13+ PAST PAPER PACK

Oundle School 13+ Science 2022

Complete Past Paper Pack

CONTENTS

OUNDLE
School

EXAMINATION PAPER
Non Common Entrance 2022

Science

Time allowed: 1 hour

Name: _____

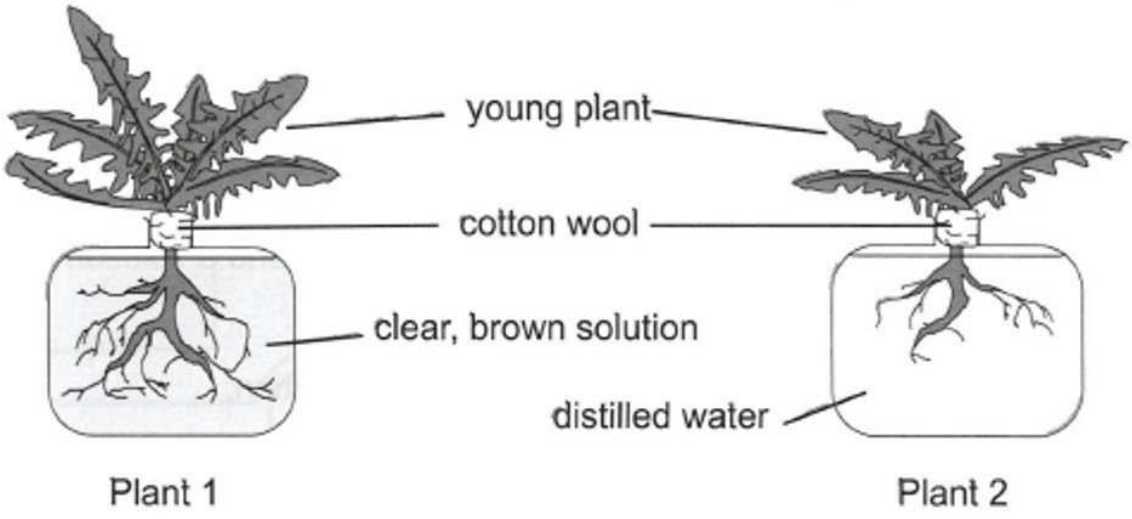
Instructions

- Write your name clearly in the space above.
- Answer in the space on 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.

Biology Section

1. Plants need to take in water from the soil.

   Dr Gabion decides to do an experiment to find out if there is anything else in the soil which plants use for growth.



   Dr Gabion made the clear, brown solution for Plant 1 by mixing up soil and water, and then separating the soil particles out to leave the clear, brown solution.

   a. What method could Dr Gabion use to separate the soil particles from the brown solution?

   ..... [1]

   b. Why did Dr Gabion grow one plant in distilled water?

   ..... [1]

   c. What types of substances are in the clear, brown solution that the plant uses for growth?

   ..... [1]

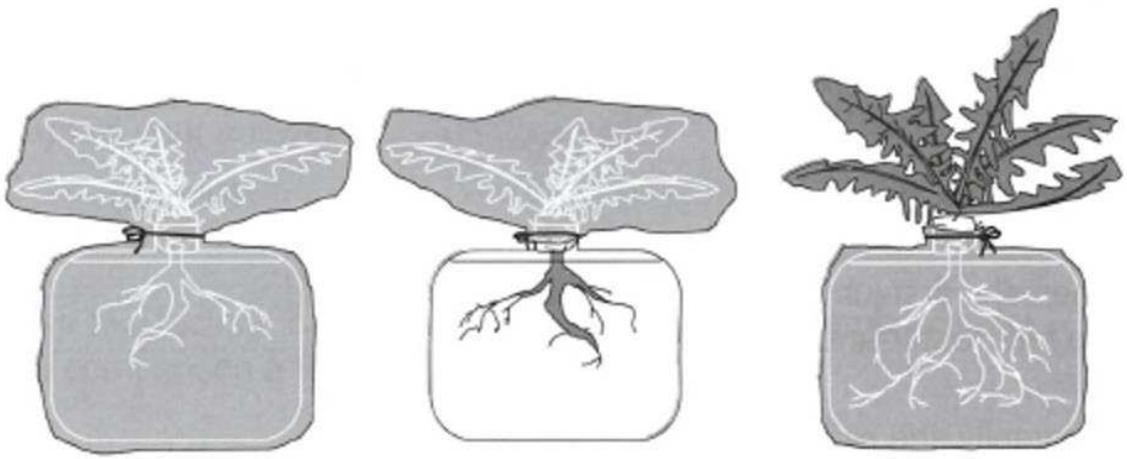
   d. Explain how roots are adapted to take in water.

   .....

   ..... [1]

Dr Gabion carried out another experiment with three similar plants.

The solutions in each container were the same. He put all the plants in a sunny place. The pictures show the results of the experiment.



Plant 3	Plant 4	Plant 5
The container holds the clear, brown solution. The container and leaves are wrapped in black plastic.	The container holds the clear, brown solution. The leaves are wrapped in black plastic.	The container holds the clear, brown solution. The container is wrapped in black plastic.

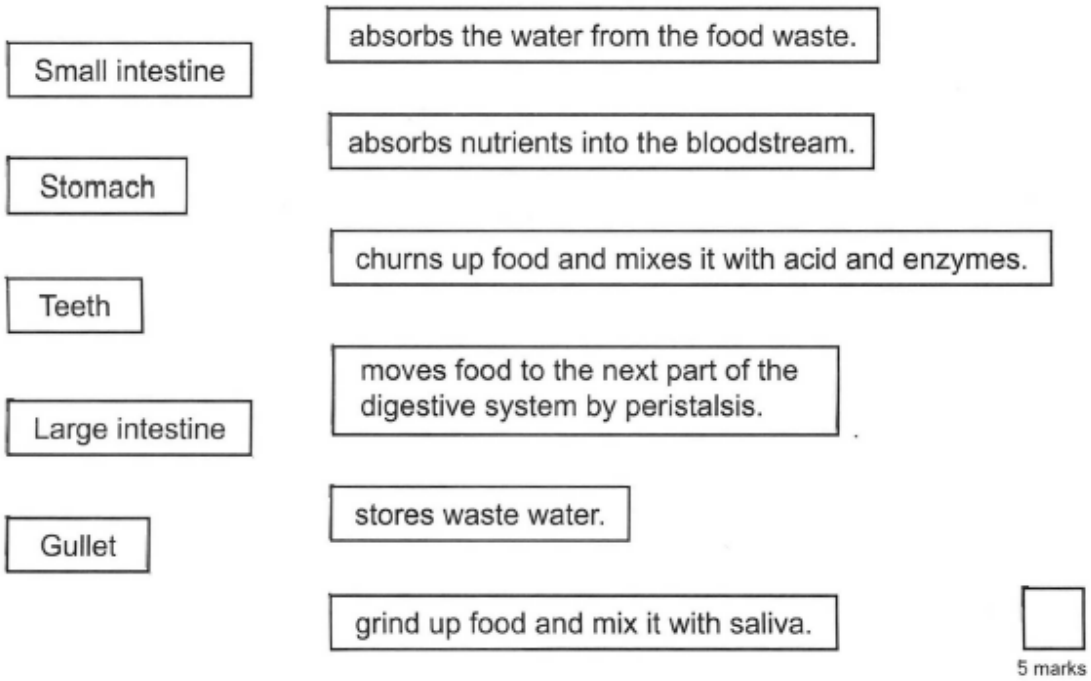
e. Explain why Plant 5 was the only one that grew well.

.....

..... [1]

[Total: 5]

2. Draw lines to match the parts of the body with the function that they carry out in human digestion.



5 marks

[Total: 5]

3. Read the following description of a garden ecosystem.

> The 'cabbage white' butterfly feeds on brassica plants. It shares this food source with slugs and snails, but the slugs and snails will also eat lettuce. Small birds like blue tits and thrushes eat the butterflies, slugs and snails. Cats eat the blue tits and the thrushes.

a. Draw out the food web in the space provided

b. A gardener uses slug pellets to kill slugs and snails to stop them eating his plants. Describe and explain the effect you would expect this to have on the number of blue tits in the garden.

.....

.....

.....

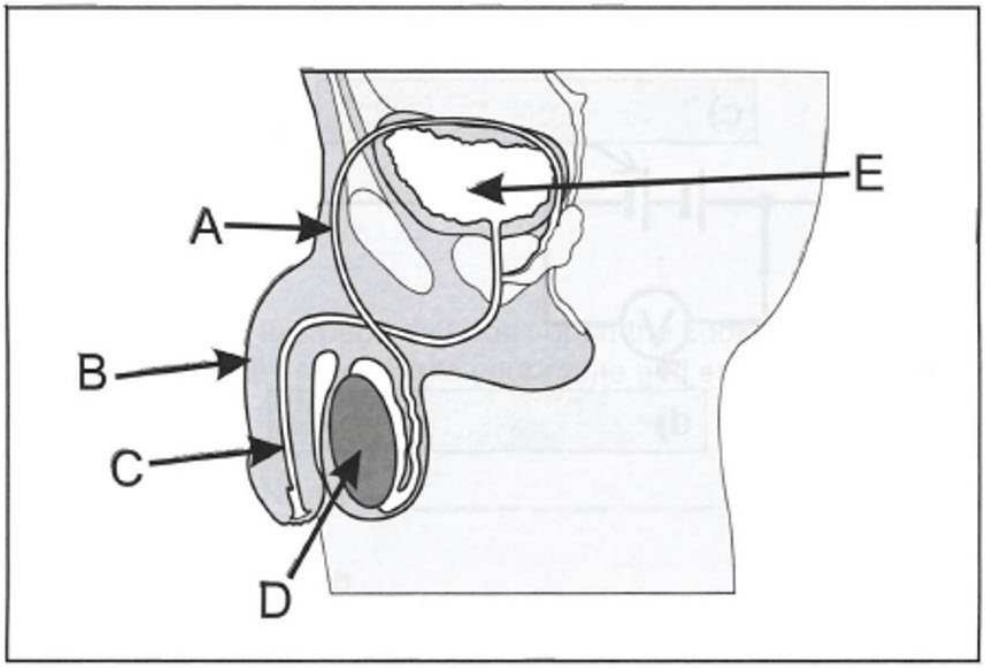
..... [2]

[Total: 5]

4. The diagram below shows the male reproductive system.

   a. Choose from the words in the box below to name each part of the male reproductive system labelled in the diagram.

sperm tube	urethra	bladder	testis	penis



A: ……

B: ……

C: ……

D: ……

E: …… [4]

   b. Name the sex cell produced by the male reproductive system.

..... [1]

[Total: 5]

Chemistry Section

1. Atoms join to other **atoms** to form **molecules**. The diagrams shown in the table represent **molecules** with the following chemical formulae.

   CO H_2 H_2O and NH_3.

   Fill in the right hand column of the table, putting the correct chemical formula with each diagram.

Key ○ oxygen atom ● hydrogen atom

◍ nitrogen atom ◐ carbon atom

diagram of molecule	chemical formula
	
	
	
	

[Total: 4]

2. Use the Periodic Table below to help you answer the questions.

Relative atomic

1	2											3	4	5	6	
									1 H Hydrog 1							4 He Helium 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
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 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	64 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	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
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	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Atomic number (Proton

a. Which element is in Group 1 Period 3?

..... [1]

b. Which element is the Noble gas in Period 4?

..... [1]

c. Which typical non-metal element is yellow, dull and brittle?

..... [1]

d. Mendeleev ordered the elements by increasing?

..... [1]

e. Carbon burns in oxygen to form carbon dioxide. What would the pH of the solution be if the gas is passed through water?

..... [1]

[Total: 5]

3. The drawing below shows a gemstone set in a gold ring.

Gemstones called rubies are made from an aluminium compound with the formula Al_2O_3. The chemical symbol for aluminium is Al.

a. Give the name of the **element** that is combined with aluminium in this compound.

..... [1]

b. Suggest the **name** of the compound with the formula Al_2O_3.

..... [1]

c. How many **atoms** are there in the formula Al_2O_3

..... [1]

d. The gemstone in the drawing is set into a gold ring. Gold is an element that is found in rocks.

Gold is never found combined with other elements. Part of the reactivity series of metals is shown below.

more reactive	aluminium
	zinc
	lead
less reactive	copper

i. Where should gold be placed in this reactivity series?

..... [1]

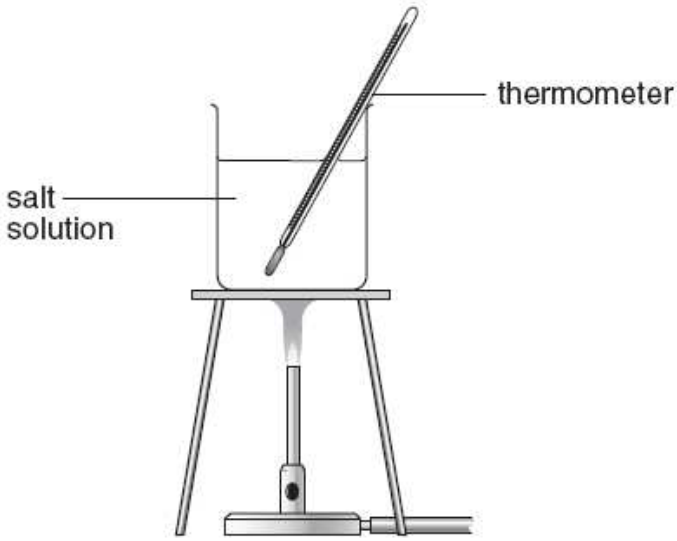
ii. The more reactive metals react with acids. Complete the word equation for the reaction of zinc with hydrochloric acid.

zinc + hydrochloric acid → ..... + ... [2]

[Total: 6]

4. Neera and Tom dissolved different masses of salt in 500 cm^3 of water.

They measured the temperature at which each salt solution boiled using the apparatus below.



a. They wrote down some variables that might affect the investigation.

