

## 13+ PAST PAPER PACK

# Eton College 13+ Science 2019

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# Eton College King's Scholarship Examination 2019

## 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.*

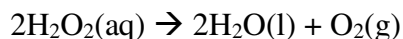
*Calculators are allowed. In questions involving calculations, all your working must be shown.*

For examiners' use only.

<b>Total [30]</b>	
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**Do not turn over until told to do so.**

1. Hydrogen peroxide undergoes a decomposition reaction to form water and oxygen according to the following equation:

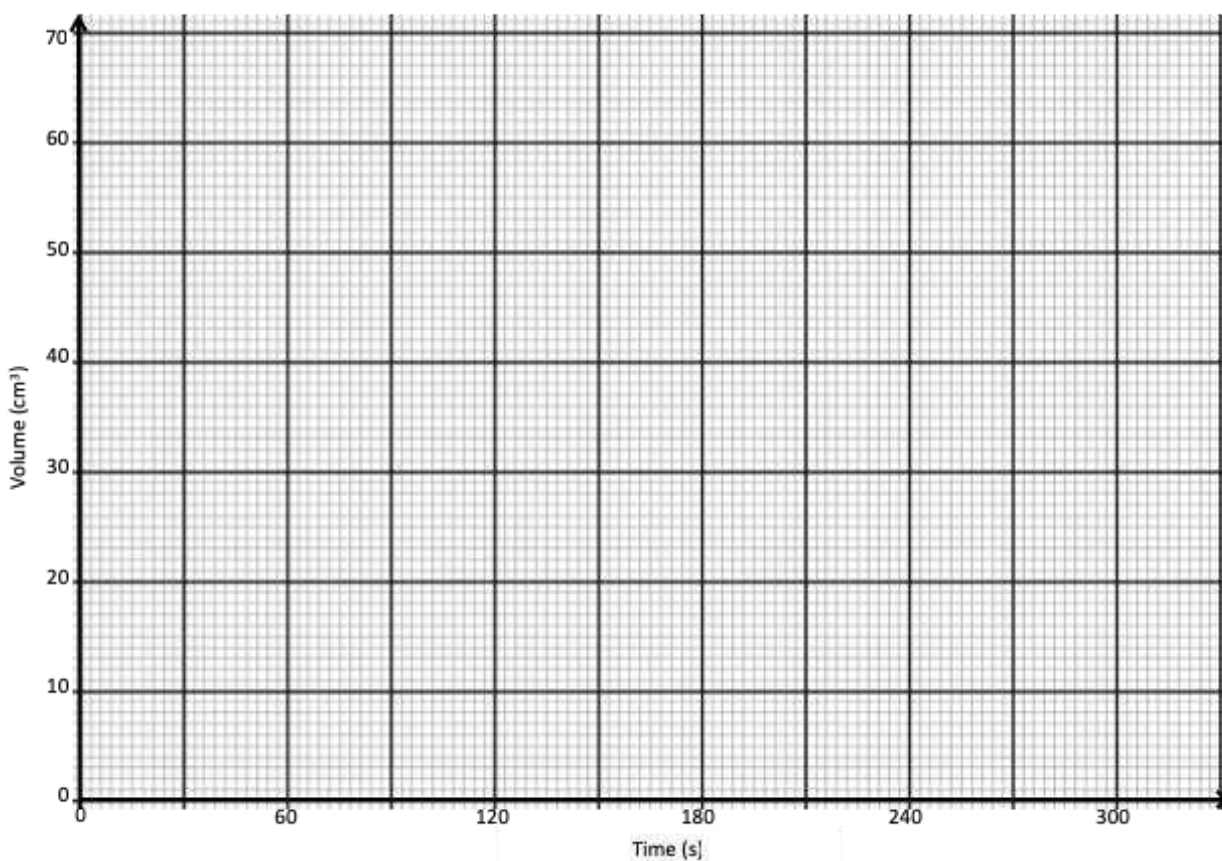


A manganese (IV) oxide catalyst is also used, which is a purple, insoluble solid. For this experiment 20 cm<sup>3</sup> of hydrogen peroxide was mixed with 30 cm<sup>3</sup> of water and 0.20 g of manganese (IV) oxide. All the chemicals were at room temperature. The volume of gas produced was recorded every 60 seconds using a gas syringe. The results are shown in the table below:

<b>Time (s)</b>	0	60	120	180	240	300
<b>Volume (cm<sup>3</sup>)</b>	0	30	48	57	60	60

- (a) Plot a graph of these results and draw a suitable line of best fit.

[3]



- (b) Use your graph to estimate how long it would take to produce 50 cm<sup>3</sup> of gas.

[2]

(c) Explain why the graph becomes horizontal after 240 seconds.

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[2]

(d) The experiment was repeated using the same quantities of everything, except this time it was placed in a warm water bath at 40 °C. On the same axis, sketch the graph you would expect to get from this reaction and label it D.

[2]

(e) The experiment was repeated at room temperature, but this time 10 cm<sup>3</sup> of hydrogen peroxide was mixed with 40 cm<sup>3</sup> of water and 0.20 g of manganese (IV) oxide. On the same axis, sketch the graph you would expect to get from this reaction and label it E.

[2]

(f) A catalyst is a substance that speeds up the rate of reaction and is chemically unchanged at the end of the reaction. How could you demonstrate that the manganese (IV) oxide is indeed a catalyst in this reaction?

