OCR

Oxford Cambridge and RSA

LEVEL 3 CERTIFICATE

Examiners' report

CORE MATHS A (MEI)

H868

For first teaching in 2016

H868/01 Summer 2022 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

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Paper 1 series overview

The great majority of candidates were able to attempt all the questions and had the opportunity to show what they could achieve and responded well to this paper.

The mean omission rate this session is slightly higher than the 2019 session and the session before that (5.9% this session compared with 5.4% and 4.6% respectively). Question 7(b)(ii) had the highest omission rate and was not attempted by just over 1 in 5 of all candidates. The mean mark for this paper is statistically significantly lower than 2019's paper but statistically significantly higher than 2018's paper. By their very nature it is almost impossible to objectively compare the difficulty of these heavily contextualised questions year on year.

Well over three quarters of candidates scored more than half of the available credit while about 1 in 50 gained less than a quarter of the marks available. There was no evidence of a significant number of candidates inappropriately entered or insufficiently prepared for the examination. There was no firm evidence that a significant proportion of candidates were denied credit by virtue of any literacy demands. As far as it is possible to judge, candidates made effective use of the pre-release materials.

Overall, the lowest attaining candidates found the questions' order of difficulty, easiest first, (judged on facility) to be 1, 6, 3, 5, 2, 7 and 4. For the highest attainers the corresponding order was 6, 3, 1, 5, 2, 4 and 7 – but only marginal differences.

The lowest attaining candidates found these pieces of content the most challenging:

- setting up an algebraic expression (Question 4(a)(i) and (ii)),
- following through a calculation involving different metric units (Questions 4(d) and (e)),
- showing whether a relationship is proportional (Question 7(b)(ii)),
- and determining the location interval of the median for data arranged in a grouped frequency table (Question 2(b)(ii)).

This group of candidates showed competency when dealing with:

- calculating the cost of a finance-related decision in a context (Question 1(a)(i) and Question 1(a)(iv)),
- drawing and interpreting a line of best fit (Questions 3(a)(ii) and (iii)),
- interpreting various statistical diagrams (Question 3(a)(i), Question 2(a)(i), Question 6(a)(i)).

The highest attaining candidates found these pieces of content the most challenging:

- setting up an algebraic expression (Question 4(a)(i) and (ii)),
- interpreting numbers given in standard spreadsheet format (Question 7(b)(i) and (ii)),
- using/interpreting proportionality in a real-world situation (Question 7(b)(ii))
- and interpreting acceleration, including units from a velocity-time graph (Question 5(b)(iii)).

Competency was particularly evident when:

- carrying out financial related calculations (Question 1(a)(i) and Question 1(a)(iv)),
- performing foreign exchange calculations (Question 6(b)(i) and (ii)),
- solving linear equations (Question 5(a)(i))
- and interpreting time series involving exchange rates (Question 6(a)(i)).

Overall, there are several questions where some credit could have been lost by incorrect or premature rounding. The rubric on the first page does state "Give your final answers to a degree of accuracy that is appropriate to the context". Notably, there is an expectation that money (£s) be given correct to two decimal places.

Another area which can result in or cause unnecessary credit loss is units. This was particularly noticeable in Question 1. Writing units can sometimes give candidates a brief period to ponder on their responses. In the same vein, while fully appreciating it is not possible that candidates' life experiences can embrace all the scenarios, a critical attitude to the magnitudes of quantities can help. Examples where wrong answers could have been picked up with a little thought include:

- Probabilities greater than 1 are impossible (Question 7(c)); 10^5 was seen on occasion.
- Times to cover the measured mile at about 300 mph are about 11 to 12 seconds, so calculated times of 3 600 000 seconds, from 3600 × 1000, to cover a mile at 1000 mph must be incorrect (Question 5(c)).
- Buying and selling back currency over a short period of time, unless there are very serious events taking place or you are a bank, cannot result in a profit (Question 6(b)(ii)).
- Given scale drawings are accurate, answers generated from them should be consistent. For example, in Question 5(d) just looking at the scale drawing should query an answer of 40 km for the track length.
- A megaton is a large unit of energy (joules), therefore an energy in joules converted into megatons must result in a smaller number (Question 7(a)). A similar argument holds when converting between currencies.

