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Oundle School 13+ Science 2023

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EXAMINATION PAPER
Non-Common Entrance 2023

Science

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above
- Answer in this paper
- Calculators are allowed
- Answer ALL the questions in all sections. Each section carries the same number of marks
- You are expected to write clearly and accurately throughout each of your answers. You should leave some time towards the end of the examination to check your work carefully.
- Where there is a multiple choice question, answer by circling the letter you wish to choose. If you change your mind, place a line through it and then circle your new answer.
- The maximum number of marks for this paper is 60

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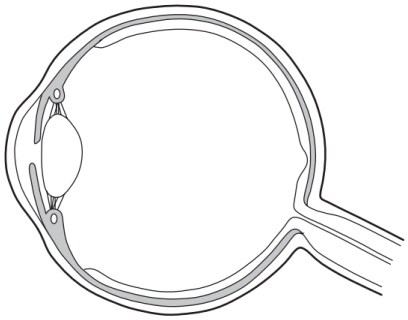
Biology Section

1) The diagram shows a structure found in the human body.



What is this structure an example of?

a. An organ
b. An organism
c. An organ system
d. A tissue

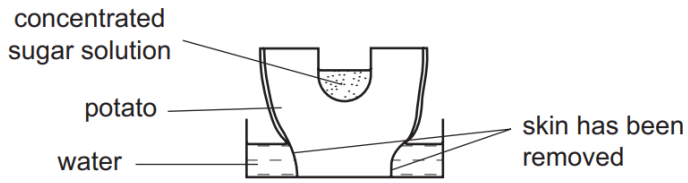
2) The table shows some features of animals.

Which animal could be a bird?

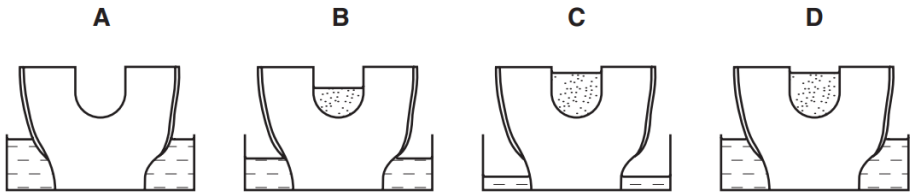
	feature			
	feathers	gills	hair	wings
A	×	✓	✓	×
B	✓	✓	×	×
C	✓	×	×	✓
D	×	×	✓	✓

key
✓ = present
× = not present

3) The diagram shows an experiment using an uncooked potato. The skin of the potato was removed as shown.



Which diagram shows the result of the experiment after 24 hours?



Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

4) A student draws a diagram of a plant cell.

The diagram is 40mm in width. The plant cell is 0.02mm in width.

What is the magnification of the student's drawing?

a. x0.005
b. x0.08
c. x200
d. x2000

5) In which order do organisms occur in the food chain?

a. carnivore → herbivore → producer
b. herbivore → carnivore → producer
c. producer → carnivore → herbivore
d. producer → herbivore → carnivore

6) Which factors, if present, may cause a population of animals to decrease?

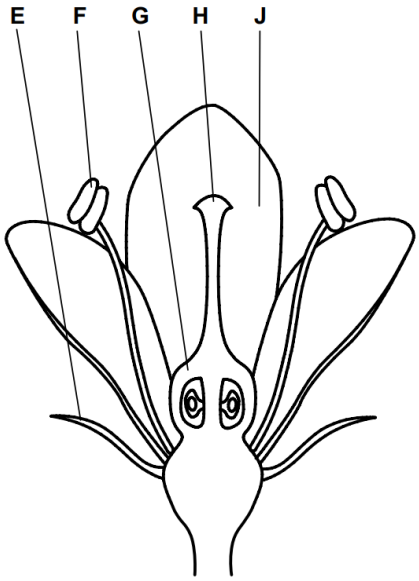
	predation	disease
A	✓	✓
B	✓	×
C	×	×
D	×	✓

7) How is energy transferred between organisms in a food chain?

a. Combustion
b. Ingestion
c. Photosynthesis
d. Respiration

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

8) The picture below shows a section through a flower.



Write **one** letter from the picture to identify each of the following.

You may use each letter once, more than once, or not at all.

a. Petal _____

b. Anther _____

c. Stigma _____

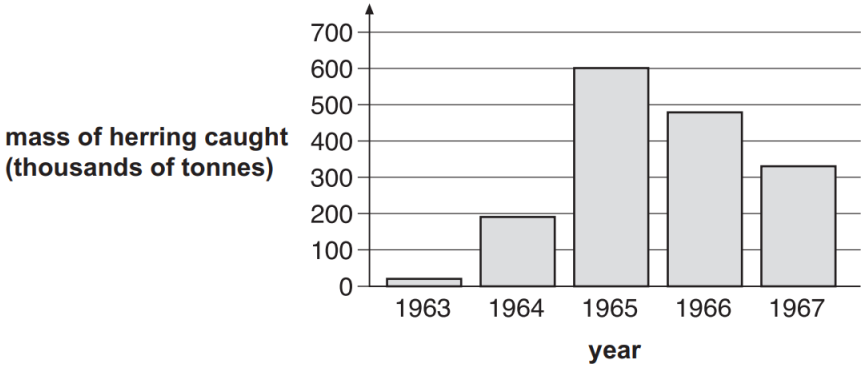
[3]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

9) The table below shows the number of boats used for catching herring fish in the Norwegian Sea between 1963 and 1967.

year	number of fishing boats
1963	16
1965	284
1967	326

The bar chart below shows the total mass of herring caught in the Norwegian Sea between 1963 and 1967.



a. Use the information above to help you answer parts i., ii. and iii.

i. Why did the mass of herring caught increase between 1963 and 1965?

_____

[1]

ii. Suggest why the mass of herring caught decreased between 1965 and 1967.

_____

[1]

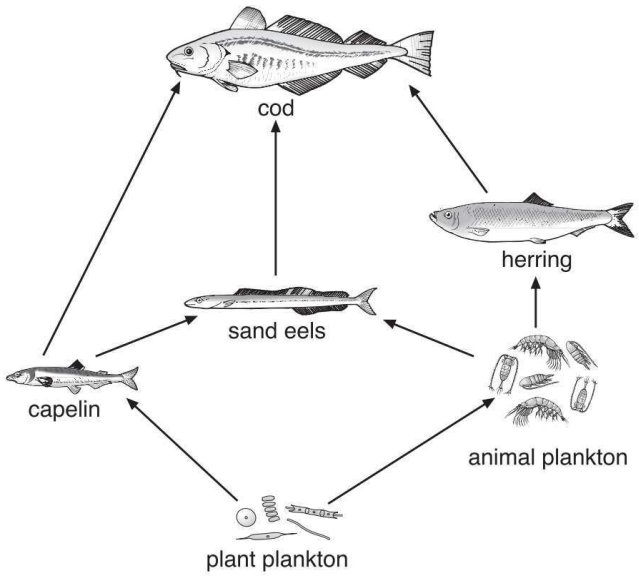
iii. Herring cannot breed until they are four years old. Fishing for herring was banned in the Norwegian Sea from 1972 to 1976. Suggest one reason why fishing for herring was banned for this period.

_____

[1]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

b. The diagram below shows a food web in the Norwegian Sea.



i. How could a decrease in the number of herring cause a decrease in the number of sand eels?

_____

_____

[1]

ii. How could a decrease in the number of herring cause an increase in the number of sand eels?

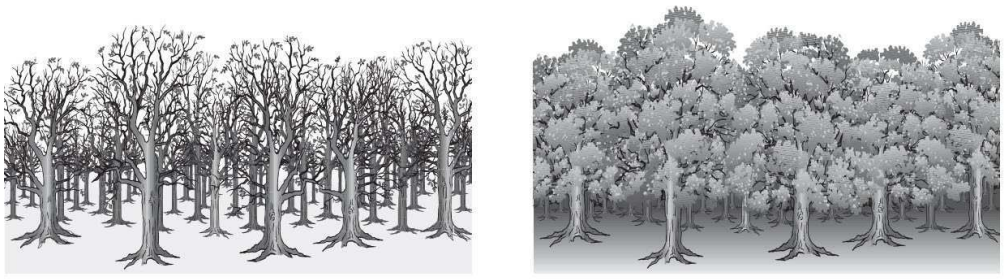
_____

_____

[1]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

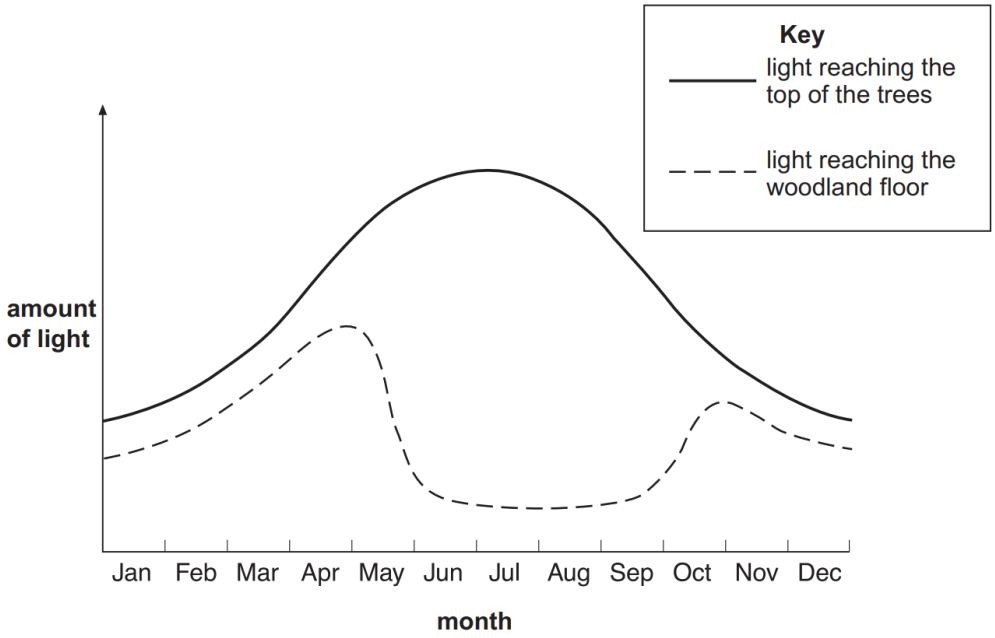
10) The drawings below show the trees in a woodland area at the beginning of May and at the end of May.



beginning of May

end of May

The graph below shows the amount of light reaching the top of the trees and the woodland floor over one year.



a. Why does the amount of light reaching the woodland floor decrease during May?

_____

_____

[1]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

b. Plants grow on the woodland floor. Explain why these plants grow bigger and faster when there is plenty of light

_____

_____

_____

_____

[2]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

c. Respiration takes place in the cells of all plants. Complete the word equation for respiration.

Oxygen + _____ → carbon dioxide + _____

[2]

[20 marks]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

Physics Section

1) What is the name given to the force of friction that acts on an object moving through air?

    a. Weight
    b. Gravity
    c. Drag
    d. Wind

2) Which of these equations correctly links energy transferred, force and distance moved?

    a. Energy transferred = force × distance
    b. Energy transferred = force ÷ distance
    c. Energy transferred = distance ÷ force

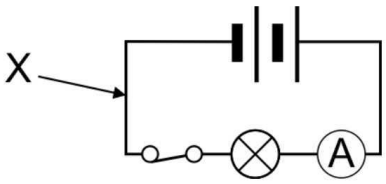
3) Batteries provide the driving force to push charge around a circuit. What is this driving force called?

    a. Potential difference
    b. Current
    c. Resistance
    d. Electricity

4) A pair of 3D glasses is made using a red filter for one lens and a green filter for the other lens. What colour will a blue box appear to be when viewed through these glasses?

    a. Black
    b. White
    c. Blue
    d. Green

5) The ammeter in the circuit below reads 2 A. If you moved the bulb to point X, what would the current flowing through it be?



