Surname	Centre Number	Candidate Number
Other Names		0

GCSE – NEW

3445UC0-1

S18-3445UC0-R1

APPLIED SCIENCE (Double Award)
UNIT 3: Food, Materials and Processes

HIGHER TIER

TUESDAY, 15 MAY 2018 – AFTERNOON

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**5**	
3.	**14**	
4.	**14**	
5.	**8**	
6.	**12**	
7.	**8**	
Total	**75**	

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ADDITIONAL MATERIALS

A calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **6***(a)* is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is printed on the back cover of the examination page.

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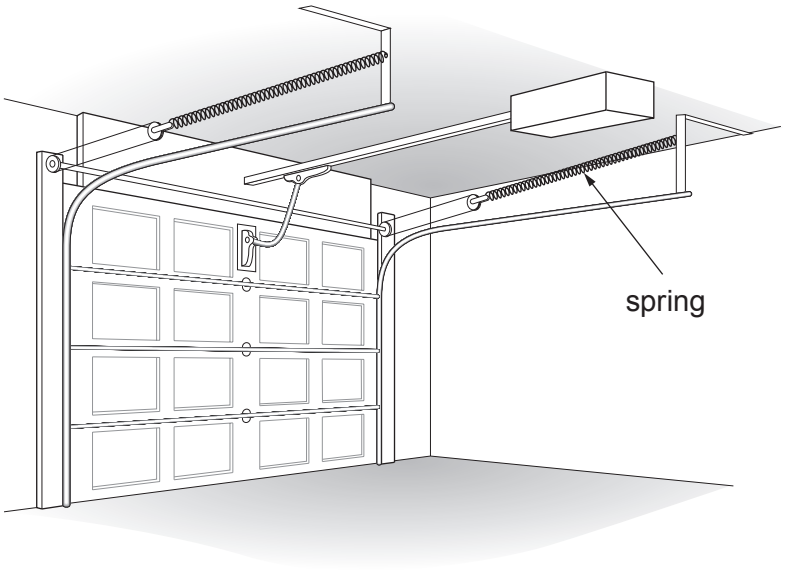
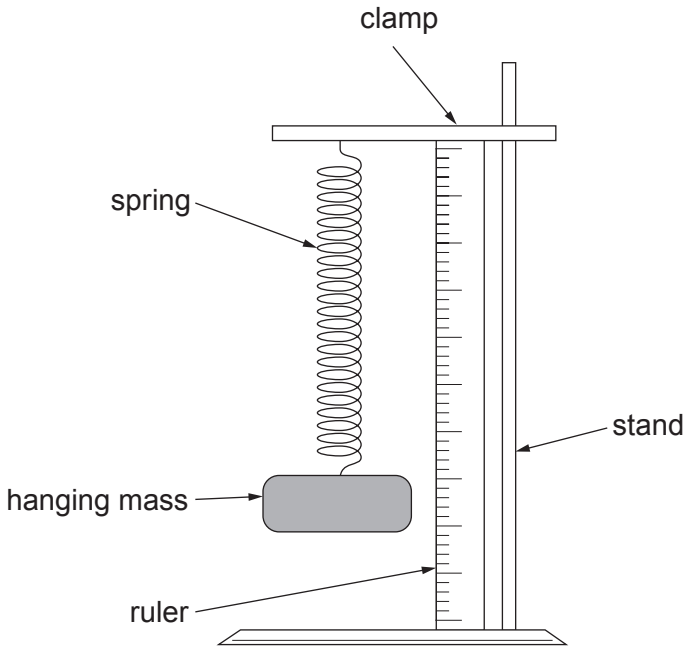
Answer **all** *the questions in the spaces provided.*

1. Springs can be used in garage doors. When the door shuts the springs are stretched and put under tension. When the door opens the spring returns to its original length making it easier to raise.

