THE OAKES COLLEGE CAMBRIDGE

Applied Science Bridging Workbook

Biology · Chemistry · Physics

AQA GCSE Triology → Cambridge Advanced National in Applied Science

A summer transition booklet

Bring this completed booklet with you to your first lesson.

Any queries please contact the Head of Vocational Sciences or the Applied Science Team via :
applied.science@netherhallschool.org

Name:

Form / Tutor group:

Date completed:

How to use this booklet

This booklet is designed to help you bridge the gap between your GCSE science and the science you'll meet in your Cambridge Advanced National in Applied Science course.

All of the content covered here is material you have already met at GCSE. Nothing in this booklet is new AAQ content — your teachers will introduce that in your lessons. The aim is simply to make sure your GCSE knowledge is fresh and secure when you arrive in September, so that lesson time can be spent on the new material rather than re-teaching what you should already know.

The booklet is divided into three parts — Biology, Chemistry and Physics — and you'll find a contents page on the next page showing what's covered in each.

Each part contains a mix of recall questions, diagrams to label, and applied questions. Work through them at your own pace over the summer — you don't have to do them all in one sitting. A separate answer booklet is available for each subject so you can check your work.

A note on chemistry moles (Part 2 — Chemistry, Topic 2): If you sat Higher Tier at GCSE, you'll have met moles and the Avogadro constant. If you sat Foundation Tier, this content will be new to you when you start in September. Don't worry if some of those questions look unfamiliar — flag them and move on.

A note on physics calculations: Wherever a question asks you to calculate something, write out the equation first, substitute the numbers in, and then give the answer with units. The course expects this kind of careful working.

Bring this completed booklet to your first science lessons — you'll use it as a reference throughout the year.

Contents

Part 1

Biology

Cells · Bioenergetics · Biological molecules · Ecosystems

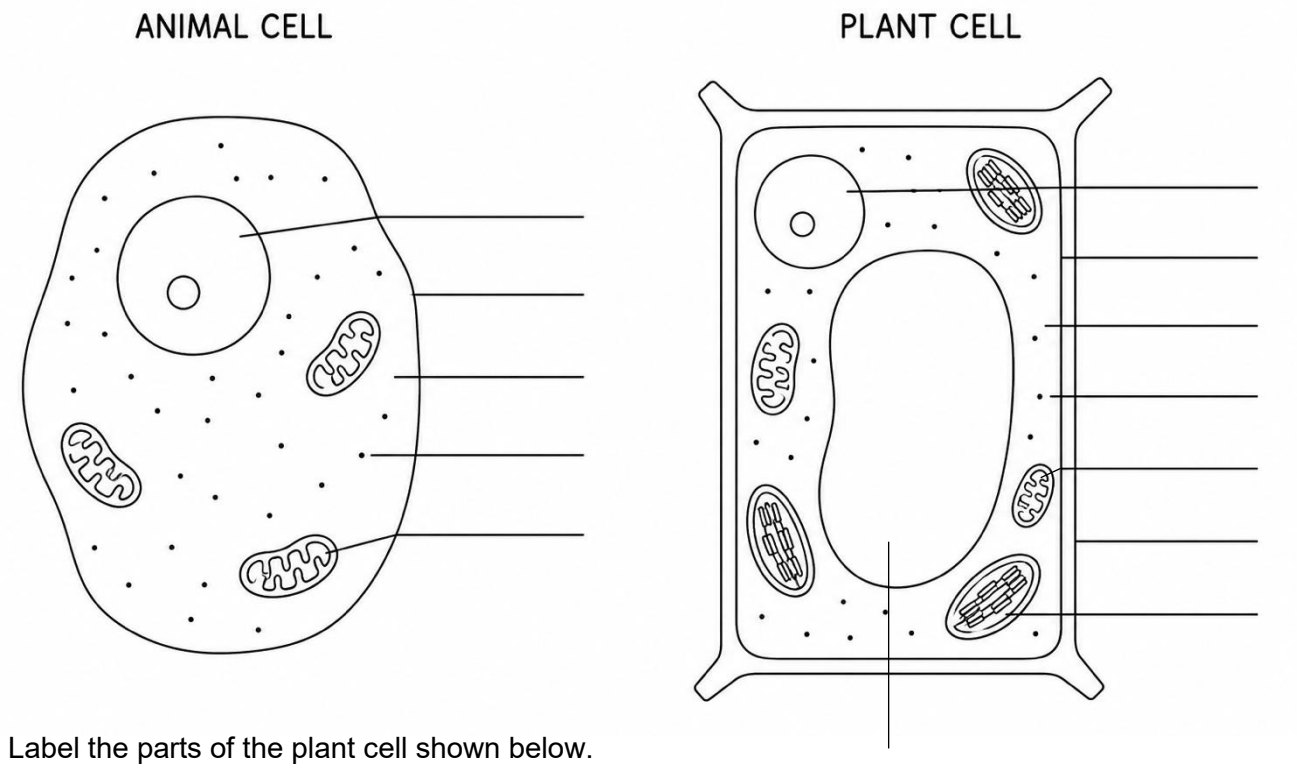
Topic 1 — Cell structure and microscopy

This is the longest Biology section because cells are the foundation of everything else in biology. Take your time over the diagrams — being able to recognise and draw cell structures from memory is a skill you'll use throughout your course.

Section A — Animal and plant cells

1. Label the parts of the animal cell shown below.

W*ord bank: nucleus · cell membrane · cytoplasm · mitochondrion · ribosome*



2. Label the parts of the plant cell shown below.

Word bank: cell wall · cell membrane · permanent vacuole · chloroplast · nucleus · cytoplasm mitochondrion · ribosome

3. Complete the table to show which structures are found in animal cells, plant cells, or both.

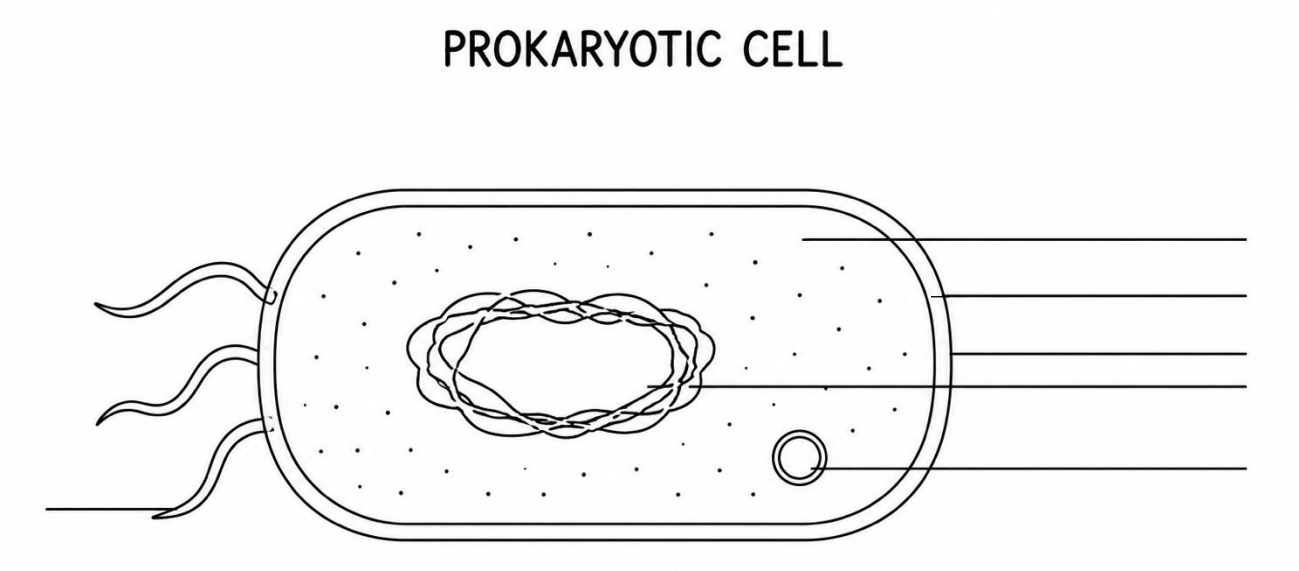
Structure	Animal cell?	Plant cell?
Cell membrane		
Cell wall		
Chloroplast		
Cytoplasm		
Mitochondrion		
Nucleus		
Permanent vacuole		
Ribosome		

4. Match each cell structure to its function by drawing a line between them.

Term	Definition
Nucleus	The site of aerobic respiration.
Mitochondrion	Where proteins are made.
Cell membrane	Contains cell sap and helps keep the cell rigid (plants).
Chloroplast	Contains the genetic material that controls the cell.
Ribosome	Controls what enters and leaves the cell.
Permanent vacuole	The site of photosynthesis (plants).

