

Surname	Centre Number	Candidate Number
Other Names		0



GCSE

3440UA0-1



**APPLIED SCIENCE (Single Award)
UNIT 1: Science in the Modern World**

HIGHER TIER

FRIDAY, 7 JUNE 2019 – AFTERNOON

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	7	
3.	6	
4.	11	
5.	6	
6.	9	
7.	7	
8.	17	
Total	75	

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ADDITIONAL MATERIALS

In addition to this paper you will require, a calculator, pencil and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

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

Question **3** is a quality of extended response (QER) question where your writing skills will be assessed.

You are reminded to show all your workings. Credit is given for correct workings even when the final answer given is incorrect.

A periodic table is printed on page 24.

Answer all questions.

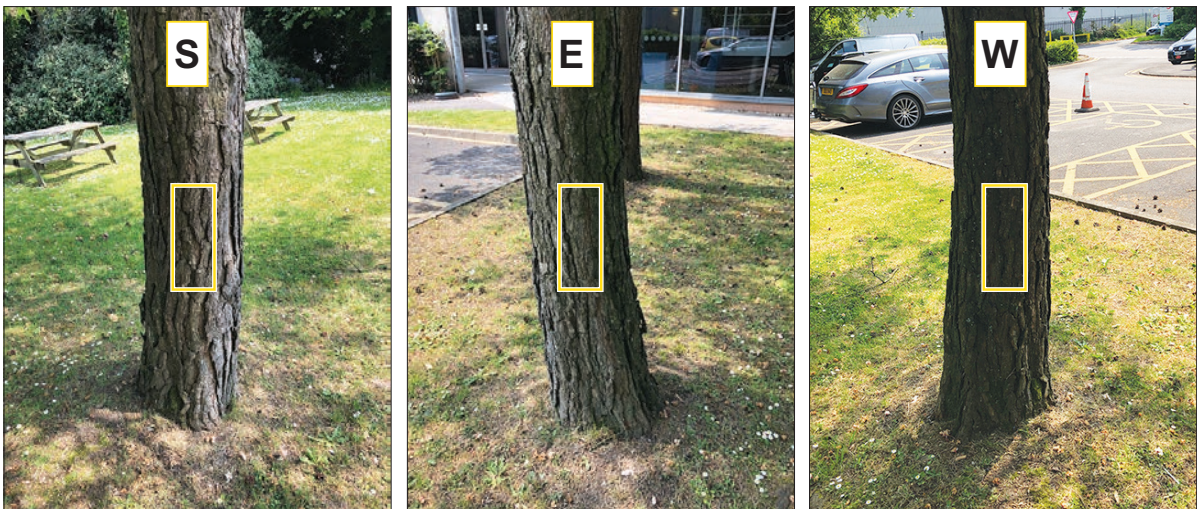
1. Some plants are more sensitive to air pollution than others. The risk of damage to these plants can be evaluated by surveying a site using living indicators.

Lichens are one type of living indicator. Some species of lichen can be used to monitor the levels of nitrogen pollutants in the air (nitrogen air quality index).

Method one: How to record indicator lichens on trunks

A 50×10 cm area is analysed on each of the three sides facing south (S), east (E) and west (W) on each trunk between 1.0 and 1.5 m above ground level as shown in **Diagram 1**. The presence of nitrogen-sensitive or nitrogen-tolerant lichen species is recorded.

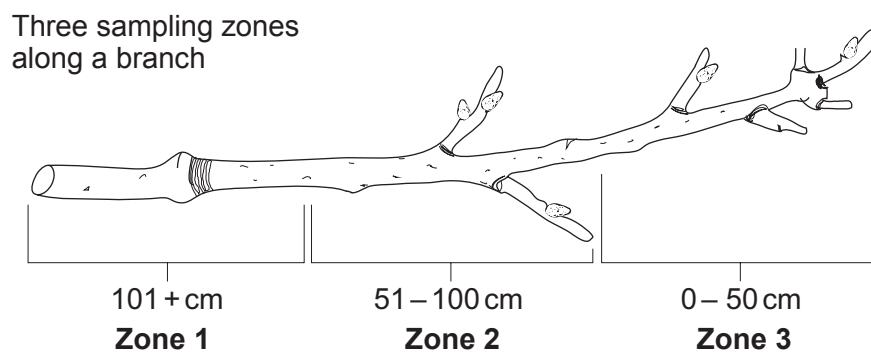
Diagram 1



Method two: How to record indicator lichens on branches

Locate the zones along the selected branch as shown in **Diagram 2**. The presence of nitrogen-sensitive or nitrogen-tolerant lichen species is recorded.