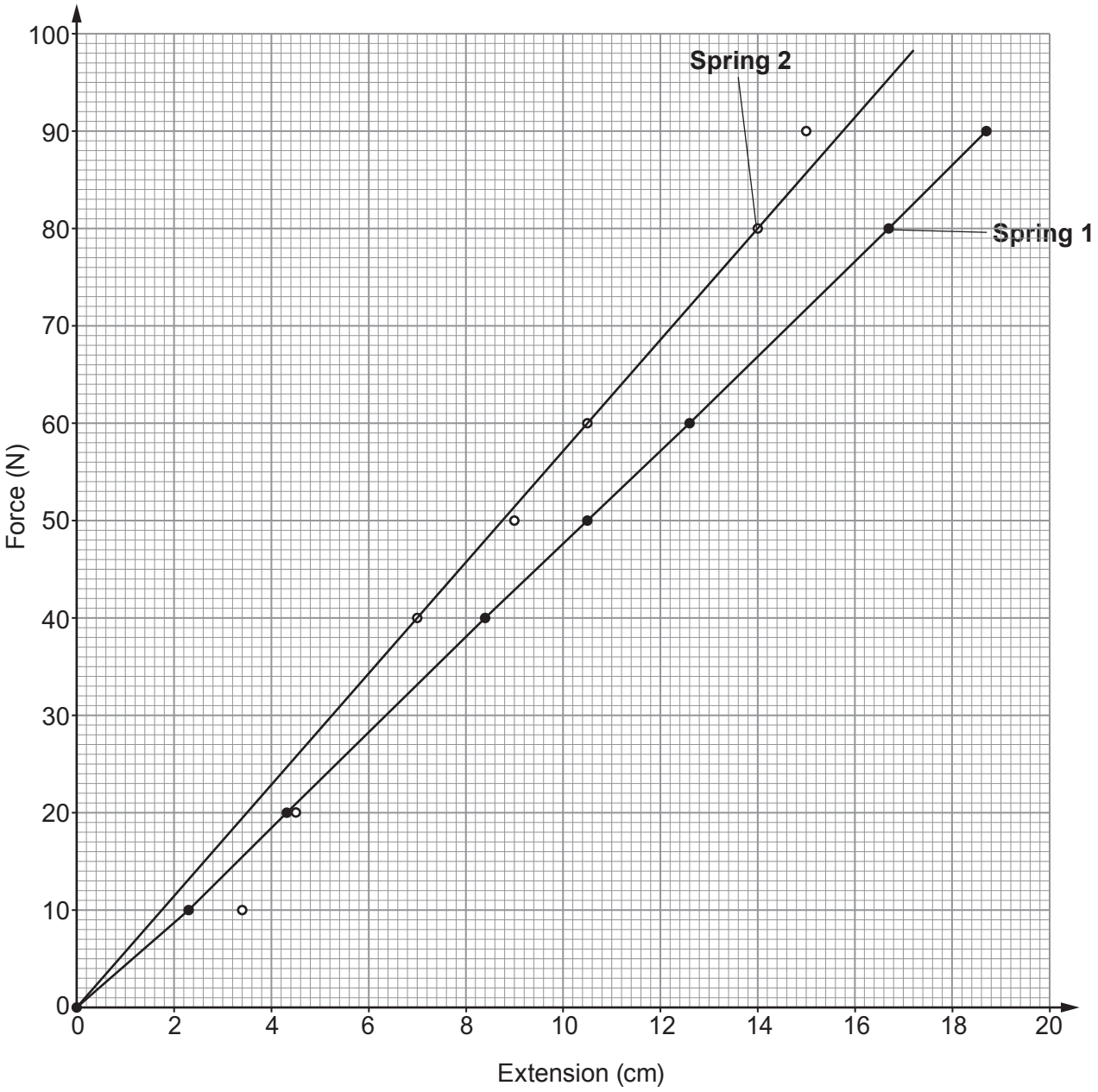


It is important that the spring is designed so that it does not become permanently stretched during the process. Springs become permanently stretched once they pass their **elastic limit**. This is the point where extension is no longer proportional to the stretching force.

Students test three springs using the apparatus shown below.



(a) Their results for two springs used in the doors are shown in the graph below.



Examiner only

(i) Compare the behaviour of the springs as the force increases from 10 N to 40 N. [2]

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(ii) Use the graph and the equation:

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

to calculate the value of the spring constant for **Spring 1**. [3]

spring constant = ... N/cm

(iii) Use the graph to state **one** reason why the students can have more confidence in the results for **Spring 1** than for **Spring 2**. [1]