- A Temperature of the laboratory
- B Starting temperature of the water
- C Volume of water
- D Mass of salt in water
- E Boiling point of salt solution
- F Type of salt solution

i. Which variable, A-F, is the independent variable in the investigation?

..... [1]

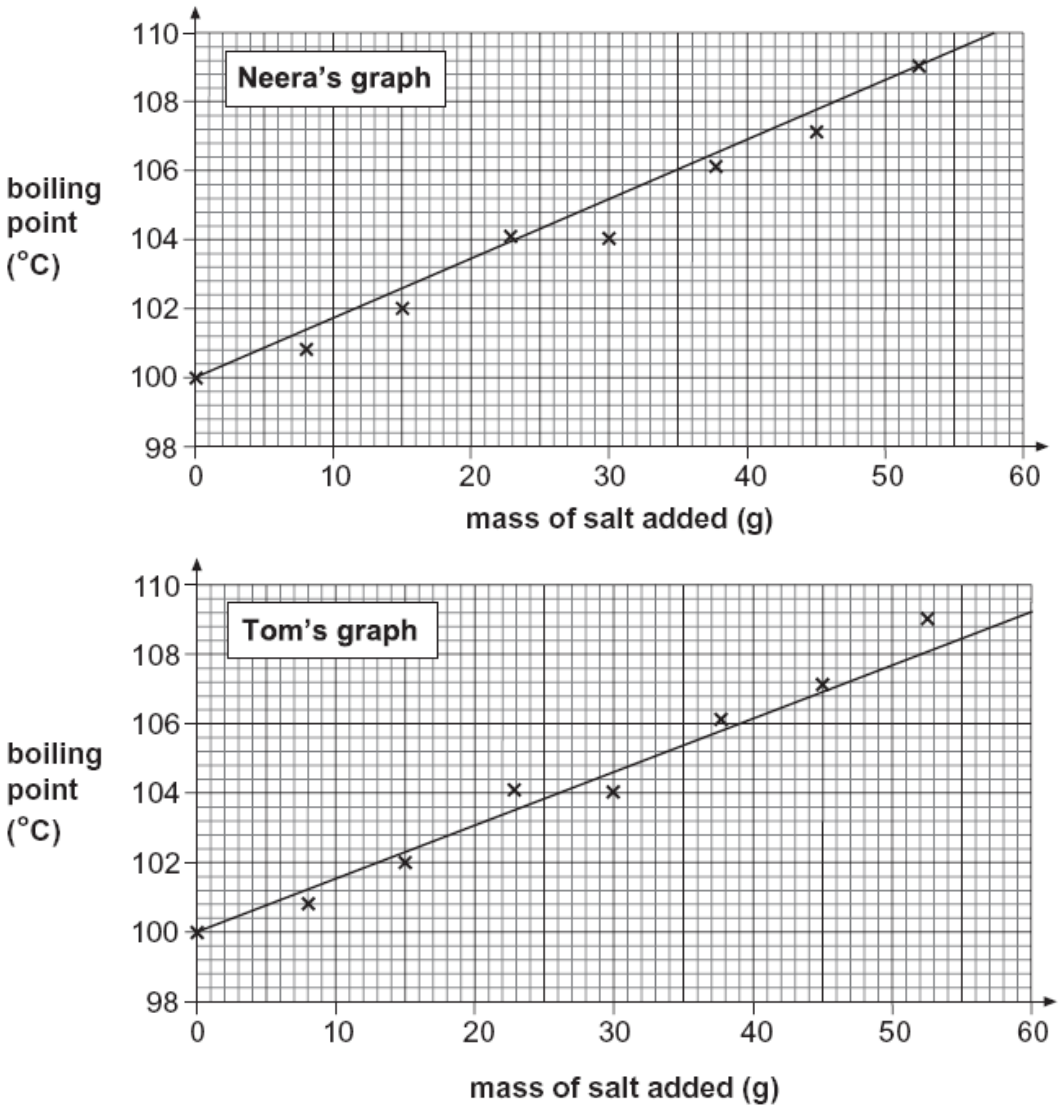
ii. Which variable, A-F, is the dependent variable in their investigation?

..... [1]

iii. Which variable above would affect the experiment **the least**?

..... [1]

Neera and Tom plotted their results and drew the graphs shown below.



b. How can you tell from the graphs that Nera and Tom started with pure water?

.....

..... [1]

c. Why is Tom's line of best fit better than Neera's line of best fit?

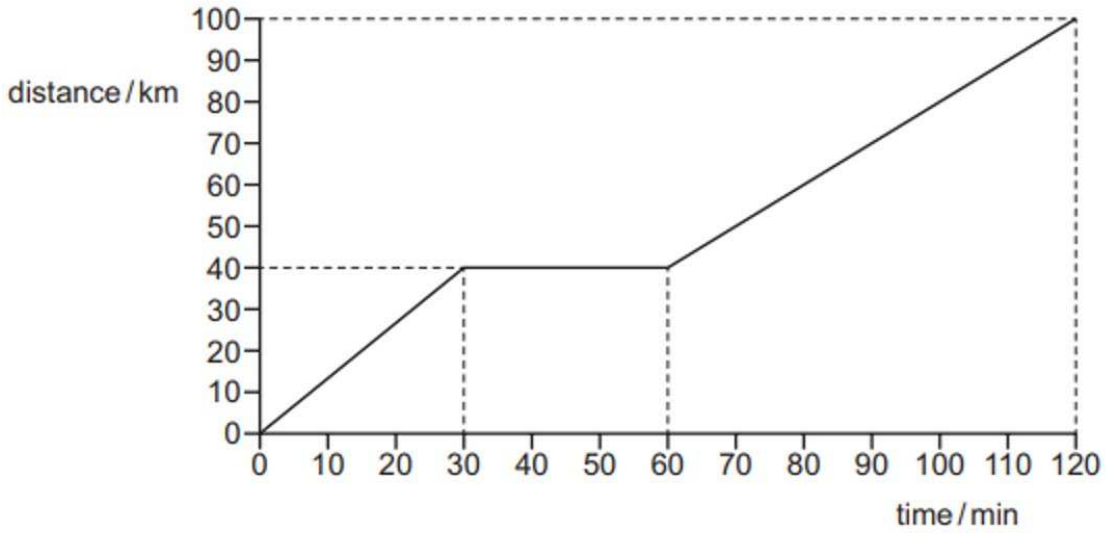
.....

..... [1]

[Total: 5]

Physics Section

1. The distance-time graph for a motorway journey is shown.



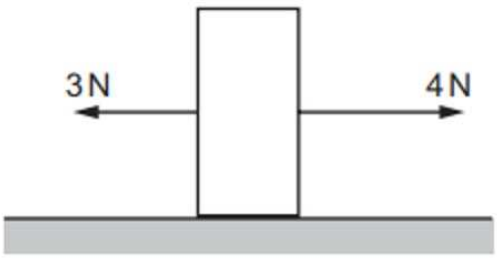
What is the average speed for the journey?

a. 50 km/h
b. 67 km/h
c. 70 km/h
d. 83 km/h

2. On Mars, the acceleration of free fall g is 3.7 m/s^{2}. What is the weight of a 2.0kg mass on Mars?

a. 0.54N
b. 1.9N
c. 7.4N
d. 20N

3. The diagram shows a solid object on a flat surface, with two forces acting on the object.

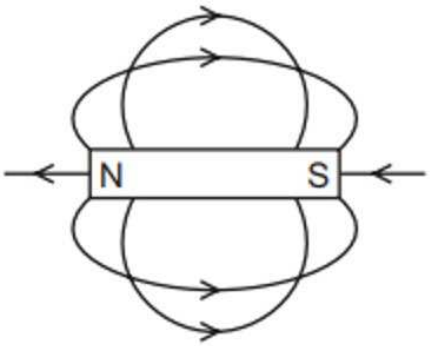


What is the resultant force on the object?

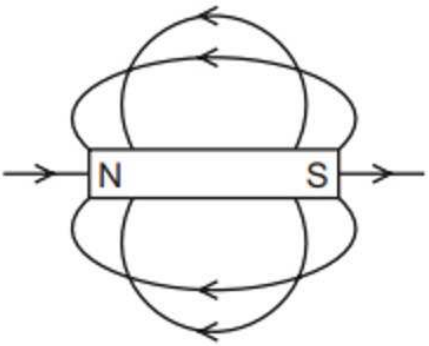
a. 1N to the left
b. 1N to the right
c. 7N to the left
d. 7N to the right

4. Which diagram shows the pattern and direction of the magnetic field lines around a bar magnet?

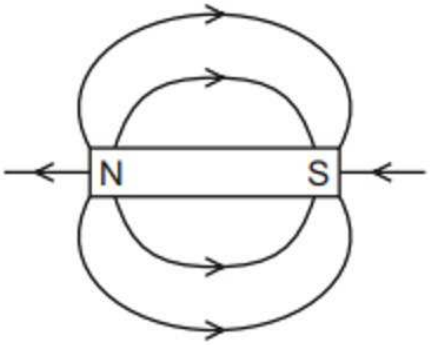
A



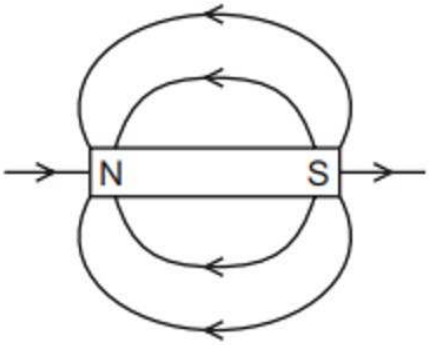
B



C



D



5. A book has a mass of 400g.

   The surface of the book in contact with a table has dimensions 0.10m x 0.20m.

   The gravitational field strength is 10 N/kg.

   What is the pressure exerted on the table by the book?

   a. 0.08 N/m^2
   b. 8.0 N/m^2
   c. 20.0 N/m^2
   d. 200.0 N/m^2

6. Fig. 6.1 shows a speed–time graph for a car

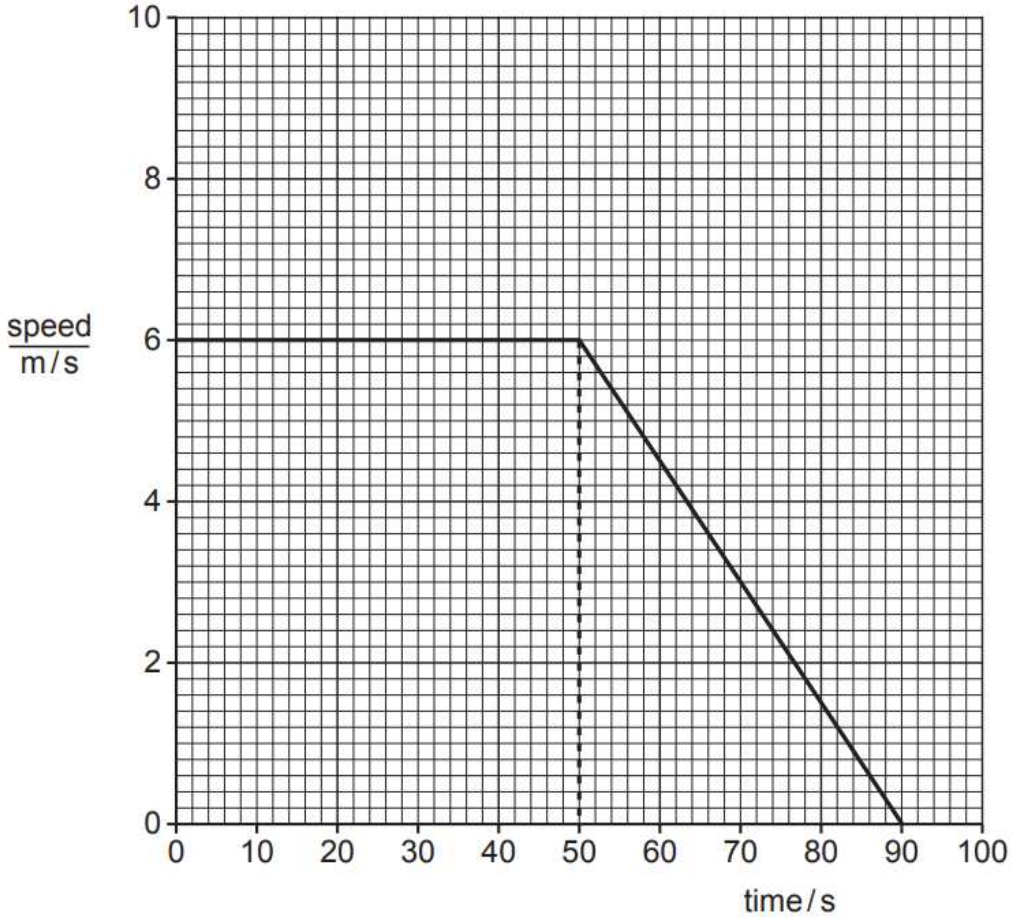


Figure 6.1

(a) Describe the motion of the car from 0 to 50s, as shown in Fig. 6.1.

