the bottom of the meniscus and ensuring it is at eye level, and the use of safety glasses. For example, dilutions could be: 10 cm^3 acid with 40 cm^3 water; 20 cm^3 acid with 30 cm^3 water; 30 cm^3 acid with 20 cm^3 water; 40 cm^3 of acid with 10 cm^3 of water and 50 cm^3 acid with 0 cm^3 water.

The girls measure the time taken for the reaction to end. They can see this when no more bubbles of gas are given off.

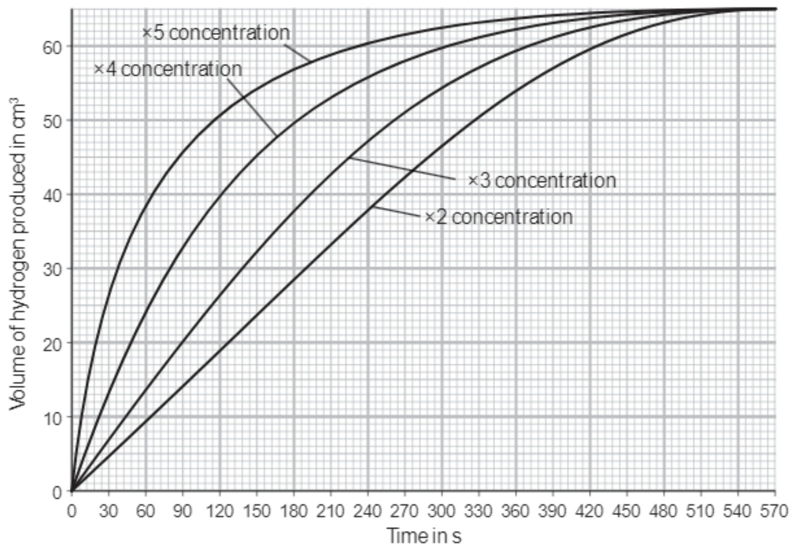
Measuring cylinders, test tubes or beakers, test tube rack, safety glasses, stopwatch.

You would expect them to find the more concentrated the acid, the faster the reaction.

This would happen because there are more acid particles in the more concentrated acid than in the less concentrated acid. The same volume of acid has been used so that there are more acid particles in the same volume. The acid particles move around and collide with the zinc particles and this is when a reaction happens. Since there are more acid particles in the higher concentration acid, there will be more collisions and so a faster reaction.

Exercise 8.4B Which results are which?

Concentration × 0 was not used because there is no acid present in it, and zinc does not react with water.



At all three concentrations of acid, the reaction rate follows the same pattern. The reaction starts o quickly and slows over time. The ×4 concentration, the most concentrated, completed the reaction in the fastest time. The least concentrated acid, ×2, took the longest to complete the reaction. All three reactions produced the same volume of hydrogen but took di erent times to reach that final volume.

Learners' answers should cover the following ideas. The ×4 acid had the most acid particles available in the volume of acid solution used, the ×3 acid had fewer and the ×2 acid had the least. This meant that, for the ×4 concentration, there were more particles in contact with the zinc so more collisions took place in each given time period until all the zinc particles had reacted with acid particles. The reaction was completed more quickly than with the ×3 and ×2 acid because the rate of collisions was always greater.

See graph in question . Credit a smooth curve to the left of the ×4 line. The curve should reach the same volume of hydrogen sooner than the other concentrations. This need only be a sketch and does not need to be exactly as in the graph shown.

Exercise 8.4C As fast as possible

Learners' diagrams should show any sensible method of carrying this out – either by collecting the gas over water, in a trough, in a beaker or in a syringe. Examples are shown in diagrams in the Learner's Book, but learners' own diagrams will be clearer if drawn in 2D, with the apparatus 'cut through'. Diagrams should be drawn in pencil, with apparatus to a suitable scale and labelled using straight lines and horizontal labels. In 2D diagrams, tubes in rubber bungs should be shown continuing through the bung.

Depending on what learners have shown in their diagram in answer to question , the list could include: top pan balance, measuring cylinder for acid, timing device of some kind, pestle and mortar, a water bath (or some other way of increasing the temperature of the acid) and thermometer for monitoring the temperature.

The mass of marble chips and the volume of dilute hydrochloric acid (credit also the type and concentration of acid used).

The surface area of the marble chips. The temperature of the acid.

Surface area: If they crush the marble chips to a powder there will be a greater surface area of reactant. This means that there will be more particles of the marble chips in contact with the acid particles so there will be more collisions between the particles and thus the reaction will be faster.

