SATs·Papers.co.uk

PAST PAPERS · QUESTION PAPERS · PAPER NOTES

13+ PAST PAPER PACK

Eton College 13+ Science 2020

Complete Past Paper Pack

CONTENTS

Eton College King's Scholarship Examination 2020

SCIENCE 2 (Data Analysis)

(30 minutes)

Candidate Number:**____________________________**

Remember to write your candidate number on every sheet in the space provided.

*You should attempt **ALL** the questions. Write your answers in the spaces provided.*

The maximum mark for each question or part of a question is shown in square brackets.

Calculators are allowed. In questions involving calculations, all your working must be shown.

Total Marks Available: 30

For examiners' use only.

Total [30]	

Do not turn over until told to do so.

1. This question is about springs and requires the use of Hooke's Law:

$$F = kx$$

Here, F is the applied force on the spring, x is the extension of the spring and k is the 'spring constant'. A student measures the length of the spring as he varies the force applied to it. Plot the following data on the grid below. Ensure the independent variable goes on the x-axis and include the origin. **[5]**

force / N	**length / cm**
1.5	14.3
3.0	19.5
4.2	22.5
6.0	28.5
7.0	28.0
9.0	36.0

(a) From the graph, determine the original, unstretched length of the spring.

____ **[2]**

(b) Calculate the spring constant of the spring. Give your answer in units of N/m.

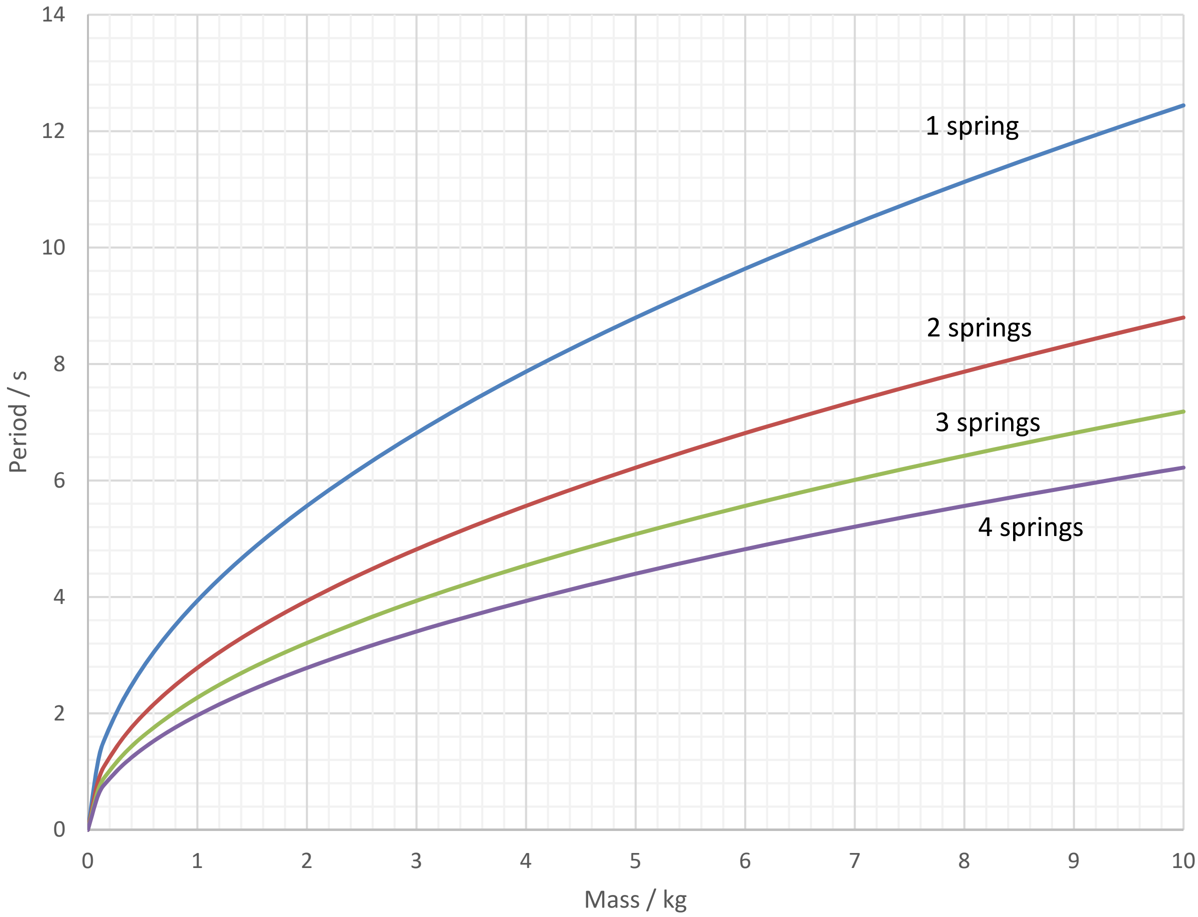
____

____

____

____ **[4]**

A different spring is used as a crude timekeeping device. A mass is hung from the spring; it is then pulled down and released. The mass oscillates (bounces) up and down with a certain time period T. The graph below shows how the period of oscillation T depends upon the mass m for different numbers of springs attached to the mass in *parallel* to each other. Note: all the springs are identical, each with spring constant k.



(c) Circle the correct dependence of period on k and m, and justify your choice using data from the graph on page 3.

$T = 2\pi\sqrt{\frac{k}{m}}$ $T = 2\pi\sqrt{\frac{m}{k}}$ $T = 2\pi\sqrt{mk}$ $T = 2\pi\sqrt{\frac{1}{mk}}$

____

____

____

____

____

____

____

____ **[4]**

The mass m hanging off the spring is 6.0 kg.

(d) From the graph, determine the period of this spring-mass system. (Assume only one spring is used.)

____

____

____ **[2]**

(e) Calculate the number of oscillations that will pass during a 1 hour period. Give your answer to the nearest oscillation.

____

____

____ **[2]**

The system is used to determine when a 1 hour duration has passed by counting the appropriate number of oscillations, i.e. the number you calculated in the previous part. However, the true value of T can only be said to lie within 5% of the value that you have determined in part (d) (no measurement is ever perfect), and so the true duration will probably be slightly more or less than 1 hour.

(f) Calculate the maximum and minimum values for the possible true duration. Give your answers in the format hh:mm:ss.

____

____

____

____

____

____

____ **[3]**

As the spring-mass oscillates the amplitude of its oscillations decreases.

(g) Explain, in terms of energy, what causes the amplitude of the oscillations to decrease.