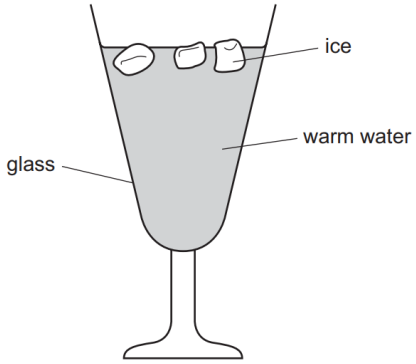
    a. 0 A
    b. 2 A
    c. 1 A
    d. 4 A

6) A 700 W blender is used for 1.5 minutes. How much energy was transferred by the blender in this time?

    a. 63 J
    b. 1050 J
    c. 63000 J
    d. 1.05kJ

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

7) The diagram shows some ice being used to lower the temperature of some warm water.



What is the main process by which the water at the bottom of the glass becomes cool

a. Condensation
b. Conduction
c. Convection
d. Radiation

8) An aeroplane flies from London to Singapore, a total distance of 7000 miles. The flight lasts 14 hours. What is the average speed of the aeroplane?

Show your working.

[2]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

9) The owner of a small factory suggests installing a wind turbine to generate some of the electricity needed by the factory.

a. Give one environmental reason for using a wind turbine.

_____

[1]

b. Discuss **three** of the factors that the owner will need to consider when deciding whether to install a wind turbine.

_____

_____

_____

_____

_____

_____

[4]

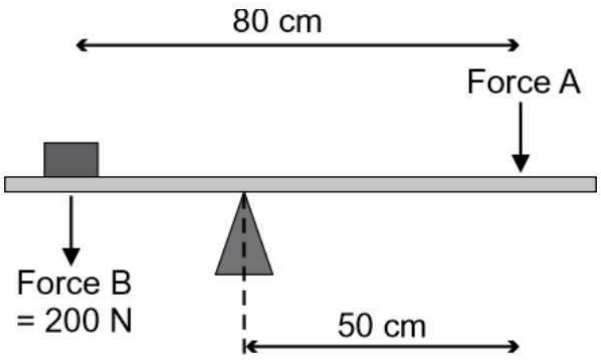
10) Brad and Lee are cycling in opposite directions. Brad is cycling at 24 mph and Lee is cycling at 33 mph. What is the speed of Brad relative to Lee?

Show your working.

[2]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

11) What is the size of the moment created by force B in the diagram?



Show your working.

[4]

[20 marks]

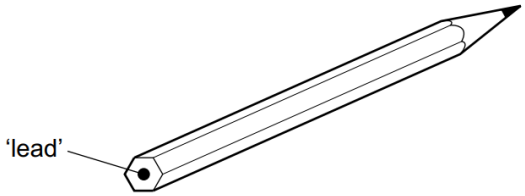
Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

Chemistry Section

1) Which statement about liquids and gases is correct?

   a) $1cm^3$ of gas contains more particles than $1cm^3$ of liquid.
   b) A given mass of liquid has a fixed volume at room temperature.
   c) Particles in a liquid can easily be forced closer together.
   d) Particles in a liquid have fixed positions

2) The 'lead' in a pencil is made of a mixture of graphite and clay.



When the percentage of graphite is increased, the pencil moves across the paper more easily.

Which statement explains this observation?

   a) Clay is a lubricant.
   b) Graphite is a form of carbon.
   c) Graphite is a lubricant.
   d) Graphite is a non-metal

3) Which changes are physical changes?

   1 Melting ice to form water
   2 Burning hydrogen to form water
   3 Adding sodium to water
   4 Boiling water to form steam

   a) 1 and 2
   b) 1 and 4
   c) 2 and 3
   d) 3 and 4

4) Four different solutions, J, K, L and M, are tested with universal indicator.

solution	J	K	L	M
colour with universal indicator	green	red	purple	orange

Which solutions are acidic?

   a) J and M
   b) K and M
   c) K only
   d) L only

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

5) What is a property of all metals?

1 They conduct electricity
2 They conduct heat
3 They are solid at room temperature
4 They react with water

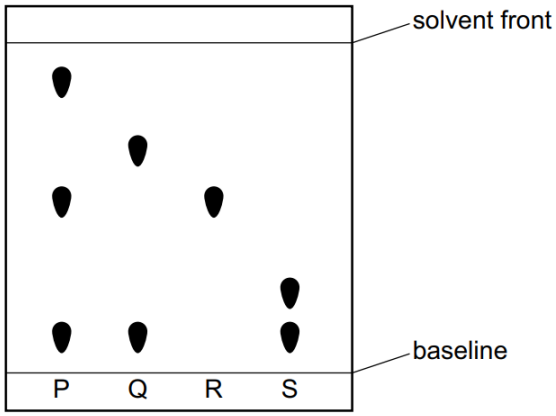
a) 1 and 2
b) 1 and 3
c) 1, 2 and 3
d) All of them

6) Limestone fizzes and dissolves in dilute hydrochloric acid.

What is the word equation for this reaction?

a) calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide
b) calcium hydroxide + hydrochloric acid → calcium chloride + hydrogen
c) calcium oxide + hydrochloric acid → calcium chloride + water
d) calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

7) The chromatogram obtained from four mixtures of dyes, P, Q, R and S, is shown.



What is the total number of different dyes identified in the four mixtures?

a) 3
b) 4
c) 5
d) 8

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

8) The picture below shows the periodic table.

1	2											3	4	5	6	7	0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	63.5 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	[98] Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La* lanthanum 57	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111	Elements with atomic numbers 112 – 116 have been reported but not fully authenticated						

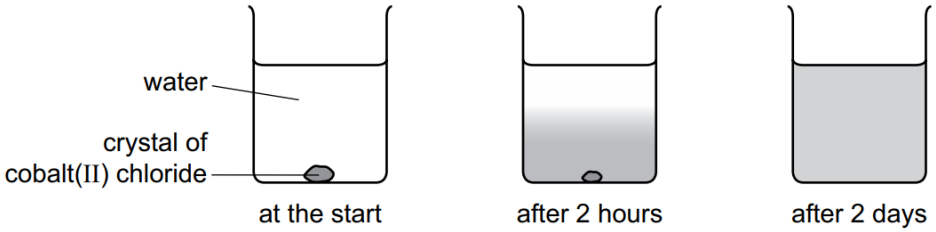
Which statement is correct?

a) The elements are organised in increasing relative atomic mass
b) The symbol for the element in Group 1 and Period 3 is K
c) Chlorine is a non-metal solid that is yellow
d) An element that is used in the manufacture of steel is carbon

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

9) A coloured crystal of cobalt(II) chloride is placed at the bottom of a beaker containing water.

Colour spreads throughout the water over time. The picture below shows the spread of colour after two days.



a) Explain these observations

[3]

b) The table of data below compares the reactivity of cobalt with that of three other metals.

metal	reactivity with cold water	reactivity with steam
barium	reacts rapidly	
cobalt	no reaction	reacts slowly when heated
magnesium	reacts very slowly	reacts rapidly
zinc	no reaction	reacts easily when heated

Use this information to put the four metals in order of their reactivity. Put the least reactive metal first.

least reactive → most reactive

[2]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

c) State the boiling point of pure water at room temperature and pressure.

_____

[1]

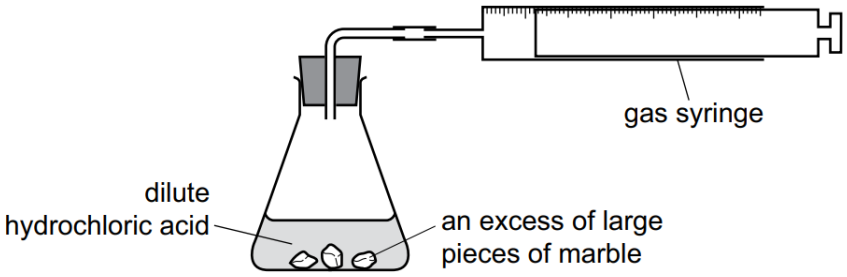
d) When cobalt(II) oxide, CoO, is heated in air an oxide with the formula Co_3O_4 is formed.

Balance the equation for this reaction.

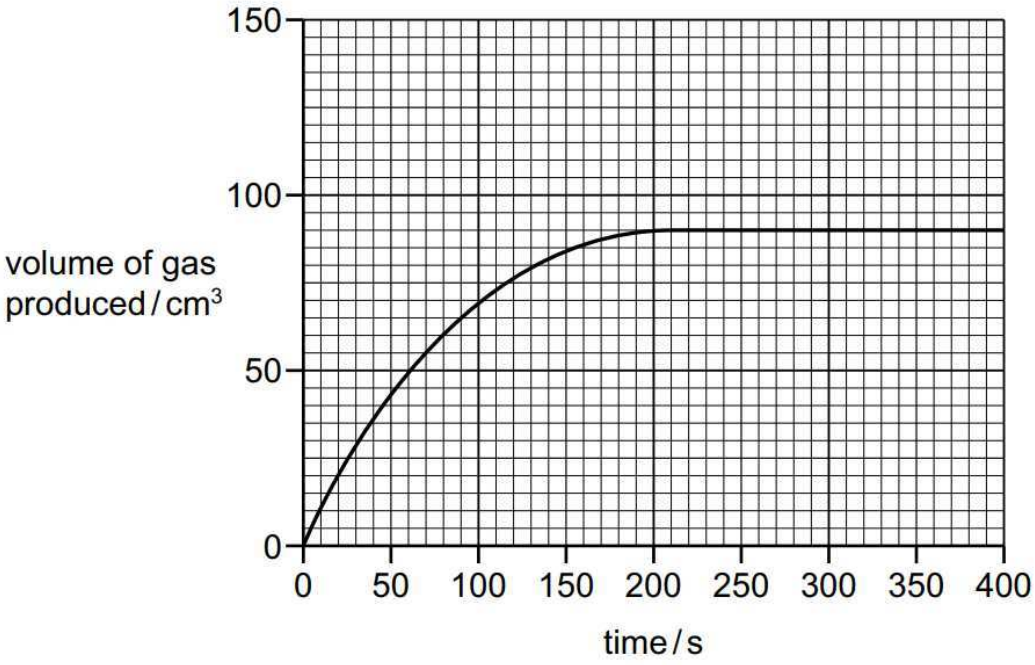
$$\_\_\_\_\_CoO + \_\_\_\_\_O_2 \rightarrow 2Co_3O_4$$

[1]

10) A student investigates the progress of the reaction between dilute hydrochloric acid, HCl, and an excess of large pieces of marble, CaCO3, using the apparatus shown in the picture below.



A graph of the volume of gas produced against time is shown in below



The rate of reaction is how much gas is produced in a given amount of time.

a) State how the shape of the graph shows that the rate of reaction decreases as the reaction progresses.

_____

_____

[1]

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

b) Suggest why the rate of reaction decreases as the reaction progresses

_____

_____

[1]

c) Deduce the time at which the reaction finishes

_____

[1]

d) The experiment is repeated using the same mass of smaller pieces of marble.

All other conditions are kept the same.

Using smaller pieces of marble increases the rate of reaction.

Draw on the graph to show the progress of the reaction using the smaller pieces of marble.

[2]

[20 marks]

End of Paper

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Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2023))

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

Overview

This is a **13+ entrance examination** in **Science**, published by **Oundle School** in Northamptonshire for candidates applying for Year 9 entry in 2023. The paper is labelled **Non-Common Entrance**, meaning it is an internal school assessment rather than the standard Common Entrance syllabus.

The paper is divided into three equal sections covering **Biology**, **Physics**, and **Chemistry**, each carrying 20 marks and testing a broad range of topics from the Key Stage 3 curriculum. Questions range from multiple-choice to short written responses and numerical calculations, with marks awarded for both factual recall and the application of scientific reasoning. Candidates have **one hour** to complete all 60 marks.