Ideally candidates should get into the habit of always quickly looking at their answers with healthy scepticism.

The other, all too obvious, strategy is to re-read question and answer, both as a pair and individually. This should make sure that the question has in fact been answered and that the working towards it is clear and unambiguous (Question 1(b) and Question 7(b)(ii)). This is particularly important in questions of the type "Which is the better deal?" when candidates work through faultlessly but simply forget to state the better deal.

One observation, possibly subjective and a result of the situation over the last two years, is the instances of less well-written numbers and working generally. This seemed to have increased on previous years.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
- showed clarity in their working - made sure to consider units - appeared to reflect on the question. (e.g. Question1(b) – did not rush in and change from annual to monthly payments without reason. e.g. Question 2(c) – realised that the totals in the spreadsheet table can be used to estimate the mean.) - recognised numbers in spreadsheet formats and equivalent.	- did not review answers critically to check units and "reasonableness" of the numbers - gave insufficient consideration as to how their workings read and their clarity - may not have read the questions at least twice (as this tends to encourage omitting the vital decision statement or "X is the better deal" based on their previous calculations).

Question 1 (a) (i)

1   Mia wants to buy an electric bike to get to work. She currently travels to work by bus.

- Electric bikes travel 80 miles on a single electric charge.
- A single electric charge costs about £0.30.
- It is a **total** distance of 10 miles to cycle to work from home and back.
- It costs £5.50 a day by bus.
- She works for 20 days each month.

     (a) (i)   Calculate how much Mia spends a month to get to work by bus.   **[2]**

A very well answered question, almost all achieved full credit. The main error was omission of the correct money units.

Question 1 (a) (ii)

     (ii)   Mia reads that the cost to charge an electric bike is just over 1p per mile. Use the above information to determine if this is true.   **[2]**

A significant minority found using the correct units a challenge. Omission of units was not uncommon. The majority achieved full credit, with a very small minority scoring no marks.

Question 1 (a) (iii)

     (iii)   How much could Mia save a month by using an electric bike to get to and from work? For the electric bike, only consider the cost of electricity to charge it.   **[2]**

Most candidates were successful with very few not gaining any credit. There were few problems with money units.

Question 1 (a) (iv)

(iv) The batteries for electric bikes are expensive.
Their lifetime is about 1000 charges from empty.

Mia plans to use her bike for work and visiting friends.
This is a total of 350 miles a month.

Determine whether the bike's battery is likely to last more than 4 years. **[3]**

Most candidates successfully responded. Several valid methods were used – vis total number of battery recharges or total mileage needed over the 4 years. Several candidates did not give a conclusion.

Question 1 (b)

(b) In addition to paying for electricity, Mia will need to pay for a crash helmet, insurance and bike maintenance as well as paying for the bike itself.

The prices of bikes available in her local shop are shown in **Fig. 1.1**.

The shop is offering deposit-free loans. **Fig. 1.2** shows the monthly repayments.

Cost of bike

Bike	Cost
Electric Blue	£800
Electric Rider	£1000
Electric Comet	£1200

Fig. 1.1

Monthly loan repayments

		Loan period	
Loan	12 months	24 months	36 months
£600	£54.85	£29.79	£21.52
£800	£73.13	£39.72	£28.70
£1000	£91.41	£49.65	£35.87
£1200	£109.69	£59.58	£43.04
£1500	£137.12	£74.48	£53.81

Fig. 1.2

Crash helmet, insurance, and bike maintenance cost in total about £20 a month.
Mia needs to take out a loan.

- She wants her total monthly cost to be less than she is currently paying for bus fares, taking account of the crash helmet, insurance, bike maintenance, battery recharging and loan repayment.

- She also wants to pay off the loan in a year.