Diagram 2



(a) (i) State the dependent variable in the survey. [1]

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(ii) State **two** variables that are controlled when surveying tree trunks in **Method one**. [2]

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(b) Results from a survey of four trees, **A, B, C** and **D** in Aberdare park are shown in the tables below. **P, R, S** and **T** are four branches from tree **A**.

1 = lichen present
0 = lichen not present

Tree trunk	A			B			C			D			Total	Mean score per trunk
	W	S	E	W	S	E	W	S	E	W	S	E		
Direction														
Nitrogen-sensitive lichen present	1	0	1	1	1	1	0	0	1	0	1	1	8	2
Nitrogen-tolerant lichen present	0	0	0	1	0	0	1	0	1	1	0	0	4	1

Branches	P			R			S			T			Total	Mean score per branch
	1	2	3	1	2	3	1	2	3	1	2	3		
Zone														
Nitrogen-sensitive lichen present	1	0	1	1	1	1	1	1	1	0	1	1
Nitrogen-tolerant lichen present	0	1	0	0	0	0	0	0	0	0	0	1

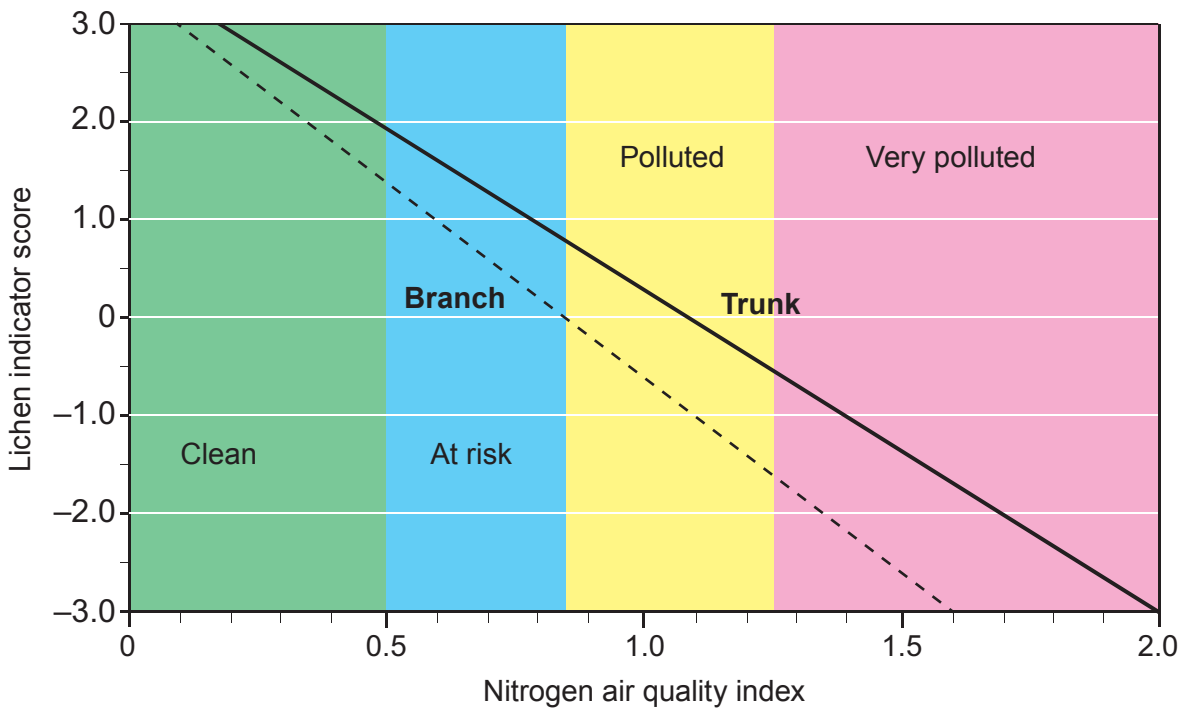
(i) **Complete** the table for branches. [3]

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- (ii) The lichen indicator score allows the air quality to be determined.
The lichen indicator score is calculated using the equation:

$$\text{Lichen indicator score} = \text{Nitrogen-sensitive lichen mean score} - \text{Nitrogen-tolerant lichen mean score}$$

The graph below shows how the lichen indicator score can be used to determine the nitrogen air quality index.



The **conclusion** from the branch data is that the nitrogen air quality is **clean**.