..... [1]

(b) Describe the motion of the car from 50s to 90s, as shown in Fig. 6.1.

.....

..... [1]

(c) Calculate the distance travelled by the car between 50s and 90s.

distance travelled = ... m [3]

(d) A motorcycle travels at a constant speed. The motorcycle travels 710m in 87s.
Calculate the speed of the motorcycle and show that it is close to 8m/s.

[3]

[Total: 8]

7. Fig. 7.1 shows two men repairing a weak roof using a crawler-board.

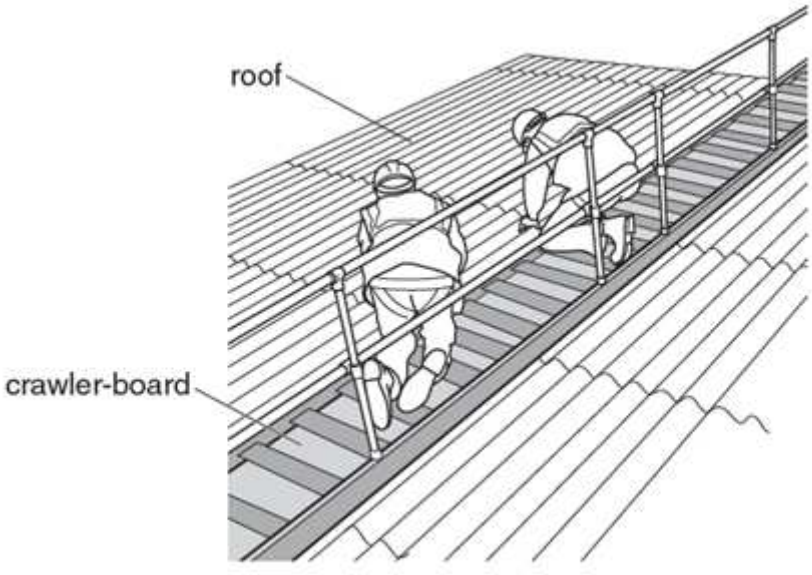


Figure 7.1

a) Explain why use of the crawler-board prevents the men from falling through the roof.

.....

.....

.....

.....[2]

b) The crawler-board has a weight of 400 N. The total weight of the two men is 1600N

The area of the crawler-board in contact with the roof is 0.8 m^2.

Calculate the pressure on the roof when the men are on the crawler-board.

Include the unit.

pressure = ...[5]

[Total: 7]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2022))

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

Overview

This is **Oundle School's 13+ Science entrance examination** from 2022, designed for candidates seeking entry to Year 9. The paper tests **Biology, Chemistry, and Physics** across three equal-weighted sections, with a total of 60 marks available and a one-hour time limit. Calculators are permitted throughout.

The paper is structured as a comprehensive test of Key Stage 3 science knowledge, combining short-answer questions, calculations, and diagram-based tasks. **Each section carries the same number of marks** (20 marks per section), requiring candidates to demonstrate breadth across all three disciplines. Questions range from experimental design and data interpretation to chemical formulae, force diagrams, and speed-time graphs.

This paper suits students preparing for **13+ entrance examinations at independent schools**, particularly those targeting competitive entries where a solid grounding in all three sciences is expected. The mixture of recall, application, and analysis makes it a rigorous assessment of scientific literacy at this level.

How this paper is organised

The paper opens with clear instructions emphasising that **all questions must be answered** and that candidates should write directly on the paper. The three sections (Biology, Chemistry, Physics) are presented sequentially, with no indication that candidates may tackle them in any order, though the equal mark allocation suggests balanced time management.

The **Biology section** includes five questions worth 5 marks each, covering plant nutrition, human digestion, food webs, and reproduction. Questions vary from one-mark short answers to a five-mark matching task. The **Chemistry section** follows with four questions (totalling 20 marks), incorporating molecular diagrams, periodic table interpretation, reactivity series, and experimental variables. The **Physics section** closes the paper with seven questions (20 marks), mixing five multiple-choice items with two structured calculation and explanation tasks.

The layout is clean and spacious, with clearly labelled diagrams and adequate space for written responses. The final two physics questions are more substantial, each worth 7–8 marks, requiring multi-step calculations and extended explanations.

Topics covered

- Plant nutrition and mineral uptake from soil, including experimental design for testing nutrient solutions
- Separation techniques (filtration) to isolate dissolved substances from soil mixtures
- Root adaptations for water absorption, including structural features such as root hair cells
- Photosynthesis and the necessity of light for plant growth, as demonstrated through controlled experiments
- Human digestive system anatomy and physiology, matching organs to their specific functions
- Food webs and ecological relationships, including predator-prey dynamics and the impact of pesticides on food chains
- Male reproductive system anatomy, labelling key structures such as testes, sperm tube, urethra, bladder, and penis
- Chemical formulae and molecular structure, interpreting diagrams of simple molecules (H_2, CO, H_2O, NH_3)
- The Periodic Table: identifying elements by group and period, recognising noble gases and typical non-metal properties
- The reactivity series of metals, predicting chemical behaviour and placement of unreactive elements like gold
- Acid-metal reactions and word equations, completing equations for zinc and hydrochloric acid
- Compounds and nomenclature, naming aluminium oxide (Al_2O_3) and counting atoms in formulae
- pH of solutions formed when non-metal oxides dissolve in water, understanding acidic products
- Experimental variables: independent, dependent, and control variables in scientific investigations
- Boiling point elevation by dissolved salts, interpreting graphs and evaluating lines of best fit
- Speed-time graphs: interpreting motion, calculating distance travelled, and understanding uniform deceleration
- Weight calculation using the formula W = mg, applying gravitational field strength on Mars
- Resultant force from opposing horizontal forces, determining net force and direction

- Magnetic field patterns around bar magnets, recognising correct field line direction from north to south poles
- Pressure calculations using P = F/A, including unit conversions and summing forces

How to use this paper for revision

- Practise drawing food webs from written descriptions, ensuring arrows always point from food source to consumer, and double-check that all organisms mentioned are included.
- Revise the functions of each part of the digestive system using a labelled diagram, then test yourself by covering the labels and writing them from memory.
- For molecular formulae questions, sketch the molecules yourself using coloured pens for different atoms to reinforce the relationship between structure and formula.
- Memorise the reactivity series order (potassium, sodium, calcium, magnesium, aluminium, zinc, iron, lead, copper, silver, gold) using a mnemonic or flashcards.
- When interpreting distance-time or speed-time graphs, calculate the gradient step-by-step and always include units in your final answer to avoid losing marks.
- For experimental variables, practise identifying what the experimenter changes (independent), what they measure (dependent), and what they keep constant (control) in sample investigations.
- Review pressure calculations by working through at least five examples where you must convert mass to weight, then divide by area, always stating the unit Pa or N/m^2.

Common mistakes to avoid

- Confusing filtration with other separation methods: filtration separates insoluble solids from liquids, not dissolved substances from solutions.
- Drawing food web arrows in the wrong direction: arrows must point from the organism being eaten to the organism that eats it, showing energy flow.
- Forgetting to convert mass to weight before calculating pressure: weight (in newtons) equals mass (kg) times gravitational field strength (10 N/kg on Earth).
- Miscounting atoms in chemical formulae: in Al_2O_3, the subscripts mean 2 aluminium atoms and 3 oxygen atoms, totalling 5 atoms, not 23.
- Misinterpreting speed-time graphs: the area under the graph gives distance travelled, not the gradient, which represents acceleration or deceleration.
- Writing incomplete word equations: for zinc plus hydrochloric acid, students often omit hydrogen gas as one of the products, writing only zinc chloride.

Exam technique

Allocate **20 minutes per section** (Biology, Chemistry, Physics) to maintain balance, as each section carries equal marks. Start with the section you find most confident to build momentum, but avoid spending excessive time on any single question. If a question is worth only 1 mark, your answer should be concise (one sentence or a single word), whereas a 5-mark question demands a detailed, multi-point response.

For calculation questions in Physics and Chemistry, always **show your working step-by-step**, even if the question does not explicitly request it. This approach allows you to earn method marks if your final answer is incorrect. Write the formula first, substitute the values, then calculate, and finally box or underline your answer with the correct unit. If you finish early, use the remaining time to check your units, reread graph axes, and verify that all parts of multi-step questions have been attempted.

In diagram-based tasks (food webs, molecular structures, magnetic fields), use a ruler for straight lines and draw arrows clearly. Label your diagrams neatly and double-check that all required elements are present. For matching tasks, draw a single clear line between each pair; multiple lines or corrections can confuse the marker and cost marks.

What to revise alongside this paper

Students should consolidate their understanding of **cells and tissues**, particularly plant and animal specialised cells (root hair cells, sperm cells) and their adaptations. Revise the circulatory system alongside digestion, as nutrient absorption in the small intestine links directly to transport in the bloodstream. In Chemistry, extend your study of the Periodic Table to include **atomic structure** (protons, neutrons, electrons) and how it determines an element's position and properties.

For Physics, practise more complex motion graphs, including velocity-time graphs with changing gradients, and explore **Newton's laws of motion** to deepen your understanding of forces and acceleration. Work on additional pressure problems involving different shapes and liquids to build confidence with the formula P = F/A. Tackle past papers from other schools' 13+ entrance exams to familiarise yourself with alternative question styles and reinforce your recall of key equations.

Finally, strengthen your experimental design skills by writing out method steps for classic investigations (testing acidity, measuring reaction rates) and identifying variables. This will prepare you for the practical reasoning questions that appear across all three sciences.

Key terms

> **Filtration**, **Distilled water**, **Mineral salts**, **Root hair cells**, **Photosynthesis**, **Food web**, **Consumer**, **Peristalsis**, **Enzyme**, **Sperm**, **Testes**, **Chemical formula**, **Molecule**, **Periodic Table**, **Noble gas**, **Reactivity series**, **Word equation**, **Aluminium oxide**, **Independent variable**, **Dependent variable**, **Control variable**, **Boiling point**, **Line of best fit**, **Speed-time graph**, **Resultant force**, **Weight**, **Pressure**, **Magnetic field**, **Newton (N)**, **Pascal (Pa)**

OUNDLE
School

EXAMINATION PAPER
Academic Scholarship 2021

Science (Paper 1)

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above.
- Write your answer on the question 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 64.

SECTION ONE: BIOLOGY [24 Marks]

1. When Liam fell off his bike, he dislocated his shoulder. A doctor examined Liam's shoulder joint and the muscle surrounding it.

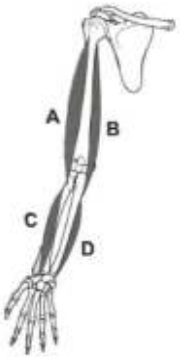
    a. Muscles work in antagonistic pairs. What does this mean?

    …….

    …….

    [2 marks]

    b. The diagram below shows the muscles and bones in the arm.

    Which of the muscles in the diagram, **A, B, C** or **D** contracts to bend the arm at the elbow?

    …….

    [*1 mark*]

2. Animals get characteristics from their parents. Complete the following sentences.

    a. Information about an animal's characteristics is passed on by a molecule called

    ……

    b. The female's genes are passed in the egg. The male's genes are passed in the

    …….……

    c. The genes are held in the …….…… of the cells.

    d. The process of passing characteristics by genes has a special name. We say that the children ……..…….. characteristics from their parents.

    [4 marks]

3. Keith wants to find out which snack has the highest energy content. He does an experiment to look at the amount of energy in two brands of crisps.

He burns a sample of the food to see how much this raises the temperature of the water in the test tube. This rise in temperature uses the energy from the food.

a. Suggest two things Keith should have done to make the experiment a fair test.

- ……...
- ……...

[2 marks]

b. Keith should also take some precautions to increase the safety of the experiment. Give two things he could do to make the experiment safer.

- ……...
- ……...

[2 marks]

c. The table shows the nutritional details from the packets of the different brands.

	Energy /kJ	Protein /g	Carbohydrate /g	Fat /g	Fibre /g
100g of Runner's Crisps	2050	6.2	52.6	28.7	4.2
100g of Health Snacks	1300	9.2	45.1	10.5	9.1

Keith repeats his experiment using 10g of each brand. Write down the letter of the correct statement.

A: The temperature will rise more with the Runner's Crisps.
B: The temperature change will be the same.
C: The temperature will rise more with the Health Snacks.

The correct statement is ……

[1 mark]

d. Neither snack contains vitamin C. Give an example of a food that provides a good source of vitamin C.

……

[1 mark]

e. Why is fibre important to a balanced diet?

……

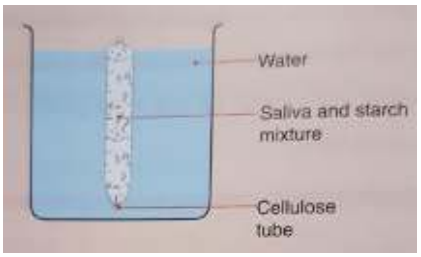
[1 mark]

f. Using the table, give **two** reasons why Health Snacks are healthier than Runner's Crisps.