____

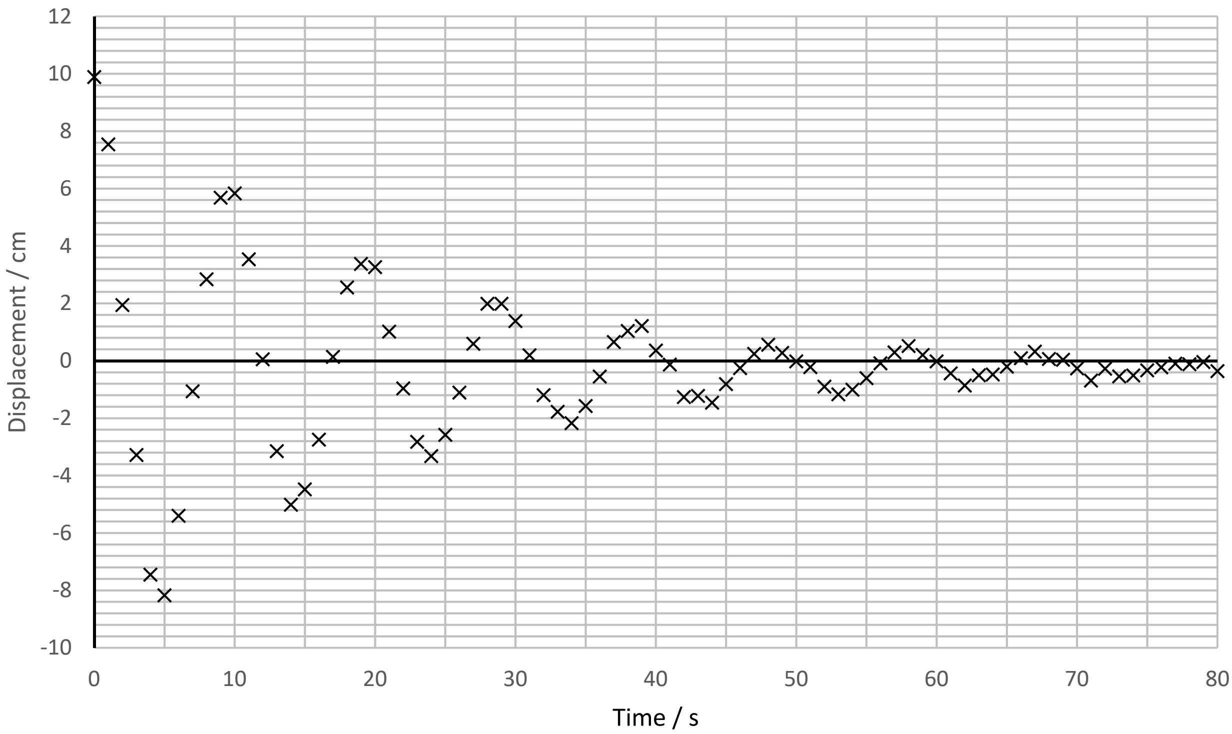
____

____

____

____ **[2]**

The displacement of mass on the spring (i.e. how far it is above and below the equilibrium position) is measured as a function of time. The data is given below.



(h) Use the graph on the previous page to answer this part of the question.

i. Draw an appropriate line through the data points. **[1]**

ii. The amplitude of the oscillations take the same time to decrease by the same factor. By taking readings from the graph, determine the 'half-life' of the oscillations, i.e. how long it takes for the amplitude of the oscillations to halve.

____

____

____ **[2]**

iii. The initial amplitude was 10 cm. Calculate the amplitude if this system is allowed to run for 1 hour. Comment upon this value.

____

____

____

____ **[3]**

[End of paper]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2020))

Compiled by SATs-Papers.co.uk to help you get the most from this paper.

Overview

This is a **Science Data Analysis paper** published by **Eton College** for its **King's Scholarship Examination 2020**, designed to assess candidates seeking Year 9 entry at the **13+ level**. The paper is worth **30 marks** and must be completed in **30 minutes**, making it a tightly paced test of analytical and mathematical reasoning in a physics context.

The entire paper revolves around **Hooke's Law** and the behaviour of spring-mass oscillators. Candidates must plot experimental data, extract physical constants from graphs, apply formulae for oscillation period, and analyse damped harmonic motion using concepts of energy transfer and exponential decay. This is not a knowledge-recall test: every mark depends on interpreting graphs, performing calculations, and reasoning from first principles.

The paper suits mathematically confident candidates preparing for selective independent schools. Calculators are permitted and all working must be shown, emphasising process over final answers. The focus on **data handling, graphical analysis, and error propagation** reflects the high standard expected at Eton's scholarship level, where physics meets quantitative rigour.

How this paper is organised

The paper comprises a single extended question with nine lettered sub-parts, running from part (a) to part (h)(iii). The question begins with **plotting raw force-extension data** (5 marks), then moves through gradient calculation, graph interpretation, formula selection, period determination, error analysis, and finally exponential decay fitting. The mark distribution is uneven: the opening plot and spring constant calculation together account for 9 marks, whilst later parts such as determining the period or explaining energy loss carry 2 marks each.

Candidates write answers in spaces provided on the exam paper itself. Two graphs are supplied: a blank grid for plotting data and a pre-drawn set of curves showing period versus mass for different numbers of springs in parallel. The final question presents a scatter plot of displacement versus time that candidates must interpret by drawing a decay envelope and calculating a half-life.

With **30 marks in 30 minutes**, candidates have one minute per mark on average. However, plotting, calculating spring constants, and performing multi-step error propagation will take longer than brief explanatory answers, so pacing is critical.

Topics covered

- **Hooke's Law**: applying $F = kx$, identifying force as the independent variable, and calculating spring constant from gradient in N/m
- **Graph plotting**: selecting appropriate axes, including the origin, marking points accurately, and drawing best-fit or smooth curves
- Reading values from multi-curve graphs: extracting period data for different spring configurations and interpolating between grid lines
- **Oscillation formulae**: choosing the correct relationship $T = 2\pi\sqrt{(m/k)}$ by reasoning from how period scales with mass and spring constant
- **Unit conversion and calculation**: converting time to seconds, determining number of oscillations over an hour, and presenting times in hh:mm:ss format
- **Percentage error and uncertainty propagation**: calculating maximum and minimum durations when the measured period lies within ±5%
- Energy transfer in damped oscillations: explaining amplitude decay in terms of dissipation to thermal energy via air resistance and internal friction
- **Exponential decay and half-life**: drawing an envelope through oscillation peaks, measuring the time for amplitude to halve, and applying repeated halving over extended intervals
- Extended calculation requiring iteration: determining amplitude after 3600 seconds by counting how many half-lives have elapsed
- Commenting on physical realism: recognising when a calculated amplitude is negligibly small and what that implies for the system's usefulness as a timekeeper

How to use this paper for revision

- Practise plotting data with force or time on the x-axis and making sure your axes span the full range of values, including the origin when instructed.
- Revise calculating gradients in different units: here spring constant must be in N/m, so convert extension from cm to m before dividing.
- Familiarise yourself with the form $T = 2\pi\sqrt{(m/k)}$ for spring-mass systems; know that doubling mass increases period by $\sqrt{2}$, and doubling k decreases it by the same factor.
- Work through percentage error problems methodically: if T can be 5% higher or lower, multiply or divide by 1.05 and then propagate that through all subsequent steps.
- Understand exponential decay: amplitude halves every half-life, so after two half-lives it quarters, after three half-lives it drops to one-eighth, and so on.
- When drawing curves through scattered data, aim for a smooth line that balances points above and below rather than zigzagging through every cross.
- Always show all working, even for multi-step calculations; partial marks are available if your method is sound but an arithmetic slip occurs.