Section B — Prokaryotic cells

5. Bacterial cells (prokaryotes) are different to plant and animal cells (eukaryotes). Label the bacterial cell shown below.



Word bank: cytoplasm · DNA loop · plasmid · flagellum · cell membrane · cell wall

6. Give TWO ways in which a bacterial cell differs from a plant cell.

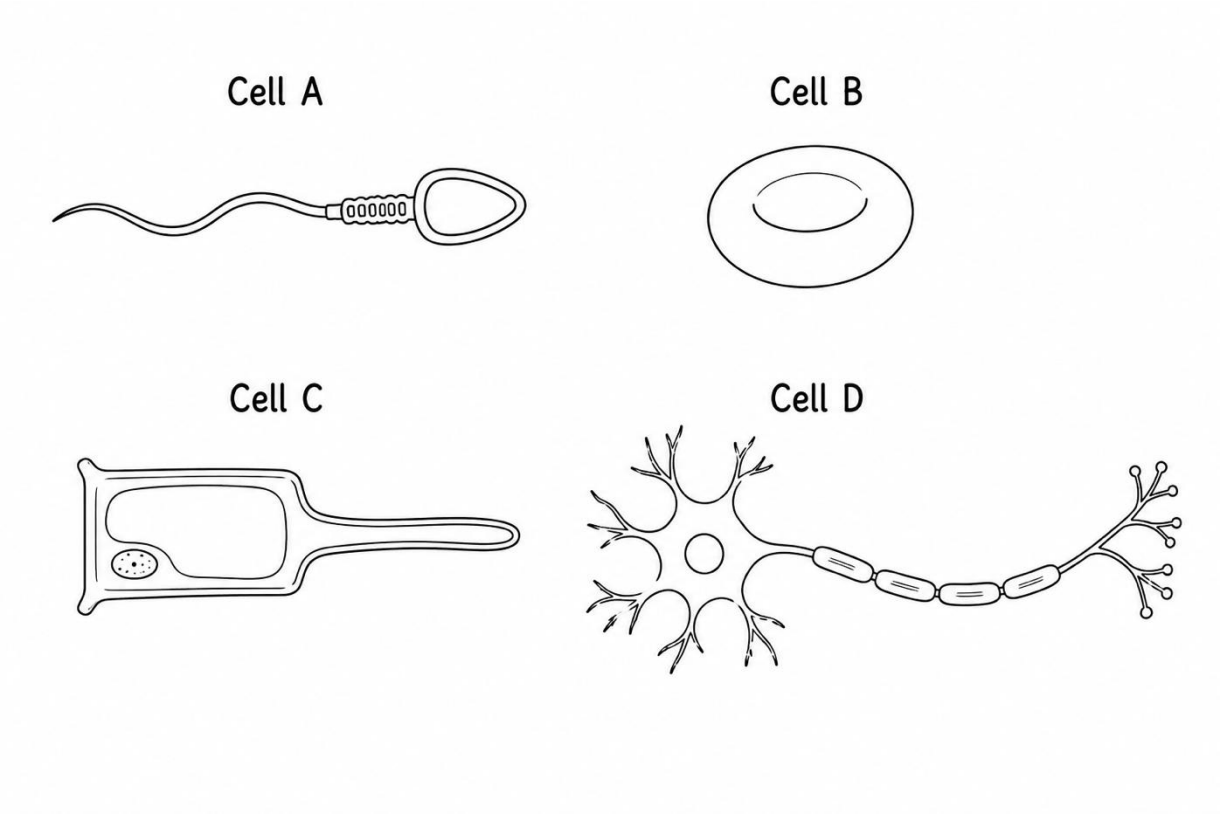
7. A typical animal cell is about 20 micrometres (μm) across. A typical bacterial cell is about 1 μm across.

a) Write 1 μm in metres, using standard form.

b) Approximately how many times larger is the animal cell than the bacterial cell?

Section C — Specialised cells and tissues

8. The diagram below shows four specialised cells. Name each cell (A–D) and give ONE feature that helps it carry out its function.



Cell	Name	One feature that helps it carry out its function
A		
B		
C		
D		

9. Define the following terms in your own words:

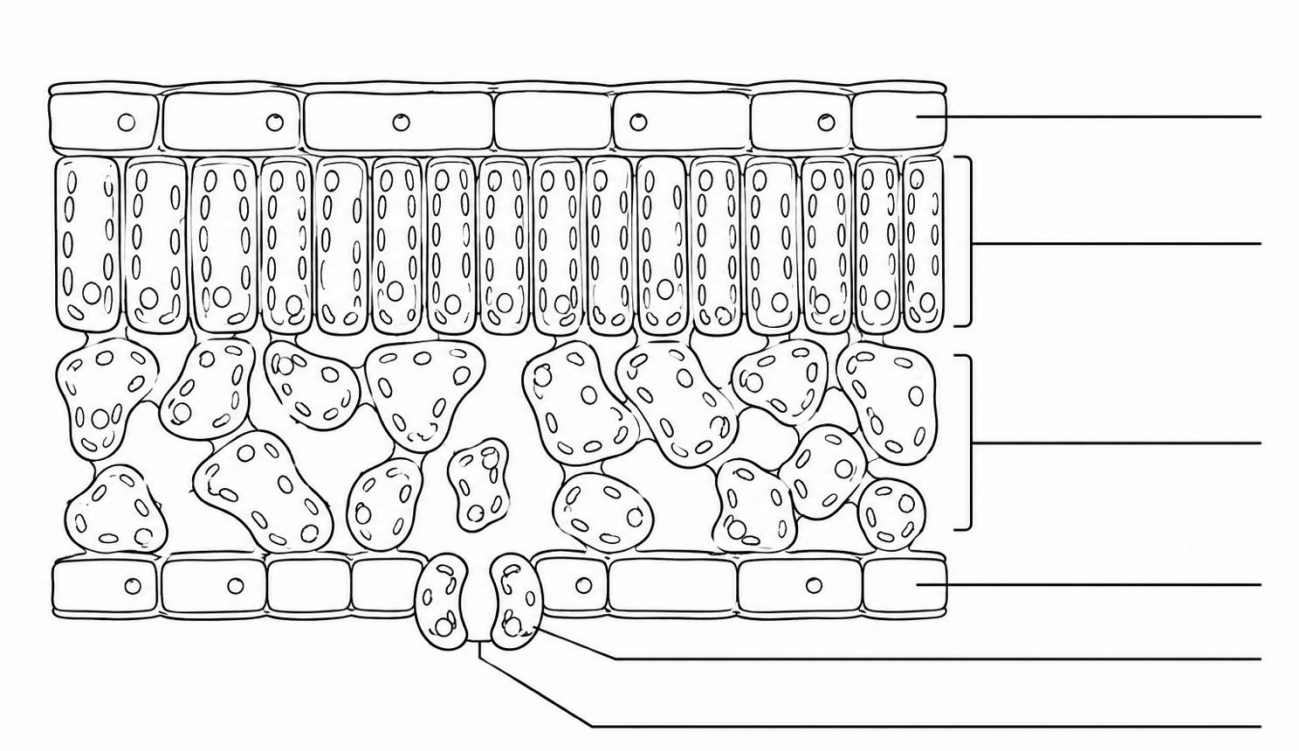
a) Tissue

b) Organ

c) Organ system

Section D — Plant tissues

10. Label the cross-section of a leaf shown below.



Word bank: upper epidermis · guard cell · stoma · lower epidermis · · spongy mesophyll palisade mesophyll

11. Xylem and phloem are two specialised plant tissues. Complete the table to compare them.

Feature	Xylem	Phloem
What substance does it transport?		
In which direction does the substance flow?		
Name the process used to transport substances in this tissue.		