This paper is designed for students preparing for selective independent school entry at 13+, and assumes a solid grounding in science at Key Stage 3 level. It is particularly useful for those targeting competitive independent schools, as it reflects the depth and variety of scientific understanding expected at this entry point.

How this paper is organised

The paper totals **60 marks**, split evenly across three sections: **Biology**, **Physics**, and **Chemistry**, each worth 20 marks. Candidates are instructed to answer all questions and are allowed to use a calculator. The time allowance is **one hour**, meaning students must allocate roughly 20 minutes per section.

Each section contains a mix of multiple-choice questions (typically four-option) and free-response questions requiring short written explanations, calculations, or labelling of diagrams. For instance, Biology includes questions on cell structure, food chains, ecology, and plant reproduction. Physics covers forces, energy transfers, electricity, and moments. Chemistry addresses states of matter, reactions, the periodic table, and rates of reaction.

Many questions are scaffolded with diagrams, data tables, or graphs, and candidates are expected to interpret these carefully. Marks are shown in square brackets at the end of each question or sub-part, guiding candidates on how much detail is expected. The layout is clear, with ample space for working, and the paper is printed directly in the answer booklet.

Topics covered

- Biology: levels of organisation (cells, tissues, organs, organ systems)
- Biology: classification and characteristics of animal groups (birds, invertebrates)
- Biology: osmosis and water movement in plant cells (potato osmosis investigation)
- Biology: magnification calculations for microscopy and biological drawings
- Biology: food chains and food webs, including predator-prey relationships and energy transfer
- Biology: population dynamics and factors affecting animal populations (predation, disease)
- Biology: structure and function of flower parts (anther, stigma, petal)
- Biology: ecology and human impact (overfishing, sustainability, fishing bans)
- Biology: photosynthesis in woodland floor plants and light availability
- Biology: respiration as a cellular process (word equation)
- Physics: forces including drag (air resistance), gravity, and moments
- Physics: energy transfers (work done, power, energy calculations)
- Physics: electrical circuits, potential difference, current, and series circuit behaviour
- Physics: light and colour filters (additive colour mixing with 3D glasses)
- Physics: heat transfer processes (conduction, convection, radiation)
- Physics: speed calculations and relative velocity
- Physics: renewable energy considerations (wind turbines, environmental and practical factors)
- Chemistry: particle theory and states of matter (liquids, gases, fixed volume)
- Chemistry: properties of graphite (lubricant, layered structure)
- Chemistry: physical vs. chemical changes (melting, burning, dissolving)
- Chemistry: acids and bases, universal indicator colours and pH
- Chemistry: properties of metals (conductivity, reactivity with water)
- Chemistry: reaction of limestone (calcium carbonate) with hydrochloric acid
- Chemistry: chromatography (interpreting chromatograms, counting distinct dyes)
- Chemistry: periodic table organisation (groups, periods, element properties)
- Chemistry: diffusion of coloured solute through water (particle motion)
- Chemistry: reactivity series and displacement reactions
- Chemistry: balancing chemical equations (metal oxide formation)
- Chemistry: reaction rates and surface area effects (marble and acid experiment)

How to use this paper for revision

- Review the **particle model** for all three states of matter, as Chemistry Section questions rely on understanding how particles move in liquids and gases.
- Practise **balancing chemical equations** by working through metal oxide and acid-base reactions, ensuring atom counts match on both sides.
- Revise how to interpret **food webs** and predict population changes when one species is removed or reduced, a common Biology question type.
- Memorise the word equations for **photosynthesis** and **respiration**, and be ready to complete them in either direction under exam conditions.
- Work through **magnification calculations** using the formula: magnification = size of image ÷ actual size, and check your units carefully.
- Understand the difference between **physical and chemical changes** by listing examples of each and explaining whether new substances are formed.
- Practise drawing and interpreting **distance-time graphs** and **rate of reaction graphs**, noting how gradient changes indicate speed or rate.

Common mistakes to avoid

- Confusing **organs** with **organ systems** or **tissues** in Biology classification questions, leading to incorrect multiple-choice answers.
- Forgetting to convert units in Physics calculations, such as minutes to seconds when calculating energy transferred from power and time.
- Misreading the direction of arrows in food webs, thinking predators provide energy to prey instead of the reverse.
- Writing incomplete word equations for respiration by omitting either **glucose** or **water** as a reactant or product.
- Assuming all metals react vigorously with water, when in fact many (like cobalt or zinc) show no reaction or react only when heated.
- Confusing **diffusion** with **dissolving** in Chemistry questions, not explaining particle movement in answers about coloured crystals spreading through water.

Exam technique

Begin by reading the entire paper quickly to identify which questions you find easiest, then tackle those sections first to secure marks early. Each of the three sections is worth the same, so aim to spend no more than 20 minutes on any one discipline,

leaving a few minutes at the end to check calculations and re-read longer written answers.

For multiple-choice questions, eliminate obviously incorrect options first and use your knowledge to choose between the remaining answers. If a question provides a diagram, graph, or data table, annotate it lightly with observations or trends before writing your answer. For numerical questions, always show your working clearly, even if the answer seems straightforward, as partial credit is often awarded for method.

In extended-response questions (such as the wind turbine discussion in Physics or the diffusion explanation in Chemistry), aim to write in complete sentences and include at least two or three distinct points per mark awarded. Check that you have answered all parts of multi-part questions, and ensure units are included with all numerical answers. Use the last five minutes to scan for unanswered questions and verify that your handwriting is legible throughout.

What to revise alongside this paper

Students should consolidate their understanding of **Key Stage 3 Biology** by revising cell biology (including specialised cells and microscopy), human body systems (circulatory, digestive, respiratory), and ecosystems and interdependence. For Physics, ensure you are confident with **forces and motion** (including balanced and unbalanced forces), energy resources, and basic electricity including series and parallel circuits.

In Chemistry, practise writing and balancing **symbol equations** as well as word equations, and revise the **reactivity series** of metals in depth, including displacement reactions. Study the structure and trends of the periodic table, and be able to explain the properties of metals, non-metals, and transition metals. Extend your reading to include **rates of reaction** experiments and how temperature, concentration, surface area, and catalysts affect reaction speed.

For broader preparation, consider looking at past papers from other independent schools at 13+ level, as well as **Common Entrance** Science papers, which cover similar content. Textbooks such as CGP KS3 Science or the Oxford Smart series provide targeted revision and practice questions aligned with this level.

Key terms

> **Osmosis**, **Magnification**, **Food chain**, **Predation**, **Anther**, **Stigma**, **Respiration**, **Photosynthesis**, **Potential difference**, **Drag**, **Moment**, **Conduction**, **Convection**, **Physical change**, **Chemical change**, **Universal indicator**, **Chromatography**, **Reactivity series**, **Diffusion**, **Rate of reaction**

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OUNDLE
School

EXAMINATION PAPER
13+ Academic Scholarship 2023

Science (Paper 1)

Time allowed: 1 hour

Name: _____

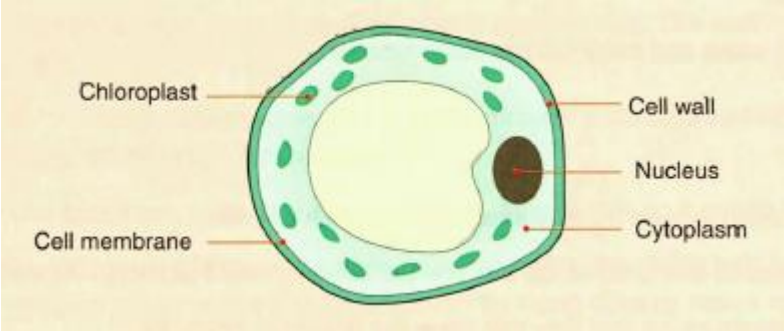
Instructions

- Write your name clearly in the space above.
- Answer on this paper.
- Calculators are allowed.
- Answer ALL the questions in all sections.
- You are expected to write clearly and accurately throughout each of your answers. You should leave some time towards the end of the examination to check your work carefully.
- The maximum number of marks for this paper is 58.

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

SECTION ONE: BIOLOGY *[20 Marks]*

1. The diagram below shows a plant cell.



a. The cell is a leaf cell. Give the name of the part which is present in this leaf but not present in root cells.

…….....

[1 mark]

b. Give two parts of the cell, labelled on the diagram, which are not present in animal cells.

……...……

……...

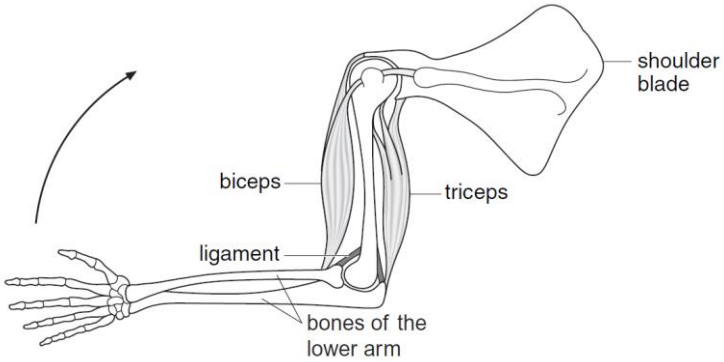
[2 marks]

c. The five parts of the cell labelled on the diagram have different functions. Complete the table below and write the name of the correct part of the cell next to its function. The first has been done for you.

Function	**Part of the cell**
A place where many chemical reactions take place.	Cytoplasm
Photosynthesis takes place here.	
It controls the cell's activities	
It helps to keep the shape of the cell.	
It controls the substances entering and leaving the cell.	

[3 marks]

2. The diagram below shows bones and muscles of the human arm.



The biceps and triceps are muscles that contract to move the bones of the lower arm.

a. What do the biceps and triceps do to move the arm in the direction shown by the arrow?

Tick the correct box.

	The biceps and the triceps contract at the same time.
	The biceps contracts and the triceps relaxes.
	The biceps relaxes and the triceps contracts.
	The biceps and the triceps relax at the same time

[1 mark]

b. Ligaments hold bones together at a joint. Ligaments can stretch.

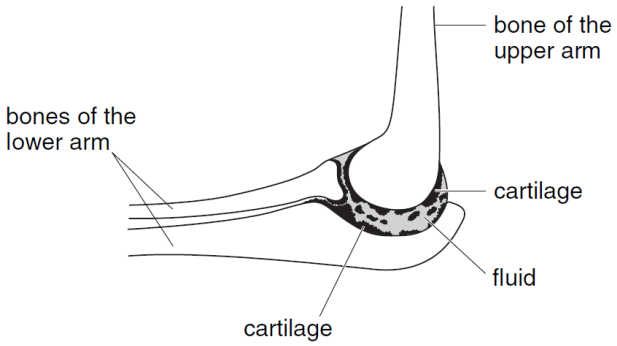
Why must ligaments be able to stretch?

……
…

……
…

[1 mark]

c. The diagram below shows an elbow joint.



i. The ends of the bones at a joint are covered by a layer of smooth material called cartilage.

There is also a fluid in the joint.

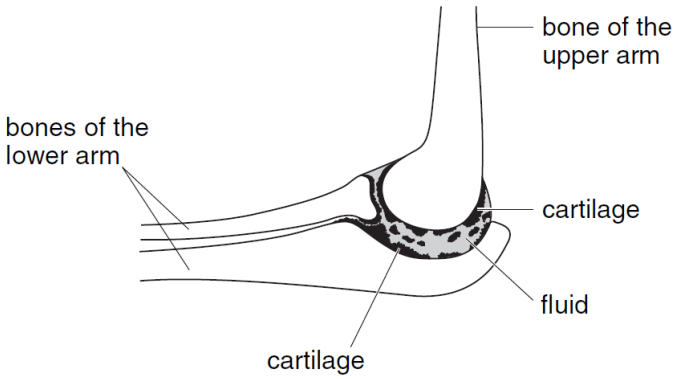
Why are cartilage and fluid needed in a joint?