Determine whether the **tree trunk** data agrees with this conclusion.
Show your working.

[4]

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- (c) (i) In the 18th century Carl Linnaeus developed the system of giving all living organisms a two-word scientific name.
State how this system helps scientists in different countries who are studying these organisms. [1]
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- (ii) The scientific classification of three species of lichen is shown below.

Kingdom:	Fungi	Fungi	Fungi
Phylum:	Ascomycota	Ascomycota	Ascomycota
Class:	Lecanoromycetes	Lecanoromycetes	Lecanoromycetes
Order:	Lecanorales	Candelariales	Lecanorales
Family:	Ramalinaceae	Candelariaceae	Ramalinaceae
Genus:	<i>Ramalina</i>	<i>Candelaria</i>	<i>Frutidella</i>
Species:	<i>farinacea</i>	<i>concolor</i>	<i>caesioatra</i>

Ramalina farinacea is sensitive to nitrogen pollutants. *Candelaria concolor* is a nitrogen-tolerant lichen.

Use the information in the table to suggest why *Frutidella caesioatra* is likely to be sensitive to nitrogen pollutants. [1]

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2. The table gives information about 4 planets in the Solar System.

Planet	Orbital speed (km/h)	Time to orbit the Sun (years)	Diameter of planet (km)	Circumference of the planet's orbit (AU)
Earth	10.7×10^4	1	12800	6.28
Mars	8.1×10^4	2	6784	9.43
Jupiter	4.7×10^4	12	143360	32.68
Saturn	3.5×10^4	30	120320	59.71

The circumference of the planets' orbits is given in astronomical units (AU).

$$1 \text{ AU} = 150\,000\,000 \text{ km}$$

(a) Use your knowledge and data from the table to answer the following questions.

(i) Estimate the circumference of the asteroid belt. [1]

Circumference = AU

(ii) State **two** reasons why Saturn takes longer than Mars to orbit the Sun. [2]

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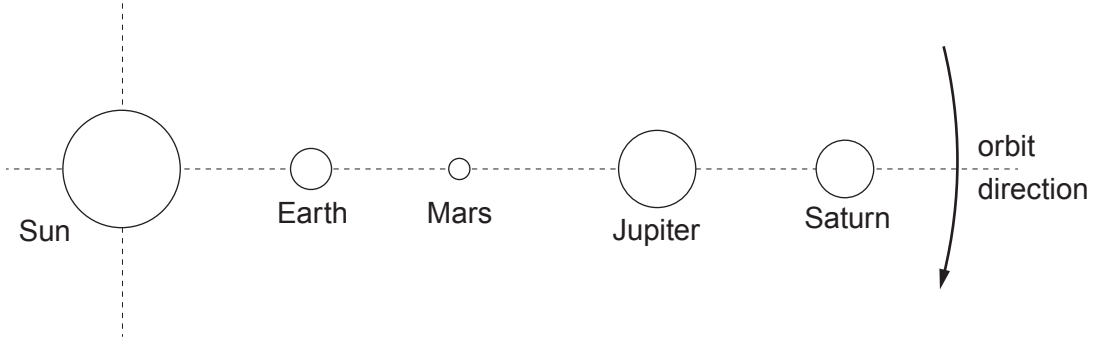
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(iii) The radius of the Sun is 695700 km. Calculate how many times Earth would fit along this radius. [1]

Number of times =

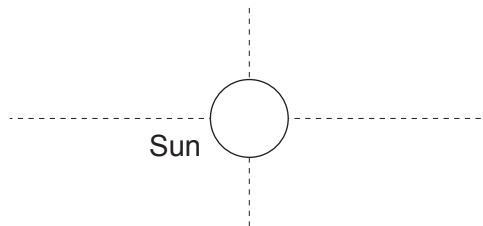
(b) The diagram below (not to scale) shows one alignment of the 4 planets with respect to the Sun.



(i) Use information in the table to find the number of years it will take for the alignment to occur next. [1]

Number of years =

(ii) Complete the diagram below to show the position of the planets with respect to the Sun, 12 years after the alignment above. [2]



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4. Riversimple is a Welsh car manufacturer of hydrogen-powered fuel cell electric vehicles. It is based in Llandrindod Wells.

Their working prototype car is the two-seat Rasa. The Rasa fuel cell generates electricity by combining hydrogen with oxygen to form water. The electricity then powers a small, lightweight 4 kW motor in each wheel, giving the car four-wheel-drive.

Each of the car's electric motors works as a generator when the brakes are applied and recovers 70% of the kinetic energy during heavy braking. This energy is used to make the car accelerate.