12. Root hair cells are specialised for the uptake of water and mineral ions from the soil. Explain ONE way in which the structure of a root hair cell helps it carry out this function.

Section E — Microscopy

13. Use the equation below to answer the questions that follow.

magnification = size of image ÷ size of real object

a) A cell measures 50 mm across in an image. The real cell is 0.05 mm across. What is the magnification?

b) An image of a bacterium shows it 30 mm long. The magnification is ×15 000. Calculate the real length of the bacterium in micrometres (μm).

14. Give ONE advantage of using an electron microscope rather than a light microscope to study cells.

Stretch yourself

Think about why scientists couldn't 'see' structures like ribosomes until electron microscopes were developed in the 20th century. What does this tell you about how scientific understanding builds on advances in technology?

Topic 2 — Bioenergetics

This section covers photosynthesis and respiration — the two reactions that power all life on Earth.

Section A — Photosynthesis

1. Complete the word equation for photosynthesis below, and write the balanced symbol equation underneath.

_____ + water → glucose + _____

Symbol equation:

2. What is the source of energy used in photosynthesis, and where in the plant cell does photosynthesis happen?

3. Name THREE factors that affect the rate of photosynthesis.

a)

b)

c)

4. A student investigated the effect of light intensity on the rate of photosynthesis in pondweed. They counted the number of bubbles of oxygen produced per minute at different distances from a lamp.

a) Suggest TWO variables the student should have kept the same throughout the experiment.

b) Describe and explain what would happen to the rate of photosynthesis as the lamp was moved closer to the pondweed.

Section B — Respiration

5. Write the word equation for aerobic respiration.

6. Aerobic and anaerobic respiration are different. Complete the table to compare them.

Feature	Aerobic respiration	Anaerobic respiration (in muscles)
Is oxygen needed?		

Products formed		
Relative amount of energy transferred (more / less)		

7. Anaerobic respiration in yeast is also called fermentation. Write the word equation for fermentation.

8. Give TWO examples of industries that use fermentation.

9. A student sprints for 100 m and notices that they continue to breathe heavily for a few minutes after stopping.

a) Explain why the student's muscles started to respire anaerobically during the sprint.

b) Name the substance that builds up in muscles during anaerobic respiration.

Stretch yourself

At GCSE you learned that mitochondria are the site of aerobic respiration. In your A-level course you'll look at WHAT actually happens inside the mitochondrion — and why active cells (like muscle and sperm cells) contain so many of them. Have a guess: why do you think a sperm cell needs so many mitochondria?

Topic 3 — Structure and function of biological molecules

This is a short section. Most of this topic is new content that you'll cover at A-level, so we're only checking the parts you've already met at GCSE: food tests, enzymes, and the basics of DNA.

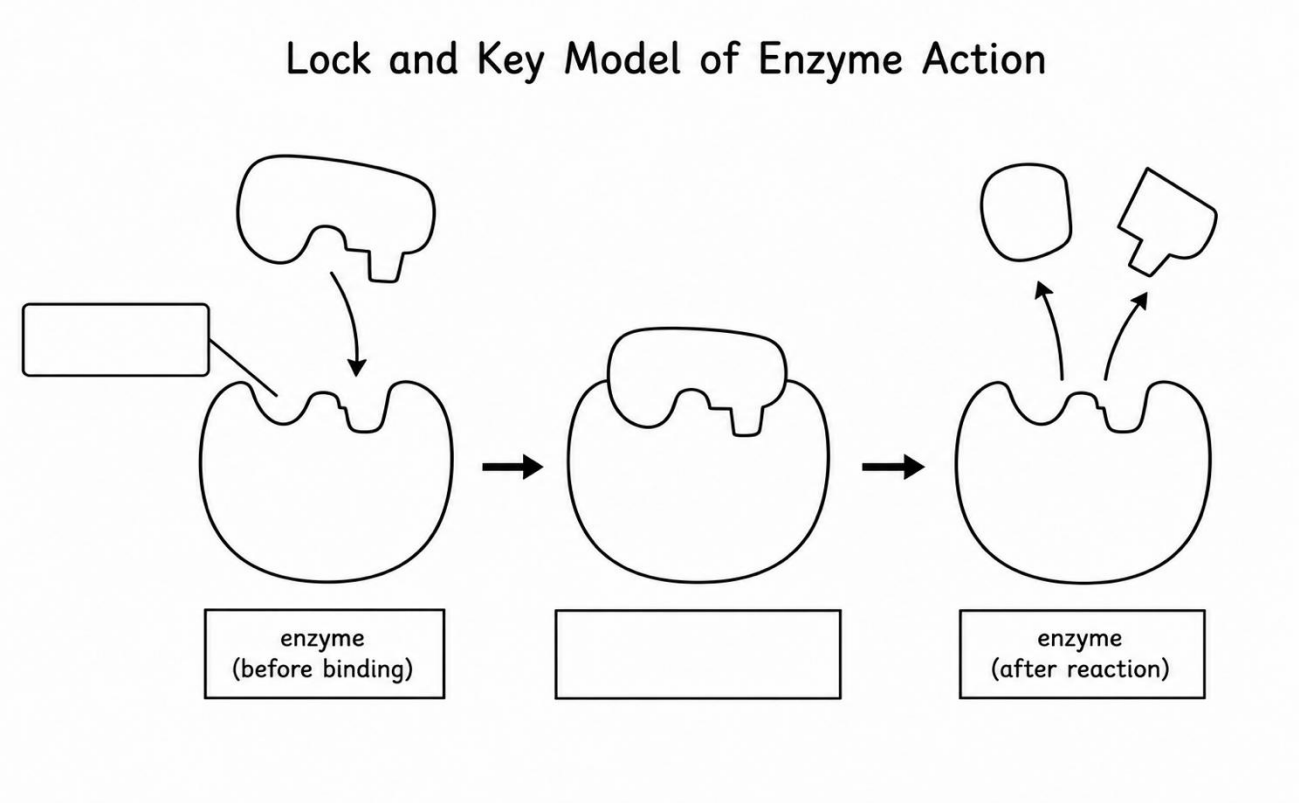
Section A — Food tests

1. Complete the table to show the food tests you carried out at GCSE.

Food group being tested	Reagent used	Positive result (colour change)
Starch		
Sugars (reducing)		
Protein		

Section B — Enzymes

2. The diagram below shows the 'lock and key' model of enzyme action. Label the active site and the enzyme-substrate complex.



3. Match each enzyme to the substance it breaks down.

Term	Definition
Amylase	Breaks down proteins into amino acids.
Protease	Breaks down lipids into glycerol and fatty acids.
Lipase	Breaks down starch into simple sugars.