……

……

[1 mark]

ii. In the joint shown below, some of the cartilage has broken off.



Suggest **one** way this damage will affect the joint.

……

……

[1 mark]

3. This table shows the causes of death of cigarette smokers in Great Britain.

Cause of death	Percentage of deaths
Lung cancer	8
Bronchitis and emphysema	17
Circulatory diseases	20
Other causes (not related to smoking)	55

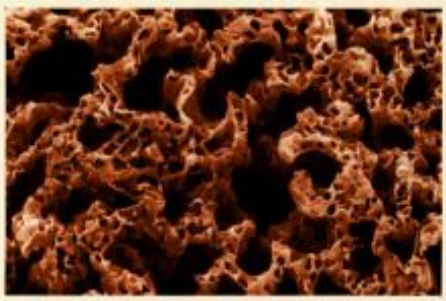
a. What percentage of smokers die from smoking-related diseases?

……

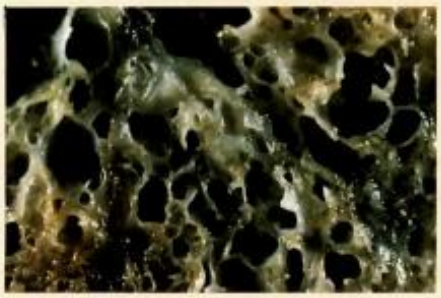
……

[2 marks]

b. Emphysema is a disease caused by smoking. The photograph on the left shows normal lung tissue and the photo on the right shows lung tissue from a person with emphysema.



Air sacs (alveoli) in human lung tissue.



A section of lung affected by emphysema.

i. Describe two differences between the normal lung tissue and lung tissue from a person with emphysema.

……

……

……

[2 marks]

ii. Suggest how these differences affect the supply of oxygen to the blood in the person with emphysema?

……

……

……

[2 marks]

iii. Name two other diseases caused by smoking, and say what the symptoms would be (i.e. how the patient would be affected).

……

……

……

……

……

……

[4 marks]

SECTION TWO: CHEMISTRY *[20 Marks]*

A Periodic Table is provided.

Sourced from SATs-Papers.co.uk

THE PERIODIC TABLE

Period	1	2											3	4	5	6	7	0
	Group																	
1	1 H Hydrogen 1																	4 He Helium 2
2	7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
3	23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
4	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
5	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

Relative atomic mass
Symbol
Name
Atomic number

https://www.SATs-Papers.co.uk/11-plus-papers/

1. A student investigated the rate of reaction between marble chips and hydrochloric acid. **Figure 1** shows the apparatus the student used.

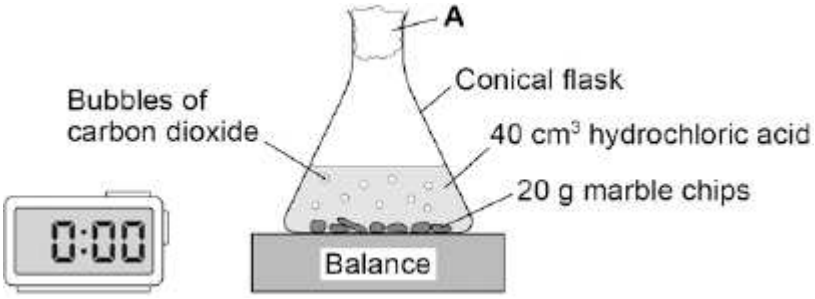


Figure 1

a. What is **A**?

Tick **one** box.

cotton wool ☐

limestone ☐

poly(ethene) ☐

rubber bung ☐

[1 mark]

b. **Table 1** shows the student's results for one investigation.

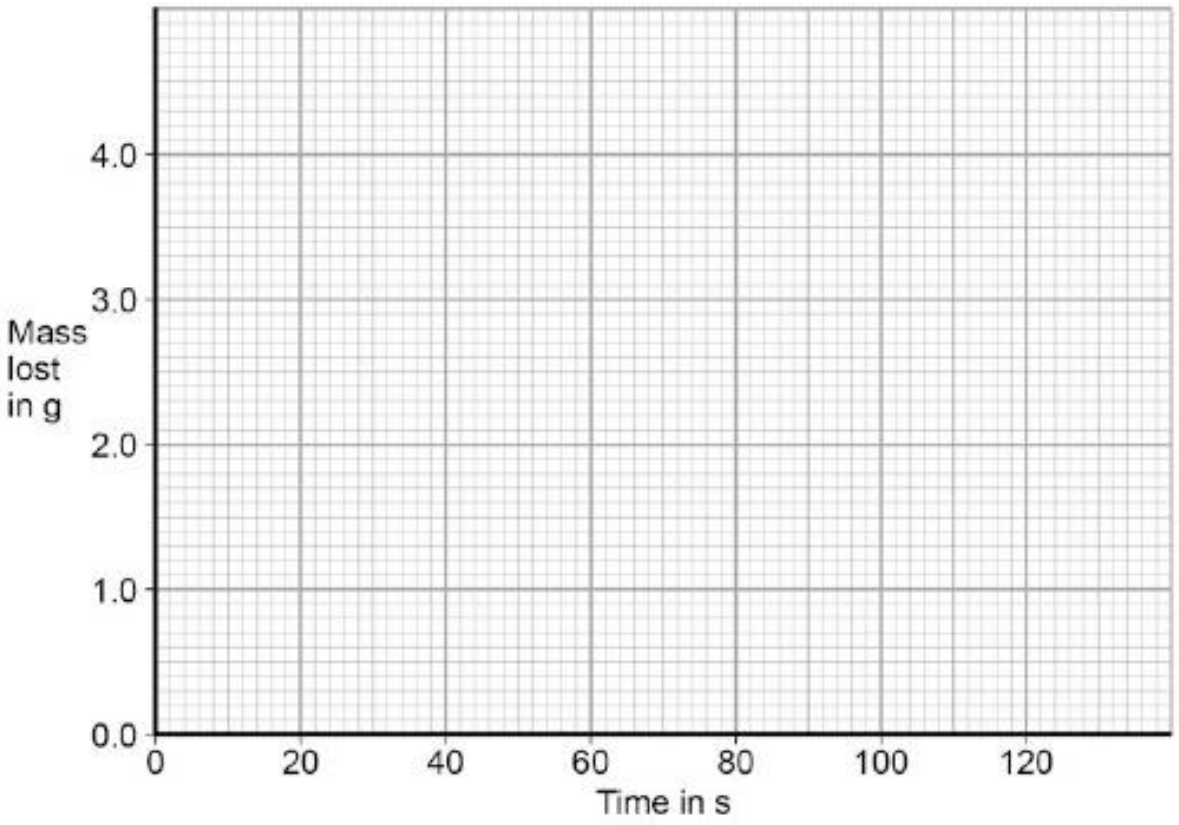
Table 1

Time in s	**Mass lost in g**
0	0.0
20	1.6
40	2.6
60	2.9
80	3.7
100	4.0
120	4.0

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

On the grid below:

- Plot these results
- Draw a line of best fit



[3 marks]

c. Circle the anomalous point.

Explain how this anomaly could have occurred.

……

……

[2 marks]

d. Use **your graph** to complete **Table 2**.

Table 2

Mass lost after 0.5 minutes	_____ g
Time taken to complete the reaction	_____ s

[2 marks]

e. The equation for the reaction is:

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Explain why there is a loss in mass in this investigation.

……

……

……

……

[2 marks]

f. Another student investigated the rate of a different reaction.

Table 3 shows the results from the different reaction.

Table 3

Mass lost when the reaction was complete	9.85 g
Time taken to complete the reaction	2 minutes 30 seconds

Calculate the mean rate of the reaction using **Table 3** and the equation:

$$\text{mean rate of reaction} = \frac{\text{mass lost in g}}{\text{time taken in s}}$$

Give your answer to two decimal places.

Mean rate of reaction = _____ g / s

[2 marks]

g. The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and hydrochloric acid.

……

……..……

……..……

……

[2 marks]

2. The atoms of each element have different masses. These masses are given in the Periodic table.

a. Use the table below to calculate the masses of each of the **compounds** in the equation for the reaction between magnesium and sulphuric acid given.

Atom	**Mass** (μ)
Mg	24
H	1
S	32
O	16

Equation:

	$Mg\ (s) + H_2SO_4\ (aq)$	à	$MgSO_4\ (aq) + H_2\ (g)$	
Mass (g)	24			2

[2 marks]

b. Explain how these masses prove that mass is conserved in reactions.

……

……

[2 marks]

c. So, if 24g of magnesium reacts with sulphuric acid, 2g of hydrogen is produced. Calculate the mass of $MgSO_4$ that is formed from 1.2g of magnesium.

……

……

[2 marks]

SECTION THREE: PHYSICS [*18 Marks*]

Questions 1 -9 are multiple choice. Clearly underline or circle the correct letter for each of the questions.

1.

A student measures the volume of a quantity of water.

Which apparatus is suitable?

A a balance

B a measuring cylinder

C a ruler

D a thermometer

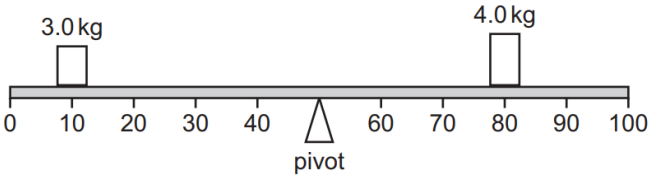
2.

Which substance in the table has the lowest density?

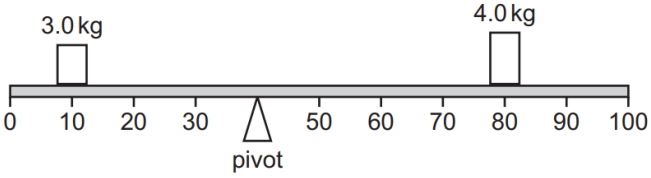
	substance	mass / g	volume / cm^3
A	nylon	1.2	1.0
B	cotton	1.5	1.0
C	olive oil	1.8	2.0
D	water	2.0	2.0

3.

A 100 cm beam balances as shown.



The pivot is moved 10 cm to the left.

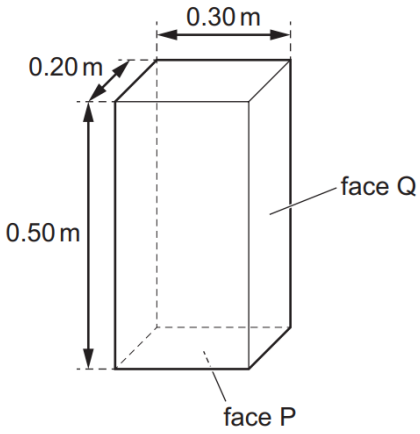


What will be the effect of this change on the anticlockwise and clockwise moments about the pivot?

	anticlockwise moment	clockwise moment
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

4.

The box shown has a weight of 15 N.



The box is resting on a horizontal surface with face P in contact with the surface.

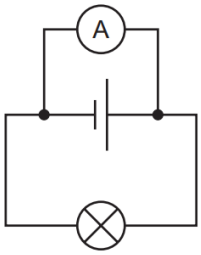
What is the change in pressure on the surface if the box falls over onto face Q?

A $0.0040\,m^2/N$ **B** $0.0067\,m^2/N$ **C** $100\,N/m^2$ **D** $250\,N/m^2$

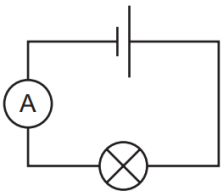
5.

In which circuit is the ammeter measuring the flow of charge through the lamp?