Common mistakes to avoid

- Plotting length rather than extension on the y-axis; the question asks for extension x, which is length minus the unstretched length.
- Forgetting to convert extension from centimetres to metres before calculating spring constant, leading to an answer that is off by a factor of 100.
- Choosing $T = 2\pi\sqrt{(k/m)}$ instead of $T = 2\pi\sqrt{(m/k)}$ because the graph shows period increasing with mass, not decreasing.
- Reading period at 6 kg from the wrong curve; ensure you are using the '1 spring' line, not the multi-spring data.
- Dividing 3600 seconds by the period without recognising that a 5% error in T propagates to a 5% error in the total duration, not in the number of oscillations.
- Stating that amplitude decreases because 'energy is lost' without specifying the mechanism: air resistance and internal damping convert kinetic and elastic potential energy into heat.
- Drawing a straight line through the displacement peaks rather than a smooth exponential envelope, or measuring half-life from arbitrary points instead of successive peak amplitudes.

Exam technique

Start by reading the entire question to understand the scenario: you are following the same spring system through multiple experimental analyses. Tackle part (a) by reading the y-intercept from your plotted graph, which gives the unstretched length directly. For part (b), pick two widely spaced points on your line of best fit, calculate the gradient in cm/N, then convert to N/m by multiplying by 100.

In part (c), test each formula against the graph: if period increases when mass increases, m must be in the numerator; if adding more springs (higher effective k) reduces period, k must be in the denominator. Write your reasoning explicitly to earn full marks even if you circle the wrong equation. For parts (d) and (e), read the graph carefully at m = 6.0 kg on the '1 spring' curve, then divide 3600 s by that period and round sensibly.

Part (f) requires disciplined arithmetic: calculate $T \times 1.05$ and $T \times 0.95$, then multiply each by your oscillation count to find the range of possible durations. Convert seconds to hours, minutes, and seconds without rounding intermediate steps. In parts (g) and (h), quality of explanation matters: name the forces or processes involved, and for half-life, measure from peak to peak at half the original amplitude. Finally, apply exponential decay systematically by determining how many half-lives fit into one hour and halving the amplitude that many times. If the result is microscopic, say so and explain why the system would be impractical.

What to revise alongside this paper

Extend your revision to cover **Newton's second law** and how restoring force in a spring produces simple harmonic motion, including deriving $T = 2\pi\sqrt{(m/k)}$ from $F = ma$. Study **energy in oscillators**: the interconversion of kinetic and elastic potential energy, and how amplitude relates to total mechanical energy. Practice plotting and interpreting data with **logarithmic scales**, which linearise exponential decay and make half-life determination more straightforward.

Review **units and dimensional analysis** so you can check whether a formula is plausible before applying it: period has units of seconds, so anything inside a square root involving mass and spring constant must reduce to s^2. Consolidate your understanding of **experimental uncertainty**: how percentage errors combine, why systematic errors affect intercepts differently from gradients, and how to present a result with appropriate significant figures.

For stretch, investigate **damping mechanisms** in real oscillators (viscous drag, hysteresis in materials) and how the quality factor Q quantifies how quickly energy is lost. Look at coupled oscillators and resonance, which underpin everything from clocks to suspension bridges, and connect the mathematics you have applied here to real engineering challenges.

Key terms

> **Hooke's Law**, **Spring constant (k)**, **Extension (x)**, **Independent variable**, **Best-fit line**, **Period (T)**, **Oscillation**, **Parallel springs**, **Damped harmonic motion**, **Amplitude**, **Half-life**, **Exponential decay**, **Percentage uncertainty**, **Error propagation**, **Energy dissipation**

Eton College King's Scholarship Examination 2020

SCIENCE 1 (Theory)

(60 minutes)

Candidate Number: ___________________________

<u>Remember to write your candidate number on every sheet in the space provided.</u>

*You should attempt **ALL** the questions. Write your answers in the spaces provided.*

The maximum mark for each question or part of a question is shown in square brackets.

Calculators are allowed. In questions involving calculations, all your working must be shown.

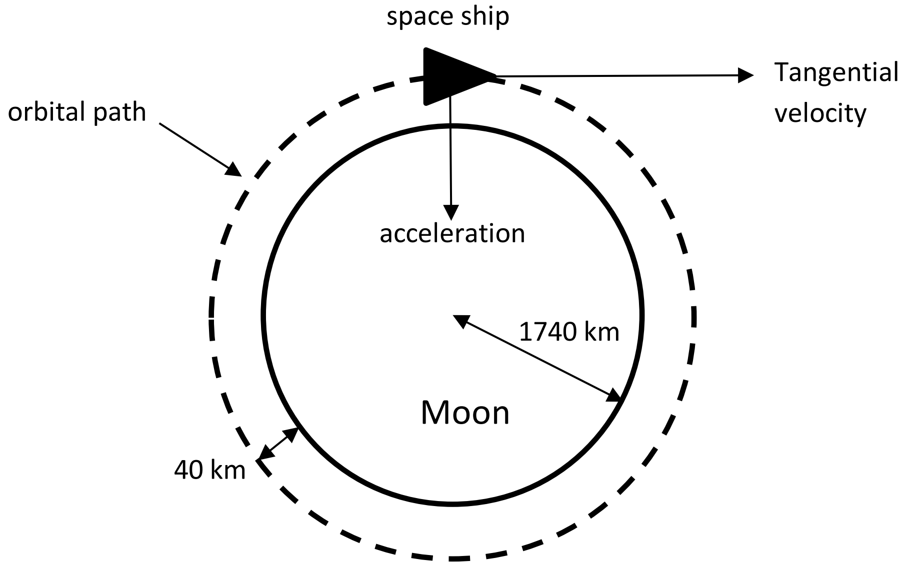
Total Marks Available: 70

For examiners' use only.

1	2	3	4	5	TOTAL [70]

Do not turn over until told to do so.

1. A 20 tonne space ship is orbiting the Moon 40 km above its surface. The radius of the Moon is 1,740 km and it is 380,000 km from the Earth.



(a) Mission Control, back on the Earth's surface, is communicating with the astronauts in the space ship.

i. Explain why there is a delay between sending a message from Earth and receiving a reply.

____

____

____ **[1]**

ii. Calculate the length of the time delay. The speed of light in a vacuum is $3x10^8$ m/s.

____

____

____ **[1]**

The gravitational field strength at the altitude of the space ship is 1.6 N/kg.

(b) Calculate the weight of the space ship.

____

____ **[1]**

(c) Newton's Second Law of Motion states that,

$$F = ma$$

where F is the resultant force on an object, m is the mass of the object and a is its acceleration.

i. If the space ship's weight is the only force it experiences, calculate its acceleration. Include the correct units.

____

____

____ **[1]**

ii. Comment on its value compared with other data you have been given.