The Rasa is able to travel 483 km on 1.5 kg of hydrogen, and achieves the equivalent of 250 mpg with a top speed of 96 km/h. Hydrogen refuelling for the Rasa takes three minutes.

Emissions from the exhaust are zero (apart from water).

Adapted from <https://www.riversimple.com/>

- (a) (i) The reactants in the fuel cell are elements and the product is a compound. Explain the difference between an element and a compound. [2]

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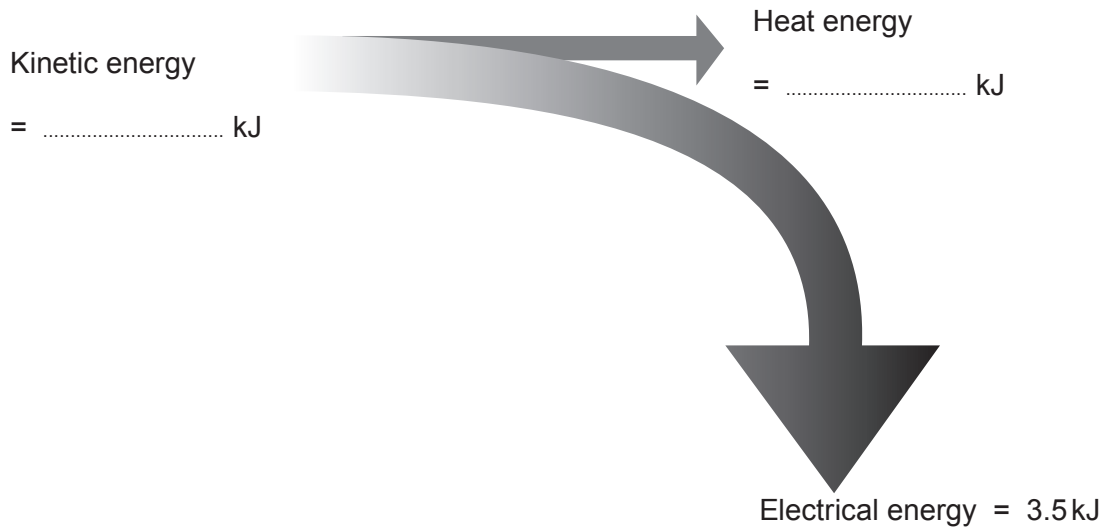
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- (ii) Write a balanced symbol equation for the reaction in the fuel cell. [3]

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- (b) Complete the Sankey diagram below (not drawn to scale) that shows the energy changes during heavy braking. [2]

Space for working



- (c) The four electric motors are connected in parallel to the fuel cell. Explain how this affects the current that flows from the fuel cell. [2]

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- (d) Explain how an increase in the use of hydrogen-powered fuel cell cars will have a positive impact on the environment. [2]

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5. (a) Describe how you would prepare a pure sample of zinc sulfate from zinc oxide powder.

[3]

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- (b) The table gives information about the solubility of salts.

Soluble salts	Insoluble salts
all nitrates	no insoluble nitrates
sodium carbonate potassium carbonate	most carbonates
most chlorides most bromides most iodides	silver chloride silver bromide silver iodide lead chloride lead bromide lead iodide
most sulfates	lead sulfate barium sulfate
sodium hydroxide potassium hydroxide	most hydroxides

In a precipitation reaction, two soluble salts are used to make an insoluble salt.

Use the information opposite to complete the table below if salts **1** and **2** are mixed together. [3]

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Salt 1 in water	Salt 2 in water	Name of insoluble salt if produced
Lead nitrate	Potassium iodide
Copper sulfate	Sodium carbonate
Silver nitrate	Iron sulfate

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6. Crude oil is a mixture of hydrocarbons which is separated to produce useful products.

Once separated, large hydrocarbon molecules can be broken down into smaller, more useful hydrocarbon molecules, including alkanes and alkenes.

Alkenes are unsaturated hydrocarbons. They contain at least one double covalent bond, which is shown as two lines between two of the carbon atoms.

Some alkenes can be used as monomers which can be joined together to make very large molecules called polymers.

Alkene	Molecular formula	Structural formula
ethene	C_2H_4	<pre> H H C = C H H </pre>

Alkanes are saturated hydrocarbons. Their carbon atoms are all joined to each other by single covalent bonds.