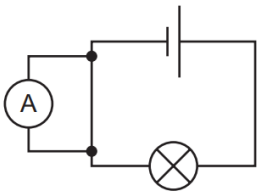
A



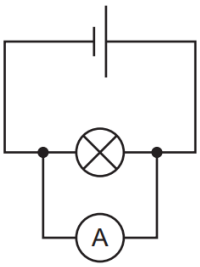
B



C

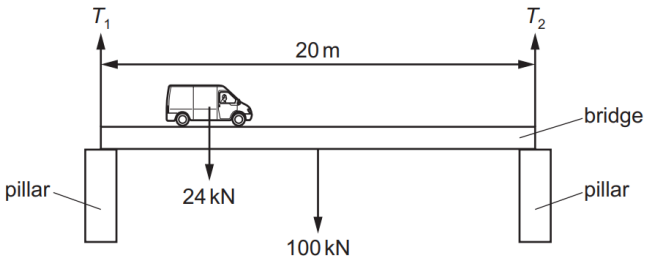


D



6.

A 20 m long, uniform bridge of weight 100 kN is supported at each end by pillars, as shown.



The pillars exert forces T_1 and T_2 on the ends of the bridge.

What are the values of T_1 and T_2 when a van of weight 24 kN is on the bridge, 5 m from the left-hand pillar?

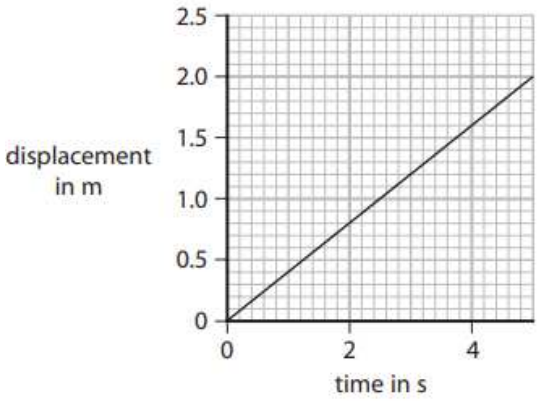
	T_1 / kN	T_2 / kN
A	56	68
B	62	62
C	68	56
D	74	50

7.

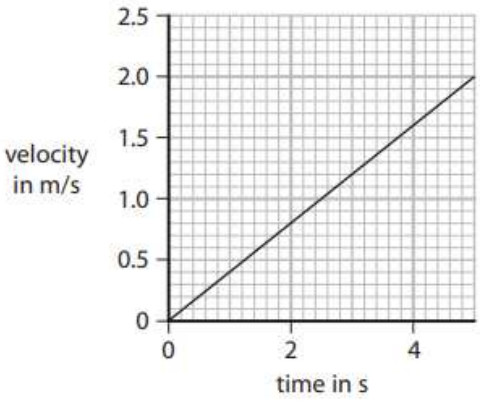
(a) Which of these graphs represents an object moving with a constant velocity of 2 m/s?

(1)

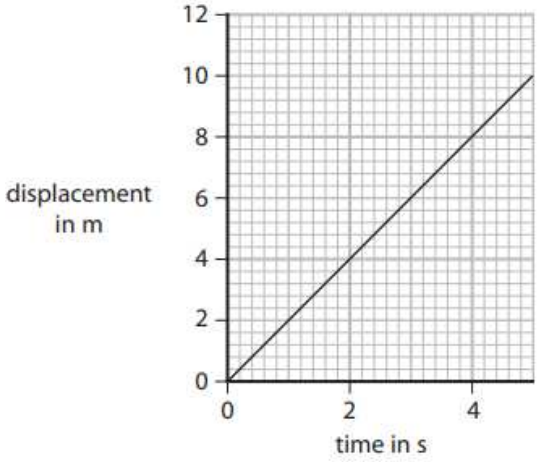
☐ A



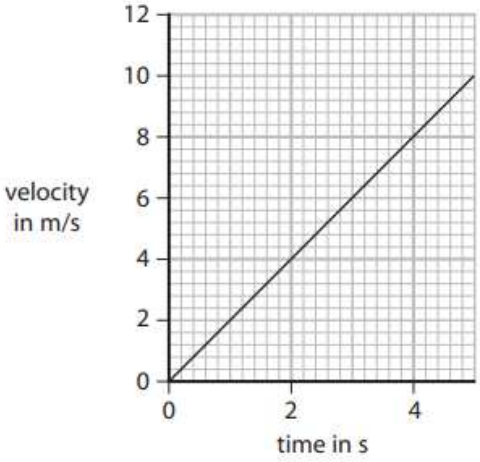
☐ B



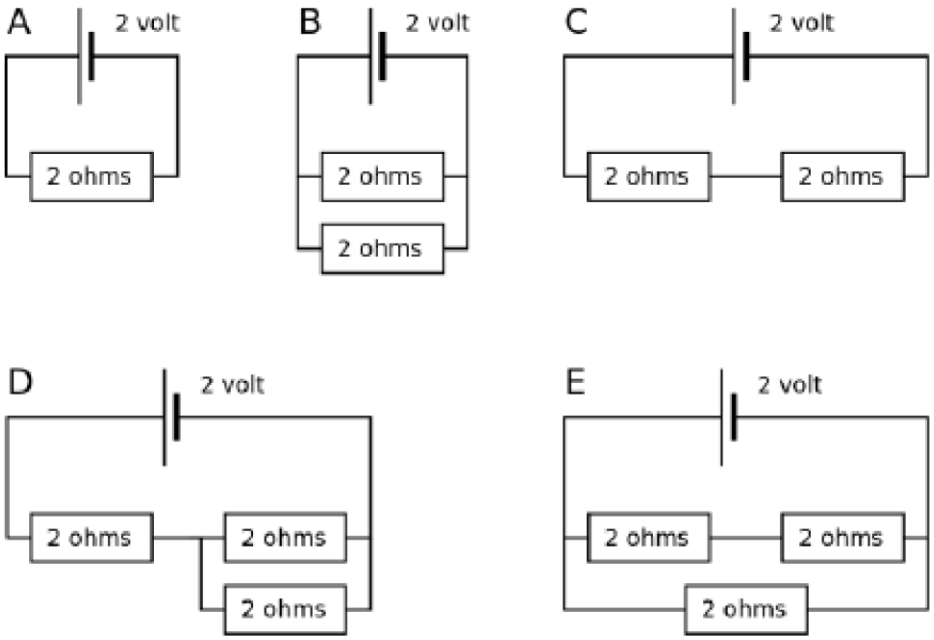
☐ C



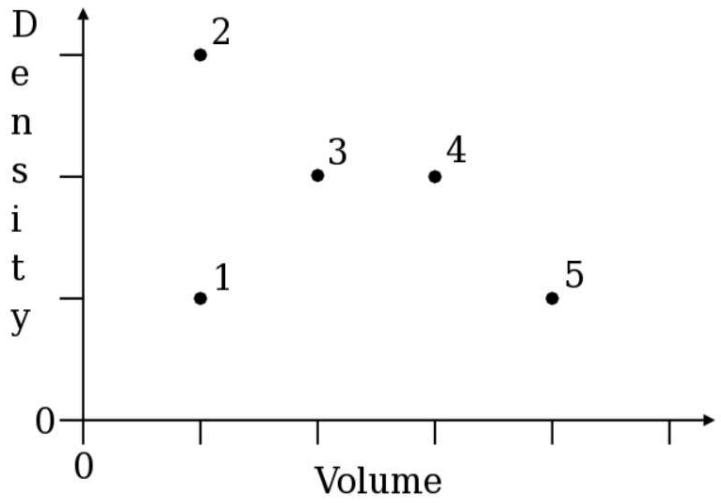
☐ D



8. Consider the circuits shown below.
In which circuit is the current flowing through the cell the largest?



9. The density and volume of five samples of material are plotted on the graph as shown. Which two samples have the same mass?



A. 3 & 5 B. 3 & 4 C. 1 & 2 D. 1 & 3 E. 1 & 5

10.

a. Figure 1 shows some water in a tank.

Figure 1

i. The bottom of the tank has an area of $0.80m^{2.}$

The force on the bottom of the tank, due to the water, is 2400N

Calculate the pressure, due to the water, on the bottom of the tank.

Pressure = _____

[3 marks]

ii. More water is added to the tank.

Explain how the pressure on the bottom of the tank changes when more water is added to the tank.

……

……

……

[2 marks]

b. Figure 2 is a graph showing how the atmospheric pressure change with the height above sea level on the Earth's surface.

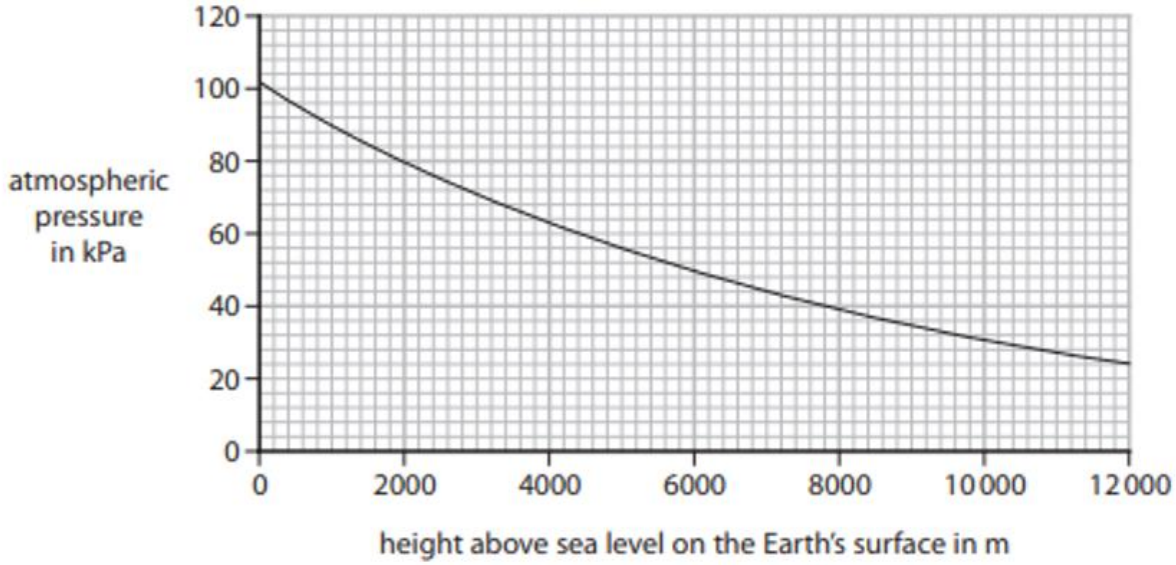


Figure 2

An aeroplane descends from 600m to 2000m.

Use the graph to find the change in atmospheric pressure as the aeroplane descends.

Change in pressure = _____Pa

[2 marks]

c. Figure 3 show two drawings of the same person on a bed.

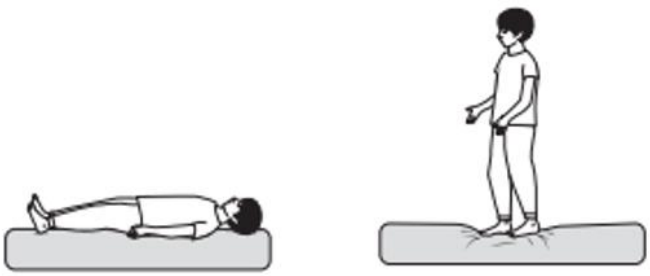


Figure 3

Explain why the person exerts a different pressure on the bed when standing up than when lying down.

……

……

……

[2 Marks]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2023))

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

Overview

This is the **13+ Academic Scholarship Science (Paper 1)** examination paper published by **Oundle School** in Northamptonshire. The paper was set for candidates sitting the **13+ entry examination in 2023**, and it assesses scientific knowledge and reasoning across biology, chemistry, and physics in a single one-hour examination. Candidates are permitted to use calculators and must answer all questions on the paper itself.