4. A student investigated the effect of pH on the rate of an enzyme-catalysed reaction. They found that the reaction worked best at pH 7. At pH 2 there was almost no reaction at all.

a) Use the lock and key model to explain why the enzyme stopped working at pH 2.

b) Other than pH, name ONE factor that affects the rate of an enzyme-catalysed reaction.

Section C — DNA and proteins

5. Complete the following sentences using words from the box. Each word may be used once, more than once, or not at all.

amino acids · *chromosomes* · *DNA* · *double helix* · *gene* · *genome* · *protein*

The genetic material in the nucleus is made of _____, which is arranged as a _____. A _____ is a small section of DNA that codes for a sequence of _____, which join together to make a specific _____. The _____ of an organism is the whole of its genetic material.

Stretch yourself

At GCSE you learned what DNA does. At A-level you'll learn what it's actually made of (nucleotides), and how the order of bases controls which proteins your cells make. Have a think: if a mistake (mutation) changed one letter of the DNA code, what might happen to the protein it codes for?

Topic 4 — Biodiversity and ecosystems

This section covers food chains, ecosystems, the factors that affect where organisms live, and how scientists sample populations in the field.

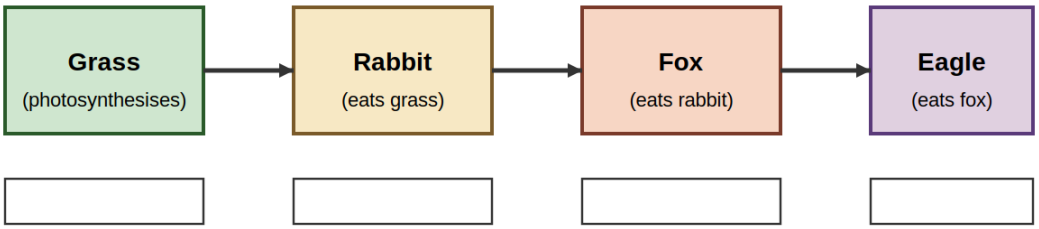
Section A — Levels of organisation

1. Match each term to its definition.

Term	Definition
Population	All the organisms of all the different species living together in an area.
Community	The interaction of a community with the non-living parts of the environment.
Habitat	All the members of a single species living in an area at the same time.
Ecosystem	The place where an organism lives.

2. Label the trophic level of each organism in the food chain below.

Write the correct trophic level (e.g. producer, primary consumer...) in each box below.



3. In a stable community, the numbers of predators and prey rise and fall in cycles. A graph of fox and rabbit numbers over time shows two wavy lines, with the fox line lagging slightly behind the rabbit line.

a) Explain why an increase in the rabbit population is followed by an increase in the fox population.

b) Explain why the fox population then decreases.

Section B — Biotic and abiotic factors

4. Sort the following factors into biotic (living) and abiotic (non-living) by writing each one in the correct column.

Soil pH · Light intensity · Availability of food · Temperature · Wind intensity · Arrival of new predators · Moisture levels · New pathogens being introduced

Biotic factors	Abiotic factors

5. Polar bears live in the Arctic. Suggest ONE structural adaptation and ONE behavioural adaptation that helps polar bears survive in extreme cold.

a) Structural adaptation:

b) Behavioural adaptation:

Section C — Sampling

6. Quadrats and transects are used by ecologists to sample populations.

a) What is a quadrat?

b) Describe how a student could use quadrats to estimate the number of daisies on a school field.

7. A student wants to investigate how the number of plants of a particular species changes as you move from the shaded side of a field to the sunny side. Suggest which sampling technique would be most appropriate, and give a reason for your choice.

Section D — Human impacts

8. Rising levels of carbon dioxide in the atmosphere are linked to global warming. Give TWO ways in which human activities have caused atmospheric carbon dioxide levels to rise.

9. Explain why deforestation reduces biodiversity.

> **Stretch yourself**
> At A-level you'll meet the idea of energy transfer efficiency — only about 10% of the energy stored in one trophic level reaches the next. Have a think: why do you think most food chains have no more than 4 or 5 levels?

Part 2

Chemistry

Atoms · Quantitative chemistry · Bonding · Rates and energy

Topic 1 — Atomic structure and the Periodic Table

This topic has very strong overlap with your GCSE work, so it's the longest Chemistry section. Take your time over the diagrams — being able to draw atoms, work out electron arrangements, and explain group properties is fundamental to everything that follows.

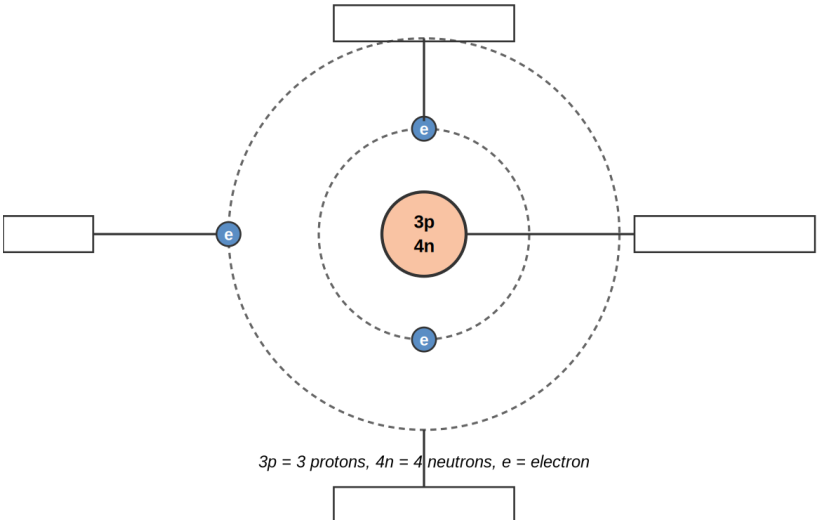
Section A — Atomic structure

1. Complete the table below to show the relative charge and relative mass of each sub-atomic particle.

Particle	Relative charge	Relative mass	Where in the atom?

(The particles are: proton, neutron, electron — fill them in down the left column.)

2. Label the diagram of a lithium atom below.



Word bank: nucleus · electron · inner shell (or first energy level) · outer shell (or second energy level)

3. An atom can be represented as $^{23}_{11}\text{Na}$.

a) What is the atomic (proton) number of sodium?

b) What is the mass number of this sodium atom?

c) How many protons, neutrons and electrons does this atom have?

4. Chlorine has two isotopes: chlorine-35 and chlorine-37.

a) What is meant by the term isotope?

b) A sample of chlorine contains 75% chlorine-35 and 25% chlorine-37. Calculate the relative atomic mass of chlorine in this sample. Show your working.

5. Write the electronic structure (electron arrangement) of the following atoms. The first one is done for you.

Carbon (Z = 6): 2, 4

a) Oxygen (Z = 8):

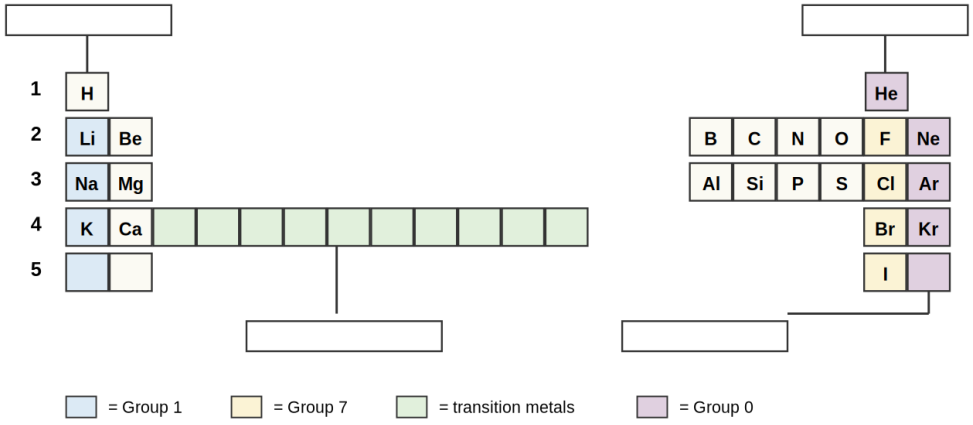
b) Sodium (Z = 11):

c) Chlorine (Z = 17):

d) Calcium (Z = 20):

Section B — The Periodic Table

6. Label the simplified periodic table below using the boxes provided. The legend tells you what each colour represents.



A simplified Periodic Table

Label each highlighted region using the boxes.