____

____

____ **[1]**

iii. Given your previous answer and without any calculation state the acceleration due to gravity near the Earth's surface.

____

____ **[1]**

(d) Any object moving in a circle of radius, *r,* with a tangential speed, *v,* must have an acceleration, *a,* towards the centre of that circle such that,

$$a = \frac{v^2}{r}$$

i. Calculate the tangential velocity, *v,* of the space ship in this orbit.

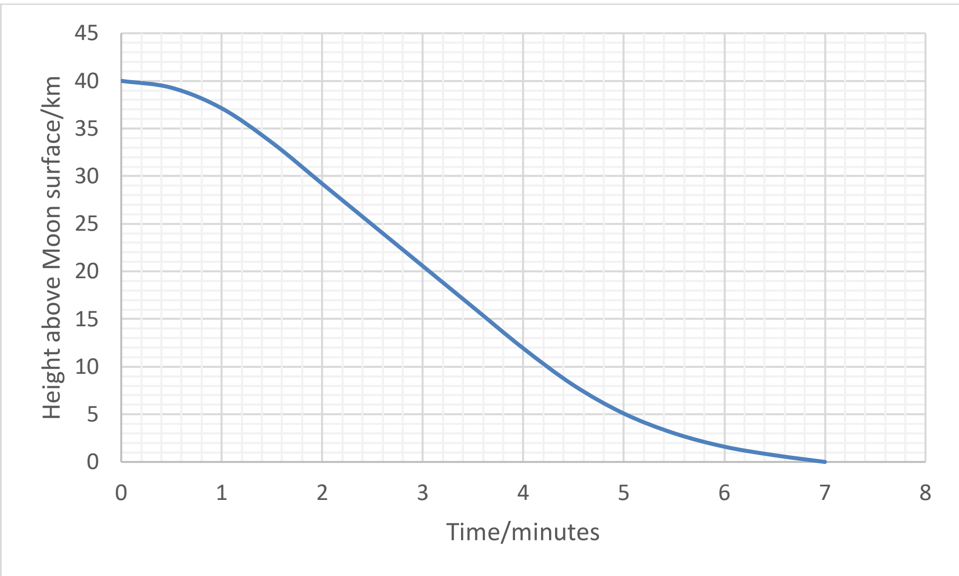
[2]

ii. State the radial speed (the speed towards the centre of the circle).

[1]

The space ship fires its rockets to bring it to a stationary hover relative to the moon. It then switches off the rockets so that the space ship goes into freefall. After a while the rockets are fired again to eventually bring the space ship to a halt at the Moon's surface. (This is not how they do it but it makes the physics much easier for us!)

The following graph shows how the space ship's height above the Moon's surface varies with time.



(e) Describe in as much detail as you can the motion of the space ship between 1.5 minutes and 4.0 minutes.

____

____

____ **[1]**

(f) Compare the upward thrust exerted by the rocket on the space ship with the weight of the space ship, justifying your answer:

i. between 0.0 minutes and 1.5 minutes;

____

____ **[1]**

ii. between 4.0 minutes and 7.0 minutes.

____

____ **[1]**

(g) As the space ship goes from a stationary hover above the Moon's surface to being stationary on the Moon's surface its total energy store reduces. The Law of Conservation of Energy states that the total energy of a closed system must remain constant. What has happened to the energy the space ship has lost?

____

____

____

____

____

____

____

____ **[2]**

2. A balanced diet includes appropriate quantities of a variety of components, including carbohydrates, fats, vitamins and minerals.

   (a) Name two other components of a balanced diet.

   1. ______________________________ 2. ______________________________ **[1]**

   (b) The most abundant mineral in the human body is calcium, and almost all of the calcium in a human is found in the skeleton.

   Give two functions of the human skeleton.

   1. ____

   2. ____ **[2]**

   (c) A group of research scientists investigated the mass of six people and compared their bone mass to total body mass. Some of the results are shown below:

	Bone mass (kg)	**Total body mass (kg)**	**Proportion of body mass that is bone (%)**
Male 1		62.1	14.5
Male 2	7.7	70.0	
Male 3	12.6		14.0
Female 1	8.2	120.0	6.9
Female 2	9.1	72.8	12.5
Female 3	6.3	63.0	10.0

   i. Calculate and add the missing values in the table. **[2]**

   ii. The percentage of body mass that is bone varies widely between individuals. Suggest and explain possible reasons for this variation.

____

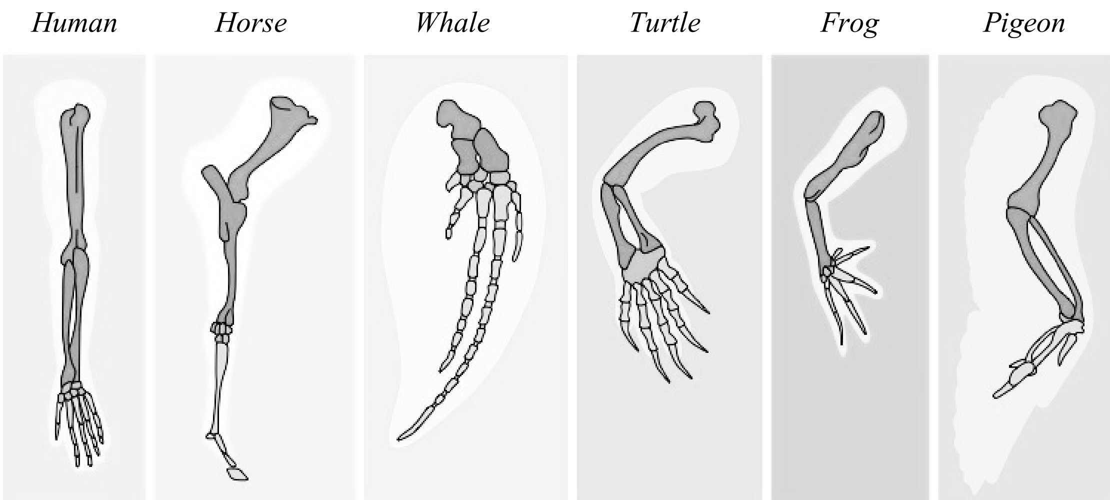
____

____

____

____ **[4]**

(d) The diagram below shows the arrangement of bones in the forelimbs of several different vertebrates.



i. Complete the table below to identify which vertebrate group each animal belongs to. **[2]**

Animal	Vertebrate group
Human	
Horse	***Mammal***
Whale	
Turtle	
Frog	
Pigeon	***Bird***

The arrangement of bones in vertebrate limbs is evidence that supports the theory that all vertebrate groups are evolutionarily related, and have descended from a common ancestor many millions of years ago.

ii. Explain to what extent you think the bone arrangements of human and pigeon forelimbs support this theory.

____

____

____

____

____

____

____ **[3]**

3. **Figure 1** below depicts a section of leaf with arrows indicating the **net movement** of gases into and out of the leaf through holes called stomata.