The paper is divided into **three equal-weight sections**: Biology (20 marks), Chemistry (20 marks), and Physics (18 marks), totalling 58 marks. Each section blends structured short-answer questions with data interpretation, diagram labelling, calculations, and extended writing. The Biology section focuses on cell structure, the musculoskeletal system, and health issues related to smoking. The Chemistry section explores rates of reaction through practical investigation and conservation of mass in chemical equations. The Physics section includes multiple-choice questions on measurement, density, pressure, moments, and circuits, followed by extended calculation and explanation tasks.

This paper suits students preparing for competitive entry to independent senior schools at 13+, particularly those aiming for **academic scholarships**. It rewards clear scientific communication, numeracy, and the ability to apply knowledge to unfamiliar contexts. The breadth of content and mark allocation reflect the expectation that candidates will have covered Key Stage 3 material comprehensively and can work at a brisk pace under timed conditions.

How this paper is organised

The paper is organised into **three distinct subject sections** (Biology, Chemistry, Physics) with a combined total of **58 marks** to be completed in **one hour**. Section One (Biology) carries 20 marks and comprises three multi-part questions covering plant and animal cells, the human musculoskeletal system (muscles, ligaments, cartilage, and joints), and the health effects of smoking, including data interpretation from tables and micrographs. Section Two (Chemistry) also carries 20 marks and features two questions: the first is an extended practical investigation into reaction rates using marble chips and hydrochloric acid, requiring graph plotting, anomaly identification, and

calculation of mean reaction rate; the second explores conservation of mass and stoichiometry using the reaction between magnesium and sulphuric acid.

Section Three (Physics) carries 18 marks and begins with **nine multiple-choice questions** covering volume measurement, density, moments on a beam, pressure, circuits, and motion graphs. These are followed by a final extended question on pressure in liquids and gases, requiring calculation of pressure from force and area, graph interpretation of atmospheric pressure variation with altitude, and explanation of how surface area affects the pressure exerted by a person on a bed. The paper includes diagrams, data tables, and a separate Periodic Table for reference during the Chemistry section.

Questions are printed with answer spaces directly on the paper, and candidates are instructed to check their work carefully towards the end of the hour. The blend of calculation, practical interpretation, and written explanation reflects the academic scholarship standard expected at Oundle.

Topics covered

- Plant cell structure: identification and function of chloroplasts, cell wall, nucleus, cytoplasm, and cell membrane; comparison with animal cells and root cells
- Human musculoskeletal system: antagonistic muscle pairs (biceps and triceps), the role of ligaments in joint flexibility, cartilage and synovial fluid in reducing friction and wear
- Health and disease: interpretation of mortality data for smokers, analysis of lung tissue affected by emphysema, description of symptoms for smoking-related diseases including lung cancer, bronchitis, and circulatory disease
- Rates of reaction: practical investigation of the reaction between marble chips and hydrochloric acid, plotting and interpreting mass-loss graphs, identifying anomalous data points, calculating mean reaction rate
- Conservation of mass: calculating relative formula masses using the Periodic Table, applying stoichiometry to the reaction $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$, explaining mass balance in chemical equations
- Pressure in fluids: calculating pressure from force and area ($P = F/A$), explaining how depth of water affects pressure on the base of a tank, interpreting graphs of atmospheric pressure variation with altitude
- Moments and equilibrium: analysing the effect of moving a pivot on anticlockwise and clockwise moments, calculating tensions in pillars supporting a loaded bridge
- Electric circuits: identifying correct ammeter placement in series and parallel circuits, calculating current using Ohm's law ($V = IR$) for series and parallel resistor networks
- Motion graphs: distinguishing between distance-time and velocity-time graphs, identifying constant velocity from a straight-line graph with appropriate gradient
- Density and mass: interpreting a scatter graph of density versus volume to identify samples of equal mass

How to use this paper for revision

- Practise labelling and describing the functions of plant cell organelles. Make sure you can explain why chloroplasts are present in leaf cells but not root cells, and why cell walls and large vacuoles distinguish plant cells from animal cells.
- Revise antagonistic muscle pairs and joint structure. Draw diagrams showing how biceps and triceps work together to flex and extend the arm, and be ready to explain why ligaments must stretch and why cartilage wears away with age or injury.
- Study the health effects of smoking in detail. Learn specific symptoms of lung cancer, bronchitis, emphysema, and circulatory disease, and practise calculating percentages from epidemiological data tables.
- Work through rate-of-reaction experiments step by step. Practise plotting mass-loss or gas-volume graphs, drawing smooth curves of best fit, identifying anomalies, and calculating gradients or mean rates from your plotted data.
- Master the use of the Periodic Table for calculating relative formula masses. Practise applying conservation of mass to balanced symbol equations, and learn to scale stoichiometric ratios up or down for different starting masses.
- Drill pressure calculations until they become automatic. Remember that pressure equals force divided by area (P = F/A), and practise rearranging the formula. Understand that pressure in a liquid increases with depth because the weight of water above increases.
- Revise moments and equilibrium by drawing free-body diagrams. Calculate clockwise and anticlockwise moments about a pivot, and remember that when the pivot moves, the perpendicular distances to the forces change, altering the moment values.

Common mistakes to avoid

- Confusing cell wall with cell membrane. The cell wall is rigid and made of cellulose; the cell membrane is a thin, flexible layer that controls what enters and leaves. Both are present in plant cells, but only the membrane is found in animal cells.
- Stating that both biceps and triceps contract simultaneously. In reality, one muscle contracts while the other relaxes to move the arm smoothly in one direction. Antagonistic pairs work in opposition, not in tandem.
- Failing to identify the anomalous data point on the graph. Look for a plotted point that does not follow the general trend of the curve. Common causes include measurement error, spillage, or timing mistakes during the experiment.
- Forgetting to convert minutes to seconds before calculating reaction rate. The formula requires consistent units. Two minutes and thirty seconds must be converted to 150 seconds before dividing mass lost by time taken.
- Omitting units or using incorrect units in pressure calculations. Pressure in pascals (Pa) equals force in newtons (N) divided by area in square metres (m^2). Writing the answer without 'Pa' or 'N/m^2' loses marks.

Exam technique

Start by reading through the entire paper quickly to identify which questions carry the most marks and which you find easiest. The **three sections are roughly equal in marks**, so aim to spend about 20 minutes on each. If a question part is worth 3 marks, plan to write at least three distinct points in your answer; one-mark questions typically need a single word or short phrase. For graph-plotting in the Chemistry section, use a sharp pencil and plot points accurately; draw a smooth curve of best fit rather than joining dots with straight lines, and circle any anomalous point clearly.

In calculation questions, always **show your working** even if the answer is straightforward. If you make an arithmetic error but your method is correct, you can still earn method marks. Write the formula first, substitute values with units, and then calculate. For the pressure question in Physics, remember to write your final answer with the correct unit (Pa or N/m^2). When the question asks you to explain or describe, use scientific vocabulary precisely: write 'contracts' not 'tightens', 'cartilage' not 'padding', and 'chloroplast' not 'green bit'.

Leave two or three minutes at the end to check your work. Reread multi-mark questions to ensure you have given enough detail, check that your graph points are plotted correctly, and verify that every answer has a unit where required. If you are stuck on a question, move on and return to it if time permits; the multiple-choice section in Physics can be completed quickly and will secure easy marks if you are running short on time.

What to revise alongside this paper

Students should revise the structure and function of **animal cells** in detail, including the roles of mitochondria, ribosomes, and the nucleus, to complement the plant cell knowledge tested here. Review photosynthesis and respiration equations, as these underpin the function of chloroplasts and mitochondria. In human biology, extend your study of the musculoskeletal system to cover bone structure, types of joints (hinge, ball-and-socket), and the role of tendons in attaching muscle to bone. Deepen your understanding of the respiratory and circulatory systems to explain how smoking damages alveoli, reduces gaseous exchange, and increases the risk of heart disease and stroke.

In Chemistry, practise more complex stoichiometric calculations involving limiting reagents and percentage yield, and revise factors affecting reaction rate (temperature, concentration, surface area, catalysts). Study collision theory and activation energy to explain why rates change. Learn to balance symbol equations confidently, including those involving acids, bases, and salts. In Physics, extend your work on pressure to include hydraulic systems and upthrust (Archimedes' principle), and practise using pressure-depth relationships ($P = \rho gh$) in liquids.

Finally, revise series and parallel circuits in greater depth, including calculations of total resistance and potential difference across components, and study energy transfers in electrical circuits. Practise interpreting velocity-time graphs to calculate acceleration and distance travelled, and ensure you can convert between units (e.g. cm^3 to m^3, minutes to seconds) fluently. Mastery of these adjacent topics will prepare you for the full range of 13+ scholarship science questions.

Key terms

> **Chloroplast**, **Cell wall**, **Cell membrane**, **Nucleus**, **Cytoplasm**, **Antagonistic muscles**, **Ligament**, **Cartilage**, **Synovial fluid**, **Emphysema**, **Rate of reaction**, **Anomalous result**, **Conservation of mass**, **Stoichiometry**, **Relative formula mass**, **Pressure (P = F/A)**, **Moment**, **Pivot**, **Current**, **Resistance**, **Ohm's law**, **Density**, **Velocity**

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OUNDLE
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EXAMINATION PAPER
13+ Academic Scholarship 2023

Science (Paper 2)

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above.
- Answer in this paper.
- Calculators are allowed.
- Answer ALL the questions in all sections. Each section carries the same number of marks.
- You are expected to write clearly and accurately throughout each of your answers. You should leave some time towards the end of the examination to check your work carefully.
- The maximum number of marks for this paper is 60.

Sourced from SATs-Papers.co.uk https://www.SATs-Papers.co.uk/11-plus-papers/

SECTION ONE: BIOLOGY [*19 Marks*]

Comprehension Exercise

1. The following question is about inheritance. You may not know the answers but you will be able to interpret the information and offer sensible responses.

Mammals inherit their characteristics from their parents. Characteristics are controlled by genes. Genes are encoded (carried) in the DNA of the nucleus. Every cell of an individual contains the same set of genes. A single set of genes is inherited from each parent. This means that mammals contain two copies of each gene in their nuclei. The way these genes interact generates an individual's unique characteristics. For example, we may be able to roll our tongue because we have inherited the gene for 'tongue-rolling' from both our parents. Some genes come in different versions. Just like a shirt can be long-sleeved or short-sleeved, the gene for chin shape may be 'dimpled' or 'not-dimpled'. One version of the gene is said to be **dominant** if it hides the other version of the gene; the hidden version is called **recessive**. Eye lash length is a gene that comes in two forms: **long** is dominant over **short**. Biologists use letters to represent a gene. A capital letter represents the dominant version.

Two parents with long eye-lashes produce four children.

a. Complete the table – one has been done for you.

Parents	Long Eye Lash	Long Eye Lash
Genes	Ll	Ll
Gametes	L and l	L and l

Gametes	L	l
L	1 =	2 = **Ll**
l	3 =	4 =

[2 marks]

b. What type of eye lash do the four off-spring have? Complete the table.

	Type of eyelash length
Children 1	
Children 2	
Children 3	
Children 4	

[4 marks]

c. Child **number 2 (Ll)** went on to have children with a person with **short** eye lashes. Use the table below to calculate the probability of their children have **SHORT** eye lashes. (Table 2)

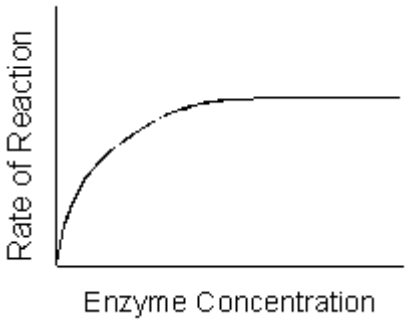
	Parent number 2 gametes	
Short eye lash parent gametes		

Answer – the probability of having short eye lashes is:……

[2 marks]

2. Enzymes are molecules found in all cells. They speed up chemical reactions but are left unaffected by the reaction – they are sometimes known as *biological catalysts*. In order to work, they must collide with their target molecule or molecules as well as have a specific shape so all the molecules fit together.
All molecules have energy which allows them to move by diffusion. As they get warmer, they gain more energy and move more quickly. As molecules move more quickly, they are more likely to collide. As they get warmer, enzymes also move more quickly but at very high temperatures they lose their shape and stop working.