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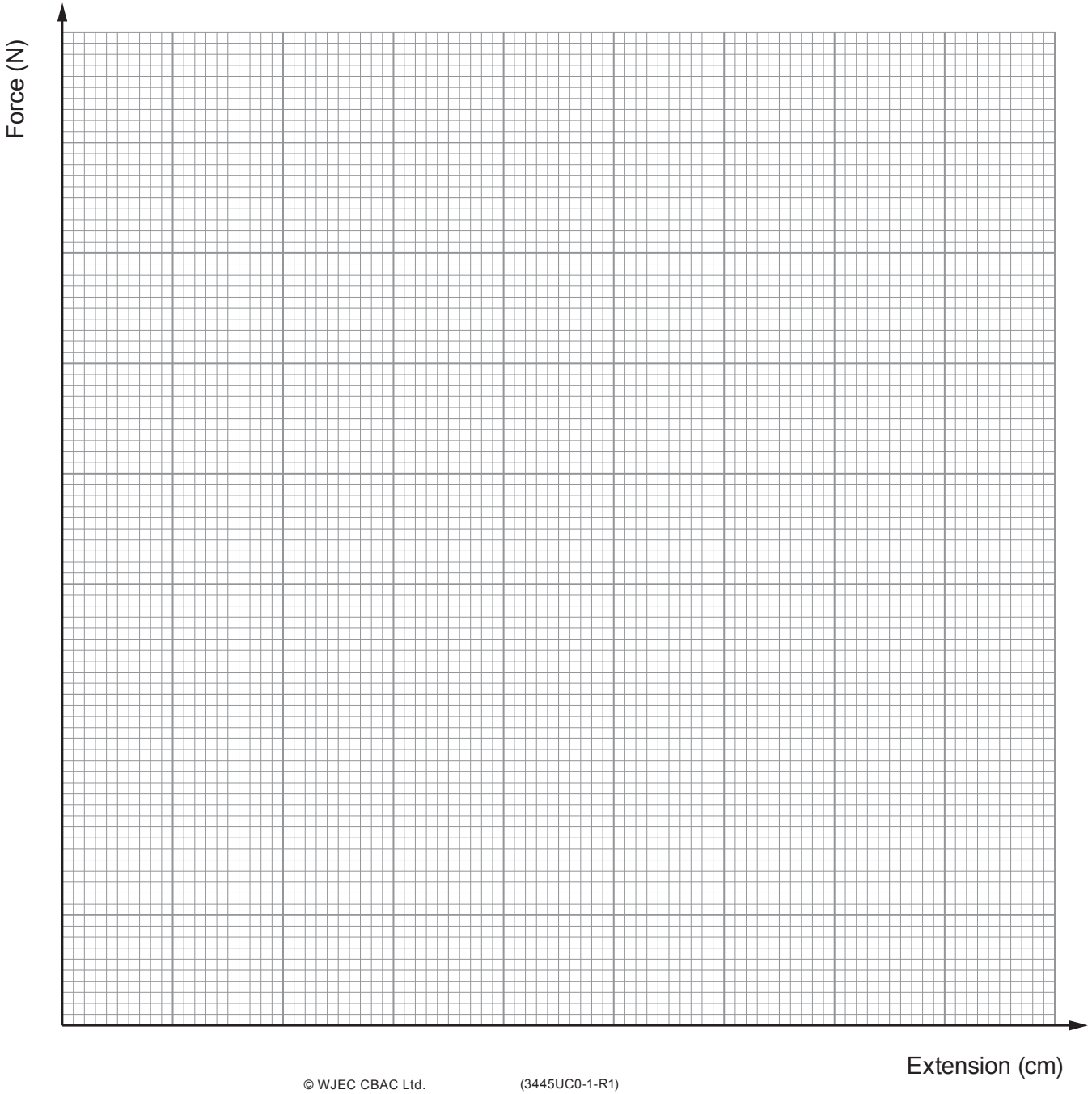
Examiner only

(b) The results for **Spring 3** are given in the table below.

Force (N)	Extension (cm)
0	0.0
10	2.4
20	4.8
40	9.6
50	12.0
60	16.0
80	28.0
90	36.0

(i) Plot the data on the grid below and draw a suitable line. [4]



Examiner only

(ii) Springs become permanently stretched once they pass their **elastic limit**. This is the point where extension is no longer proportional to the stretching force.

I. **Label** the elastic limit on your graph with a letter **E**. [1]

II. Use your graph to find the force required to reach the elastic limit. [1]

Force = ... N

(iii) During the opening and closing of the garage doors the spring will extend by 30 cm. Explain whether or not **Spring 3** is suitable for this purpose. [2]