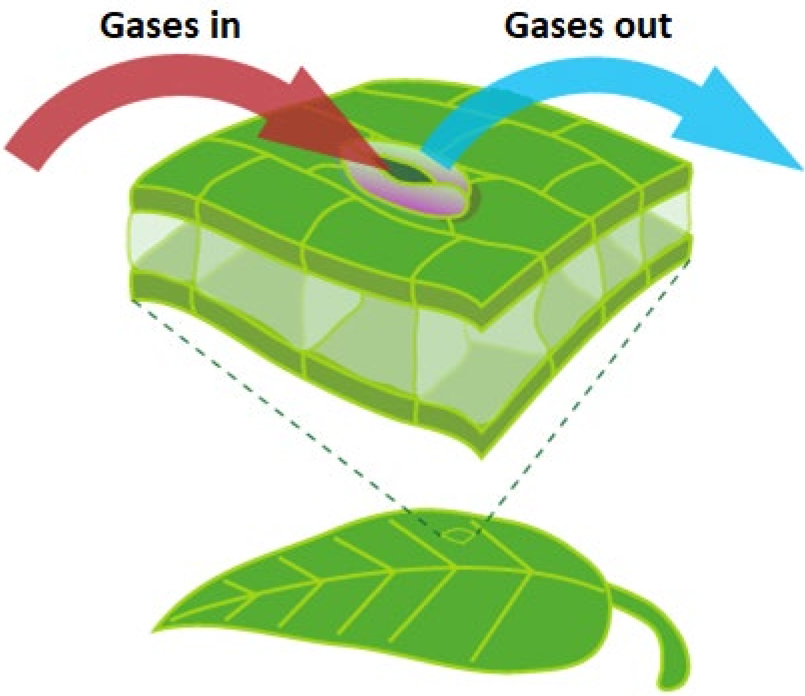


Figure 1. Image modified from evolution.berkeley.edu. (2019)

(a) There are three **key** gases moving into or out of a leaf.

i. Name the three gases moving into and/or out of a leaf.

____ **[1]**

ii. Complete the table below with the appropriate gas(es): **[3]**

	Net movement into leaf	Net movement out of leaf
Daylight		
Darkness		

iii. Suggest why rainforests are often described as '*the lungs of the planet*'.

____

____

____ **[2]**

(b) Atmospheric carbon dioxide concentrations are measured in parts per million (ppm). The graph below shows how these have fluctuated for the past 800,000 years based on ice core data.

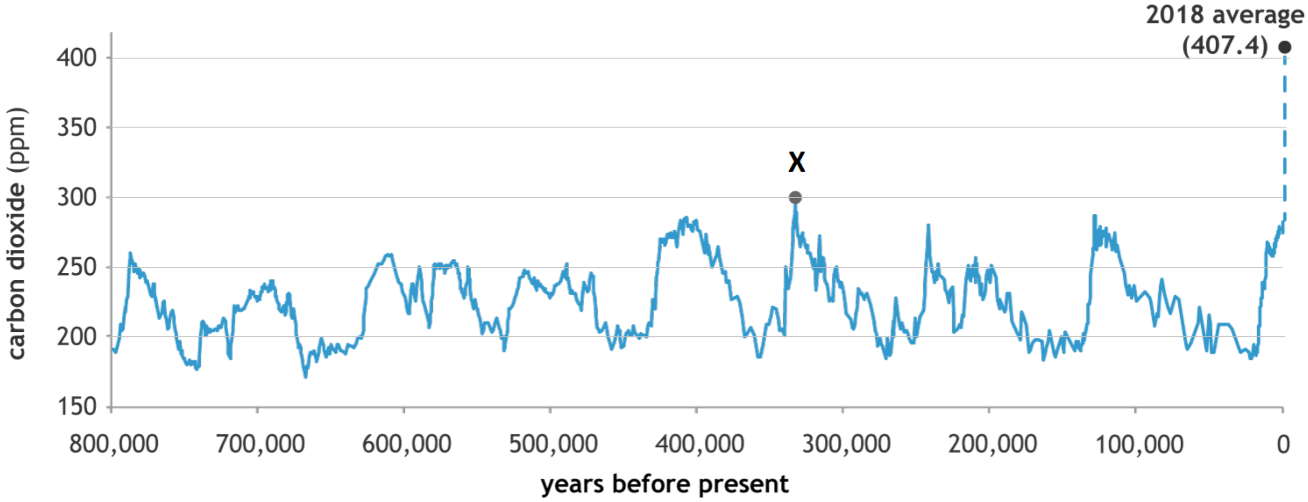


Figure 2. Image modified from NOAA Climate.gov (2019).

i. Use the graph above to calculate the percentage (%) change in atmospheric carbon dioxide concentration between point **X** and **2018**.

____

____ **[1]**

The stomata on the underside of living and fossil leaves can be seen under a microscope. The diagrams below depict two samples of leaf of the same species viewed under the microscope. The number of stomata per unit area is known as the stomatal density.

Sample A taken from time period **X**. Sample B taken in 2018.

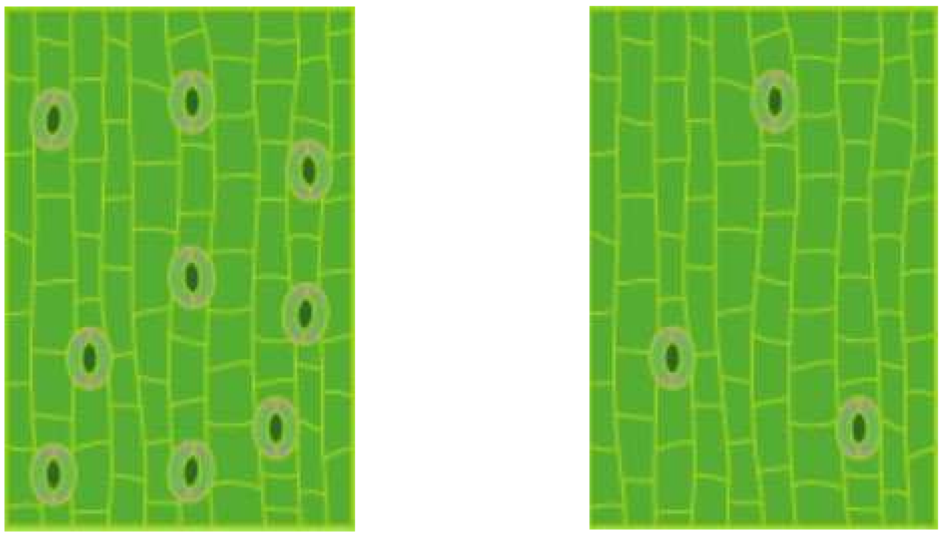


Figure 3. Image modified from evolution.berkeley.edu. (2019)

ii. Compare the stomatal density of leaf sample A with the stomatal density of leaf sample B.

____

____ **[1]**

iii. Using information from the graph in **Figure 2**, suggest explanations for the difference in stomatal density between Sample A and Sample B.

____

____

____

____

____

____

____ **[3]**

iv. Suggest why having fewer stomata might be an advantage to a plant during drought conditions.