Look at the graphs and answer the questions.



Graph 1

a. Describe the shape of the curve in graph 1.

……

……

……

……

[2 marks]

b. Suggest an explanation for the first part of the line.

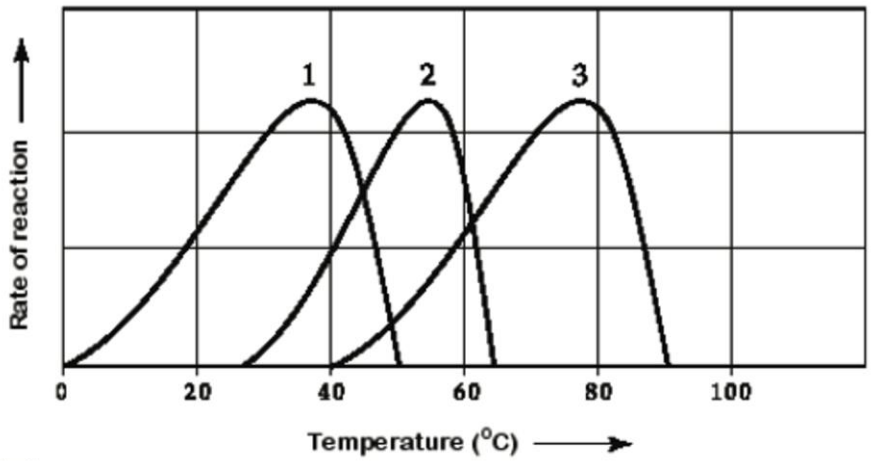
……

……

……

……

[2 marks]



Graph 2

c. Looking at Graph 2 describe the shape of **line 1.**

……

……

……

……

[2 marks]

d. Looking at graph 2 suggest an explanation for the shape of **line 1.**

……

……

……

……

[2 marks]

e. Looking at graph 2 which line (1, 2 or 3) is likely to be a mammalian enzyme?

……

……

[1 mark]

i. Why do you think this?

……

……

[1 mark]

f. Looking at graph 2 which line (1, 2 or 3) is likely to be found in an organism living in a hot spring?

……

……

[1 mark]

i. Why do you think this?

……

……

[1 mark]

SECTION TWO: CHEMISTRY [*20 Marks*]

There are many different types of fuels but currently, the most common are fossil fuels, made from the anaerobic decay of plant and animals over millions of years. Many of these fossil fuels are hydrocarbons. This means they are compounds made from only hydrogen and carbon atoms.

a. Methane, ethane and propane are the three smallest hydrocarbons and these gases are generally used in gas ovens and camping stoves.

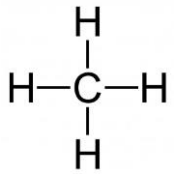
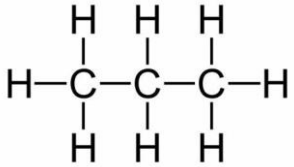
We can represent hydrocarbon compounds using different formulae:

Molecular formulae show the total number of atoms of each element in the compound

Structural formulae show the groups of atoms around each carbon atom in the compound

Displayed formulae show the atoms **and** chemical bonds between the atoms in the compound

i. Use the information above to complete the table below:

Name	Molecular formula	Structural formula	Displayed formula
methane	CH_4		
ethane		CH_3CH_3	
propane			

[*5 Marks*]

ii. There is one other type of formula called a skeletal formula. In these formulae, the carbon atoms are not drawn but are represented by the 'ends and the bends' of lines, all hydrogen atoms are assumed and not written either.

Example:

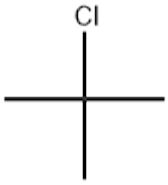
Propane can be represented by: 

Suggest **skeletal** formulae for the following compounds:

Compound	**Structural formula**	**Skeletal formula**
Butane	$CH_3CH_2CH_2CH_3$	
2-methylpropane	$CH_3CH(CH_3)CH_3$	

[4 Marks]

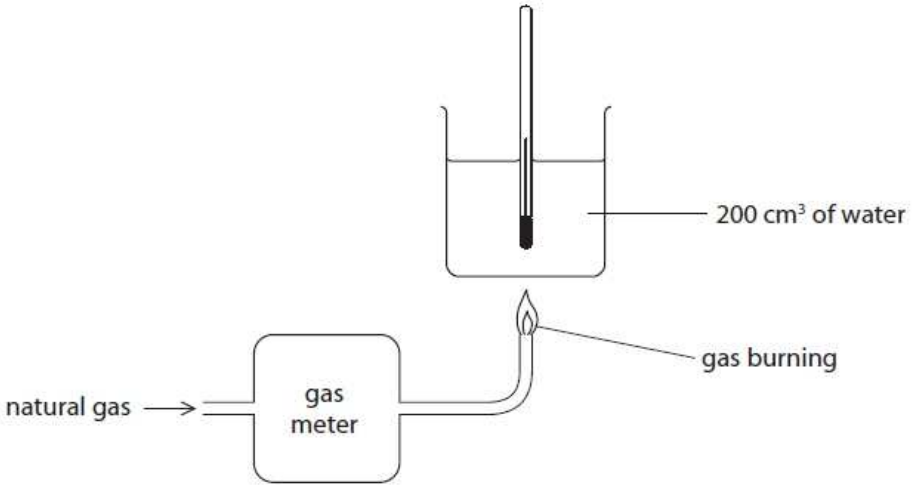
iii. Based on the definitions for the types of formulae above, write the **molecular** formulae for:



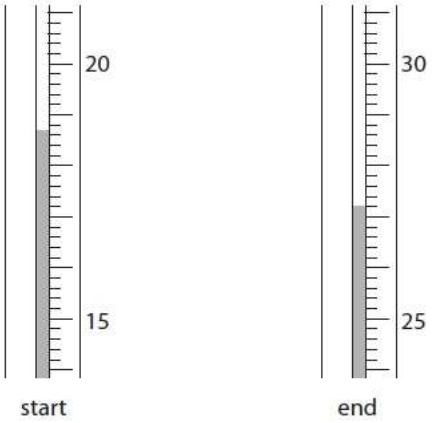
……

[*1 Mark*]

b. A student does some experiments to find the heat energy released when natural gas, methane burns. She uses this apparatus.



i. The diagram shows the thermometer readings in one of her experiments.



Use these readings to complete the table, entering all values to the nearest 0.1 °C.

temperature of water at start in °C	
temperature of water at end in °C	
temperature change in °C	

[3 *Marks*]

ii. Calculate the energy released by burning the methane gas in this experiment using the equation:

Energy = mass of water (g) x specific heat capacity of water (J/g/°C) x temperature change (°C)

where specific heat capacity of water = 4.2 J/g/°C

heat energy change = ... J

[*3 Marks*]

iii. The energy released when a range of other fuels were burned was used to raise the temperature of 100 g of water. For each fuel, the student recorded the mass of fuel burned and the increase in temperature of the water.

Her results are shown in the table:

Fuel	Average relative formula mass	Mass of fuel burned in g	Amount of fuel burned in mol	Increase in temperature in °C
diesel	170	4	0.024	15
ethanol	46	3	0.065	10
methanol	32	2	0.063	5
petrol	114	1	0.009	4

The best fuel is the one that releases the most energy.

Look at the information given in the table and state which fuel is the best fuel per gram.

Justify your answer.

Best fuel per gram is ……..……

……

……

……

……

……

[*2 Marks*]

c. All of the fuels in this question are made or separated from crude oil, a fossil fuel. Explain why it is important for us to look for new sources of power rather than continue to burn fossil fuels.

……

……

……

……

……

[2 *Marks*]

SECTION THREE: PHYSICS [*20 Marks*]

1. On the 12th July 2022 stunning images peering deep into space were released of a by NASA and ESA using the James Webb Space Telescope (JWST).

Figure 1: The Carina Nebula, as seen by Hubble (top) and James Webb (bottom). Credit NASA

This unprecedented resolution, shown in the bottom image, is owed to the fact that JWST is about 100 times more sensitive than Hubble thanks to its much larger light-collecting mirror shown below.

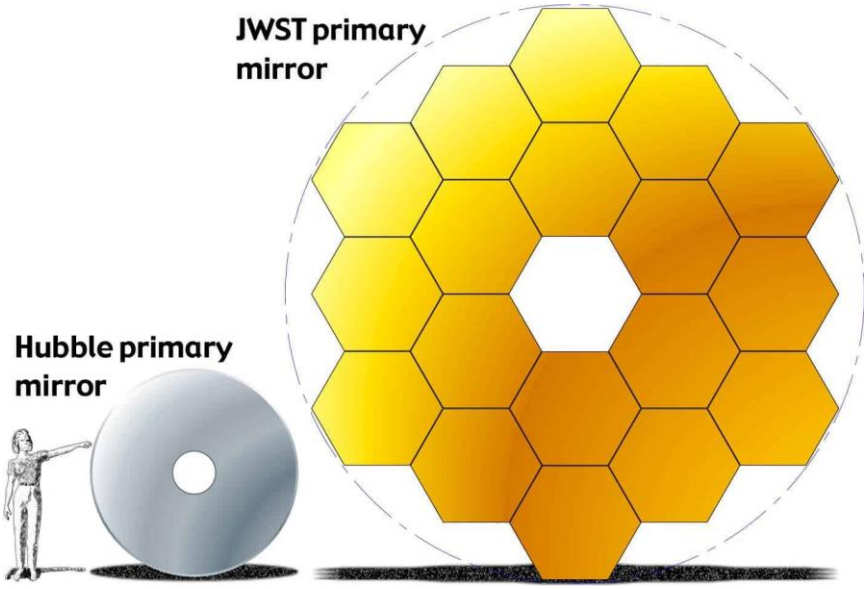


Figure 2: Webb's primary mirror has a diameter of 6.5 meters, compared to Hubble's much smaller 2.4 meters in diameter. Credit: NASA.

Unlike the famous Hubble Space Telescope, JWST is orbiting the sun approximately 1.5 million kilometres away from the Earth. It took JWST approximately 30 days to reach this point in space.

a. Calculate the average speed of JWST in kilometres per hour

Answer: _____km/hour
[2 Marks]

b. Calculate the average speed of JWST in meters per second

Answer: _____m/s
[2 Marks]

Frequency, wavelength and speed are three important properties of the electromagnetic waves that JWST uses to communicate (send back picture and data) with us back on Earth . They are related by the following equation:

Wave Speed (in metres per second) = Frequency (in Hertz) x Wavelength (in metres)

Signals from Earth to JWST are broadcast at a frequency of 2.0×10^9 Hertz. Electromagnetic waves travel at 3.0×10^8 m/s.

c. Calculate the wavelength of the radio wave signals that travel from Earth to the JWST - express your answer in metres.

Answer: _____m
[2 Marks]

The amount of light collected by a telescope depends on the **area** of the telescope's mirror.

$$Area = \pi \times (radius^2)$$

Calculate the area of both the Hubble's mirror and the JWST mirror (please consider the JWST mirror as a circle.

d. Calculate the area of the Hubble's mirror (give your answer to 2 significant figures)

Area: _____ m^2

[2 Marks]

e. Calculate the area of JWST mirror (consider the JWST mirror as a circle).

Area: _____ m^2

[1 Mark]

f. If the Hubble space telescope collects light from a distant galaxy, 36 photons are collected in the telescopes mirror per second. How many photons per second would the JWST mirror collect per second?

photons per second = _____

[2 Marks]

[Total 11 marks]

2. Whilst watching the commonwealth games Alice wanted to know how **long** (time) a high diver has to perform all their flips and spins before hitting the water when competing in the 10 meter high dive competition.