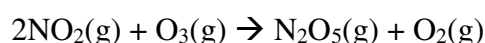
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[2]

2. Nitrogen dioxide reacts with ozone according to the following equation:



Three separate experiments were performed using varying concentrations of reactants, as shown in the table below. The rate of each reaction was measured and is recorded in the table below.

Experiment	Concentration of NO <sub>2</sub> (g) / mol dm <sup>-3</sup>	Concentration of O <sub>3</sub> (g) / mol dm <sup>-3</sup>	Rate / mol dm <sup>-3</sup> s <sup>-1</sup>
1	1.0	2.5	0.000032
2	2.0	2.5	0.000064
3	2.0	5.0	0.000128

(a) How does doubling the concentration of nitrogen dioxide affect the rate of reaction?

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[1]

(b) How is the rate of reaction affected when the concentration of ozone is doubled?

\_\_\_\_\_ [1]

(c) Predict the rate of reaction if the experiment is repeated using  $0.5 \text{ mol dm}^{-3}$  of nitrogen dioxide and  $2.5 \text{ mol dm}^{-3}$  of ozone?

\_\_\_\_\_  
\_\_\_\_\_ [1]

(d) Predict the rate of reaction if the experiment is repeated using  $4.0 \text{ mol dm}^{-3}$  of nitrogen dioxide and  $7.5 \text{ mol dm}^{-3}$  of ozone?

\_\_\_\_\_  
\_\_\_\_\_ [1]

(e) In chemistry, we can write an equation to express how the reaction rate is related to the concentration of the reactants; the rate equation for this particular reaction is written below. The rate constant,  $k$ , is a numerical value which links the rate with the concentrations of reactants. Square brackets are used around the reactants to show we are referring to the concentration values.



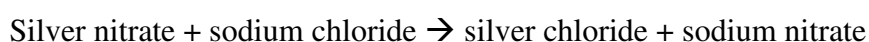
Using the data from the experiment 1, rearrange the equation to find the numerical value of  $k$  and state the units of the value you calculate. Show your working.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [3]

3. Chemical reactions do not always go to completion and often there is unreacted starting material left over. This means we achieve a lower mass of product than we expected. We can calculate the percentage yield of product from an experiment using the following equation:

$$\% \text{ yield} = \frac{\text{Actual mass}}{\text{Predicted mass}} \times 100$$

Silver nitrate solution reacts with sodium chloride solution (which is in excess) to form silver chloride and sodium nitrate according to the following equation:



The silver chloride is insoluble in water whereas sodium nitrate is soluble. If the reaction had gone to completion and all of the silver nitrate had reacted, we would expect to obtain 7.90 g of silver chloride. However, only 6.22 g of silver chloride was actually collected from this reaction.

- (a) Calculate the percentage yield of silver chloride in this reaction. Give your answer to the nearest whole number.

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[2]

- (b) The experiment was repeated using the same amounts as described above. This time the percentage yield was calculated to be 107 %. What was the actual mass of silver chloride that was collected? Give your answer to 2 decimal places.

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[2]

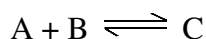
- (c) Assuming that the correct quantities of reagents were used, give a possible reason for this result.

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[1]

Some chemical reactions may be reversible, where both the forwards and reverse reactions are possible. Some reversible reactions can exist in a state of *dynamic equilibrium*, where the rate of the forwards reaction is equal to the rate of the reverse reaction, so that the concentrations of the reactants and products remain constant.



- (d) Imagine 10 molecules of A were placed in a container with 10 molecules of B and the reaction was left to reach dynamic equilibrium. When the reaction was in dynamic equilibrium, there were 4 molecules of A remaining. Complete the table below by filling in the blanks. [3]

	<b>A</b>	<b>B</b>	<b>C</b>
Number of molecules initially	10	10	
Number of molecules that have reacted / formed			6
Number of molecules remaining at dynamic equilibrium	4	4	

- (e) Assuming molecules of A are yellow in colour, molecules of B are colourless and molecules of C are blue, explain what colour you would expect the reaction mixture to appear when it is in dynamic equilibrium.

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[2]

[End of paper]

# Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2019))

Compiled by [SATs-Papers.co.uk](https://www.SATs-Papers.co.uk) to help you get the most from this paper.

## Overview

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This is **Science 2 (Data Analysis)**, a paper set by **Eton College** for the **King's Scholarship Examination 2019**. It forms part of Eton's **13+ entrance assessment** and is designed to test candidates' ability to interpret experimental data, perform calculations, and apply scientific reasoning at a level appropriate for students entering Year 9. The paper carries **30 marks** and must be completed in **30 minutes**, making time management and confident calculation skills essential.

The paper focuses exclusively on **chemistry**, covering reaction kinetics, catalysis, rate equations, percentage yield, and dynamic equilibrium. All three major questions present experimental scenarios requiring candidates to plot graphs, extract information from tables, predict outcomes under changed conditions, and perform multi-step calculations. The format demands both numerical accuracy and conceptual understanding.

This paper suits academically ambitious students preparing for selective independent school entrance at 13+, particularly those aiming for scholarship places. Calculators are permitted, and all working must be shown. The emphasis on data handling and interpretation, rather than rote recall, distinguishes this paper from more conventional end-of-topic tests.