- ……...
- ……...

[2 marks]

4. Felix and Gena got together to try to make a model gut. They used a cellulose tube, as shown in the diagram. The tube contained a mixture of saliva and starch.



a. How could they prove that starch was present at the start of the experiment?

……

……

[2 marks]

b. They believed that the saliva contained an enzyme that could break down starch. What would be the best temperature to keep the mixture at, while this breakdown was going on?

……

[1 mark]

c. After twenty minutes they tested the contents of the model gut for starch. They got a negative result. Gena thought that this was because the starch had crossed the wall of the gut into the water. How could Felix try to prove that this wasn't the explanation?

……

……

……

[3 marks]

d. Felix and Gena eventually agreed that starch could not cross the wall of their model gut. Why can't starch cross in this way?

……

[1 mark]

e. In the body, what is represented by the water in the beaker?

……

[1 mark]

SECTION TWO: CHEMISTRY [20 Marks]

For each question, choose the correct option, A, B, C or D.

[5 marks]

1. Elements are found on the Periodic Table; an element is:

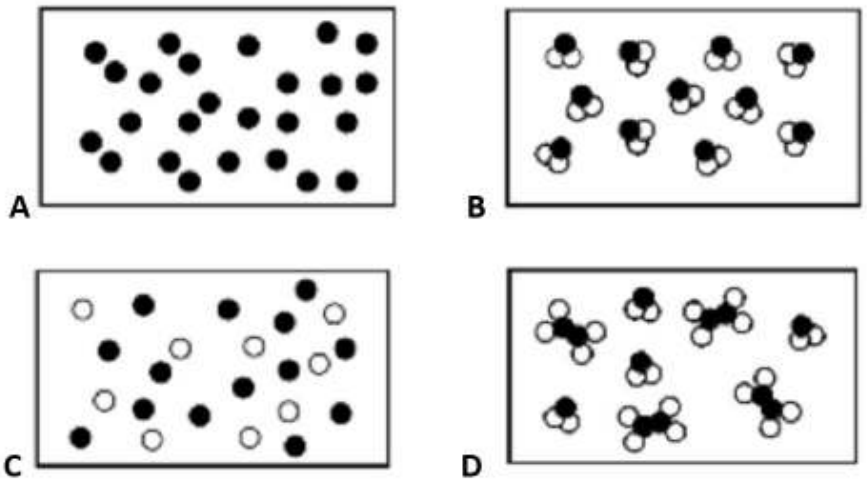
    a. A substance with more than one type of atom mixed together.
    b. A substance with more than one type of atom chemically joined together.
    c. A substance with only one type of atom.
    d. A substance that only contains individual atoms.

2. Sulphur is a typical non-metal element.

    Which of the following properties is **not** that of a typical non-metal?

    a. Low melting point.
    b. Dull appearance.
    c. An insulator.
    d. Malleable.

3. Which of the following diagrams is of a pure compound

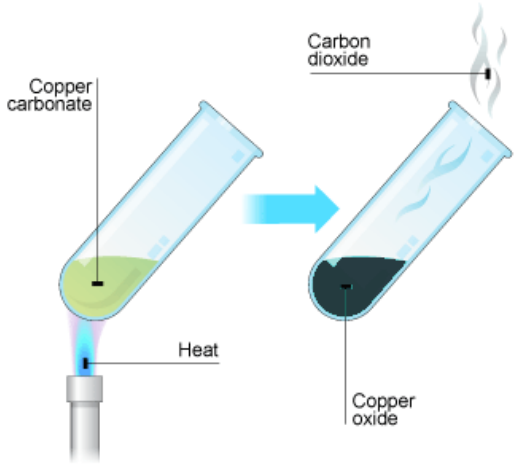


4. How many protons, electrons and neutrons are there in an atom of fluorine?

    a. 9 protons, 10 electrons and 9 neutrons.
    b. 10 protons, 10 electrons and 9 neutrons.
    c. 9 protons, 9 electrons and 10 neutrons.
    d. 10 protons, 9 electrons and 10 neutrons.

5. Which is the correct formula for magnesium hydroxide:
    a. MgOH
    b. $Mg(OH)_2$
    c. MgO
    d. $Mg(O)_2$

6. When copper carbonate is heated strongly, a thermal decomposition reaction occurs and copper oxide and carbon dioxide are produced.



a. What does the term 'thermal decomposition' mean?

……

[1 mark]

b. Write a word equation for this reaction.

……

[1 mark]

c. How could you prove that carbon dioxide is one of the products?

……

……

[2 marks]

d. Copper oxide is a black solid and a base. It reacts with sulphuric acid, H_2SO_4, to form a salt and water.

i. How many atoms are there in the formula H_2SO_4?

……

[1 mark]

ii. Name the salt produced in this reaction.

……

[1 mark]

e. Excess copper oxide is added to ensure all the acid reacts. What does excess mean?

……

[1 mark]

f. Describe a method to obtain pure salt crystals from the reaction mixture.

……

……

……

……

……

……

……

……

……

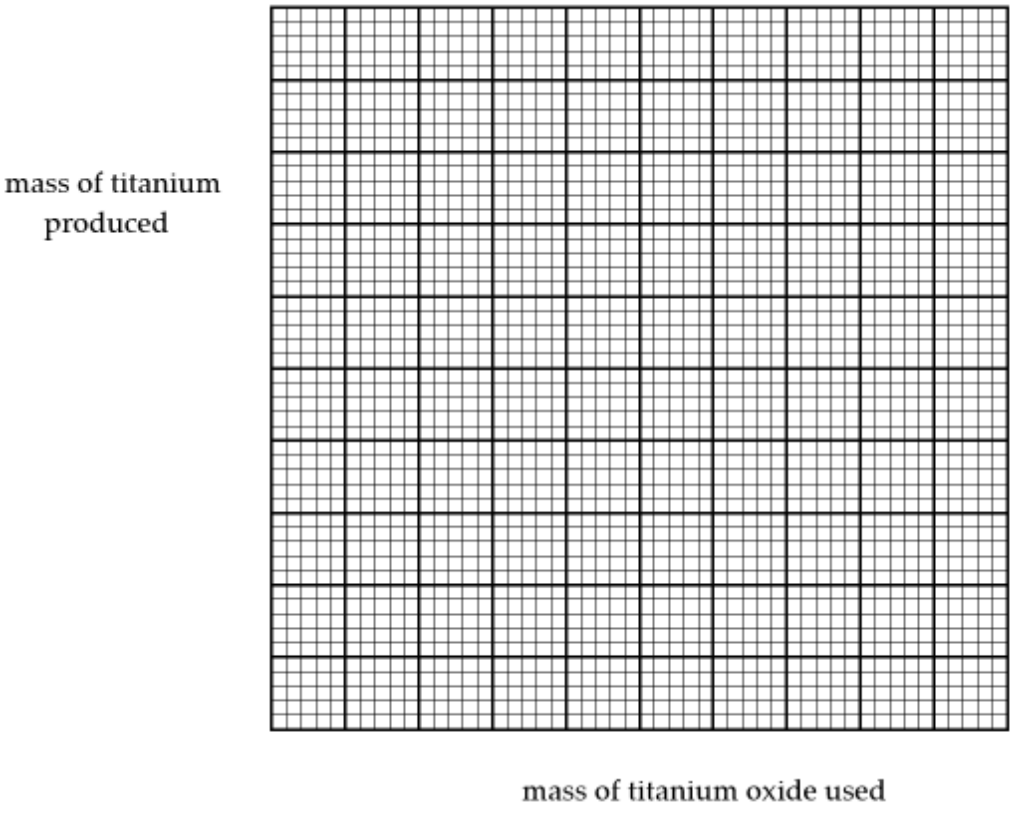
[3 marks]

7. Titanium metal, Ti, can be obtained from its ore, rutile. Rutile contains titanium dioxide, TiO_2. The titanium dioxide is first converted to titanium chloride, $TiCl_4$, then the titanium chloride is reacted with sodium to produce titanium and sodium chloride, NaCl.

   In a series of experiments Bethany measured the mass of titanium that was obtained from different masses of titanium oxide. The results were:

mass of titanium oxide used /g	mass of titanium obtained /g
2.0	1.2
4.5	2.7
7.0	4.2
9.0	5.4
12.5	7.5
15.0	9.4
17.0	10.2
19.0	11.4
22.0	13.2

   a. On the graph paper plot a graph of these results. You should choose scales on the axes so you use as much of the paper as possible; remember to add the units you have used.



[3 marks]

b. Showing your working on the graph, find the mass of titanium dioxide that must be used to obtain 5.0 g of titanium.

Mass of titanium dioxide ……./g

[1 mark]

c. Describe the trend shown on the graph.

…….

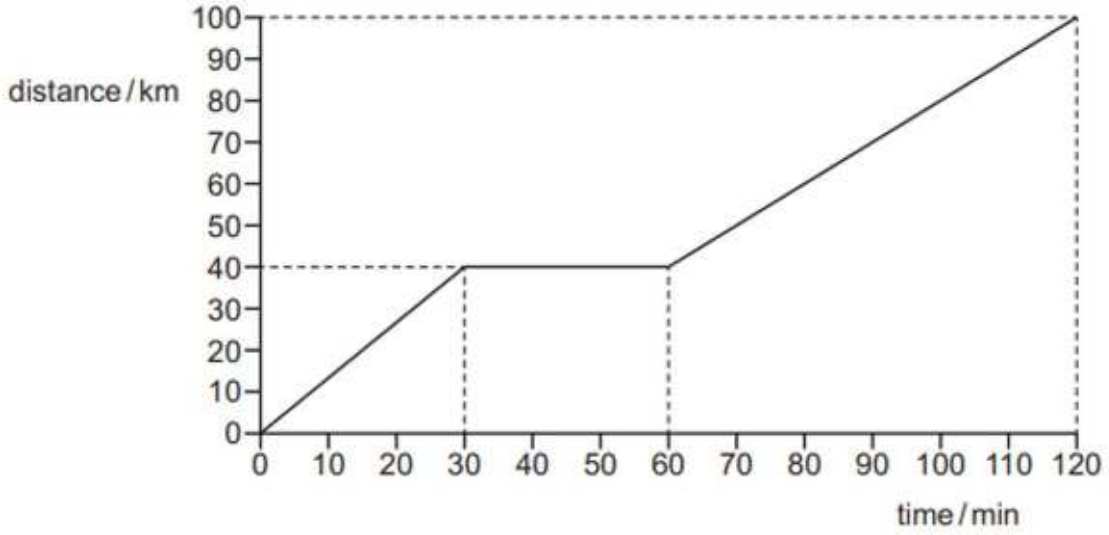
…….

[1 mark]

SECTION THREE: PHYSICS [20 Marks]

The first seven questions are worth *7 marks* in total. For each question, circle the correct answer.

1. The distance-time graph for a motorway journey is shown.



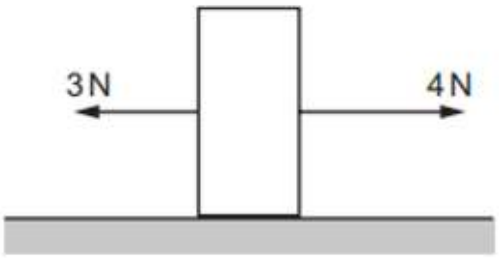
What is the average speed for the journey?

a. 50 km/h
b. 67 km/h
c. 70 km/h
d. 83 km/h

2. On Mars, the acceleration of free fall *g* is 3.7 m/s^{2}. What is the weight of a 2.0kg mass on Mars?

a. 0.54N
b. 1.9N
c. 7.4N
d. 20N

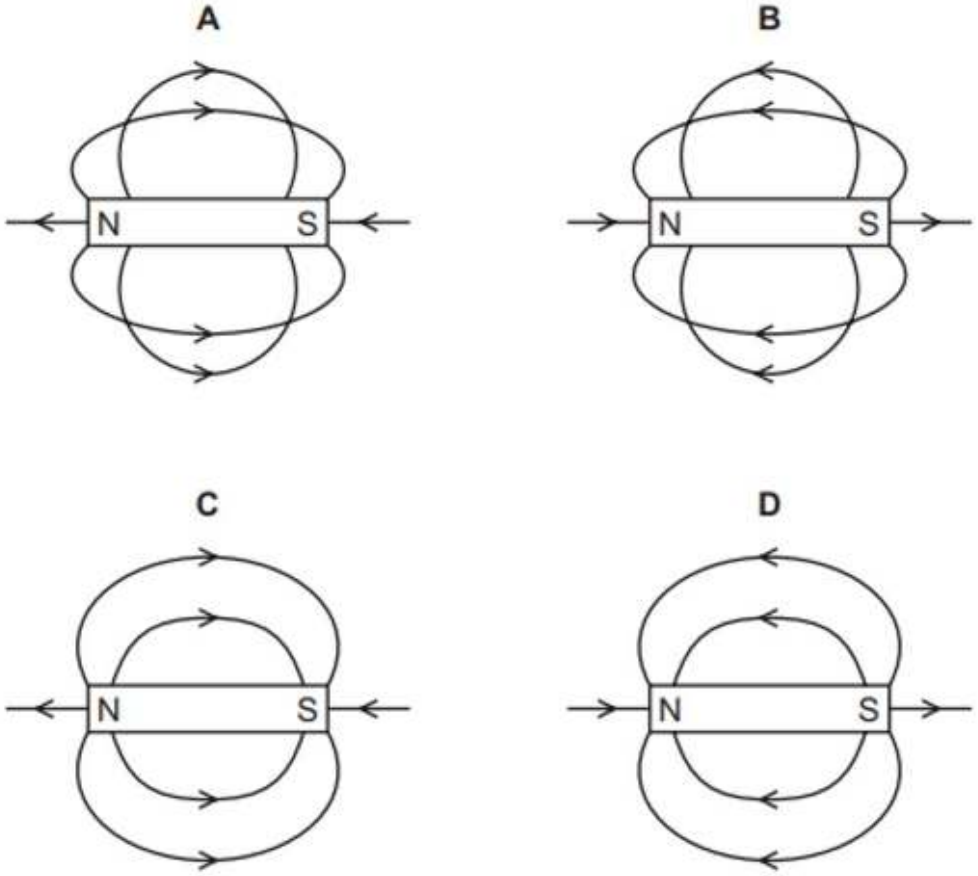
3. The diagram shows a solid object on a flat surface, with two forces acting on the object.