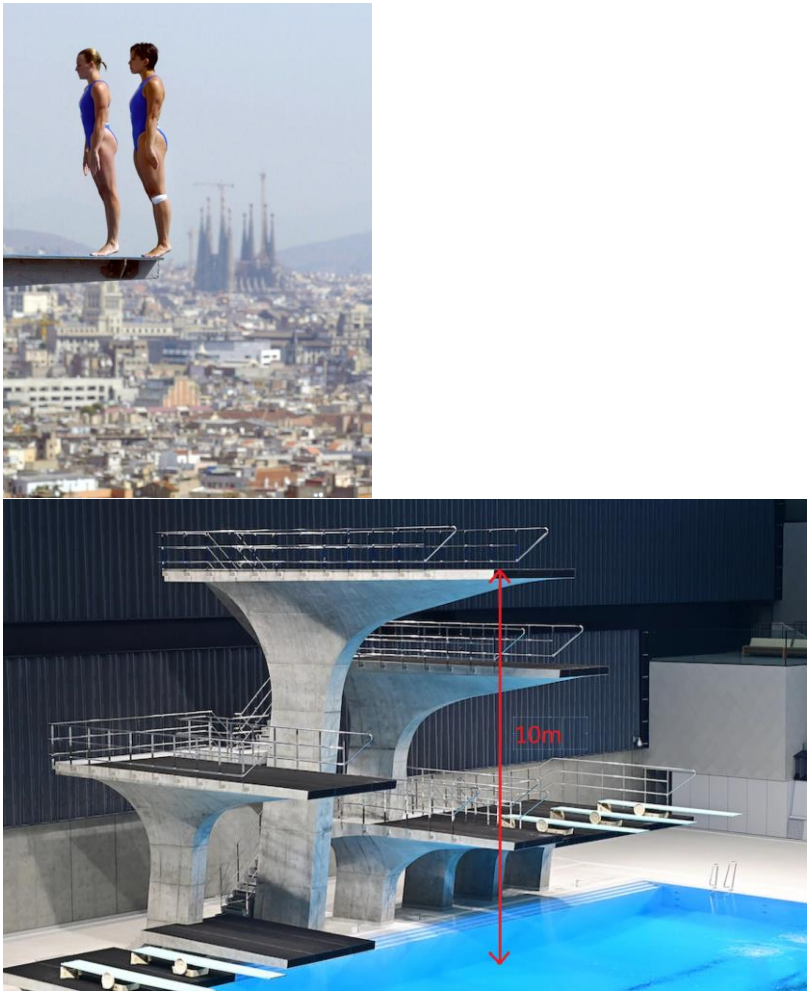


Figure 3: Divers competing in the 10 meter platform diving competition.

a. Describe the motion of the divers after they leave the diving platform in as much detail as possible.

……

……

……

……

[2 marks]

b. Describe the forces acting on them as they fall. Consider the size, direction and type of forces acting.

……

……

……

……

[2 marks]

c. Describe the energy changes that take place as they fall towards the water.

……

……

[1 mark]

d. Alice takes her question to school and asks her physics teacher for help with the calculation. Mr Roberts gives her the following formula to calculate the time to divers will be in the air before hitting the water.

$$H = \frac{1}{2} \times g \times (t^2)$$

where:

H is the hight from which they are falling
g is the acceleration due to gravity on Earth = 10m/s^2
t is the time it takes for the diver to hit the water

Using the information in the images in figure 3 calculate the time the divers have before hitting the water. Explain any assumptions you have made and show all your working below – there are many ways to get full marks in this question.

time = _____s

[*4 Marks*]

[Total 9 marks]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2023))

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

Overview

This is the **13+ Academic Scholarship 2023 Science (Paper 2)** from **Oundle School** in Northamptonshire, designed for pupils sitting scholarship examinations at age 13. The paper tests candidates across **Biology**, **Chemistry** and **Physics** in a single 60-mark examination lasting one hour. Each of the three sections carries the same number of marks (Biology 19, Chemistry 20, Physics 20), reflecting a balanced assessment of all three sciences.

The paper uses a comprehension-based approach in parts, requiring students to interpret extended written passages and data before applying their knowledge. Questions range from structured recall and calculations to graph analysis, energy transformations and molecular representation. Calculators are permitted, and students answer directly on the exam paper itself.

Oundle's scholarship examinations are intended for the most able candidates seeking academic awards, so this paper goes beyond the standard 13+ entrance level. It rewards independent thinking, careful reading and the ability to synthesise information from unfamiliar contexts. The paper is ideal for ambitious pupils preparing for scholarship or competitive entrance tests at independent senior schools.

How this paper is organised

The paper comprises **three equal-weighted sections**: Biology (19 marks), Chemistry (20 marks) and Physics (20 marks), totalling 60 marks in one hour. Section One opens with a comprehension passage on inheritance and genetics, including Punnett square completion and probability calculations, followed by a multi-part question on enzyme activity with graph interpretation. Section Two focuses on hydrocarbons and fuels: students complete molecular, structural, displayed and skeletal formulae for methane, ethane, propane and butane, then perform calorimetry calculations and evaluate fuel efficiency from tabulated data.

Section Three contains two Physics questions. The first explores the James Webb Space Telescope, requiring speed conversions, wavelength calculations from wave-speed equations, and area-based comparisons of mirror sensitivity. The second examines high diving, asking students to describe motion, forces and energy changes

qualitatively before using kinematic equations to calculate fall time from a 10-metre platform.

Each section includes a mixture of short-answer, calculation and extended-response questions. Mark allocations range from 1 to 5 marks per sub-question, clearly indicated in brackets. The paper expects concise written explanations, correct units and clearly shown working for all numerical problems.

Topics covered

- Mendelian genetics: dominant and recessive alleles, genotype and phenotype, Punnett squares and probability ratios
- Enzyme kinetics: substrate concentration and reaction rate, temperature effects on enzyme activity, optimum temperature and denaturation
- Graph interpretation: describing and explaining curve shapes, identifying optimum conditions from multi-line graphs
- Hydrocarbon chemistry: molecular, structural, displayed and skeletal formulae for alkanes (methane, ethane, propane, butane and 2-methylpropane)
- Calorimetry: calculating energy released using specific heat capacity, reading thermometer scales to 0.1°C precision
- Fuel efficiency: comparing fuels by energy per gram, interpreting tabulated experimental data
- Fossil fuels and environmental impact: explaining the need for alternative energy sources
- Wave equation: calculating wavelength from frequency and wave speed, working with standard form (scientific notation)
- Speed, distance and time calculations: unit conversions between km/h and m/s
- Area of circles: applying the formula πr^2 to compare telescope mirror sizes and photon-collection rates
- Kinematics of free fall: using the equation $H = \frac{1}{2}gt^2$ to calculate fall time from height, stating assumptions about air resistance
- Forces and energy in motion: describing gravitational force, energy transfers from gravitational potential to kinetic energy

How to use this paper for revision

- Review Punnett square techniques carefully, ensuring you can distinguish between genotype notation (e.g. LL, Ll, ll) and phenotype descriptions (long eyelashes, short eyelashes) to avoid confusion in inheritance problems.
- Practise drawing all four types of chemical formulae for simple hydrocarbons, especially skeletal formulae where carbons are implicit at bends and ends, as this format often trips students up initially.
- Familiarise yourself with enzyme graphs: recognise that reaction rate rises with temperature or substrate concentration until an optimum, then falls sharply if the enzyme denatures or substrate saturates.
- Drill unit conversions for speed (km/h to m/s involves dividing by 3.6) and work confidently with standard form; these appear repeatedly in Physics calculations.
- When reading analogue thermometers or scales, always count the interval between marked divisions to determine precision (here, each small division is 0.1°C).
- For open-ended 'describe' or 'explain' questions, structure your answer in clear sentences, covering what happens, why it happens, and any relevant scientific terms (e.g. denaturation, active site, kinetic energy).
- Show all working for calculations, including units at each stage; examiners award method marks even if the final answer is incorrect, and clear working helps you spot errors.

Common mistakes to avoid

- Confusing genotype labels (LL, Ll, ll) with phenotype outcomes (long or short eyelashes); remember that both LL and Ll produce long eyelashes because L is dominant.
- Forgetting to convert between units in multi-step calculations, such as using kilometres instead of metres or hours instead of seconds, leading to nonsensical answers.
- Drawing skeletal formulae with explicit carbons or hydrogens; in skeletal notation, every vertex and terminus represents a carbon, and hydrogens are implied, not drawn.
- Misreading the enzyme graph by selecting the wrong line (1, 2 or 3) without checking which temperature gives the peak rate for the organism in question (mammals around 37°C, hot-spring bacteria much higher).
- Dividing instead of multiplying (or vice versa) when rearranging the wave equation v = fλ; write the equation in full and solve algebraically before substituting numbers.
- Leaving thermometer readings to the nearest degree rather than 0.1°C as instructed, losing easy marks for precision and attention to detail.

Exam technique

With 60 marks in 60 minutes, you have roughly **one mark per minute**, so allocate time proportionally: about 20 minutes per section. Start with the section you find easiest to build confidence and bank marks early. In Biology, read the inheritance passage carefully before attempting the Punnett square; underline key terms like 'dominant', 'recessive' and 'gametes'. For the enzyme graphs, describe what you see first (e.g. 'the curve rises, peaks, then falls') before attempting explanations.

In Chemistry, tackle the formula table methodically: complete molecular formulae first (count atoms), then structural (group by carbon), then displayed (draw all bonds), and finally skeletal (vertices only). Double-check your bond counts (carbon always forms four bonds). For calorimetry, write the formula out, substitute values with units, and show every arithmetic step. When comparing fuels, calculate energy per gram for each by dividing total energy by mass burned, then rank them.

In Physics, use the formulae provided and rearrange algebraically before plugging in numbers. State any assumptions clearly (e.g. 'ignoring air resistance', 'treating the mirror as a perfect circle'). If a question asks you to 'describe' motion or forces, write in full sentences covering direction, magnitude and type. Finally, reserve the last five

minutes to reread your answers, check units, and verify that numerical answers are sensible (e.g. a fall time of 1.4 seconds is plausible; 140 seconds is not).

What to revise alongside this paper

In Biology, extend your genetics revision to include **co-dominance**, **sex-linked inheritance** and **pedigree diagrams**. Study enzyme action in more depth, covering lock-and-key and induced-fit models, competitive and non-competitive inhibition, and the role of pH. For cells, review DNA structure, transcription and translation, as these underpin how genes encode characteristics.

In Chemistry, consolidate your knowledge of the **alkanes** and progress to **alkenes** (with C=C double bonds), **isomerism** (structural and stereoisomerism), and the basics of **fractional distillation** of crude oil. Practise balancing combustion equations (hydrocarbon + oxygen → carbon dioxide + water) and calculating energy changes using bond enthalpies. Explore renewable energy sources (solar, wind, biofuels) to support discussion of alternatives to fossil fuels.

In Physics, revisit **Newton's laws of motion**, particularly the relationship between force, mass and acceleration. Study energy conservation in more detail: mechanical energy, thermal energy, efficiency and power. Review the **electromagnetic spectrum** (radio, microwave, infrared, visible, UV, X-ray, gamma) and properties of waves (reflection, refraction, diffraction). Strengthen algebraic manipulation of formulae and practice converting between units confidently, as these underpin almost every calculation at this level.

Key terms

> **Dominant allele**, **Recessive allele**, **Genotype**, **Phenotype**, **Punnett square**, **Enzyme**, **Denaturation**, **Substrate**, **Hydrocarbons**, **Structural formula**, **Skeletal formula**, **Calorimetry**, **Specific heat capacity**, **Wavelength**, **Frequency**, **Standard form**, **Gravitational potential energy**, **Kinetic energy**, **Free fall**, **Area (of a circle)**

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