## How this paper is organised

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The paper comprises **three major questions** worth a total of **30 marks**, to be completed in **30 minutes**. Candidates must attempt all questions and write their answers in the spaces provided on the question paper itself.

Question 1 (13 marks) focuses on the decomposition of hydrogen peroxide using a manganese (IV) oxide catalyst. It requires graph plotting, reading values from the curve, explaining why the reaction stops, and sketching modified graphs for experiments at different temperatures and concentrations. Question 2 (7 marks) examines the reaction between nitrogen dioxide and ozone, asking candidates to deduce how concentration changes affect reaction rate and to calculate the rate constant with correct units.

Question 3 (10 marks) deals with percentage yield in the precipitation of silver chloride, including a scenario where yield exceeds 100 per cent, before moving to dynamic equilibrium calculations involving molecule counts and a conceptual question on the

colour of an equilibrium mixture. The mark allocation reflects the difficulty and multi-step nature of each part.

## Topics covered

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- Decomposition reactions of hydrogen peroxide, including balanced symbol equations and state symbols
- Role of catalysts in speeding up reactions whilst remaining chemically unchanged
- Plotting graphs of gas volume against time and drawing curves of best fit through experimental data points
- Reading and interpolating values from reaction rate graphs to estimate time for a given volume of product
- Effect of temperature on reaction rate, including sketching modified graphs for experiments at elevated temperature
- Effect of concentration on reaction rate, including halving reactant concentration and predicting final gas volumes
- Rate equations linking reaction rate to reactant concentrations, including calculation of the rate constant  $k$  with correct units
- Percentage yield calculations, including rearranging the formula to find actual mass when percentage yield exceeds 100 per cent
- Dynamic equilibrium in reversible reactions, including stoichiometric relationships and molecule counts at equilibrium
- Predicting the colour of equilibrium mixtures based on the colours of individual molecular species

## How to use this paper for revision

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- Practise plotting and interpreting reaction rate curves until you can confidently sketch how temperature or concentration changes will shift the gradient and final plateau.
- When calculating the rate constant  $k$ , always work through the units systematically by substituting the units of rate and concentration into the rearranged rate equation.
- Memorise the definition of a catalyst word-for-word, including that it speeds up the reaction and is chemically unchanged at the end, so you can answer conceptual questions quickly.
- For percentage yield questions, write out the formula, substitute the numbers, and then rearrange if needed. Always check whether you are finding actual mass or predicted mass.
- In dynamic equilibrium problems, use the stoichiometry of the equation to work out how many molecules of each reactant must have been consumed to form the given number of product molecules.
- Review standard experimental techniques for measuring gas volume, such as using a gas syringe, and understand how to design a fair test by keeping variables constant.
- Practise multi-step calculation questions under timed conditions so you can identify the quickest method and avoid running out of time.

## Common mistakes to avoid

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- Joining data points with straight lines rather than drawing a smooth curve of best fit, which loses marks in graph plotting questions and makes interpolation inaccurate.
- Forgetting to show all working in calculation questions. Even if your final answer is correct, you may lose method marks if the examiner cannot see your reasoning.
- Misreading concentration units or confusing  $\text{mol dm}^{-3}$  with  $\text{cm}^3$ , leading to incorrect predictions about how rate will change when concentration is doubled or halved.
- Omitting units when stating the value of the rate constant  $k$ . The units are not standard and must be derived from the rate equation, so always work them out explicitly.
- Assuming that a percentage yield greater than 100 per cent is impossible or must be a calculation error, rather than recognising it can occur if the product is contaminated or wet.
- Confusing the number of molecules that have reacted with the number remaining at equilibrium. Always start from the initial amounts and work forwards using stoichiometry.

## Exam technique

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With only **30 minutes** for **30 marks**, you have roughly one minute per mark. Spend the first minute scanning the paper to identify which questions carry the most marks and which require extended calculation versus quick conceptual answers. Tackle the graph question first if you are confident with plotting, as it secures early marks and helps you settle into the paper.

Show all working for every calculation, even if you are certain of the answer. Write intermediate steps on separate lines and label quantities with their units. If you make an arithmetic slip but your method is correct, you will still earn most of the marks. For questions asking you to sketch a graph on the same axes, use a different style of line or label clearly so the examiner can distinguish your new curve from the original.

In the final five minutes, return to any parts you skipped and attempt them even if you are unsure. A reasoned guess based on the pattern you see in the data table is better than leaving a blank. Check that you have written your candidate number on every sheet and that all graphs are labelled with axes, units, and a title where appropriate.

## What to revise alongside this paper

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Students should revise **collision theory** and how factors such as temperature, concentration, surface area, and catalysts affect the frequency and energy of particle collisions. Understanding activation energy and energy profile diagrams will help explain why catalysts work and why higher temperatures increase reaction rates.

Review **balanced symbol equations** and how to use mole ratios to predict quantities of reactants and products. This underpins both percentage yield calculations and equilibrium problems. Practise rearranging formulae algebraically, as many marks depend on isolating the correct variable before substituting numbers.

Once comfortable with this paper, progress to more complex equilibrium concepts such as Le Chatelier's principle,  $K_c$  calculations, and the effect of pressure and temperature on equilibrium position. These topics appear in GCSE and A-level specifications and build directly on the dynamic equilibrium introduced here.