Determine which bike(s) Mia can afford. 　　　　　　　　　　　　　　　　　　**[4]**

Less than half the candidates gained more than half the available marks with a very small minority not gaining any credit. A significant number of candidates omitted to take into account the cost of charging the bike's battery. In addition, a number confused stated cost with the actual cost (including interest) and made the error of assuming that £800 was to be paid back rather than £877.56 (12 × £73.13). A small proportion worked with both annual costs and monthly costs and confused the two. Some could have improved performance by imposing a logical structure to their working, perhaps employing sub-headings to support this.

Long questions involving elements of choice

Responses to information-rich questions like this benefit from the use of bullet points or even tables – nothing too elaborate but sufficient to clarify thinking and support situations where there may be partial credit available.

Exemplar 1

1(b)	currently £110/month bus fares (5·5×20) 110 - 20 (maintenance etc) = £90 to spend/month. so she can afford £600 and £800 loans. (£800 = £73.13/month) for 12 months. electric blue = £800 ↓ electric blue is the only bike that she can afford.

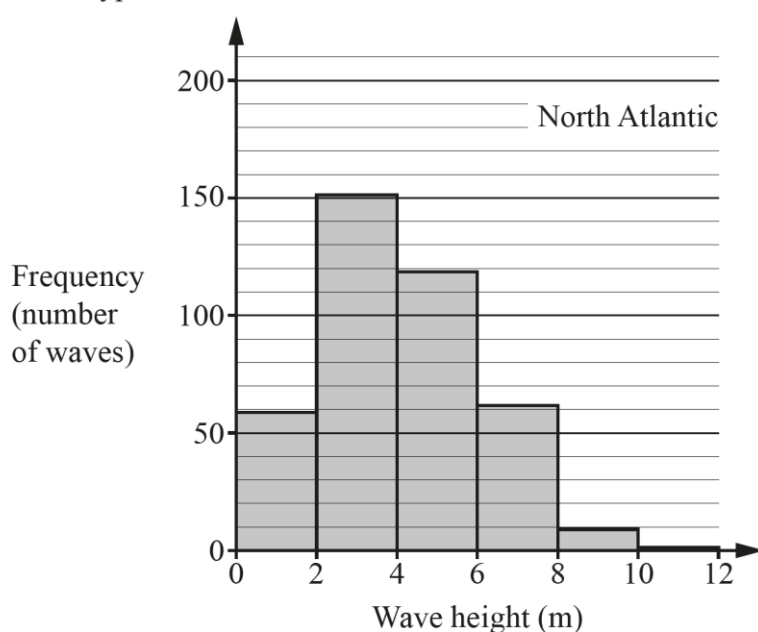A clear response but the cost of charging the bike's battery was left out.

Question 2 (a) (i)

2   **(a)** Wave heights can be recorded using signals from floating buoys, like the one shown in
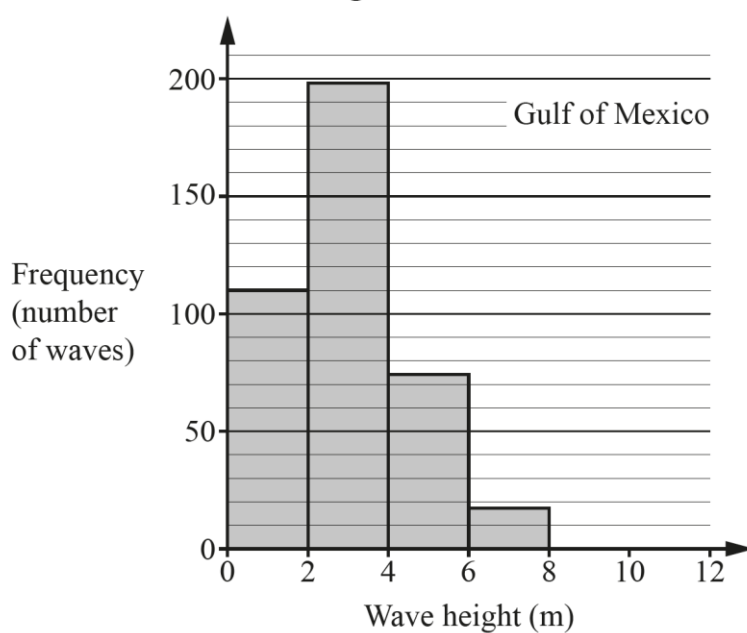**Fig. 2.1**.