Temperature: If they warm the acid the particles will have more energy and will move more rapidly. This will mean more frequent collisions of the particles, so the reaction will be quicker. It will also mean that more of the collisions will happen with enough energy for the reaction to take place.

This will depend on the method chosen. Points covered could be:

- 20 g marble chips measured, crushed in a pestle and mortar and placed in a filter paper
- 50 cm^3 dilute hydrochloric acid measured and placed in a flask
- apparatus assembled, details depending on method
- marble chips added carefully and timer started; then 100 cm^3 carbon dioxide collected and timer stopped.

Ideas could include:

- it is difficult to add the crushed marble chips quickly without losing any
- it is difficult to get the stopper back on the flask quickly
- some of the gas produced may be lost, the top of the tubes cannot easily be made airtight, or gas lost into water trough
- it is difficult to do the above and start the timer at the correct moment, for example, should it be when the chips are added, when the stopper is back in place or when the reaction starts?

Unit 9 Electricity

Topic 9.1 Parallel circuits

Exercise 9.1A Current flow in parallel circuits

Parallel circuit, because there is a branch in the circuit / because current can follow more than one path / because both lamps are connected directly across the cell (and switch).

C

3 + 3 = 6 (A)

$\frac{4}{2}$ = 2; P = 2 (A); R = 2 (A)

Exercise 9.1B Facts about parallel circuits

There is more than one path for current to flow in a parallel circuit.

Current divides through different parts of a parallel circuit.

A_4
A_3
A_2 or A_3
A_1 or A_4

The reading on A_1 must be the largest of all four ammeters.

The reading on A_2 must be smaller than that on A_1.

Exercise 9.1C Understanding current in parallel circuits

A_1 and A_2 are equal; A_1 and A_2 are greater than A_3

$A_4 = A_1 + A_2 + A_3$

no change

decreases

Topic 9.2 Current and voltage in parallel circuits

Exercise 9.2A Voltage

volts

The energy that the battery can supply.

1.5 V

1.5 V

voltmeter

3; 3 (top row)

Exercise 9.2B Current and voltage

Circuit copied and an ammeter anywhere in series with the other components and with a voltmeter in parallel with the buzzer.

The voltages across each of the lamps and across the buzzer add up to the voltage across the cell.

decreases
decreases

The voltage across each lamp is 4 V. Each lamp will not be at full brightness when the voltage across it is less than 12 V.

Circuit diagram should show battery (two cells separated by a dashed line) and three lamps, each in parallel with the battery.

Exercise 9.2C Changes in current and voltage

decrease decrease

Increase, because there are two lamps connected directly across the battery / because the same current will flow through both lamps.

Stay the same, because L_1 will still be connected directly across the terminals of the cell / because the voltage across each branch of a parallel circuit is equal to that of the cell.

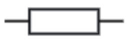
$$V_L = \frac{V_C}{N}$$

$$V_L = V_C$$

Topic 9.3 Resistance

Exercise 9.3A Describing resistance

ohms



current decreases

$\frac{12}{4} = 3\,(\Omega)$

Exercise 9.3B Calculating resistance, voltage and current

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

$$\text{resistance} = \frac{\text{voltage}}{\text{current}} = \frac{6}{2} = 3\Omega$$

$$\text{resistance} = \frac{\text{voltage}}{\text{current}} = \frac{12}{1} = 12\Omega$$

$$\text{resistance} = \frac{\text{voltage}}{\text{current}} = \frac{6}{0.2} = 30\Omega$$

voltage = current × resistance
= 3 × 10 = 30 V

voltage = current × resistance
= 2 × 12 = 24 V

voltage = current × resistance
= 0.1 × 0.5 = 0.05 V

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{30}{15} = 2\,\text{A}$$

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{4}{0.4} = 10\,\text{A}$$

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{0.5}{0.1} = 5\,\text{A}$$

Exercise 9.3C Ohm's law

current

As increases and stays the same, .

As increases and stays the same, .

drops by half / becomes 0.5 A

doubling the resistance will halve the current

0.001 Ω

Topic 9.4 Practical circuits

Exercise 9.4A Variable resistors

1 – 50 Ω

current will decrease
brightness will decrease

Exercise 9.4B Uses of variable resistors

The resistance of a variable resistor can be changed. The resistance of a fixed resistor cannot be changed. (Descriptions can be given in terms of values in ohms.)

Circuit diagram should have a cell, a lamp and a variable resistor in series.

Circuit diagram should have a cell, two lamps and a variable resistor in series.

Circuit diagram should have a cell, a variable resistor close to the cell, and two lamps in parallel (variable resistor in unbranched part).

Exercise 9.4C Comparing circuits

C

B

D

B

A, C and D

B and D