## Key terms

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**Decomposition reaction, Catalyst, Manganese (IV) oxide, Gas syringe, Rate of reaction, Concentration, Rate equation, Rate constant (k), Percentage yield, Predicted mass, Actual mass, Dynamic equilibrium, Reversible reaction, Stoichiometry, Equilibrium position**

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# Eton College King's Scholarship Examination 2019

## SCIENCE 1 (Theory)

(60 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.*

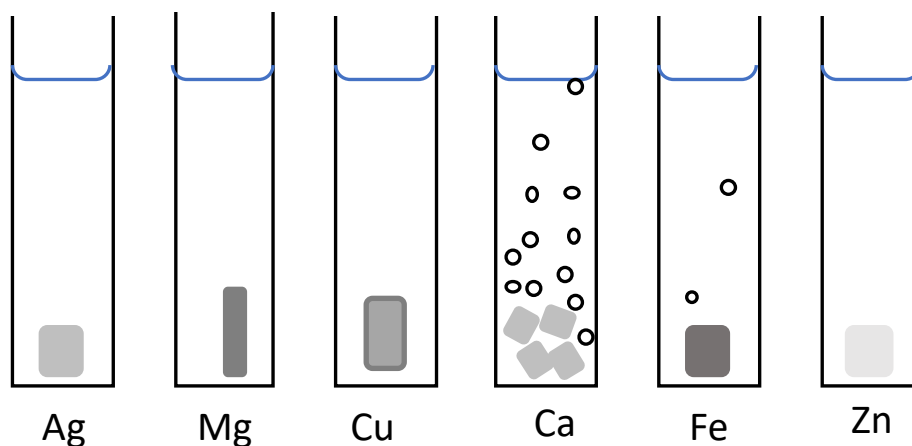
*Calculators are allowed. In questions involving calculations, all your working must be shown.*

For examiners' use only.

1	2	3	4	5	6	TOTAL [70]

**Do not turn over until told to do so.**

1. Samples of various metals were placed into the same volume ( $20\text{ cm}^3$ ) of hydrochloric acid which had a concentration of  $0.05\text{ mol dm}^{-3}$ . The diagram below was used to represent the difference in reactivity of the metals by showing the number of bubbles of hydrogen that were observed during the reaction. No bubbles were seen in the copper (Cu) or silver (Ag) tubes.



- (a) Complete the diagram to show the approximate number of bubbles you would expect to see in the magnesium (Mg) and Zinc (Zn) tubes. [1]

- (b) Write the word equation for the reaction of calcium (Ca) and hydrochloric acid. [1]

- (c) Describe a chemical test for the gaseous product from this reaction. [2]

- (d) Eventually, bubbles stopped being produced from the reaction between zinc and hydrochloric acid and some of the zinc remained in the test tube. Explain why the reaction stopped. [1]

(e) The same volume and concentration of acid was used in each tube, and the same amount of each metal. However, in the test tube containing calcium and hydrochloric acid, bubbles continued to be produced for much longer and a white solid appeared in the flask. Suggest a reason for this.

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---

[1]

(f) It is not possible to determine which is more reactive out of copper and silver using this experiment as neither react with the acid. How could you determine which is more reactive using the following chemicals; silver, copper, silver nitrate solution and copper(II) nitrate solution.

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[2]

2. There are many different types of fire extinguisher; some contain water, some contain powder and some contain carbon dioxide. It can be dangerous if you choose the wrong type of extinguisher for a particular fire. For example, you should never use a water-containing fire extinguisher on an electrical fire.

(a) Carbon dioxide is denser than air. Explain how this property enables carbon dioxide to be used to extinguish fires.

---

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[1]

(b) Magnesium is a reactive metal and burns in air with a brilliant, bright white light. Explain what would happen if you used a carbon dioxide fire extinguisher in this instance.

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[2]

The halogens are the elements in group 7 of the periodic table.

F Fluorine
Cl Chlorine
Br Bromine
I Iodine
At Astatine

Some of them can be dissolved in water to form aqueous solutions, depending on their reactivity; the more reactive halogens will react with water, and so it is difficult to make an aqueous solution.

When bromine solution is added to a solution of potassium iodide, a displacement reaction occurs and a colour change from orange to brown is observed.

(c) Write the word equation for the reaction that is occurring.

---

[1]

(d) Explain why this reaction occurs.

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[1]

(e) Explain if it would be possible to make an aqueous solution of fluorine.