Alkane	Molecular formula	Structural formula
ethane	C_2H_6	<pre> H H H - C - C - H H H </pre>

- (a) Explain the main processes involved in producing polymers from crude oil. [3]

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(b) Suggest why alkanes cannot be used to make polymers.

[1]

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(c) Butene is an alkene containing four carbon atoms. Butane is an alkane also containing four carbon atoms.

(i) Draw a structural formula of **butene**.

[2]

(ii) State the molecular formula for a molecule of **butane**.

[1]

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(d) Ethene molecules can be joined together to make the polymer poly(ethene).

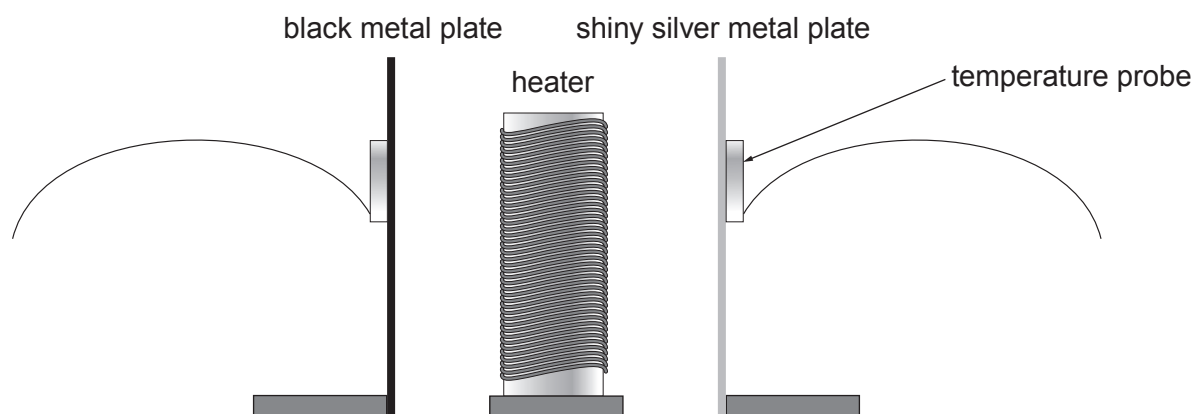
Draw the structure of poly(ethene).

[2]

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7. Heat can be transferred through materials in different ways.

A group of students intend to investigate how the temperature change of a material varies with the surface colour.



- (a) Explain why the plates are not heated by conduction or convection. [2]

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- (b) Data from the investigation is shown in the table below.

Time (minutes)	Temperature (°C)	
	Black metal plate	Shiny silver metal plate
0	16.2	16.0
2	20.3	18.3
4	24.2	20.6
6	27.9	22.8
8	32.1	25.1
10	36.4	27.7
12	40.9	29.9
14	45.2	32.1

- (i) Explain why there is a difference in the rate of temperature increase. [2]

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- (ii) Andrew suggests black plates heat up at twice the rate of silver plates. Use the equation:

$$\text{rate of temperature increase (}^{\circ}\text{C/min)} = \frac{\text{change in temperature (}^{\circ}\text{C)}}{\text{time taken (min)}}$$

to explain whether Andrew is correct.

[3]

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8. Electricity is distributed from power stations to consumers through the National Grid. Different energy resources are used to generate the country's electricity to meet the varying demand.

(a) (i) State what is meant by the term *base load*. [1]

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(ii) Explain the role of transformers in the National Grid. [3]

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- (b) The UK Government plans to ban the sale of new diesel and petrol cars by 2040. One alternative will be for people to buy electric vehicles. The National Grid company recently warned that, by 2040, electric cars could require 8 GW of additional capacity, on top of the current peak demand of 60 GW ($1\text{GW} = 10^9\text{W}$).

Power source	Typical contribution made by one power station ($\times 10^6\text{W}$)	Current contribution to the National Grid ($\times 10^9\text{W}$)	Percentage contribution to the National Grid (%)
Gas	1 360	25.0	39.3
Coal	1 800	6.8	10.7
Oil	1 600	0.4	0.6
Nuclear	3 200	12.5	19.7
Wind	4 (per turbine)	7.1	1.1
Solar	1 (for every 5 acres)	1.8	2.8
Hydro-electric	50	1.4	2.2
Bio-energy	53	5.4	8.4

Bob thinks that the increased power demand on the National Grid would be best met by nuclear power rather than renewable sources. Use data from the table above to evaluate if Bob is correct. [4]