7. Use the periodic table to answer the following questions.

a) What is the name given to a vertical column of elements?

b) What is the name given to a horizontal row of elements?

c) Why do elements in the same group have similar chemical properties?

8. Group 1 elements are the alkali metals.

a) How many electrons does an alkali metal have in its outer shell?

b) Describe what you would see when a small piece of sodium is placed on water.

c) Does reactivity increase or decrease as you go down Group 1? Explain why.

9. Group 7 elements are the halogens.

a) How many electrons does a halogen have in its outer shell?

b) Chlorine, bromine and iodine are halogens. State the trend in reactivity going down Group 7.

c) Chlorine displaces bromine from a solution of potassium bromide. Write a word equation for this reaction.

10. Group 0 elements are the noble gases.

a) Why are the noble gases very unreactive?

11. Complete the table to show the difference between metals and non-metals.

Property	Metals	Non-metals

(Properties to compare: position on the periodic table, do they form positive or negative ions, are they good or poor conductors of electricity.)

Stretch yourself

At A-level you'll learn that electrons are actually arranged in sub-shells called s, p and d. The order 2, 8, 8 you've used at GCSE is a simplification. Have a think: why might the d-block in the middle of the periodic table need its own name?

Topic 2 — Quantitative chemistry

This section is short because much of the content (titrations, gas volumes, empirical formulae) is new and will be taught in lessons. Here we're consolidating what you already know about formulae, equations and concentrations.

Important: Questions on moles assume you sat Higher Tier at GCSE. If you sat Foundation Tier, skip questions marked HT — your teacher will introduce moles to you in lessons.

Section A — Equations and conservation of mass

1. State the law of conservation of mass.

2. Balance the following chemical equations by adding the correct numbers in front of each formula.

a) ____ H_2 + O_2 → ____ H_2O

b) ____ Mg + O_2 → ____ MgO

c) ____ Na + Cl_2 → ____ NaCl

d) $CaCO_3$ → CaO + CO_2 (already balanced — confirm by counting atoms)

e) ____ HCl + Mg → $MgCl_2$ + H_2

3. Write a balanced symbol equation, including state symbols, for each of the following reactions:

a) Hydrochloric acid solution reacting with magnesium metal to produce magnesium chloride solution and hydrogen gas.

b) Solid calcium carbonate decomposing on heating to form solid calcium oxide and carbon dioxide gas.

Section B — Acids, alkalis and neutralisation

4. Complete the general word equation for neutralisation:

acid + alkali → _____ + _____

5. Match each acid to the type of salt it produces.

Term	Definition
Hydrochloric acid (HCl)	Produces nitrate salts.
Sulfuric acid (H_2SO_4)	Produces chloride salts.
Nitric acid (HNO_3)	Produces sulfate salts.

6. Predict the name of the salt formed in each of the following reactions:

a) Sodium hydroxide + hydrochloric acid → _____

b) Potassium hydroxide + sulfuric acid → _____

c) Copper oxide + nitric acid → _____

d) Calcium carbonate + hydrochloric acid → _____

7. What ion is responsible for a solution being acidic? What ion is responsible for a solution being alkaline?

Section C — Concentration and reacting masses (HT)

8. [HT] Calculate the relative formula mass (Mr) of each of the following:

Use these relative atomic masses: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, S = 32, Cl = 35.5, Ca = 40.

a) H_2O

b) NaCl

c) $CaCO_3$

d) H_2SO_4

9. [HT] Use the equation: number of moles = mass ÷ Mr

a) Calculate the number of moles in 18 g of water (H_2O).

b) Calculate the mass of 0.5 moles of sodium chloride (NaCl).

10. A solution contains 4 g of sodium hydroxide (NaOH) dissolved in 250 cm³ of water. Calculate the concentration of the solution in g/dm³.

(Hint: 250 cm³ = 0.25 dm³)

Stretch yourself

At A-level you'll work with concentrations in mol/dm³ (also called molarity) rather than g/dm³. You'll also meet titrations — a technique for finding the exact concentration of an unknown solution by reacting it with a solution of known concentration. Have a guess: which piece of glassware do you think gives the most accurate volume measurement?

Topic 3 — Structure and bonding

This topic has very strong overlap with your GCSE work, so it's the longest section. Being able to draw dot-and-cross diagrams and explain why substances have particular properties is essential for the rest of your course.

Section A — Types of bonding

1. Complete the table below.

Type of bond	What types of atom are involved?	What happens to the electrons?

(The three types are: ionic, covalent, metallic.)

2. Identify the type of bonding in each of the following substances. Choose from: ionic, covalent (simple molecular), giant covalent, metallic.

a) Sodium chloride (NaCl):

b) Water (H_2O):

c) Copper (Cu):

d) Diamond (C):

e) Magnesium oxide (MgO):

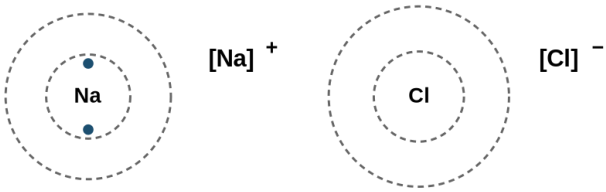
f) Methane (CH_4):

Section B — Dot-and-cross diagrams

3. Complete the dot-and-cross diagrams below to show the bonding in (1) sodium chloride and (2) water.

Diagram 1: Sodium chloride (ionic)

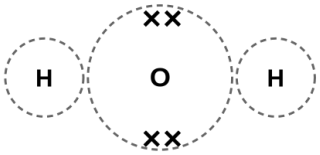
Sodium loses 1 electron to chlorine.
Show the electrons in each ion using dots for Na and crosses for Cl.



Na ion (lost outer electron) Cl ion (gained one electron)

Diagram 2: Water (covalent)

Each H atom shares 1 electron with O.
Add the shared electron pairs (dot for H, cross for O).



Water molecule (each H shares a pair with O)

4. Sodium has the electron arrangement 2, 8, 1 and chlorine has 2, 8, 7.

a) What is the charge on a sodium ion? Explain how this charge is formed.

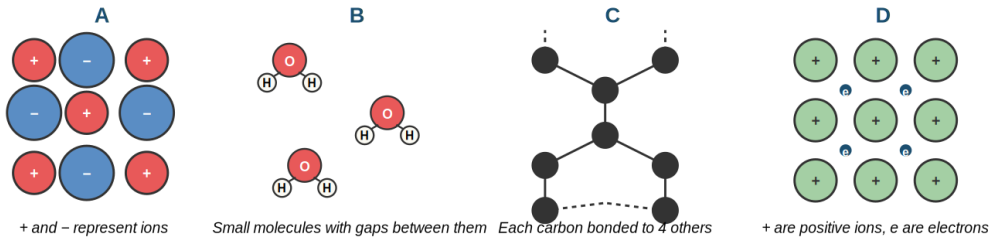
b) What is the charge on a chloride ion? Explain how this charge is formed.

5. Work out the charge on the ion formed by each of these elements. (Hint: think about which group each element is in, and how many electrons it gains or loses.)