What is the resultant force on the object?

a. 1N to the left
b. 1N to the right
c. 7N to the left
d. 7N to the right

4. Which diagram shows the pattern and direction of the magnetic field lines around a bar magnet? Circle the correct letter.



5. A book has a mass of 400g.

   The surface of the book in contact with a table has dimensions 0.10m x 0.20m.

   The gravitational field strength is 10 N/kg.

   What is the pressure exerted on the table by the book?

   a. 0.08 N/m^2
   b. 8.0 N/m^2
   c. 20.0 N/m^2
   d. 200.0 N/m^2

6. The mass of an empty flask is 34g.

   The volume of the flask is 20cm^3.

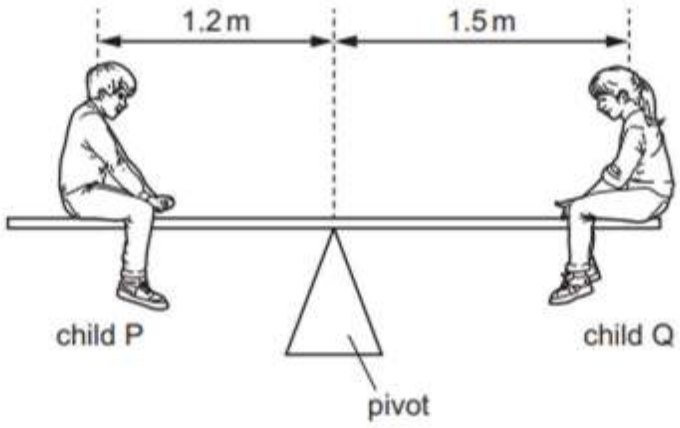
   The total mass of the liquid and flask is 50g.

   What is the density of the liquid?

   a. 0.80 g/cm^3
   b. 1.25 g/cm^3
   c. 2.50 g/cm^3
   d. 4.20 g/cm^3

7. A uniform plank rests on a pivot at its centre.

Two children P and Q sit on the plank in the positions shown.



The mass of child P is 25kg.

The plank is balanced. What is the mass of child Q?

a. 20kg
b. 25kg
c. 31kg
d. 45kg

8. Fig. 8.1 shows a speed–time graph for a car.

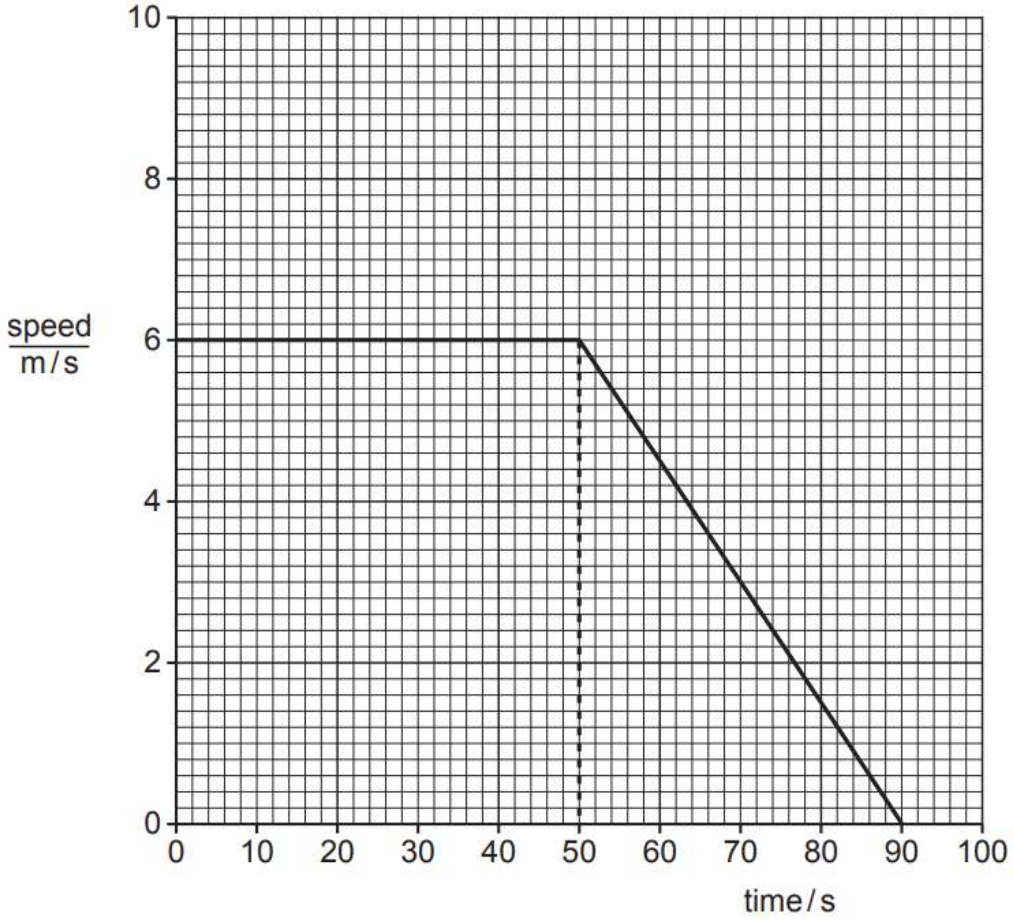


Figure 8.1

a. Describe the motion of the car from 0 to 50s, as shown in Fig. 8.1.

.....

[1 mark]

b. Describe the motion of the car from 50s to 90s, as shown in Fig. 8.1.

.....

[1 mark]

c. Calculate the distance, in m, travelled by the car between 50s and 90s.

.....

.....

.....

.....

.....

[3 marks]

d. A motorcycle travels at a constant speed. The motorcycle travels 710m in 87s. Calculate the speed of the motorcycle and show that it is close to 8m/s.

.....

.....

.....

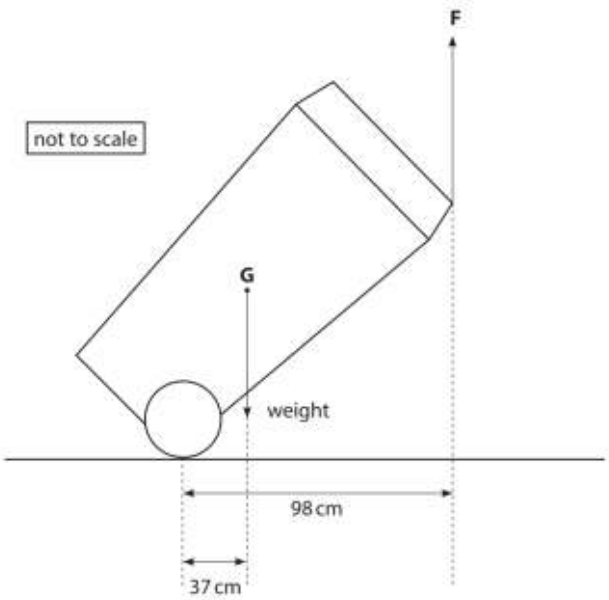
.....

.....

.....

[3 marks]

9. The diagram shows some of the forces acting on a large rubbish bin on wheels.



The mass of the bin is 23kg.

a. What is the weight of the bin?

A: 23kg
B: 230kg
C: 230N
D: 23,000N

[1 mark]

b. State the principle of moments.

.....

.....

[2 mark]

c. A person applies force F to the bin to keep it stationary.

Calculate the magnitude of force F.

.....

.....

.....

.....

.....

[2 marks]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2022))

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

Overview

This is the **Academic Scholarship 2021 Science (Paper 1)** published by **Oundle School** in Northamptonshire, designed for candidates seeking academic scholarships at **13+ entry**. The paper assesses scientific knowledge and application across **Biology**, **Chemistry**, and **Physics** at a level appropriate for Year 8 students preparing to enter Year 9. Candidates have **one hour** to complete the paper, which is worth a total of **64 marks**.

The paper is divided into **three equal sections** (Biology 24 marks, Chemistry 20 marks, Physics 20 marks), testing both factual recall and practical reasoning. Questions range from multiple-choice items and short-answer definitions to multi-step calculations and experimental design. Calculators are permitted, and students are expected to write their answers directly on the question paper.

This paper suits high-achieving students aiming for academic scholarships at independent schools. It rewards clear written expression, methodical working, and the ability to apply scientific concepts to unfamiliar scenarios. The breadth of topics covered makes it an excellent tool for revision and benchmarking performance against scholarship-level expectations.

How this paper is organised

The paper opens with clear instructions: candidates must answer **all questions** in **all sections**, writing neatly on the question paper itself. The first section, **Biology**, carries 24 marks and covers four multi-part questions on musculoskeletal anatomy, genetics, nutritional analysis, and digestion. Questions include a mix of definitions (2 marks), diagram interpretation (1 mark), data analysis from tables (1–2 marks each), and experimental reasoning (up to 3 marks).

Section Two (Chemistry) awards 20 marks and begins with five multiple-choice questions (7 marks total) on elements, atomic structure, formulae, and particle diagrams. The remaining questions are structured: defining thermal decomposition (1 mark), writing word equations (1 mark), designing tests (2 marks), counting atoms in formulae (1 mark), naming salts (1 mark), explaining practical terms (1 mark), describing crystallisation methods (3 marks), and plotting and interpreting a graph of experimental data (5 marks).

Section Three (Physics) also awards 20 marks. Seven multiple-choice questions (7 marks total) test speed calculations from distance-time graphs, weight on Mars, resultant forces, magnetic field patterns, pressure, density, and moments. The remaining questions require students to describe motion from speed-time graphs (1 mark each), calculate distance travelled (3 marks), calculate speed and verify it matches a given value (3 marks), identify weight in different units (1 mark), state the principle of moments (2 marks), and calculate force magnitude using moments (2 marks).

Topics covered

- Antagonistic muscle pairs and joint mechanics, specifically the biceps and triceps in arm movement
- Inheritance and genetics: DNA, genes carried in eggs and sperm, nucleus location, and terminology (inherit)
- Food energy content and calorimetry: experimental design, fair testing variables, and safety precautions when burning food samples
- Nutritional analysis: interpreting tables of energy, protein, carbohydrate, fat, and fibre content; identifying healthier options and sources of specific vitamins
- Digestion and enzyme action: testing for starch, optimal enzyme temperature, designing model gut experiments, and understanding why large molecules like starch cannot cross membranes
- Atomic structure and the periodic table: defining elements, properties of non-metals (malleability, conductivity, appearance), and distinguishing mixtures from pure compounds using particle diagrams
- Atomic composition: counting protons, electrons, and neutrons in fluorine; writing chemical formulae for compounds such as magnesium hydroxide and sulphuric acid
- Thermal decomposition reactions: defining the term, writing word equations (copper carbonate to copper oxide and carbon dioxide), and testing for carbon dioxide gas
- Neutralisation reactions: reacting copper oxide with sulphuric acid, naming salts (copper sulphate), understanding the concept of excess reactant, and crystallisation methods
- Plotting and interpreting graphs from experimental data: mass of titanium produced from titanium dioxide, drawing best-fit lines, reading values from graphs, and describing trends
- Calculating speed from distance-time graphs and verifying given values; interpreting constant speed sections and rest periods
- Weight and gravitational field strength: calculating weight on Mars using mass and g, and distinguishing mass from weight
- Resultant forces: determining net force from two opposing horizontal forces acting on an object
- Magnetic field patterns: recognising correct field line directions and shapes around bar magnets
- Pressure calculations: using mass, gravitational field strength, and contact area to find pressure exerted on a surface
- Density calculations: finding the density of a liquid from the mass of flask plus liquid, subtracting the flask mass, and dividing by volume

- Moments and levers: stating the principle of moments, calculating turning moments (force × perpendicular distance), and solving for unknown forces in balanced systems

How to use this paper for revision

- Practise writing **word equations** for common reactions (thermal decomposition, neutralisation, combustion) so you can recall products quickly under timed conditions.
- When designing experiments, always consider **fair testing**: identify the independent variable, the dependent variable, and at least two control variables to keep constant.
- For calculations involving formulae (e.g. H_2SO_4), **count atoms carefully**: subscripts multiply the element directly before them, and brackets multiply everything inside.
- In moments questions, **label your distances clearly** on a diagram, measure perpendicular to the pivot, and check that clockwise moments equal anticlockwise moments for equilibrium.
- When plotting graphs, choose **sensible scales** that use most of the grid, plot points accurately, and draw a single best-fit line (or curve) that balances points above and below rather than connecting every dot.
- For speed-time graphs, remember that the **area under the line** represents distance travelled; break complex shapes into rectangles and triangles to simplify calculations.
- Revise key **practical tests**: iodine solution turns blue-black with starch, limewater turns milky with carbon dioxide, and universal indicator or pH paper identifies acids and alkases.