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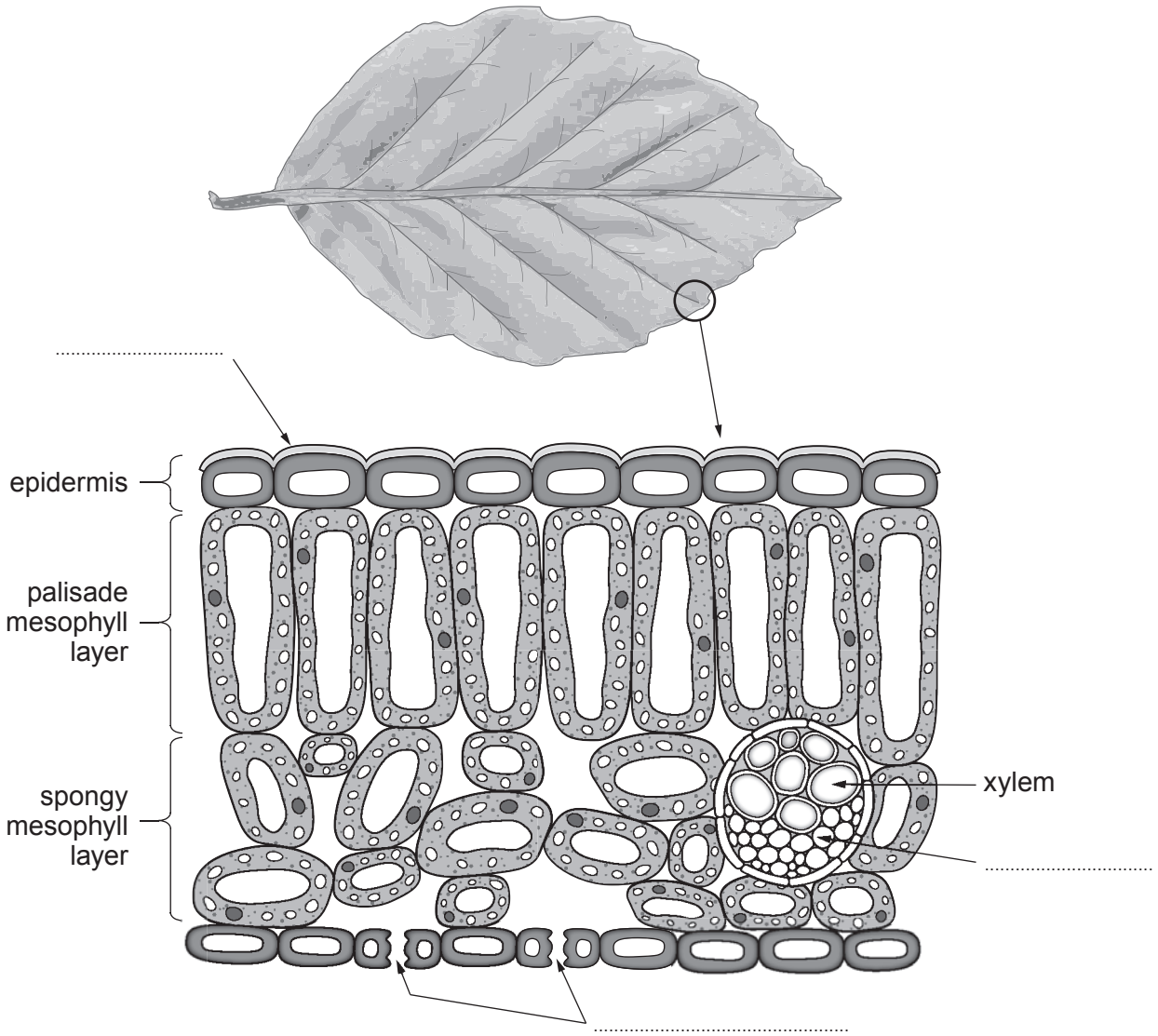
Turn over.

Examiner only

2. Students are learning about plants. They are interested in the structure and function of leaves.

(a) **Complete** the labelling of the parts of the leaf in the diagram below. [3]



(b) State the advantage of a transparent epidermis. [1]

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(c) State the purpose of the spongy mesophyll layer containing air spaces. [1]

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Examiner only

3. Metals have a variety of applications in industry, including making the wings and wiring for aeroplanes.

(a) (i) Describe metallic bonding. [2]

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(ii) Explain the property of metals which allows them to be used to make sheets for aeroplane wings. [2]

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(iii) Explain why the metals used in wires are good conductors of electricity. [2]

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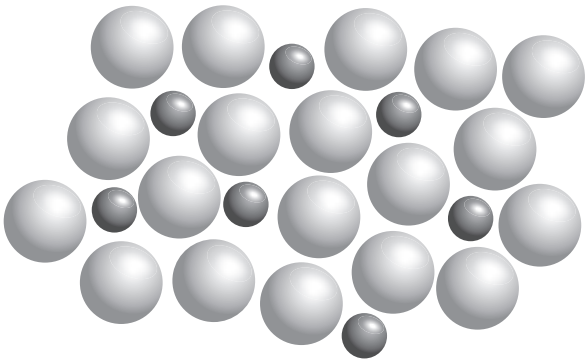
(b) Wings of modern jet fighter aircraft are made from alloy X which is composed of titanium, aluminium and vanadium. Wings on older aircraft were made from steel.