____

____

____

____

____ **[2]**

v. Suggest why conclusions drawn from the differences observed in these samples might not be valid.

____

____

____ **[1]**

4. This question is about a series of chemical reactions.

(a) Write a word equation for the reaction of magnesium with sulfuric acid.

____ **[1]**

A student reacted some magnesium with sulfuric acid, making sure that the magnesium was in excess. He measured the time taken for the reaction to finish, and found that the reaction finished after 120 seconds.

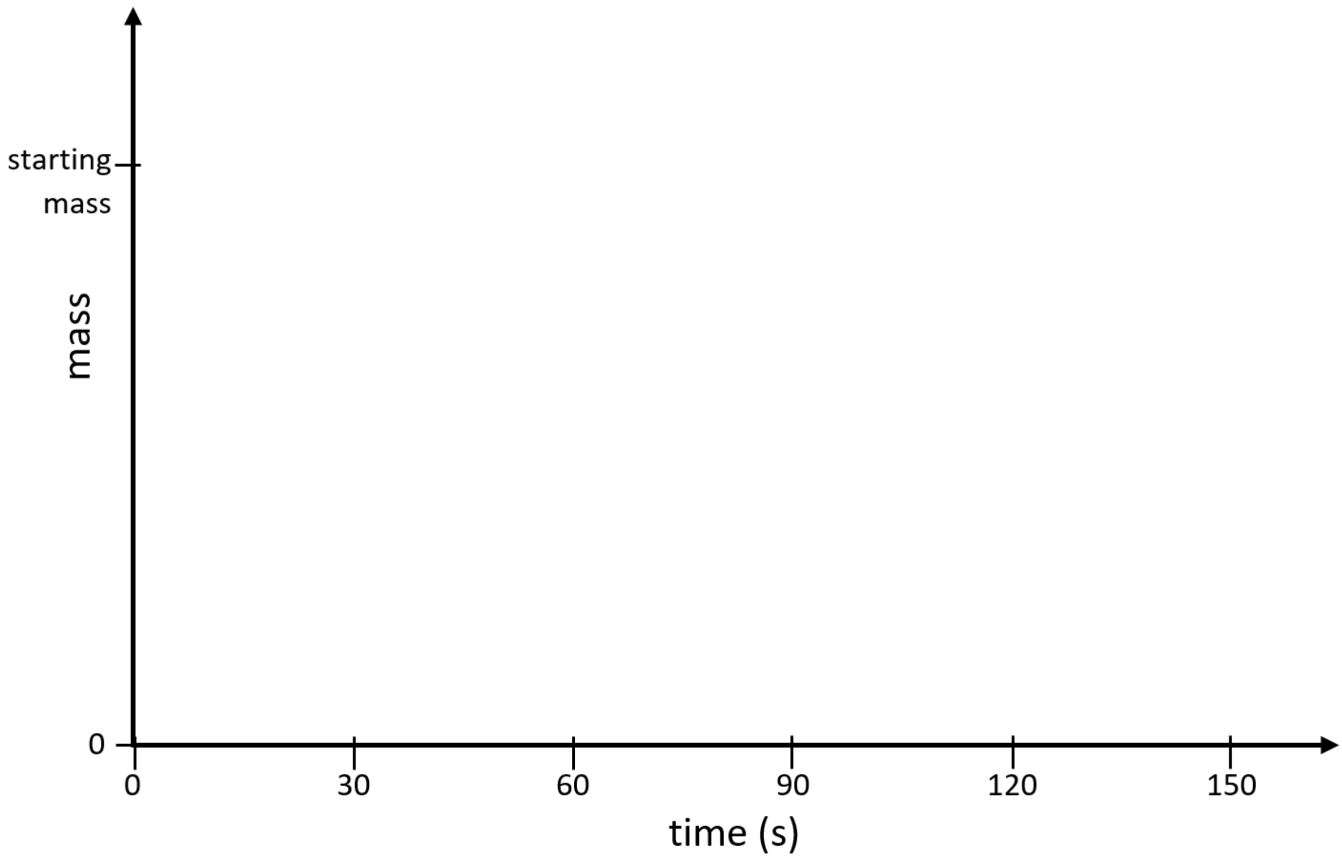
(b) Give one observation that would show that the reaction had finished.

____ **[1]**

The above reaction was performed again, with exactly the same conditions and amounts of chemicals, but this time in a beaker on top of a balance.

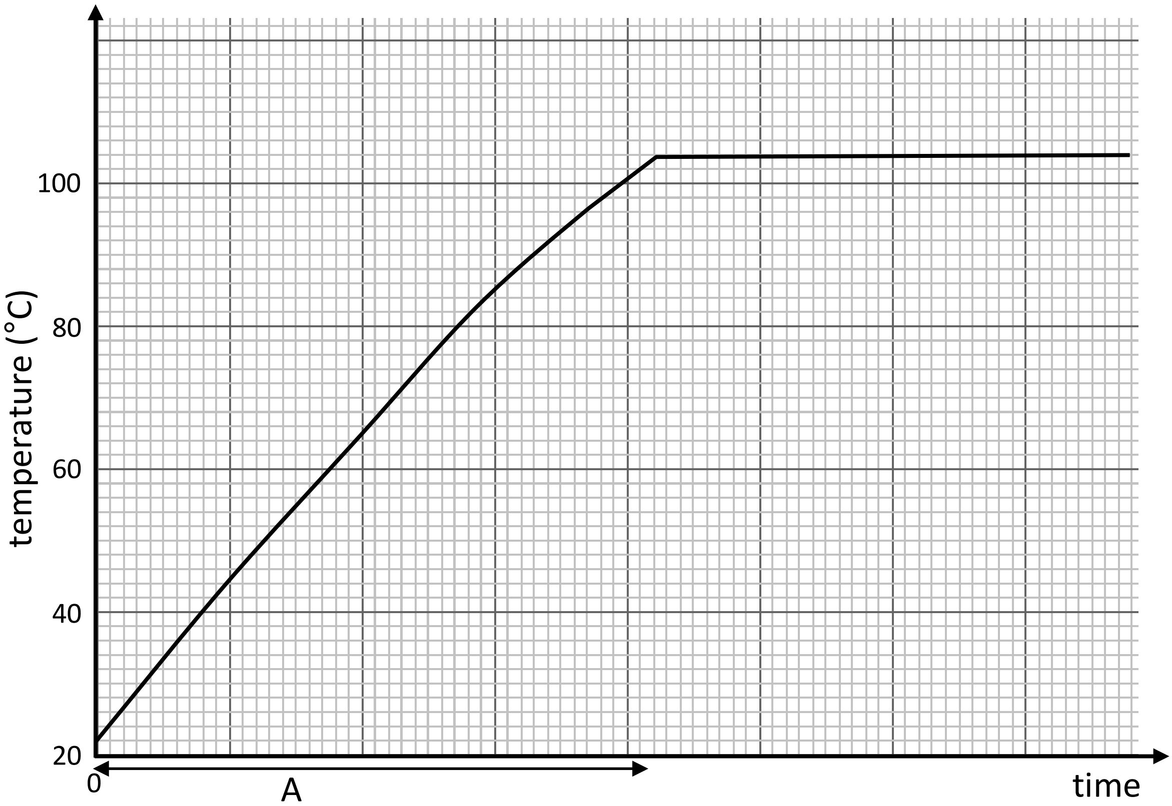
(c) Sketch on the axes below the shape of the graph for the mass measured by the balance against time, from the beginning of the reaction to 150 seconds.