Common mistakes to avoid

- Confusing **mass** (measured in kg or g) with **weight** (a force measured in N). Weight equals mass times gravitational field strength, so a 2 kg object on Mars (g = 3.7 m/s²) weighs 7.4 N, not 2 kg.
- Miscounting atoms in chemical formulae when brackets are present. In $Mg(OH)_2$, the subscript 2 multiplies both O and H, giving 1 magnesium, 2 oxygen, and 2 hydrogen atoms, not 1 oxygen and 2 hydrogen.
- Failing to **show working** in multi-step calculations. Even if the final answer is correct, examiners award method marks for intermediate steps, so write out formulae and substitutions clearly.
- Plotting graphs with **uneven or awkward scales** (e.g. increments of 3 or 7 per square) that make reading values difficult. Choose scales like 1, 2, 5, or 10 per square to simplify plotting and interpolation.
- Describing motion vaguely (e.g. 'the car is moving') rather than precisely. State whether speed is constant, increasing, or decreasing, and specify numerical values from the graph axes where appropriate.
- Giving the **wrong units** or omitting them entirely. Density must be in g/cm³ or kg/m³, pressure in N/m² (or Pa), speed in m/s or km/h, and distance in m or km as the question specifies.

Exam technique

Begin by reading the instructions carefully and noting the **total time available** (one hour) and the **mark distribution** (Biology 24, Chemistry 20, Physics 20). Allocate roughly 20 minutes per section, leaving five minutes at the end to check your work. Attempt every question, even if you are uncertain, because unanswered questions score zero whereas a reasoned attempt may earn partial credit.

For multiple-choice questions, **eliminate obviously incorrect options** first to improve your odds if you must guess. In calculation questions, write out the formula, substitute values with units, and show each step of working. If you make an arithmetic error, method marks can still be awarded if your approach is sound. When asked to describe or explain, use **scientific terminology** precisely (e.g. 'antagonistic pairs' rather than 'opposite muscles') and structure your answer in clear sentences.

In graph-plotting tasks, **use a sharp pencil** and a ruler for straight best-fit lines. Label both axes with quantities and units, and mark your working on the graph itself when asked to read off values (draw dashed lines to show how you found the answer). For longer written responses (e.g. crystallisation method, experimental design), plan a

logical sequence of steps before you begin writing. Check spellings of technical terms and re-read your answers in the final five minutes to catch errors or omissions.

What to revise alongside this paper

To deepen understanding of the Biology content, revise the **structure and function of joints** (ball-and-socket, hinge), the role of ligaments and tendons, and the process of **mitosis and meiosis** in passing genetic material to offspring. For digestive enzymes, study amylase, protease, and lipase in detail, including their pH optima and where they are secreted in the digestive system.

In Chemistry, consolidate knowledge of the **periodic table layout** (groups, periods, metals vs non-metals) and practise balancing **symbol equations** for the reactions covered here (e.g. $CuCO_3 \rightarrow CuO + CO_2$). Extend to writing full balanced equations with state symbols. Explore **separation techniques** beyond crystallisation (filtration, distillation, chromatography) and understand when each is appropriate.

For Physics, build on moments by studying **levers and gears**, mechanical advantage, and real-world applications (e.g. seesaws, wheelbarrows, crowbars). Revise **motion graphs** in more depth: acceleration-time graphs, distinguishing speed from velocity, and using gradients to find acceleration. Practise calculations involving **pressure in fluids**, upthrust, and Archimedes' principle to connect solid and liquid pressure concepts.

Key terms

> **Antagonistic pairs**, **DNA**, **Inherit**, **Nucleus**, **Enzyme**, **Element**, **Compound**, **Proton**, **Neutron**, **Electron**, **Thermal decomposition**, **Neutralisation**, **Excess reactant**, **Crystallisation**, **Resultant force**, **Moment**, **Pivot**, **Equilibrium**, **Weight**, **Density**, **Pressure**

OUNDLE
School

EXAMINATION PAPER
Academic Scholarship 2021

Science (Paper 2)

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above.
- Write your answer on the question 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 59.

SECTION ONE: BIOLOGY [19 Marks]

Comprehension Exercise

Read the following passage then answer the questions. You may not have met this material or the concepts before: your answers will reflect your level of engagement with the material, not your recall.

There are three significant ways in which molecules travel across the membranes of living cells. Membranes found around cells (cell membranes) and the those inside (plasma membranes) are generally impermeable and most larger molecules cannot cross this barrier. Very small molecules such as gases, water and soluble salts can cross the membranes quite freely. Larger molecules, such as sugars and proteins can only cross through special channels, called pores. Membranes have these pores for specific molecules according to tissue function.

Most particles move because they have kinetic energy. This allows them to travel from an area of high concentration to an area of lower concentration – down their concentration gradient. This is known as **diffusion**. This happens when sugar dissolves in a cup of tea – the dissolved sugar molecules spread out in the drink until they are evenly distributed. When the sugar is dissolved it is called a **solute**; the water is the **solvent**; the mixture is a **solution**.

Water moves in a similar fashion but from a low solute concentration to a high solute concentration, down the water concentration gradient. Membranes of living cells cannot control water movement so it is important that the concentration of water and solute is the same on either side of a membrane, otherwise water will move down its own gradient. When this happens, plant cells can become turgid or flaccid; animal cells collapse or burst. The movement of water across a membrane like this is called **osmosis**.

The third way particles move is against their concentration gradient. This requires energy because the particles are moving across a membrane from a low concentration to a higher concentration. This is called **active transport** because it requires energy. Diffusion and osmosis do not require energy and are considered **passive.**

1. Komodo dragons have chemical receptors on their tongues that allow them to taste the air. When hunting, their tongue flicks in and out. This helps them find their prey, often large mammals such as buffalo.

   Suggest how they can use their tongue to find their food.

   ……

   ……

   [2 marks]

2. Predatory fish, such as shark and piranha, are thought to swim towards an injured mammal following the blood. Suggest why they do this.

……

……

[2 marks]

3. Gardeners will get rid of soft-bodied organisms like slugs using two types of traps:

   - Sweet smelling water – beer sometimes – is placed in a bowl. The slugs get into the water and then expand before dying. Suggest why.
   - Salt traps are used. These are baited traps that contain dry salt. Suggest how this may kill the slugs

……

……

……

……

……

……

……

……

……

……

[4 marks]

4. Honey is well known as an antibacterial agent. It also has a very long shelf-life. Suggest why it may kill microbes.

……

……

[2 marks]

5. Many seabirds have glands by their eyes that excrete salt droplets. Suggest why.

……

……

[2 marks]

6. Very few aquatic creatures can live in salt water and in fresh water. Suggest why.

……

……

……

……

[3 marks]

7. Plants need minerals from the soil, dissolved in soil water, to make a large number of different molecules.
    a. Suggest what process allows plants to absorb minerals.

    ……

    [1 mark]

    b. After prolonged heavy rain or flooding, oxygen concentrations in the soil become reduced. Newly sprouting crops can suffer from mineral deficiencies. Suggest why.

    ……

    ……

    ……

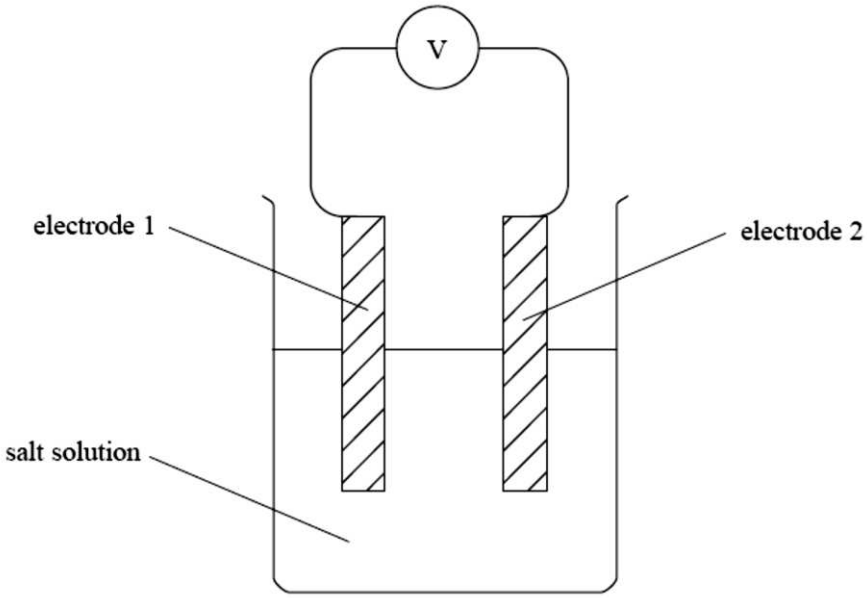
    ……

    ……

    [3 marks]

SECTION TWO: CHEMISTRY [20 Marks]

The relative reactivity of metals can be compared using the apparatus shown below.



- Electrode 1 and electrode 2 are made from two different metals.
- The greater the value of the voltmeter reading (ignoring the sign), the bigger the difference in reactivity between the two metals.
- If the reading on the voltmeter is negative, the metal used for electrode 1 is more reactive than the metal used for electrode 2.
- If the reading on the voltmeter is positive, the metal used for electrode 1 is less reactive than the metal used for electrode 2.

A pupil used the apparatus shown to investigate four metals, **P**, **Q**, **R** and **S**. The table below shows the voltmeter readings that she took using the metals as electrodes 1 and 2.

		metal used for electrode 1		
		P	**Q**	**R**
metal used for electrode 2	**Q**	+1.6 V		
	R	–1.1 V	–2.7 V	
	S	–0.9 V	–2.5 V	+0.2 V

a) Use the data in the table to answer the questions below.

i. Which metal is the **most** reactive? .....

[1 mark]

ii. Which **two** metals are most similar in reactivity? .....

[1 mark]

b) Suggest what the reading on the voltmeter would be when the same metal is used for both electrode 1 and electrode 2.

Explain your answer.

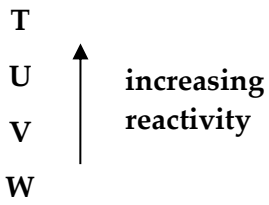
reading = ...V

explanation.....

.....

[2 marks]

A pupil investigated four other metals, **T**, **U**, **V** and **W**.
The order of reactivity of these metals is:



c) When metal **S** is used as electrode 1 and metal **T** is used as electrode 2, the voltmeter reading is –0.8 V.

Calculate the voltmeter reading when metals **P** and **T** are used as electrode 1 and electrode 2 respectively. Explain your answer and show your working.

.....

.....

.....

[2 marks]

d) The pupil continued her investigation into reactivity and found that when metal **T** is added to a solution of the sulfate of metal **U**, a displacement reaction occurs.

Experiment ①	Metal **S** is added to a solution of the sulfate of metal **R**.
Experiment ②	Metal **V** is added to a solution of the sulfate of metal **U**.
Experiment ③	Metal **T** is added to a solution of the sulfate of metal **W**.
Experiment ④	Metal **T** is added to a solution of the sulfate of metal **R**.

Use the information given to you earlier in this question to decide in which of the following experiments a displacement reaction will also occur.

Explain your answer.

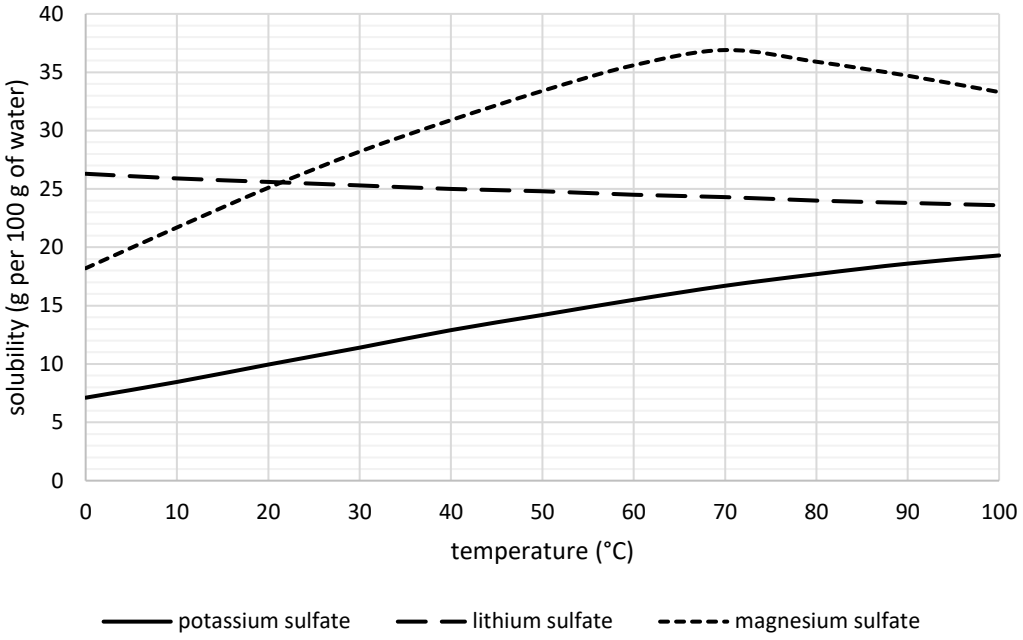
.....