Element	Group	Charge on ion
Potassium (K)	1	
Magnesium (Mg)	2	
Oxygen (O)	6	
Bromine (Br)	7	

Section C — Structure and properties

6. Identify the type of structure shown in each diagram. Choose from: ionic, simple molecular, giant covalent, metallic.



Write the type of structure shown (ionic, simple molecular, giant covalent, or metallic) in each box.

7. Complete the table to explain the properties of each type of substance.

Substance type	Melting point (high / low)	Conducts electricity? (and why)
Ionic compound (e.g. NaCl)		
Simple molecular (e.g. H_2O)		
Giant covalent (e.g. diamond)		
Metallic (e.g. Cu)		

8. Diamond and graphite are both forms of pure carbon (allotropes), but they have very different properties.

a) Diamond is the hardest known natural substance. Explain why diamond is so hard, in terms of its structure and bonding.

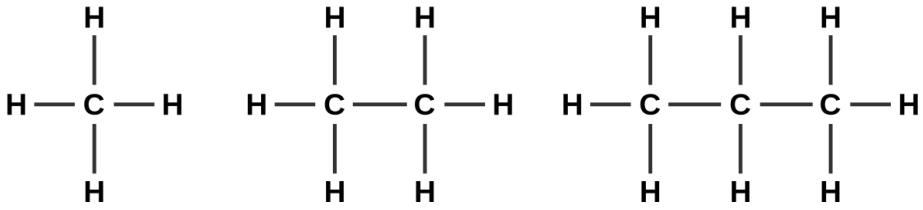
b) Graphite conducts electricity, but diamond does not. Explain why.

9. Explain why metals are good conductors of electricity.

Section D — Organic chemistry: alkanes

10. The diagram below shows the displayed formulae of the first three alkanes. Identify the alkane with 3 carbons and write its name and formula.

Displayed formulae of alkanes



Methane (1 carbon)

CH_4

Ethane (2 carbons)

C_2H_6

3 carbons — write its name and formula:

name _____ formula _____

11. Alkanes are a homologous series of hydrocarbons.

a) What is a hydrocarbon?

b) Write the general formula for the alkanes.

c) Use the general formula to predict the molecular formula of pentane, the alkane with 5 carbon atoms.

12. Methane (CH_4) burns in oxygen to produce carbon dioxide and water. This is called complete combustion.

a) Write a balanced symbol equation for the complete combustion of methane.

b) Is the combustion of methane exothermic or endothermic? Give a reason.

Stretch yourself

At A-level you'll meet other organic families: alcohols, carboxylic acids, alkenes and more. They all follow the same idea — a series of compounds with the same general formula. You'll also learn proper rules for naming organic compounds (called IUPAC nomenclature). Have a think: why might chemists need a strict system for naming compounds rather than just calling them whatever they like?

Topic 4 — Rates of reaction and energy changes

This section covers rate of reaction (good overlap with GCSE) and exothermic and endothermic reactions. The detailed enthalpy calculations are new and will be taught in lessons.

Section A — Rate of reaction

1. Write down the equation for the mean rate of a chemical reaction.

2. List the FIVE factors that affect the rate of a chemical reaction.

a)

b)

c)

d)

e)

3. Collision theory explains how chemical reactions happen. Complete the following sentences.

For a reaction to occur, particles must _____ with each other and must have enough energy. The minimum amount of energy needed for a reaction to occur is called the _____ _____.

4. For each factor below, explain how (and why) it affects the rate of a reaction, using collision theory.

a) Increasing the concentration of a reactant in solution:

b) Increasing the temperature:

c) Increasing the surface area of a solid reactant (e.g. crushing it into a powder):

5. A student investigates the rate of reaction between calcium carbonate (marble chips) and dilute hydrochloric acid. They measure the volume of CO_2 gas produced every 10 seconds.

a) Sketch a graph (on rough paper, or describe in words below) showing the shape you would expect for volume of gas produced against time, and explain its shape.

b) How could you use the graph to find the rate of reaction at a particular moment in time?

6. What is a catalyst? Explain how a catalyst increases the rate of a reaction.

Section B — Energy changes

7. Define the following terms in your own words.

a) Exothermic reaction:

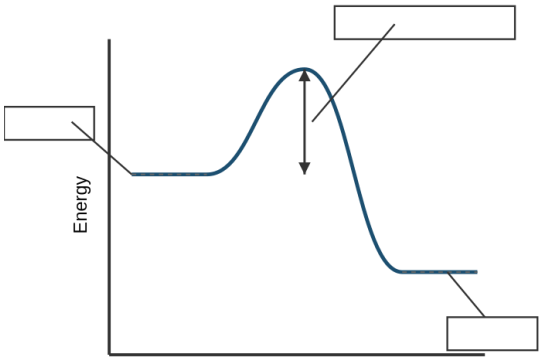
b) Endothermic reaction:

8. Classify each of the following as exothermic or endothermic.

Reaction or process	Exothermic or endothermic?
Combustion (e.g. burning methane)	
Thermal decomposition of calcium carbonate	
Neutralisation of an acid with an alkali	
The reaction in a sports injury cold pack	
The reaction in a hand warmer	

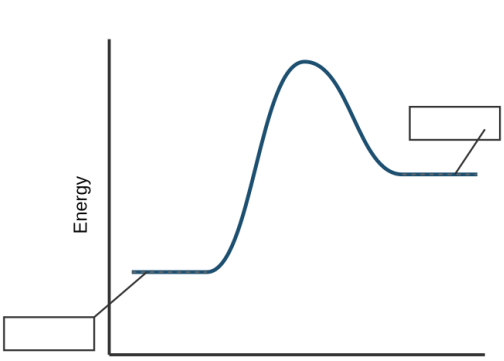
9. The diagram below shows two reaction profiles. For each one, label the reactants, products and activation energy, and state whether it shows an exothermic or endothermic reaction.

Diagram A



Is this exothermic or endothermic?

Diagram B



Is this exothermic or endothermic?

10. On a reaction profile, what does the activation energy show?

Stretch yourself

At A-level you'll meet the symbol ΔH (delta H). This is the enthalpy change of a reaction — a precise way of saying how much energy is transferred. Exothermic reactions have a negative ΔH (energy leaves the reaction); endothermic reactions have a positive ΔH (energy enters the reaction). You'll also do experiments to measure ΔH for the combustion of fuels.

Part 3

Physics

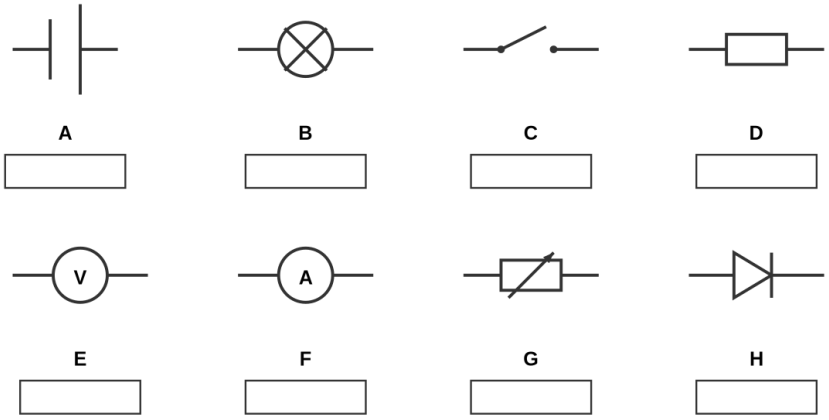
Electricity · Motion · Medical physics

Topic 1 — Electricity

This topic covers electric charge, current, potential difference, resistance, and series and parallel circuits. You'll meet a few extra components and a new equation for parallel circuits at A-level, but the core ideas are exactly the same as GCSE.

Section A — Circuit symbols

1. Name each circuit symbol below. Choose from: cell, switch, lamp, resistor, voltmeter, ammeter, variable resistor, diode.