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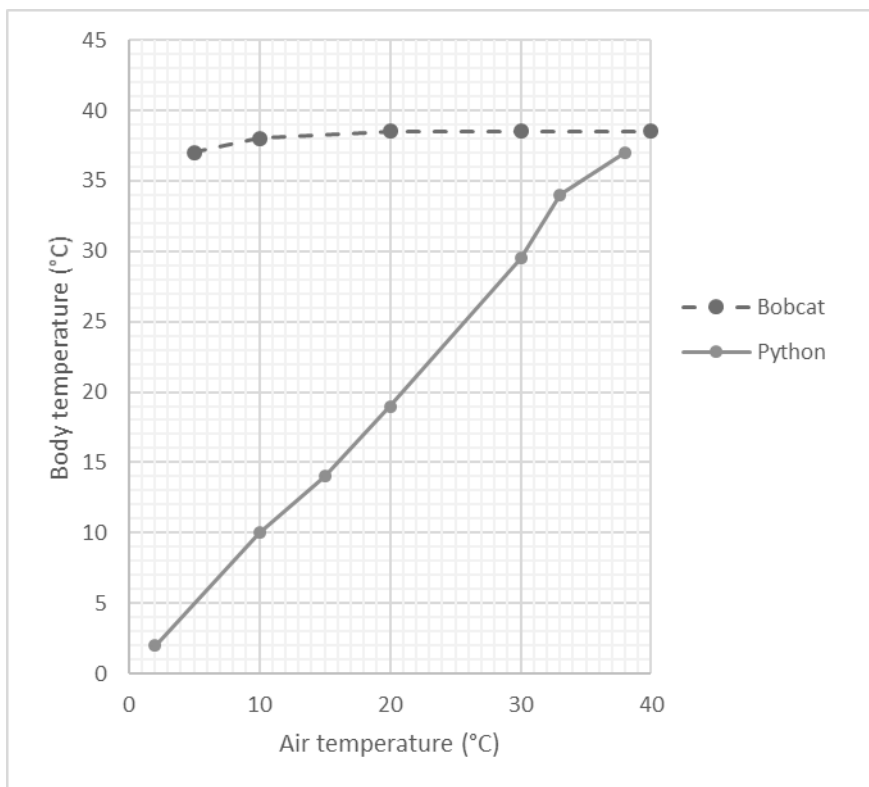
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[1]

3. The photographs below show two animals, a bobcat (left image) and a python (right image). Both have a body mass of 10kg.



The graph below shows the body temperatures of these animals over a range of different air temperatures.



- (a) Describe what the graphs show you about the effect of air temperature on the body temperature of the two animals.

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(b) The graph only shows how body temperature changes over a limited range of air temperatures. Suggest why scientists did not investigate air temperatures up to 60°C.

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[1]

(c) The bobcat and the python look very different, but in terms of classification they belong to the same kingdom. Name the kingdom.

---

[1]

(d) The bobcat is classified as a mammal, and the python as a reptile. Compare and contrast three features of these groups in the table below.

[3]

Mammals	Reptiles

(e) The bobcat consumes far greater quantities of food than the python during the course of a year. With reference to the graph, and using your own knowledge, explain why this is so.

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[3]

(f) Bobcats are found in the wild over a much wider range of habitats and climates than pythons. One reason for this is their ability to tolerate a broad range of temperatures. Discuss other possible reasons for this difference in distribution.

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[4]

4. Digestive enzymes in the gut break down (digest) food into soluble substances. One of these is a protease enzyme called pepsin. Pepsin acts in the stomach to break down protein in the diet into soluble amino acids, which can then be absorbed into the bloodstream.

(a) Why are proteins required in the diet?

\_\_\_\_\_ [1]

(b) Suggest what happens to the amino acids once they have been absorbed into the bloodstream.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

(c) As well as containing pepsin, the stomach also contains hydrochloric acid. This creates an acidic environment (pH 3). Suggest possible benefits of this.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

(d) When egg white, which consists of protein, is added to a solution of pepsin it slowly disappears. What causes the egg white to disappear?

\_\_\_\_\_  
\_\_\_\_\_ [2]

You are required to plan an investigation into the effect of different temperatures on the rate at which pepsin can digest egg white. Spend a few minutes thinking carefully about how you would like to carry out this investigation and what you need to do to produce accurate and reliable results, then complete the questions below.

(e) List the apparatus you require.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]



(b) Explain why the mass moves to the right.

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[2]

(c) Explain why the mass doesn't stop at the lowest point of the swing.

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[1]

(d) We will define one swing as the mass starting from the highest point on the left and returning to the highest point on the left. A student wants to measure the time it takes for one swing. They measure 40 swings in a time of 50s.

i. Explain why the student didn't measure just one swing.

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[1]

ii. Calculate the time it takes for one swing.

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[1]

(e) The teacher explains that the time taken,  $T$ , for one swing is proportional to the square root of the length of the string as shown in the equation below, where  $c$  is a constant.

$$T = c\sqrt{L}$$

What length of string would give a time period twice as long?

---

---

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[2]

- (f) The teacher demonstrates another example of periodic motion using an old record player. The same mass is placed 15 cm from the centre of the rotating plate, as shown in Figure 2, and moves along a circular path without slipping on the rotating plate.