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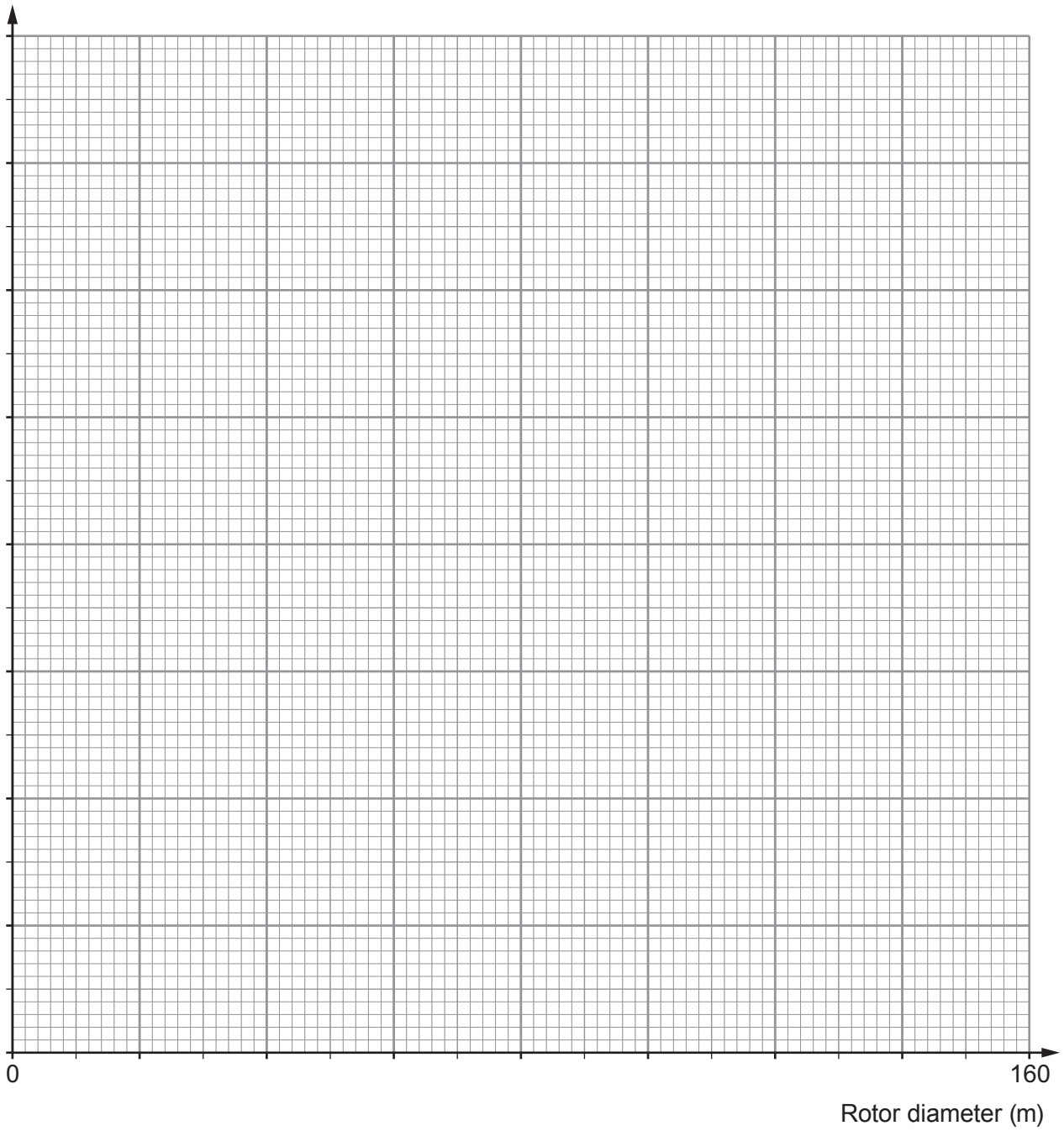
- (c) Hundreds of wind turbines produce electricity off-shore in the North Sea. Wind turbine developers are continually looking to create larger, more powerful turbines. The maximum power output from a wind turbine depends on its rotor diameter as shown in the table below.

Rotor diameter (m)	Maximum power output (MW)
0	0
20	0.3
60	1.2
80	2.0
100	3.1
120	4.5
140	6.2

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

[4]

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- (ii) The largest wind turbine has a rotor diameter of 160 m. Its mean output is 22% of its maximum power output.
The initial set-up cost of this turbine is approximately £9 000 000.
Use the graph in order to calculate the minimum payback time in years when the electricity is sold to the National Grid at a cost of £45 per MWh. [5]

Payback time = years

END OF PAPER

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