Write the name of each component in the box below it.

Section B — Current, potential difference and resistance

2. Define the following terms in your own words.

a) Electric current:

b) Potential difference (also called voltage):

c) Resistance:

3. State the units (and the unit symbols) used to measure each of the following:

Quantity	Unit	Unit symbol
Charge		
Current		
Potential difference		
Resistance		

4. Write down the equation linking charge, current and time.

5. Write down the equation linking potential difference, current and resistance (sometimes called Ohm's law).

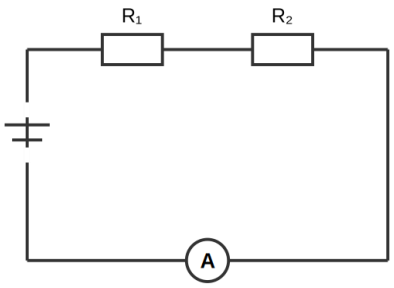
6. A current of 3 A flows through a resistor for 60 seconds. Calculate the charge that flows through the resistor in this time. Show your working and give the answer with units.

7. A potential difference of 12 V is applied across a resistor and a current of 0.5 A flows through it. Calculate the resistance of the resistor. Show your working and give the answer with units.

Section C — Series and parallel circuits

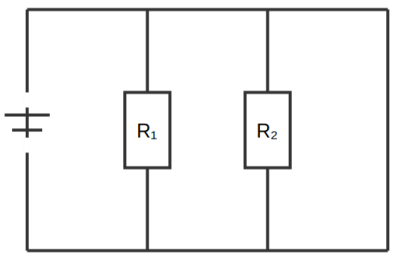
8. Two simple circuits are shown below. One is a series circuit and the other is a parallel circuit.

Circuit A: Series



Components in a single loop

Circuit B: Parallel



Components on separate branches

9. Complete the table to compare series and parallel circuits.

Feature	Series circuit	Parallel circuit
Current at different points in the circuit (same / different)		
Potential difference across each component (same / shared)		
What happens to total resistance when you add another resistor		

10. Two resistors, R_1 = 4 Ω and R_2 = 6 Ω, are connected in series. Calculate the total resistance of the circuit.

11. Why are most household appliances wired in parallel rather than in series?

Section D — Power in circuits

12. The power transferred by an electrical component depends on the potential difference across it and the current through it. Write down the equation linking these three quantities.

13. A 230 V kettle has a current of 10 A flowing through it when in use.

a) Calculate the power of the kettle.

b) If the kettle is on for 2 minutes (120 seconds), calculate the total energy transferred. (Hint: energy = power × time)

Stretch yourself

At A-level you'll meet a new equation for the total resistance of parallel resistors: $1/R_t = 1/R_1 + 1/R_2 + \ldots$ Try it out: what is the total resistance of two 6 Ω resistors connected in parallel? You'll also meet potential divider circuits, which use a chain of resistors to produce a smaller voltage from a larger one — useful for sensors like LDRs and thermistors.

Topic 2 — Motion (energy, forces, and motion equations)

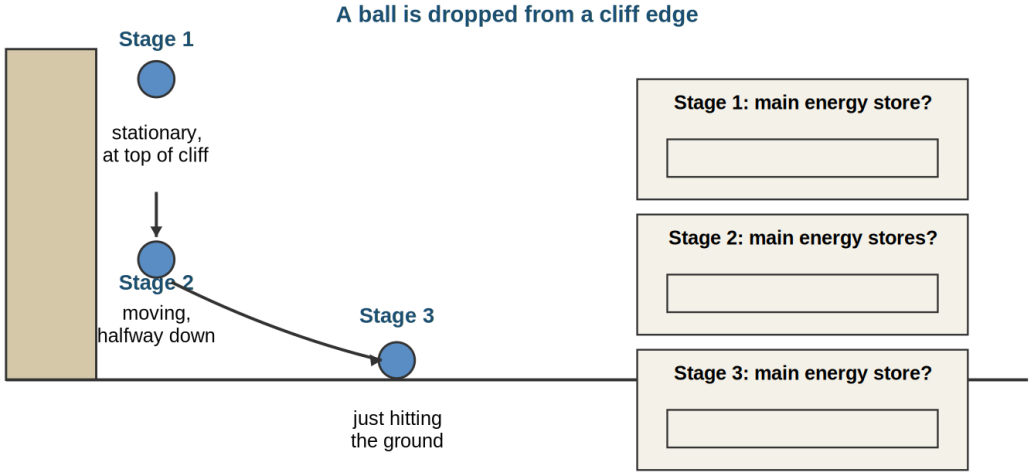
This is the longest section because it has the strongest overlap with your GCSE physics. You'll consolidate energy stores, work done, force equations, motion graphs, and Newton's laws.

Section A — Energy stores and transfers

1. Match each type of energy to its description.

Term	Definition
Kinetic energy	The energy stored in a stretched or compressed spring.
Gravitational potential energy	The energy stored by an object due to its motion.
Elastic potential energy	The energy associated with the temperature of an object.
Thermal energy	The energy stored by an object due to its position in a gravitational field.

2. A ball is dropped from the top of a cliff. Identify the main energy store(s) at each stage of its fall.



3. Write down the equations for each of the following energy stores. State what each symbol represents.

a) Kinetic energy (E_k):

b) Gravitational potential energy (E_p):

4. A 2 kg ball is held 5 m above the ground. (Take g = 9.8 N/kg.)

a) Calculate its gravitational potential energy.

b) The ball is dropped. Assuming all the gravitational potential energy is transferred to kinetic energy as it falls, calculate the speed of the ball just before it hits the ground.

Section B — Work, power and efficiency

5. What does it mean to say that 'work is done' on an object?

6. Write down the equation linking work done, force and distance.

7. A force of 50 N pushes a box 4 m across a floor. Calculate the work done on the box.

8. Define power. Write down the equation linking power, energy transferred and time.

9. Write down the equation for efficiency.

10. A motor uses 500 J of electrical energy. It does 350 J of useful work (the rest is dissipated as heat). Calculate the efficiency of the motor as a percentage.

Section C — Forces

11. Sort the following quantities into scalar and vector by writing each one in the correct column.

Distance · Displacement · Speed · Velocity · Force · Mass · Weight · Time · Acceleration · Energy

Scalar quantities (size only)	Vector quantities (size and direction)

12. Write down the equation linking weight, mass and gravitational field strength.

13. Calculate the weight of a 70 kg person on Earth, where g = 9.8 N/kg.

14. State Hooke's law for a spring (the relationship between force and extension), and write down the equation that links force, spring constant and extension.

15. State the THREE Newton's laws of motion in your own words.

a) First law:

b) Second law:

c) Third law:

16. A car of mass 1200 kg accelerates at 2 m/s². Calculate the resultant force acting on the car.

Section D — Motion equations and graphs

17. Define each of the following motion quantities.

a) Speed:

b) Velocity:

c) Acceleration:

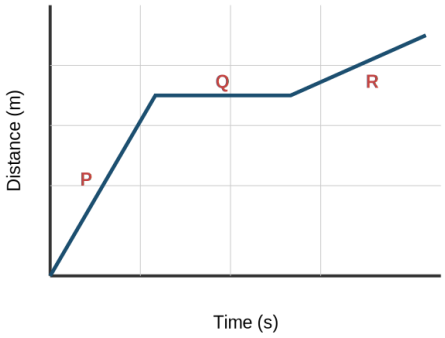
18. Write down the equation linking acceleration, change in velocity and time.

19. Write down the equation linking final velocity (v), initial velocity (u), acceleration (a) and distance (s). [This is one of the GCSE motion equations.]