The starting mass at time = 0 seconds has been marked for you.



[3]

The resulting mixture was first filtered, then the solution obtained was heated with a Bunsen burner. As it was heated the temperature was recorded and plotted on the graph below.



(d) Explain why the mixture was filtered.

____ **[1]**

(e) **Name** the change of state which was occurring during time period A.

____ **[1]**

(f) Explain why the graph levels off at 104 ºC.

____

____

____ **[2]**

The student finished off the experiment, and produced a sample of dry magnesium sulfate crystals.

These crystals were heated very strongly, causing them to decompose into magnesium oxide, sulfur dioxide gas, and oxygen gas. The equation for this reaction is:

$$MgSO_4 \longrightarrow MgO + SO_2 + \tfrac{1}{2}O_2$$

Atoms of different elements have different masses. These masses are recorded on the Periodic Table. The masses are recorded relative to each other – so, for example, a sulfur atom (mass 32) has twice the mass of an oxygen atom (mass 16), and a magnesium atom (mass 24) is 1.5 times the mass of an oxygen atom.

(g) Given this data, predict the mass of magnesium oxide remaining after 30g of magnesium sulfate is decomposed completely. Show your working.

[3]

(h) The gas from the above reaction is bubbled through a solution of universal indicator in distilled water. The indicator turns red.

Explain fully why this change occurs.

____

____

____ **[2]**

5. A scientist is taken to the top of Mount Everest (an altitude of nearly 9 km above sea level) early one morning, to do some experiments.

He hasn't had time for breakfast, so the first thing he does is boil an egg. He likes his egg hard boiled, and knows that it usually takes exactly 6 minutes and one teaspoon of salt in the water to get his egg hard boiled. He boils some water, puts in the salt, places the egg in and leaves it for exactly 6 minutes, all just as he does at home.

One of his colleagues has suggested that when very high above sea level, where the air pressure is lower, molecules of water require less energy to escape from a liquid to form a gas.

(a) State the observation that he makes when he cracks open the egg, and explain why this shows that his colleague was correct.

____

____

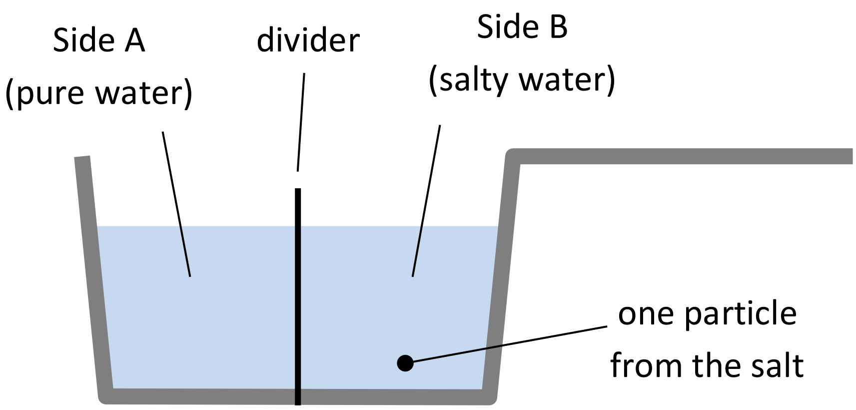
____ **[2]**

(b) Suggest why molecules of water require less energy to escape from the liquid state at that altitude.

____ **[1]**

The saucepan is of an unusual design. It is made of iron, and is divided into two sections by a removable, plastic, water-tight divider.

At the same time as boiling his egg, he has been heating pure water on the other side of the pan, to make coffee. However, as his egg is no good, he decides to skip the coffee as well, and leaves the saucepan to one side. The diagram below shows his saucepan at this point:



He removes the divider from the pan once it is cool.

(c) Name the process which then occurs as a result of removing the divider.

____ **[1]**

(d) Imagine one particle from the salt can be labelled and tracked. This has been done in the diagram. Once the divider has been removed, and the process in part (c) is complete, where is that particle most likely to be found? **Underline** the correct answer. **[1]**

On the left side (A) in the above diagram

One the right side (B) in the above diagram

Exactly in the middle

Equally likely to be found in any location

The scientist then pours away the water, replaces the divider, and heats up two solutions that he has bought with him – one in each side of the pan. The solutions are silver nitrate and zinc nitrate.

He is surprised to find a hole appearing in his saucepan under one of the solutions.

(e) State under which solution the hole appears.

____ **[1]**

(f) Explain why the hole appears on that side and not the other.

____

____

____

____ **[3]**

The scientist decides to leave some hot water for the next person to climb to the summit. He rinses out the undamaged side of his pan, uses it to melt some snow, and continues to heat until the water boils. He fills an insulating flask (made from stainless steel, so it won't rust) to the brim with the hot water, screws the lid on very tightly, and leaves it next to the summit. Unfortunately, the flask is only found 3 months later, and is of no use to the mountaineer who finds it.

(g) <u>Explain</u> all the reasons why the flask and its contents are of no use to the mountaineer.

____

____

____

____

____

____ **[3]**

The scientist uses a small camping stove to heat his breakfast and his experiments. He notices that the flame is a different colour when he uses it at the top of Mount Everest, compared with what he observes when he uses it on his holidays at the seaside.

(h) Describe the difference in the flame colours, and explain this observation.

____

____

____

____ **[2]**

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2020))

Compiled by SATs-Papers.co.uk to help you get the most from this paper.

Overview

This is the **King's Scholarship Examination 2020 Science 1 (Theory)** paper, published by **Eton College** for entry at **13+** (Year 9 entry). It is a free-response question paper covering physics, biology, and chemistry in equal measure, designed to assess not only curriculum knowledge but also problem-solving and analytical reasoning at a level suitable for the most academically able candidates.

The paper consists of **five substantive questions** totalling **70 marks** and must be completed in **60 minutes**. Calculators are permitted, and all working must be shown for calculation-based questions. Each question opens with a scientific scenario or observation and tests depth of understanding through multi-part sub-questions that often build on one another.

This paper is ideal for students preparing for 13+ entrance examinations at selective independent schools, particularly those applying for scholarships or aiming to demonstrate strong scientific literacy. The questions are intellectually demanding and reward candidates who can explain, analyse, and apply concepts across several domains of science. The paper is suitable for students in Year 8 who have covered core GCSE-level material and are confident in reasoning under timed conditions.