.....

.....

[2 marks]

The graph below shows how temperature affects the solubilities of three sulfate salts of reactive metals. Use the graph to help you answer the following questions.



e) The pupil had a beaker containing 18 g of potassium sulfate dissolved in 100 cm^3 of water at 90°C. She cooled the solution to 20°C and then filtered the contents of the beaker.

State and explain all the observations the pupil made in this experiment. Be as precise as you can in your answer.

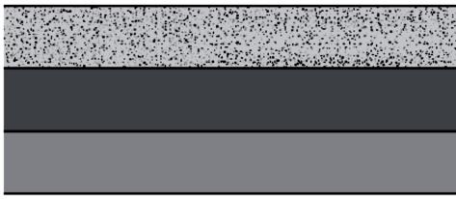
.....

.....

.....

[3 marks]

f) After her experiments, the pupil poured the three solutions of lithium sulfate, magnesium sulfate and potassium sulfate into the same waste beaker. The pupil left the beaker in the laboratory over the weekend. When she returned to the laboratory, she discovered that the water had evaporated from the beaker, leaving layers of the sulfate salts deposited in the order shown below.



magnesium sulfate

lithium sulfate

potassium sulfate

Look at the graph on the previous page.
Suggest what was the temperature of the laboratory over the weekend.
Explain your answer.

.....

.....

.....

[2 marks]

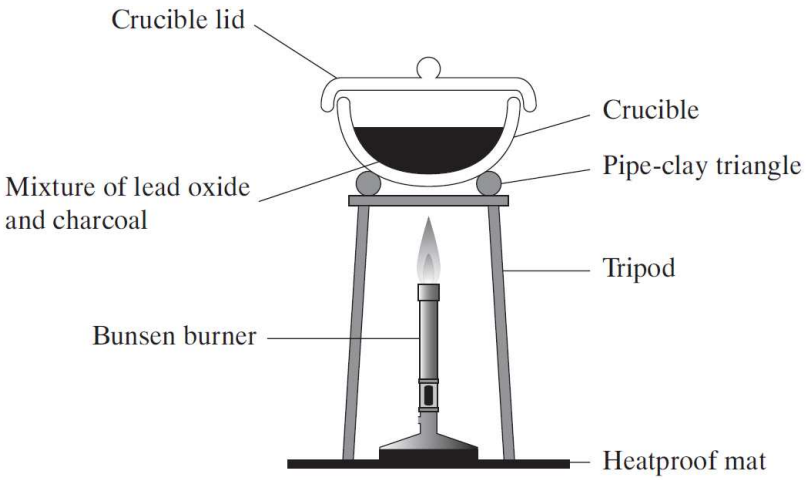
g) The solubility of sulfate at different temperatures is given in the table below.

temperature (°C)	0	10	20	30	40	50	60	70	80	90	100
solubility (g per 100 g of water)	12	14	16	19	22	25	28	32	36	40	45

Plot these data on the graph on the previous page.

Draw a smooth line through the points. *[3 marks]*

Lead is a relatively unreactive metal, used in the construction and electronics industries.
Lead metal can be extracted from lead oxide (PbO) in the laboratory.



The mixture of lead oxide and charcoal is heated in a crucible.

h) The crucible is made from a ceramic material.

Suggest the property of a ceramic that makes it a good choice for making the crucible.

.....

[1 mark]

i) Charcoal (carbon) acts as a reducing agent in this reaction.

$$\text{lead oxide} + \text{carbon} \rightarrow \text{lead} + \text{carbon dioxide}$$

How does the charcoal reduce the lead oxide?

.....

.....

[1 mark]

j) After heating, the crucible lid is kept on the crucible until the apparatus has cooled to room temperature.

Suggest why this is the case.

.....

.....

[2 marks]

SECTION THREE: PHYSICS [20 Marks]

A cable that hangs vertically has a maximum possible length beyond which it can no longer support its own weight.

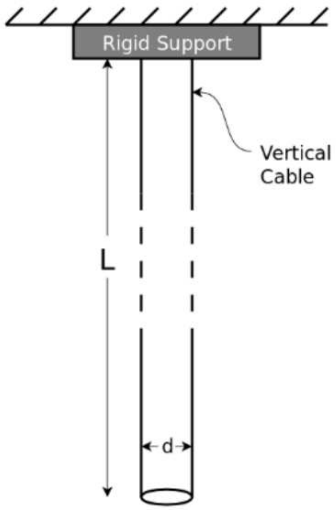


Figure 1

(a) For a steel cable with a diameter of 4 cm and a length of 1 m, calculate that the mass of the cable.

diameter = 4 cm

Length = 1 m

density of steel = 8000 kg / m^3

[2 marks]

(b) What is the weight force on this 1 m cable if it hangs downwards W = m g, where m is the mass and g = 10 N/kg?

[1 mark]

(c) Stress (σ) is defined as Force ÷ Cross sectional Area and the unit is Pascal (Pa).

$$\text{Stress} = F / A$$
$$1 \text{ Pa} = 1 \text{ N/m}^2$$

Calculate the stress at the top of the 1 m cable (Figure 1) where it is joined to the rigid support.

[2 marks]

(d) The maximum stress that a steel cable under tension can withstand, before it breaks, is 400 000 000 Pa. This is often referred to as the ultimate tensile strength of the material.

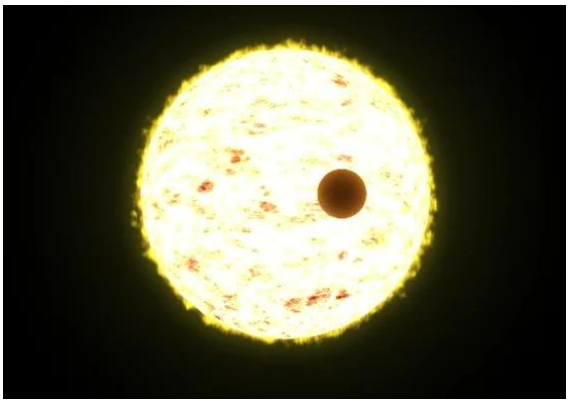
Calculate the maximum length of a steel cable with a diameter of 4 cm that can be hung vertically from a suitable rigid support such that it can support its own weight.

maximum length = _____

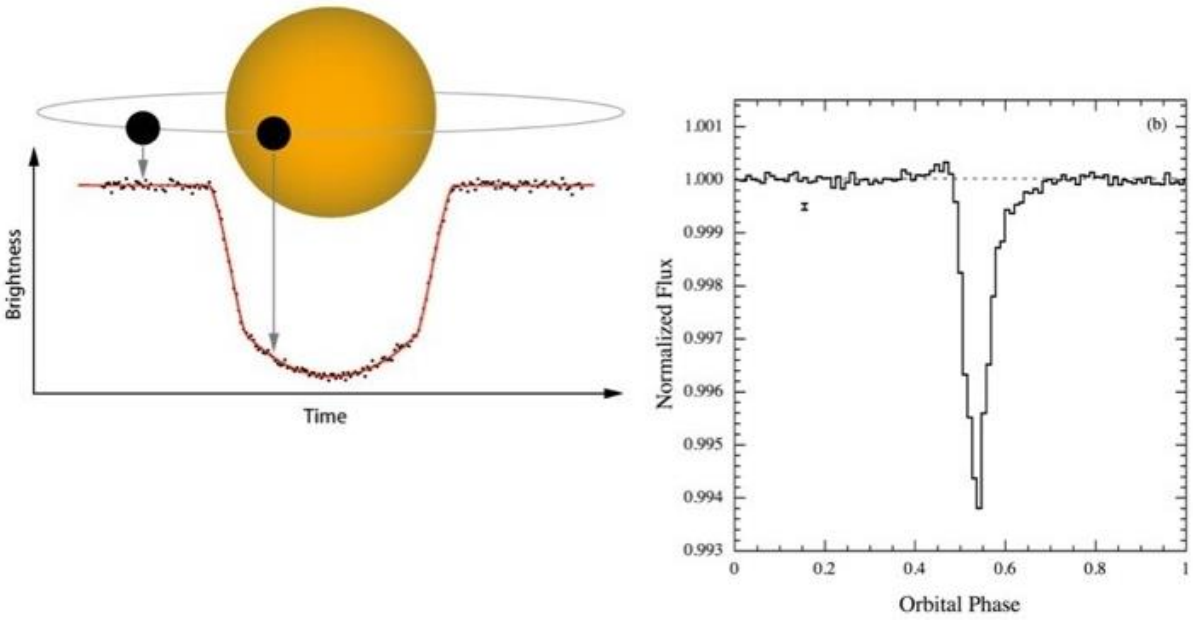
[2 marks]

Exoplanets

2. Exoplanets are planets that orbit a star other than our sun. Most known exoplanets have been discovered using the transit method. A transit occurs when a planet passes between a star and its observer. Transits within our solar system can be observed from Earth when Venus or Mercury travel between us and the Sun.

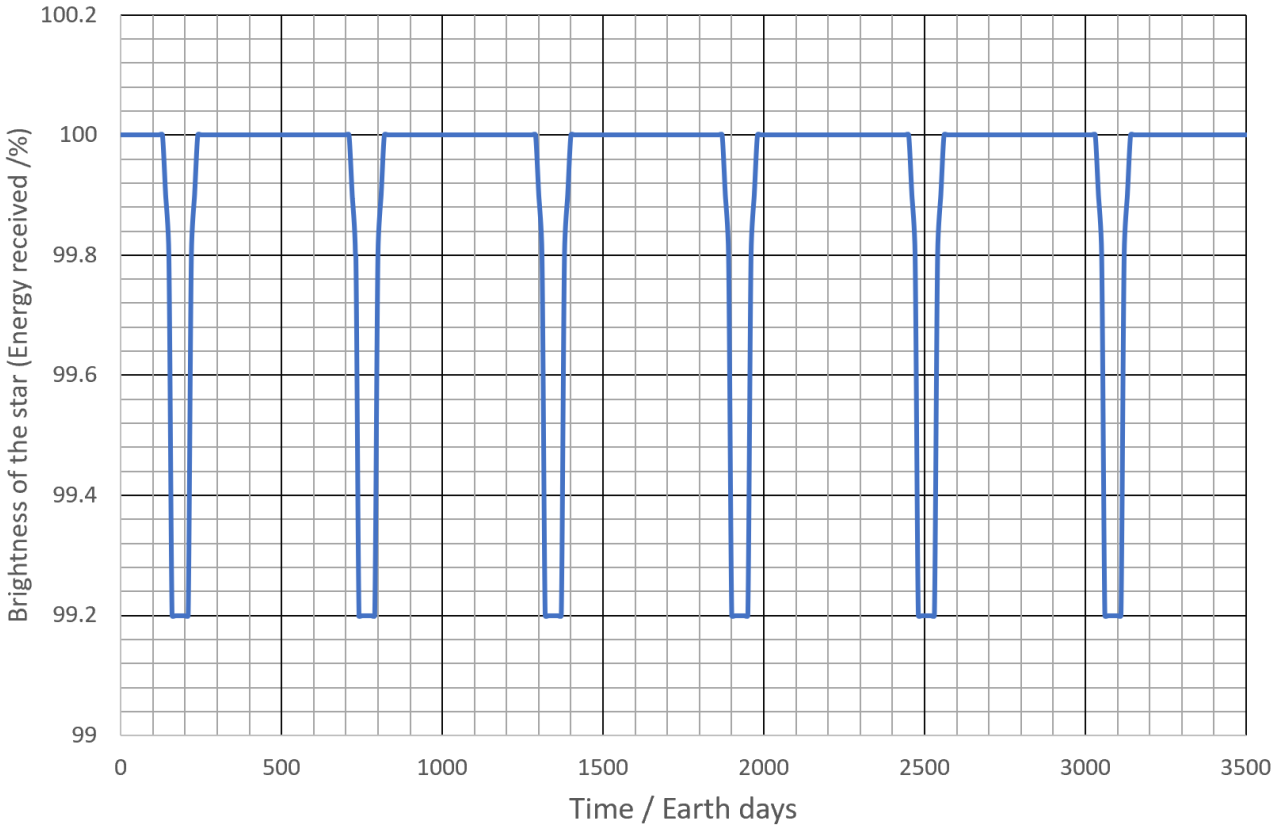


Transits reveal an exoplanet not because we directly see it from many light-years away, but because the planet passing in front of its star ever so slightly dims its light. This dimming can be seen in light curves – graphs showing light received over a period of time. When the exoplanet passes in front of the star, the light curve will show a dip in brightness.



This data is part of why transits are so useful: Transits can help determine a variety of different exoplanet characteristics. The size of the exoplanet's orbit can be calculated from how long it takes to orbit once (the period), and the size of the planet itself can be calculated based on how much the star's brightness lowered.

a) The graph below is a light curve for star P625, with the dips in brightness being seen as sharp downward spikes due to an exoplanet.