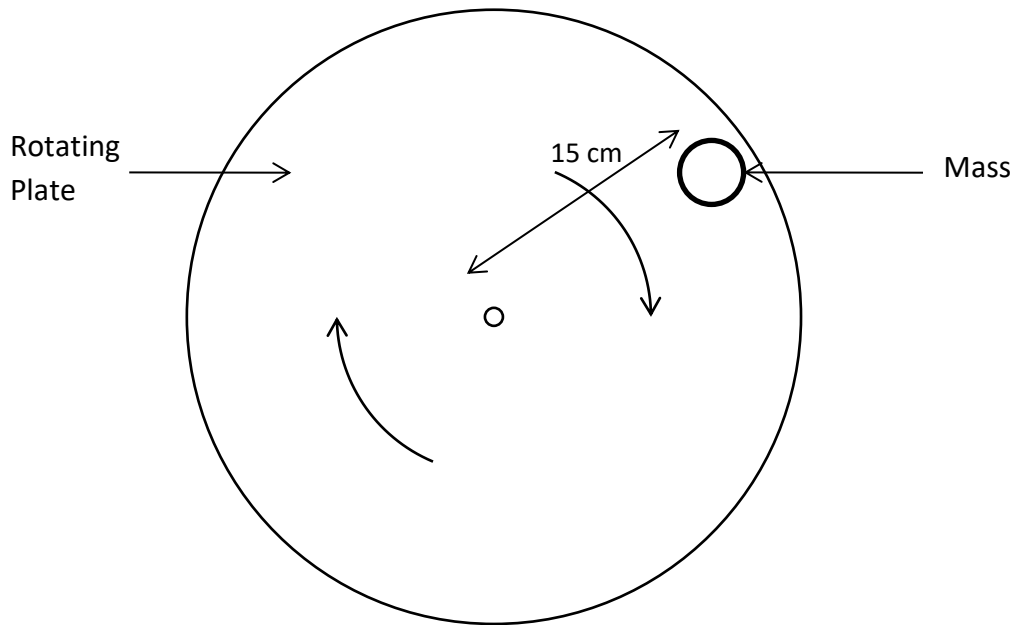


Figure 2: A record player with the plate rotating clockwise and a mass placed on it and moving with the plate.

- i. Draw an arrow on the diagram showing the direction of the resultant force acting on the mass and label it  $F$ . [1]
- ii. The plate rotates 78 times per minute. Calculate the time it takes to do one rotation in seconds.

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[2]

- iii. Calculate the speed of the mass on the rotating plate in metres per second (m/s).

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[2]

- iv. The rotating plate suddenly stops and the mass rolls off the plate. On the diagram draw a line showing the direction the mass rolls and label it  $v$ . [1]

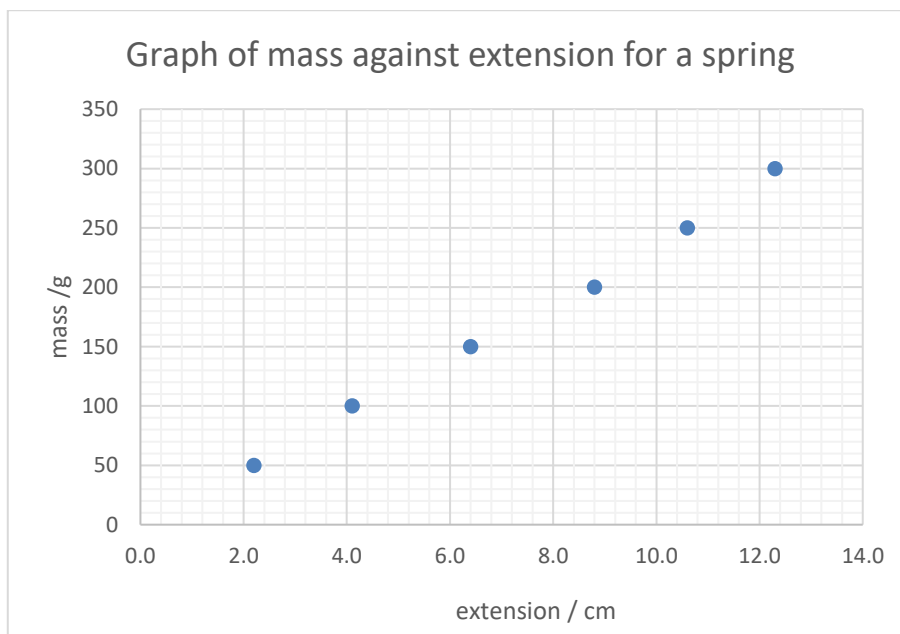
6. Hooke's Law states that the extension of a spring is directly proportional to the force applied, provided the elastic limit has not been exceeded. The equation for Hooke's Law can be set out as  $F = kx$ , where  $F$  is the force applied to the spring,  $k$  is the spring constant and  $x$  is the extension.

(a) A student hung a mass of 0.3 kg on a spring with a spring constant 10 N/cm. Assuming the spring has an elastic limit of 5 N, by how much would the spring extend on Earth, where the gravitational field strength is 10N/kg?

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[2]

The student then wanted to find out if a second spring was more or less stiff than the first. He hung a number of different masses from the second spring and measured the respective extensions. His results are displayed in the graph below.



(b) Plot a line of best fit, calculate the gradient of the line using a triangle and then calculate the spring constant of this second spring in N/cm. Make sure you show all your working clearly.