(i) Alloys consist of more than one type of atom, as shown in the diagram below.



Explain why this increases the strength. [2]

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Examiner only

(ii) Some properties of these metals and alloys are given in the table below.

Metal	Density (kg/m^3)	Stiffness (GPa)	Tensile strength ($\times 10^7$ Pa)
titanium	4500	110	55
aluminium	2700	69	10
vanadium	5700	138	63
alloy X	4400	110	100
steel	7800	210	40

I Compare the use of alloy X with steel for making aeroplane wings. [2]

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II The mass of a wing made from alloy X is 2500 kg. The alloy is 90 % titanium and 6 % aluminium.
Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

to calculate the volume of vanadium needed for each wing. [4]

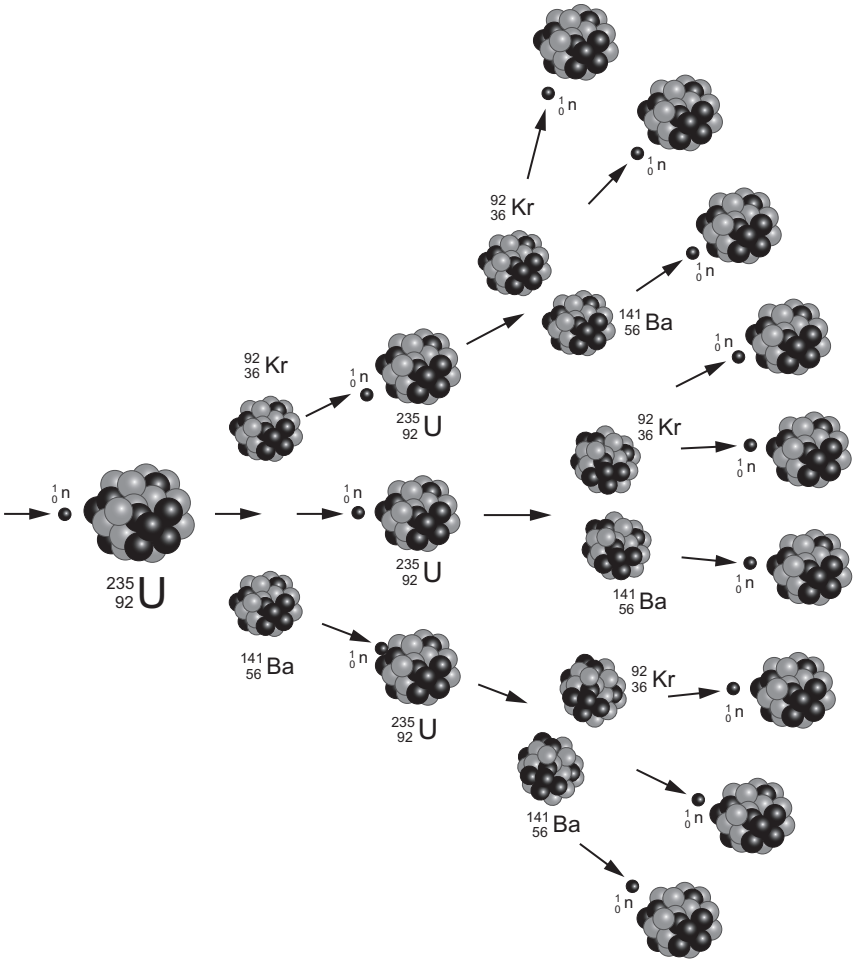
Volume = ... m^3

14

4. Information about two natural isotopes of uranium is given in the table.

Isotope	Symbol	Type of decay	Half life (years)	Product
uranium-235	$^{235}_{92}U$	alpha	7×10^8	thorium-231
uranium-238	$^{238}_{92}U$	alpha	4.5×10^9	thorium-234

One type of fission reaction involving uranium-235 is shown in the diagram.



Another type of reaction occurs in a fast breeder fission nuclear reactor. Uranium-238 (U-238) can be used to generate plutonium-239 (Pu-239), which also acts as a reactor fuel supply. An intermediate stage involves the production of neptunium-239 (Np-239).

The reaction follows the three stages below:

U-238 + n ⟶ U-239
U-239 ⟶ Np-239 + β
Np-239 ⟶ Pu-239 + β

Examiner only

(a) (i) State what is meant by the term half-life. [2]

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(ii) The isotopes of uranium in the table have been in existence since the Earth was formed. One estimate of the Earth's age is 4.2 billion years. Calculate the fraction of uranium-235 that remains on Earth today. [3]

Fraction = ...