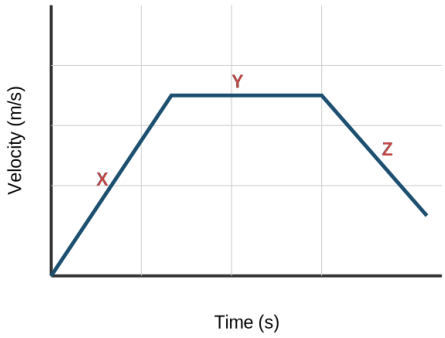
20. A car accelerates from rest (0 m/s) to 20 m/s over a distance of 50 m. Use the equation $v^2 - u^2 = 2as$ to calculate the acceleration.

21. The graphs below show the motion of two different objects.

Graph A: Distance-time graph



Graph B: Velocity-time graph



a) Graph A is a distance-time graph. Describe the motion shown in segment P, segment Q and segment R.

b) Graph B is a velocity-time graph. Describe the motion shown in segment X, segment Y and segment Z.

c) On Graph A, how could you calculate the speed of the object during segment P?

d) On Graph B, how could you calculate the acceleration of the object during segment X?

Stretch yourself

At A-level you'll meet the full set of SUVAT equations — five interconnected equations for objects moving with constant acceleration. $v^2 - u^2 = 2as$ is one of them. You'll also use vector triangles to add forces or velocities that don't act along the same line, and you'll measure the acceleration of free fall (g) in the lab using light gates.

Topic 3 — Medical physics

This section covers atomic structure, the electromagnetic spectrum and wave properties, and radioactivity — the core GCSE ideas that the medical physics topic at Cambridge builds on. New A-level content (X-rays, ultrasound, quantum energy) will be taught in lessons.

Section A — Atomic structure

1. Describe the basic structure of an atom in your own words. Include the names of the three sub-atomic particles and where each one is located.

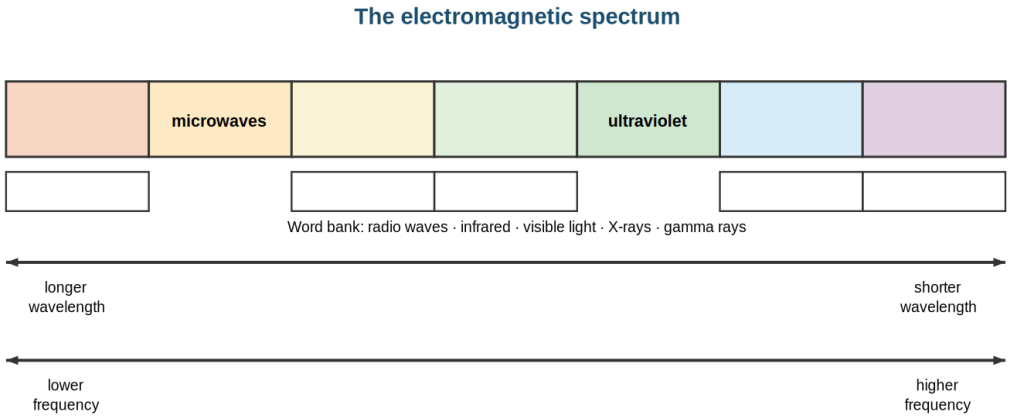
2. Approximately how many times larger is an atom than its nucleus?

3. Describe how the model of the atom developed over time. Use the following words in your answer: plum pudding, nuclear model, alpha particle scattering, Bohr.

4. What is an isotope?

Section B — Electromagnetic waves

5. Complete the electromagnetic spectrum below by filling in the missing types of wave.



6. What property do all electromagnetic waves share that distinguishes them from sound waves (or water waves)?

7. Match each type of electromagnetic wave to a typical use.

Term	Definition
Radio waves	Fibre-optic communications.
Microwaves	Sterilising medical equipment / treating cancer.
Infrared	Television and radio broadcasts.
Visible light	Energy-efficient lamps; tanning beds.
Ultraviolet	Satellite communications and cooking food.
X-rays	Medical imaging of bones.
Gamma rays	Electrical heaters and infrared cameras.

8. Why are ultraviolet, X-rays and gamma rays potentially harmful to humans?

Section C — Wave properties

9. Label the diagrams of a transverse wave and a longitudinal wave below.

Diagram A: Transverse wave

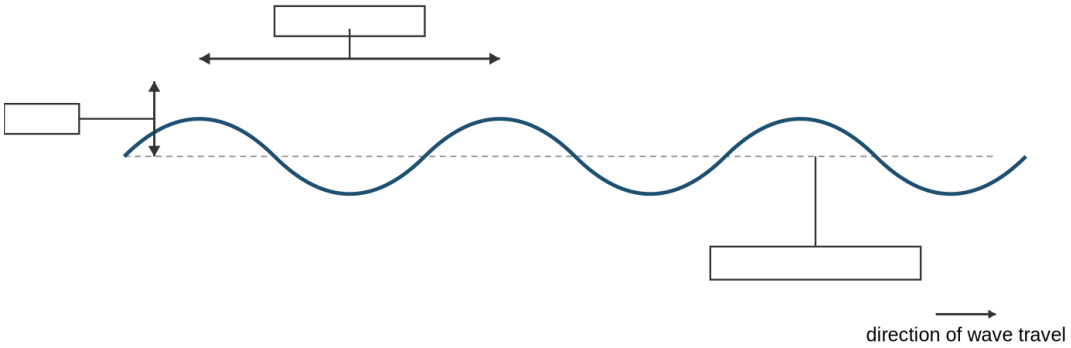
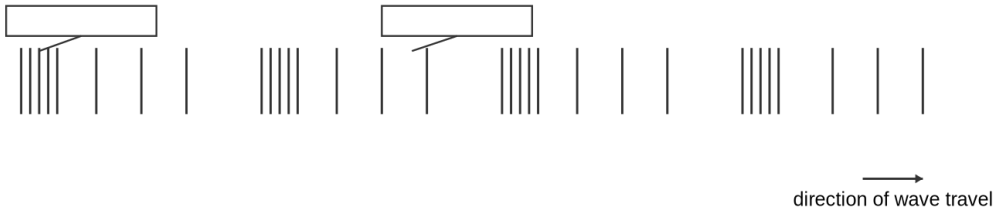


Diagram B: Longitudinal wave



Word bank (transverse): wavelength · amplitude · undisturbed position

Word bank (longitudinal): compression · rarefaction

10. Write down the wave equation linking wave speed, frequency and wavelength.

11. A sound wave travels at 340 m/s. If its frequency is 170 Hz, calculate its wavelength.

Section D — Radioactivity

12. Describe the three main types of nuclear radiation. For each one, state what it is and give one property (its penetration through materials, its range in air, or its ionising power).

a) Alpha (α):

b) Beta (β):

c) Gamma (γ):

13. What is meant by the half-life of a radioactive isotope?

14. A sample of a radioactive isotope has an initial activity of 800 Bq. The half-life of the isotope is 2 hours.

a) What will the activity be after 2 hours?

b) What will the activity be after 6 hours?

15. Explain the difference between irradiation and contamination.

Stretch yourself

At A-level you'll meet the medical applications of these GCSE ideas: X-ray imaging, ultrasound scans (where pulses are sent into the body and reflected back), and radionuclide tracers (radioactive substances introduced into the body to follow biological processes). You'll also use a more powerful equation for radioactive decay: $N = N_0 e^{(-\lambda t)}$, where λ is the decay constant. Have a think: what makes a radioactive isotope suitable for a medical tracer rather than too dangerous to use?

You've finished!

Well done for working through this booklet over the summer. You should now feel confident with all the GCSE biology, chemistry and physics content that your Level 3 course will build on.

Don't forget to:

- Check your answers using the separate answer booklets for each subject
- Mark any topics you found tricky so you can revisit them
- Bring this booklet to your first science lessons

See you in September!