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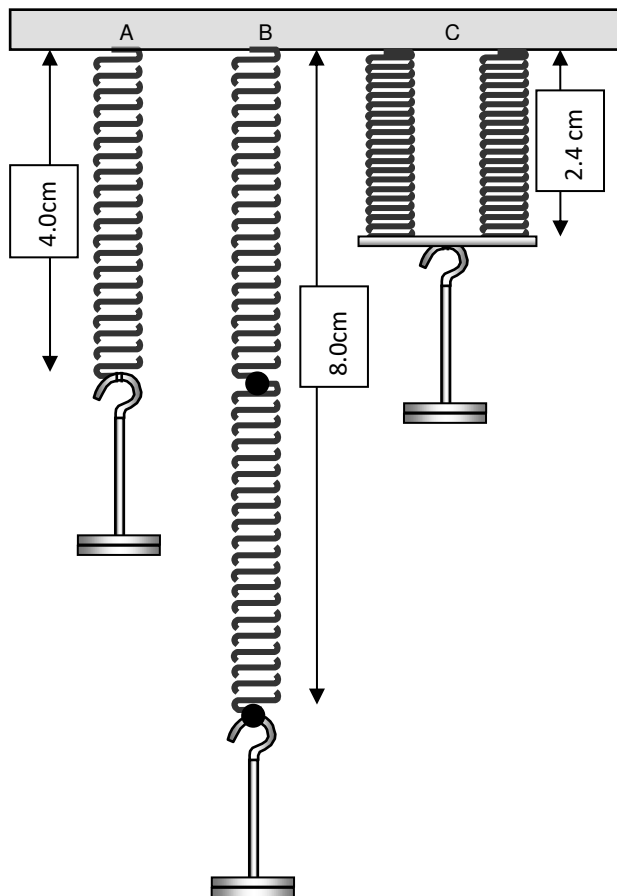
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[4]

(c) State whether the second spring is more or less stiff than the first.

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[1]



The diagram to the left shows five identical springs arranged in three combinations:

A: a single spring

B: two springs hung end to end (in series)

C: two springs hung side by side (in parallel)

The mass on each combination is the same and the overall length of the stretched springs is marked on the diagram.

Diagram modified from: [www.iop.org](http://www.iop.org)

(d) Explain why two springs in parallel have a smaller extension than a single spring.

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[2]

(e) Using the information provided, calculate the length of the individual spring when it has no weight hanging on it. Remember that all five springs are identical! Show your working clearly.

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[4]

(f) State any assumptions you have made in arriving at your answer to part (e).

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[1]

[End of paper]

# Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2019))

Compiled by [SATs-Papers.co.uk](https://www.SATs-Papers.co.uk) to help you get the most from this paper.

## Overview

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This is the **Eton College King's Scholarship Examination 2019, Science 1 (Theory)** paper. It forms part of the **13+ entrance assessment** for candidates seeking scholarships to Eton College, one of the UK's most prestigious independent schools. The paper is designed to test scientific knowledge and understanding across chemistry, biology, and physics at a level appropriate for students entering Year 9.

The examination lasts **60 minutes** and carries a maximum of **70 marks**. Questions are free-response, requiring written answers, word equations, calculations, and experimental planning. Candidates must attempt all questions, showing full working for calculations, and are permitted to use calculators. The paper is structured into six major questions, each exploring a different area of science in considerable depth.

This paper is aimed at academically able students aged around 13 who are applying for King's Scholarships at Eton. It demands not only recall of scientific facts but also the ability to apply knowledge, interpret data, explain phenomena, and design investigations. The questions are rigorous and expect candidates to demonstrate scientific literacy, logical reasoning, and clarity of expression at a high standard.

## How this paper is organised

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The paper comprises **six questions** distributed across **12 pages**, with a cover sheet and space for candidate details. Each question is divided into multiple sub-parts, labelled (a), (b), (c), and so on, with marks clearly indicated in square brackets after each part. The total mark allocation is **70 marks**, and candidates have **60 minutes** to complete the paper.

Question 1 focuses on the reactivity series of metals and displacement reactions, with seven sub-parts totalling approximately 8 marks. Question 2 examines fire safety and the reactivity of halogens, totalling around 6 marks. Question 3, the longest, explores animal classification, body temperature regulation, and energy use, with six sub-parts worth approximately 15 marks. Question 4 addresses digestion, enzyme action, and experimental design, totalling around 14 marks. Question 5 tests understanding of periodic motion, pendulums, and circular motion, with six sub-parts totalling approximately 13 marks. Question 6 concludes with Hooke's Law and spring mechanics, totalling around 14 marks.

The paper is clearly laid out with diagrams, graphs, and data tables embedded within the questions. Space is provided beneath each sub-part for candidates to write their answers. Instructions at the front remind candidates to write their candidate number on every sheet and to show all working for calculations.

## Topics covered

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- Reactivity series of metals: comparing reactivity of magnesium, calcium, iron, zinc, copper, and silver with hydrochloric acid, interpreting bubble formation as evidence of hydrogen production
- Word equations for metal-acid reactions: writing balanced word equations for calcium reacting with hydrochloric acid to produce calcium chloride and hydrogen
- Chemical tests for gases: describing the 'pop' test for hydrogen gas using a lighted splint
- Limiting reagents and reaction completion: explaining why reactions stop when one reactant is fully consumed, despite excess of the other reactant remaining
- Displacement reactions and halogen reactivity: writing word equations for bromine displacing iodine from potassium iodide, explaining reactivity trends in Group 7
- Fire extinguishers and properties of carbon dioxide: explaining how the density of  $\text{CO}_2$  allows it to blanket fires and cut off oxygen supply, and predicting reactions between burning magnesium and  $\text{CO}_2$
- Classification of organisms: identifying the kingdom Animalia, comparing and contrasting mammals and reptiles in terms of body covering, reproduction, and temperature regulation
- Body temperature regulation in endotherms and ectotherms: interpreting graphs showing constant body temperature in bobcats (mammals) versus variable temperature in pythons (reptiles)
- Energy use and metabolism: explaining why endothermic animals require more food than ectotherms of the same mass due to maintaining constant body temperature
- Digestive enzymes and protein digestion: describing the role of pepsin in breaking down proteins into amino acids, explaining the function of stomach acid, and planning an investigation into enzyme activity at different temperatures
- Periodic motion and pendulums: identifying forces acting on a pendulum, explaining motion in terms of energy transfer, calculating period from multiple oscillations, and applying the relationship  $T = c\sqrt{L}$
- Circular motion and centripetal force: calculating rotational period and speed for an object moving in a circle, identifying the direction of centripetal force, and predicting motion when circular motion ceases
- Hooke's Law and spring extension: applying  $F = kx$  to calculate extension, plotting and analysing mass-extension graphs, determining spring constants from gradients, and comparing stiffness of springs
- Springs in series and parallel: explaining why parallel springs extend less than single springs under the same load, and using experimental data to deduce unstretched spring length