(b) (i) Explain how the uncontrolled chain reaction shown in the diagram is prevented in a nuclear reactor. [3]

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(ii) Describe the structure of a nucleus of $^{141}_{56}Ba$ which is one of the fission products. [2]

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(c) Complete the following nuclear equations showing how uranium-238 generates plutonium. [4]

$$^{238}_{92}U + {}^{1}_{0}n \longrightarrow {}^{\ldots\ldots}U$$

$$^{\ldots\ldots}U \longrightarrow {}^{239}Np + {}^{\ldots\ldots}\beta$$

$$^{239}Np \longrightarrow {}^{\ldots\ldots}Pu + {}^{\ldots\ldots}\beta$$

Turn over.

5. Forensic scientists analyse substances found at crime scenes. They use analytical techniques to arrive at qualitative conclusions. These techniques are being used by students to identify samples of an unknown powder.
The table below shows the effect of adding sodium hydroxide solution to selected cations.

Cation	Effect of adding sodium hydroxide solution
aluminium (Al^{3+})	white precipitate soluble in excess sodium hydroxide to give a colourless solution
ammonium (NH_4^+)	no precipitate when heated with sodium hydroxide, ammonia gas is given off
calcium (Ca^{2+})	white precipitate insoluble in excess sodium hydroxide
copper(II) (Cu^{2+})	blue precipitate insoluble in excess sodium hydroxide
iron(II) (Fe^{2+})	green precipitate insoluble in excess sodium hydroxide
iron(III) (Fe^{3+})	reddish-brown precipitate insoluble in excess sodium hydroxide
lead(II) (Pb^{2+})	white precipitate soluble in excess sodium hydroxide to give a colourless solution
zinc (Zn^{2+})	white precipitate soluble in excess sodium hydroxide to give a colourless solution
magnesium (Mg^{2+})	white precipitate insoluble in excess sodium hydroxide

Tests for some anions are shown in the table below.

Anion	Test	Result
carbonate (CO_3^{2-})	add hydrochloric acid	carbon dioxide gas is produced
chloride (Cl^-)	acidify with dilute nitric acid, then add silver nitrate solution	white precipitate formed
iodide (I^-)	acidify with dilute nitric acid, then add silver nitrate solution	yellow precipitate formed
nitrate (NO_3^-)	add sodium hydroxide solution, then aluminium and warm carefully	ammonia gas produced
sulfate (SO_4^{2-})	acidify with dilute hydrochloric acid and then add barium chloride solution	white precipitate formed
bromide (Br^-)	acidify with dilute nitric acid then add silver nitrate solution	cream precipitate formed

Examiner only

(a) Describe the difference between qualitative and quantitative analysis. [2]

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(b) The students dissolve samples of the unknown powder in water and test for anions and cations.
The observations from the students' tests are shown below.

Test	Observations
sodium hydroxide solution added	white precipitate which did not dissolve as more sodium hydroxide was added
acidify then add barium chloride solution	white precipitate
hydrochloric acid added	bubbles of gas
dilute nitric acid then silver nitrate solution added	white precipitate

Use the information in the tables above and opposite to determine:

(i) all the possible cations that may be present. [1]

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(ii) all the anions that may be present. [1]

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(c) Describe another test that could be used to confirm the cation(s) present. [2]

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(d) Name **one** compound that could be present in the solution and use the symbols given in the tables to write down its chemical formula. [2]

Name .....