How this paper is organised

The paper is divided into **five numbered questions**, each addressing a different scientific theme. Question 1 explores physics (space travel, orbital mechanics, forces, and energy conservation), Question 2 covers biology (nutrition, skeleton, evolution), Question 3 centres on plant biology and environmental science (gas exchange, stomata, climate change data), Question 4 examines chemistry (reactions of acids, thermal decomposition, stoichiometry, indicators), and Question 5 tests applied chemistry and physics at altitude (boiling point, diffusion, reactivity, combustion). The total is **70 marks**.

Each question consists of **multiple sub-parts**, often labelled (a), (b), (c), and so on, with further subdivisions (i), (ii), (iii). Marks per sub-question range from **1 to 4 marks**, with calculations and extended explanations typically earning 2 or 3 marks. Candidates write their answers in the spaces provided on the question paper itself.

Timing is tight: **60 minutes** for five extended questions means roughly 12 minutes per question. Students must work efficiently, showing all working for calculations and writing concise, focused explanations for descriptive questions. The mark allocations give a clear guide to the depth of answer expected.

Topics covered

- Orbital mechanics and circular motion, including centripetal acceleration, gravitational field strength, and calculation of tangential velocity
- Newton's Second Law of Motion (F = ma) applied to objects in orbit and freefall scenarios
- Energy conservation and energy transfers during descent and powered flight, including interpretation of height-time graphs
- Human nutrition and the components of a balanced diet, including the role of calcium in the skeleton
- Functions of the human skeleton (support, protection, movement) and variation in bone mass between individuals
- Comparative anatomy and evolutionary biology, using homologous structures (vertebrate forelimbs) as evidence for common descent
- Gas exchange in plant leaves via stomata, identifying carbon dioxide, oxygen, and water vapour movements during daylight and darkness
- Stomatal density as an adaptive response to atmospheric carbon dioxide concentration, interpreting ice core data over geological time scales
- Chemical reactions of metals with acids, writing word equations, and observing reaction endpoints (magnesium with sulfuric acid)
- Interpretation of mass-time graphs during gas evolution, and understanding why mass decreases as hydrogen gas escapes
- Thermal decomposition of magnesium sulfate into magnesium oxide, sulfur dioxide, and oxygen, including stoichiometric calculations using relative atomic masses
- Acidic properties of sulfur dioxide when dissolved in water, explaining universal indicator colour change
- Effect of air pressure on boiling point at high altitude, explaining why water boils at lower temperatures on Mount Everest
- Diffusion of solute particles when a barrier is removed, predicting uniform distribution at equilibrium
- Reactivity series and displacement reactions, explaining why zinc nitrate corrodes an iron pan but silver nitrate does not
- Combustion in low-oxygen environments, comparing flame colour at sea level and high altitude due to reduced oxygen availability

How to use this paper for revision

- Revise the formula for circular motion acceleration ($a = v^2/r$) and practise rearranging it to find velocity or radius when given other quantities.
- For graph interpretation questions, annotate key features (constant height means hovering, steep gradient means rapid descent) to structure your answer clearly.
- Practise writing word equations for common reactions (metal + acid → salt + hydrogen) and ensure you can name the salt correctly from the metal and acid used.
- When drawing graphs, pay attention to the axes provided: mark the starting point, show smooth curves for continuous processes, and level off at endpoints when equilibrium is reached.
- Learn the reactivity series thoroughly so you can predict displacement reactions: a more reactive metal will displace a less reactive one from its compound.
- For stoichiometry questions, write out the relative atomic masses clearly, calculate the formula mass of each compound, and use ratios from the balanced equation to find unknown masses.
- Revise how boiling point depends on air pressure: lower pressure means water molecules escape more easily, so the boiling point drops at altitude.

Common mistakes to avoid

- Confusing weight (force in newtons) with mass (in kilograms or tonnes) and forgetting to multiply mass by gravitational field strength when calculating weight.
- Misreading the graph axes or time scale, leading to incorrect identification of when the spaceship is in freefall versus when rockets are firing.
- Failing to explain why the mass on the balance decreases during the magnesium and sulfuric acid reaction: the hydrogen gas escapes into the air, so total mass in the beaker falls.
- Forgetting to show all working in calculations: even if the final answer is correct, marks may be lost if intermediate steps are not written down clearly.
- Not recognising that diffusion leads to uniform distribution: after the divider is removed, the salt particle is equally likely to be anywhere in the pan, not stuck on one side.
- Assuming that the flask on Mount Everest is useless only because the water has cooled, without mentioning that the water may have frozen solid after three months at sub-zero temperatures.

Exam technique

Start by skimming the entire paper to identify which questions look most familiar, then tackle those first to build confidence and bank marks quickly. Calculation questions (orbital velocity, mass of magnesium oxide, percentage change in carbon dioxide) should be attempted methodically: write down the formula, substitute values with units, and show every step so that method marks can be awarded even if the final answer is slightly wrong.

For multi-part questions, read all sub-parts before beginning so you understand how they connect. Often part (ii) builds on part (i), so a mistake early on may carry through. If you are stuck, move on and return later rather than waste time. Allocate roughly 12 minutes per question and leave a few minutes at the end to check your work, particularly units and significant figures in calculations.

When asked to explain or suggest, use the mark allocation as a guide: a 1-mark question needs one clear point, a 3-mark question typically requires three distinct points or one developed argument with supporting evidence. Write in full sentences for extended answers, and refer directly to the data or diagrams provided in the question. For graph-drawing tasks, use a ruler where appropriate and label axes clearly if you add any annotations.

What to revise alongside this paper

Students should consolidate their understanding of **forces and motion**, particularly Newton's laws, and practise problems involving resultant forces, free-body diagrams, and equilibrium. Circular motion and orbital mechanics are often covered briefly at GCSE but are explored in greater depth at A-level, so familiarity with radians, angular velocity, and centripetal force will be helpful.

In biology, revise **human organ systems** (digestive, skeletal, respiratory), plant physiology (photosynthesis, transpiration, gas exchange), and the evidence for evolution (comparative anatomy, fossil record, DNA analysis). Understanding how organisms adapt to their environment, including stomatal density in response to atmospheric changes, links directly to ecology and climate science.

For chemistry, ensure fluency in **writing balanced equations**, both word and symbol, for reactions of acids with metals, carbonates, and bases. Practise mole calculations, percentage composition, and empirical formula problems to strengthen stoichiometry skills. Revise the reactivity series, thermal decomposition reactions, and the behaviour of gases. Understanding how temperature and pressure affect state changes (boiling, freezing, sublimation) is essential for questions set in unusual conditions such as high altitude or extreme cold.

Key terms

> **Centripetal acceleration**, **Gravitational field strength**, **Newton's Second Law (F = ma)**, **Tangential velocity**, **Freefall**, **Energy conservation**, **Balanced diet**, **Homologous structures**, **Stomata**, **Stomatal density**, **Photosynthesis**, **Respiration**, **Parts per million (ppm)**, **Displacement reaction**, **Reactivity series**, **Thermal decomposition**, **Stoichiometry**, **Relative atomic mass**, **Boiling point**, **Diffusion**, **Universal indicator**