- Experimental design and scientific method: listing apparatus, writing clear numbered method steps, identifying independent, dependent, and control variables, and ensuring reliability through repeat measurements

## How to use this paper for revision

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- Revise the **reactivity series** of metals thoroughly, including which metals react with dilute acids and which do not. Practice writing word equations for metal-acid reactions.
- Make sure you can describe standard chemical tests for common gases, especially hydrogen, oxygen, and carbon dioxide, including the expected positive result.
- For questions involving graphs, read axis labels carefully and look for patterns such as constant values, linear relationships, or proportional changes. Quote data from the graph in your explanations.
- When planning an investigation, structure your answer logically: list apparatus first, then describe the method in numbered steps, clearly stating what you will change, what you will measure, and what you will keep constant.
- Review enzyme experiments, including how temperature affects enzyme activity, and the importance of controlling pH and substrate concentration. Understand that enzymes denature at high temperatures.
- Practice calculations involving Hooke's Law ( $F = kx$ ), including rearranging the formula to find force, spring constant, or extension. Remember to convert units correctly (e.g. cm to m).
- Understand the difference between endothermic and ectothermic animals, and be able to explain how body temperature regulation affects energy requirements and habitat range.

## Common mistakes to avoid

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- Confusing the reactivity series: students often place copper or silver above zinc or iron, or forget that copper and silver do not react with dilute acids at all.
- Writing incomplete word equations: for example, writing 'calcium + hydrochloric acid → calcium chloride' and forgetting to include hydrogen gas as a product.
- In the pendulum question, failing to explain motion in terms of forces and energy: answers must mention gravity, tension, gravitational potential energy, and kinetic energy, not just describe the motion.
- Calculating spring constant from the gradient incorrectly: students often forget to convert mass (in grams) to weight (force in Newtons) by multiplying by gravitational field strength (10 N/kg), or mix up units (N/cm vs N/m).
- In experimental design, listing apparatus without specifying measurements: for example, writing 'water bath' without stating that it must have a thermometer and be set to specific temperatures.
- Explaining enzyme action without mentioning denaturation at high temperatures or the specificity of the enzyme for its substrate.

## Exam technique

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Approach this paper strategically. Skim all six questions in the first two minutes to identify which sections look most familiar and which will require more thought. Tackle the questions you find easiest first to build confidence and secure those marks quickly. Questions with multiple sub-parts often start with straightforward recall or definitions before moving to application and analysis, so aim to collect early marks even if later parts prove challenging.

Pay close attention to **mark allocations**. A one-mark question typically requires a single fact or brief explanation, while a four-mark question demands a detailed, multi-step answer. For calculations, always show full working: even if your final answer is incorrect, method marks can be awarded. Underline or circle your final answer to make it clear. When asked to 'explain', provide reasoning, not just description; link cause and effect using scientific principles.

In graph and data interpretation questions, reference specific values from the diagram to support your answer. For experimental planning, use numbered steps and be explicit about variables: state what you will change (independent variable), what you will measure (dependent variable), and what you will keep constant (control variables). Leave time to check answers, especially calculations and word equations, as small errors can lose marks easily.

## What to revise alongside this paper

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Students should revise the **Group 1 alkali metals** and **Group 7 halogens** in depth, including trends in reactivity down each group and the underlying reasons linked to atomic structure. Understanding electron configuration and ionic bonding will help explain why displacement reactions occur. For biology, consolidate knowledge of the **five kingdoms**, characteristics of vertebrate classes, and the difference between aerobic and anaerobic respiration, as energy use is a key theme.

In physics, review **Newton's laws of motion**, especially the first law (inertia) and second law ( $F = ma$ ), as these underpin both pendulum and circular motion questions. Practice drawing and interpreting free-body diagrams. Revise energy transfers (gravitational potential, kinetic, and elastic potential energy) and the principle of conservation of energy. Also ensure fluency in handling and rearranging formulae, converting units, and interpreting straight-line graphs to find gradients.

For experimental skills, practise writing full method descriptions for common investigations (enzyme activity, spring extension, reaction rates). Understand the importance of fair testing, repeat measurements, and identifying sources of error. Familiarity with standard laboratory apparatus and safety considerations is essential. Broader reading around real-world applications, such as fire safety, enzyme use in industry, and engineering uses of springs, will deepen understanding and provide context for exam questions.

## Key terms

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**Reactivity series, Displacement reaction, Limiting reagent, Endothermic (organism), Ectothermic (organism), Mammal, Reptile, Pepsin, Enzyme, Denaturation, Periodic motion, Pendulum, Centripetal force, Hooke's Law, Spring constant**

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