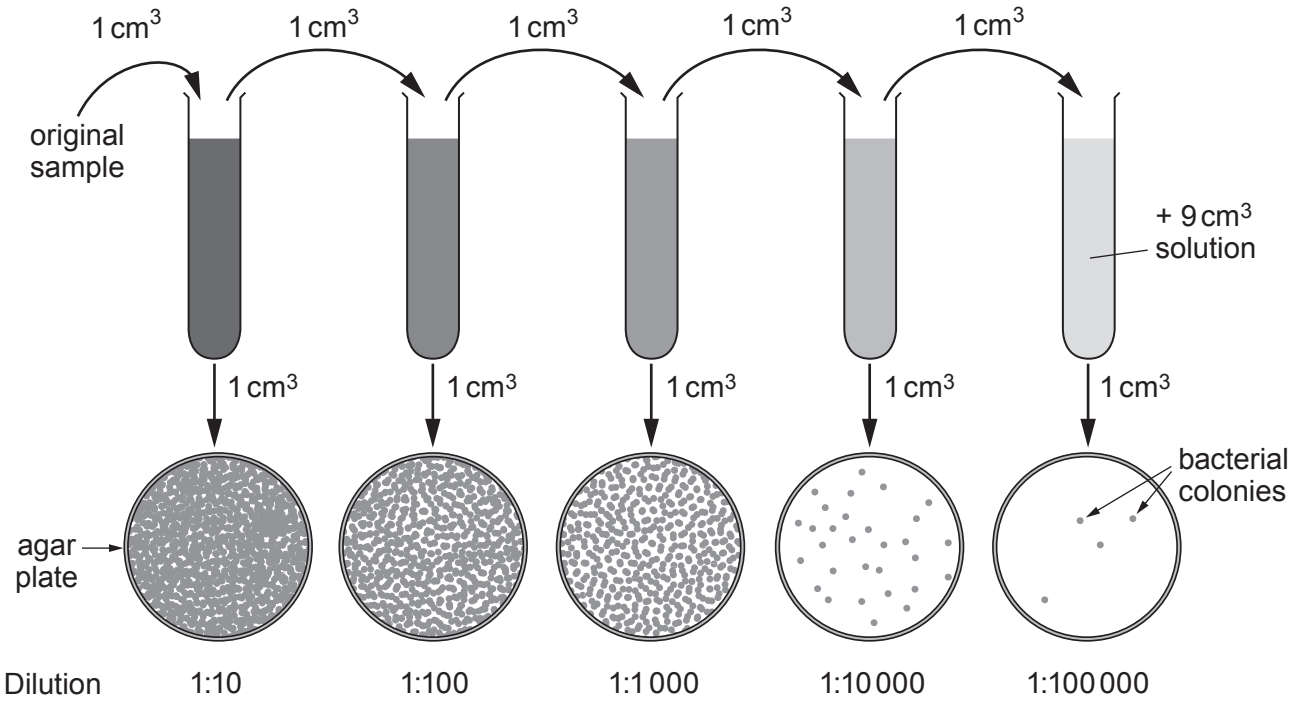
Formula .....

Examiner only

6. *(a)* Explain the methods used by the food industry to preserve food. [6 QER]

Examiner only

(b) Whenever an outbreak of food poisoning occurs, environmental health officers will carry out an investigation including testing samples of food for the presence of bacteria.
To ensure a countable agar plate a series of dilutions is carried out as shown in the diagram below. The number of bacterial colonies on each plate is counted.



(i) Suggest which dilution in the diagram above will provide the best set of results **and** give a reason for your answer. [2]

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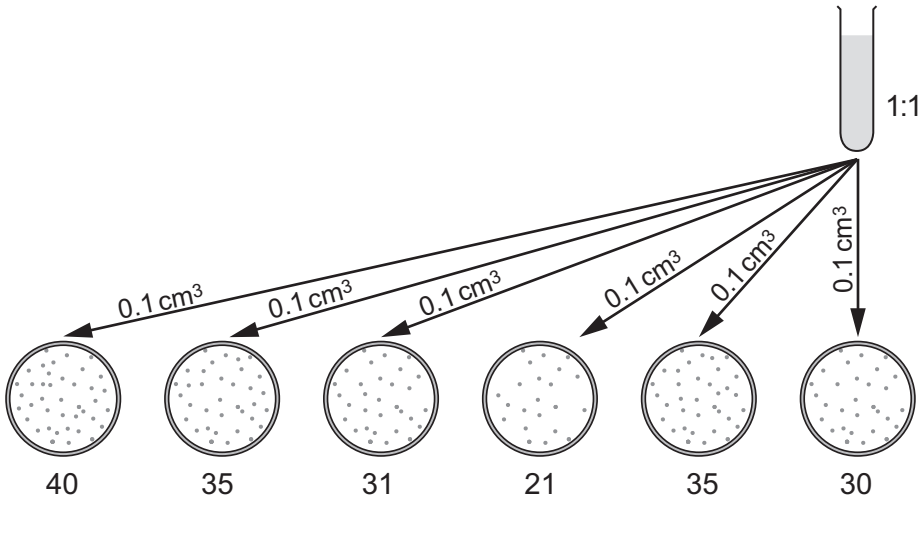
Examiner only

(ii) In another investigation, six agar plates were prepared by adding 0.1 cm^3 of solution from a 1:100 000 dilution. The agar plates were left for 72 hours. The results are shown below.



Use the information above to calculate the number of bacteria/cm^3 in the original **undiluted** sample. [4]

Number of bacteria = ... / cm^3

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Examiner only

7. The chemical industry provides many of the chemicals that people need for modern life. The chemical industry today is developing new processes to manufacture these chemicals more efficiently and with less impact on the environment.