Using the graph above:

(i) How long does it take for the exoplanet to complete 5 orbits of the star?

.....

.....

[2 marks]

(ii) Calculate the time for one orbit (using your answer from part a).

.....

[1 mark]

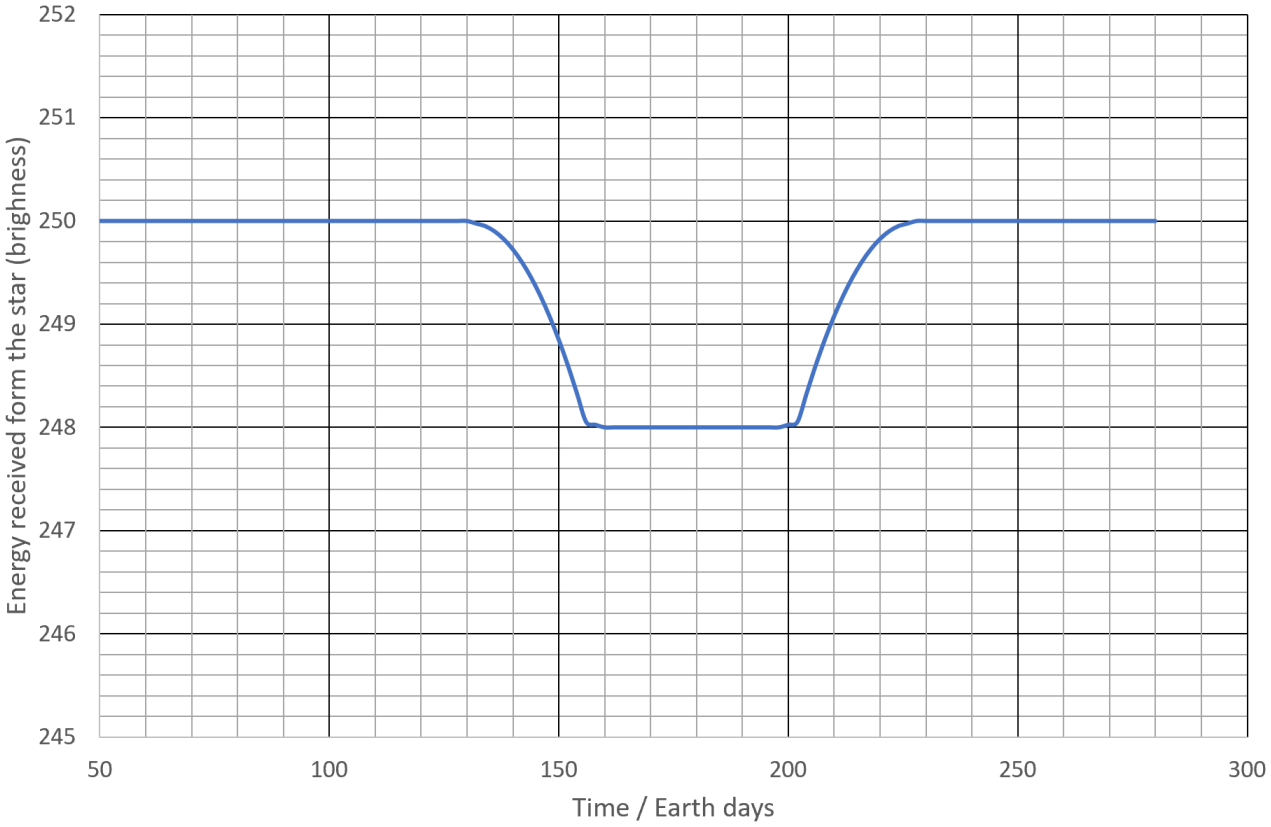
(iii) Do you think that the planet in this question is closer to its star than the Earth is to the sun, or further away from its star than the Earth is to the sun? Explain your answer

.....

.....

[2 marks]

b) The graph below is a light curve for star GR142, with the single dips in brightness due to the transit of the planet Dagobah.



(i) On the graph above please sketch an approximate light curve if Dagobah had a significantly larger diameter. Please label this line A and explain why you have drawn your curve like this below.

.....

.....

[2 marks]

(ii) On the graph above please sketch an approximate light curve if Dagobah was the same size but orbited the star at twice the distance. Please label this line B and explain why you have drawn your curve like this below.

.....

.....

.....

.....

[3 marks]

c) The Milky Way has approximately 100,000 million stars. Therefore, measuring the light from each one to see if there are planets orbiting takes a long time. If we could check five hundred stars per month, how long would it take to check every star in the Milky Way?

Most of the marks awarded for this question are for showing your working. Please make it as clear as possible.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Time taken = ... years

[3 marks]

Paper Notes: 13+ Science Question Paper (13+ Science Past Paper (2022))

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

Overview

This is **Oundle School's 2021 Academic Scholarship Science (Paper 2)**, a 13+ entrance examination set for candidates seeking entry into **Year 9**. Published by Oundle School in Northamptonshire, the paper is designed to identify pupils with genuine scientific aptitude and the ability to apply reasoning to unfamiliar concepts. The examination carries **59 marks** and must be completed in **one hour**, demanding both speed and precision.

The paper is divided into three equally weighted sections covering **Biology** (19 marks), **Chemistry** (20 marks), and **Physics** (20 marks). Each section tests not merely recall of content but the capacity to interpret new information and solve problems independently. The Biology section opens with a comprehension exercise on membrane transport, requiring students to apply concepts of diffusion, osmosis, and active transport to real-world scenarios involving Komodo dragons, predatory fish, slugs, honey, seabirds, aquatic organisms, and plant mineral uptake.

The Chemistry section explores metal reactivity through electrochemical cells, solubility curves, and extraction of lead from its ore. The Physics section examines stress in materials and exoplanet detection via the transit method. Both sections demand quantitative reasoning, graph interpretation, and the ability to extrapolate from given data. Calculators are permitted, and answers are written directly on the question paper. This paper suits academically ambitious students aiming for scholarship places at selective independent schools.

How this paper is organised

The paper opens with instructions on the cover page, stating that all **three sections carry equal marks** and that students must answer **every question**. Calculators are allowed, and candidates write their responses directly onto the question paper itself, which simplifies exam logistics but requires disciplined space management.

Section One (Biology) allocates **19 marks** across seven questions, all rooted in a comprehension passage about diffusion, osmosis, and active transport. Marks per question range from 1 to 4, reflecting the complexity of reasoning required. Questions demand extended written responses, testing the ability to transfer abstract biological principles to specific ecological and physiological contexts.

Section Two (Chemistry) carries **20 marks** and includes ten sub-questions. Early questions analyse voltmeter readings to deduce metal reactivity (parts a to d, worth 1 or 2 marks each). Later questions (e to j) involve interpreting solubility graphs, predicting crystallisation order, plotting new data, and explaining reduction reactions. Section Three (Physics) also carries **20 marks**, split between a five-part question on cable stress (parts a to d) and a three-part question on exoplanet transits (parts a to c), with individual parts worth between 1 and 3 marks. Both sections require calculations, graph work, and explanatory prose.

Topics covered

- Diffusion, osmosis, and active transport across cell membranes, with application to concentration gradients, solute and solvent definitions, and turgidity or plasmolysis in plant and animal cells
- Applying passive and active transport principles to real-world biology: chemoreception in reptiles, blood dispersal in aquatic predators, osmotic effects on invertebrates, antibacterial properties of hyperosmotic solutions, salt excretion in seabirds, and osmoregulation challenges for organisms moving between fresh and salt water
- Active transport in plant roots, including the role of oxygen and energy in mineral uptake, and the effect of waterlogged soil on nutrient availability
- Electrochemical cells and metal reactivity series, interpreting voltmeter readings to rank metals by reactivity, predicting displacement reactions, and understanding the relationship between voltage magnitude and reactivity difference
- Solubility curves for sulfate salts, reading graphs to determine solubility at different temperatures, predicting crystallisation order during evaporation, and plotting new data points with smooth curve fitting
- Reduction and extraction of metals from oxides, identifying ceramics as heat-resistant crucible materials, explaining the role of carbon as a reducing agent, and understanding why a sealed crucible prevents re-oxidation of hot lead
- Stress in materials, calculating mass from volume and density, applying weight force ($W = mg$), defining stress as force per unit cross-sectional area ($\sigma = F/A$), and determining maximum cable length from ultimate tensile strength
- Exoplanet detection using the transit method, interpreting light curves to measure orbital period, comparing exoplanet orbits with Earth's orbit around the Sun, predicting how changes in planet diameter or orbital radius affect light-curve depth and duration, and performing multi-step calculations involving large numbers to estimate survey timescales across the Milky Way

How to use this paper for revision

- Revise the definitions of **diffusion**, **osmosis**, and **active transport**, and practise explaining each process in your own words before attempting application questions.
- For osmosis problems, always identify the solute concentration on each side of the membrane and predict water movement from low solute (high water) concentration to high solute (low water) concentration.
- In electrochemistry questions, draw a quick reactivity series diagram as you work through the data, ranking metals from most reactive at the top to least reactive at the bottom based on voltage signs.
- When plotting graph points, use a sharp pencil and ruler, check units carefully, and draw smooth curves rather than joining dots with straight lines if the data suggest a continuous trend.
- For stress calculations, write down the formula ($\sigma = F/A$) and the units (Pascals or N/m^2) before substituting numbers, and remember that the cross-sectional area of a cylinder is πr^2, not πd^2.
- In exoplanet transit questions, annotate the graph with labels for each dip, count carefully, and divide total time by the number of complete cycles to find the orbital period.
- Leave five minutes at the end to check arithmetic, reread questions to ensure you answered what was asked, and verify that you included units for all numerical answers.

Common mistakes to avoid

- Confusing diffusion with osmosis: diffusion applies to any particles moving down a concentration gradient, while osmosis specifically describes water movement through a selectively permeable membrane.
- Forgetting that a negative voltmeter reading means electrode 1 is more reactive than electrode 2, not the other way round, leading to inverted reactivity rankings.
- Reading solubility graphs carelessly, especially when estimating values between gridlines, and failing to notice that the y-axis may not start at zero.
- Calculating volume of a cylinder using diameter instead of radius in $V = \pi r^2 h$, which gives an answer four times too large and cascades through subsequent stress calculations.
- Assuming that doubling orbital distance doubles orbital period, when in fact period depends on the three-halves power of distance (Kepler's third law), so predictions should be qualitative unless formulae are provided.
- Writing answers without units (e.g. '400' instead of '400 Pa' or '400 N'), which costs marks even if the numerical value is correct, or using incorrect units (e.g. kilograms instead of Newtons for force).

Exam technique

This is a scholarship paper, so examiners expect concise, confident answers that demonstrate genuine understanding rather than rote learning. Begin by reading the entire paper quickly to identify which questions you find easiest, then attempt those first to build confidence and secure marks. Aim to spend roughly **20 minutes per section**, leaving time to review.

In the Biology comprehension, underline key phrases in the passage (diffusion, osmosis, active transport, passive) and refer back to them when constructing answers. Use scientific terminology correctly, but also explain your reasoning in full sentences. For multi-mark questions, make sure you give as many distinct points as there are marks available.

In Chemistry and Physics, show all working for calculations, even if you can do some steps mentally. If you make an arithmetic error early on, clear working allows examiners to award method marks for correct approach. When sketching graphs or additional curves, label your lines clearly (as instructed, 'A' and 'B') and explain your reasoning in words. Check that your answer makes physical sense: a cable millions of metres long or an orbital period of three days when the graph shows intervals of hundreds of days

should prompt you to revisit your calculation. Finally, reread questions to confirm you answered the specific question asked, not a related but different one.

What to revise alongside this paper

Students preparing for Oundle's 13+ Science scholarship should consolidate their understanding of **transport across membranes** by reviewing both plant and animal cell structures, water potential, and the role of ATP in active processes. Revisit redox reactions, particularly the extraction of metals from ores using carbon or hydrogen, and practise balancing symbol equations for these reactions.

In Physics, extend your knowledge of **materials and forces** by exploring Hooke's law, elastic and plastic deformation, and Young's modulus. Review density, pressure, and the relationship between force, area, and stress in different contexts (cables, bridges, bones). For the exoplanet section, read about Kepler's laws of planetary motion, the inverse square law for light intensity, and how astronomers measure stellar brightness and distance using apparent magnitude.

Broaden your quantitative skills by tackling problems involving **standard form**, unit conversion, and multi-step calculations with large or small numbers. Practise interpreting and sketching graphs of non-linear relationships, and work through past papers from other selective independent schools (Westminster, Eton, Winchester) to experience similar scholarship-level reasoning questions. Revisit GCSE-level content on reaction rates, equilibrium, and energy changes to ensure you can apply foundational chemistry principles to unfamiliar scenarios.

Key terms

> **Diffusion**, **Osmosis**, **Active transport**, **Concentration gradient**, **Solute and solvent**, **Turgid and flaccid**, **Reactivity series**, **Displacement reaction**, **Voltmeter reading**, **Solubility curve**, **Reduction and oxidation**, **Stress (force per unit area)**, **Ultimate tensile strength**, **Transit method**, **Exoplanet orbital period**