(a) Explain why catalysts allow chemical reactions to be carried out at lower temperatures than would otherwise be needed. [2]

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(b) Describe the economic and environmental benefits of developing new and better catalysts. [3]

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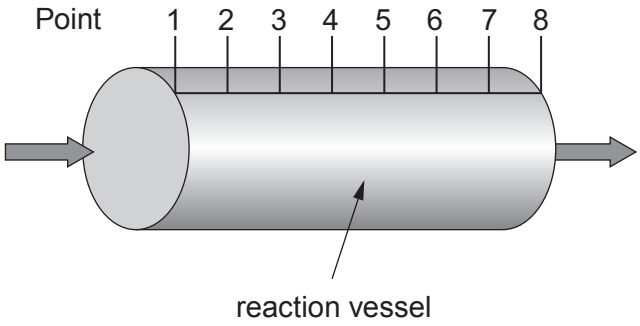
(c) Analysis of a reaction gives a good measurement of catalyst performance.



In an industrial process, waste gases, which include hydrogen sulfide, are pumped through a reaction vessel containing a catalyst. The hydrogen sulfide is removed in an **exothermic** reaction which causes an increase in gas temperature. The catalyst is performing badly if the hydrogen sulfide is not removed. Thermocouples monitor the temperature across a reaction vessel at eight different points as shown above.

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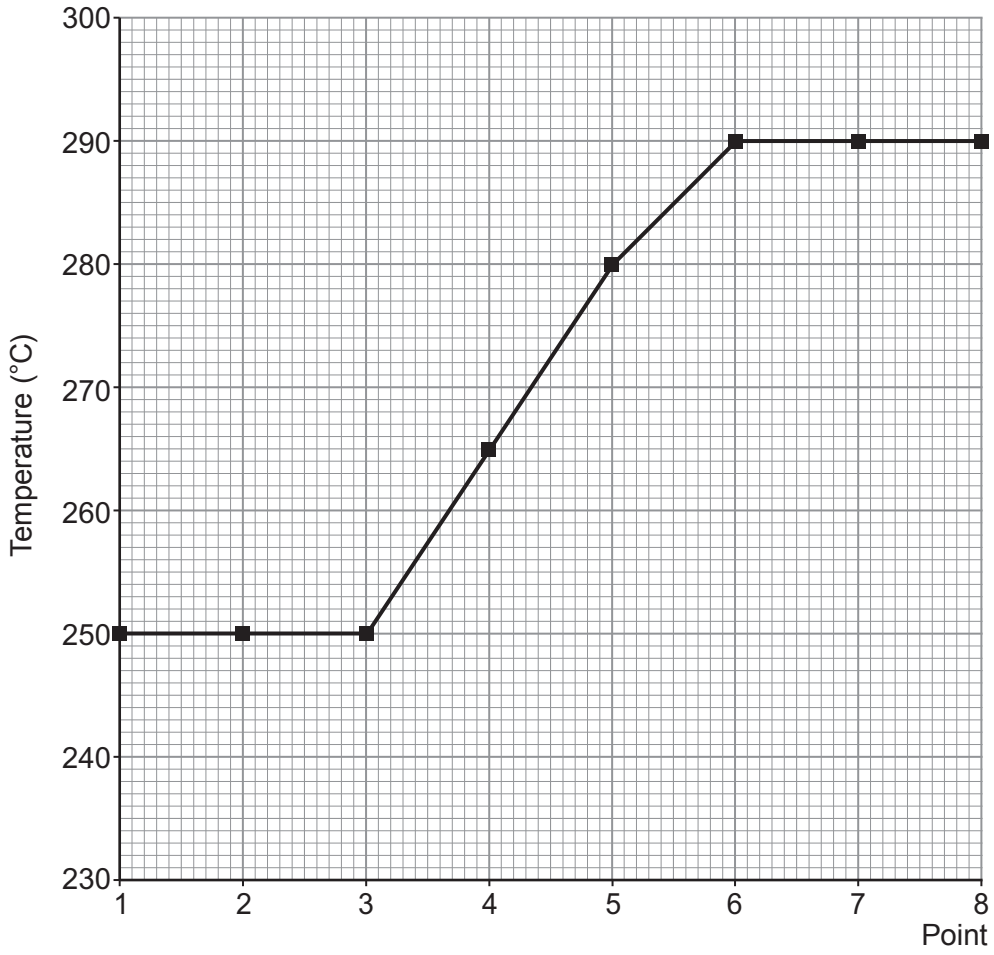
The temperature at each of the points 1 to 8 in the reaction vessel are plotted on the graph below.



Evaluate the performance of the catalyst across the reaction vessel. [3]

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THE PERIODIC TABLE

1	2	Group										3	4	5	6	7	0
							1 H Hydrogen 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 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
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
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
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key