Fig. 2.1

The grouped frequency charts in **Fig. 2.2** and **Fig. 2.3** show the wave heights of 400 waves
under typical conditions in the North Atlantic and the Gulf of Mexico.

Fig. 2.2

Fig. 2.3

(i) How many of the waves in the Gulf of Mexico sample were less than 2 m?   [1]

A moderately easy first part to this question with success achieved by nearly all candidates. There was little difference between higher and lower attaining candidates. A common incorrect response was "59 waves". There were almost no instances of reading from the wrong chart.

Question 2 (a) (ii)

(ii) Write down **one** difference and **one** similarity in the distributions of wave heights in the North Atlantic and the Gulf of Mexico.   [2]

Candidates tended to be more successful in stating similarities rather than differences; "having the same modal range" was a popular response here. Only a small minority did not gain full credit.

Describing differences, similarities or overall trends

Responses to questions about differences, similarities or overall trends usually require details of the big picture or a general pattern – identifying specific points in a chart or table will not be sufficient.

Question 2 (b) (i)

(b) Wave heights are important to shipping but also to structures such as oil rigs which, unlike ships, are unable to move away from storms.

The spreadsheet in **Fig. 2.4** shows the grouped wave heights, w metres, during a particular storm in the Gulf of Mexico. The storm lasted about an hour.

	A	B	C	D	E	F	
1		Interval		Mid-interval	Frequency	Mid-interval × frequency	
2	0	$\leq w <$	4	2	55	110	
3	4	$\leq w <$	8	6	97	582	
4	8	$\leq w <$	12	10	90	900	
5	12	$\leq w <$	16	14	43	602	
6	16	$\leq w <$	20	18	11	198	
7	20	$\leq w <$	24	22	4	88	
8	24	$\leq w <$	28	26	0	0	
9				Total	300	2480	
10							

Fig. 2.4

    (i) Find the modal interval for the wave heights.   **[1]**

This was found challenging by the least capable group where only about 1 in 4 were successful. A very common error was to give "6", the mid-range of the modal interval. A very large majority of the most capable were successful. As far as it was possible to ascertain, very few, if any, candidates used the two frequency charts rather than the tabulated data.

Question 2 (b) (ii)

    (ii) Show that the median lies in the modal interval.   **[1]**

This was a challenging question, particularly for the least capable. A common error was simply to list the numbers 2, 6, 10, 14, 18, 22, 26 and select the middle number. Most appreciated the role of the 150th data point but did not progress any further in their explanation.

Question 2 (b) (iii)

> **(iii)** Write down the formula in F2 which was copied from F2 to F8.   **[1]**

The majority, but only by a small margin, were successful here. About one third of lower attainers were successful, rising to about three quarters for the higher attainers. The most common errors were omitting the "=" or not using the asterisk symbol for multiplication.

Using spreadsheets

It is expected that candidates will have had some practical experience of spreadsheets and understand simple formulae. Practical spreadsheet activities using the large data set Excel file from H869/02 is an effective way to check that candidates can write simple formulae.

Question 2 (c)

> **(c)** Oil rigs need to withstand the exceptionally high waves which can very occasionally occur. Suitable modelling suggests that, at any time, the height of about 1 wave in 260 000 is at least 4 times the mean wave height in a storm.
>
> How high is such a wave in the Gulf of Mexico?   **[3]**

Some candidates did not make use of the relevant totals displayed in the spreadsheet to calculate an estimate of the mean wave height. These attempts from first principles were rarely successful. Partial credit was available for a calculated estimate of the mean, regardless of its correctness, if it was correctly used in the formula to calculate the height of an exceptional wave.
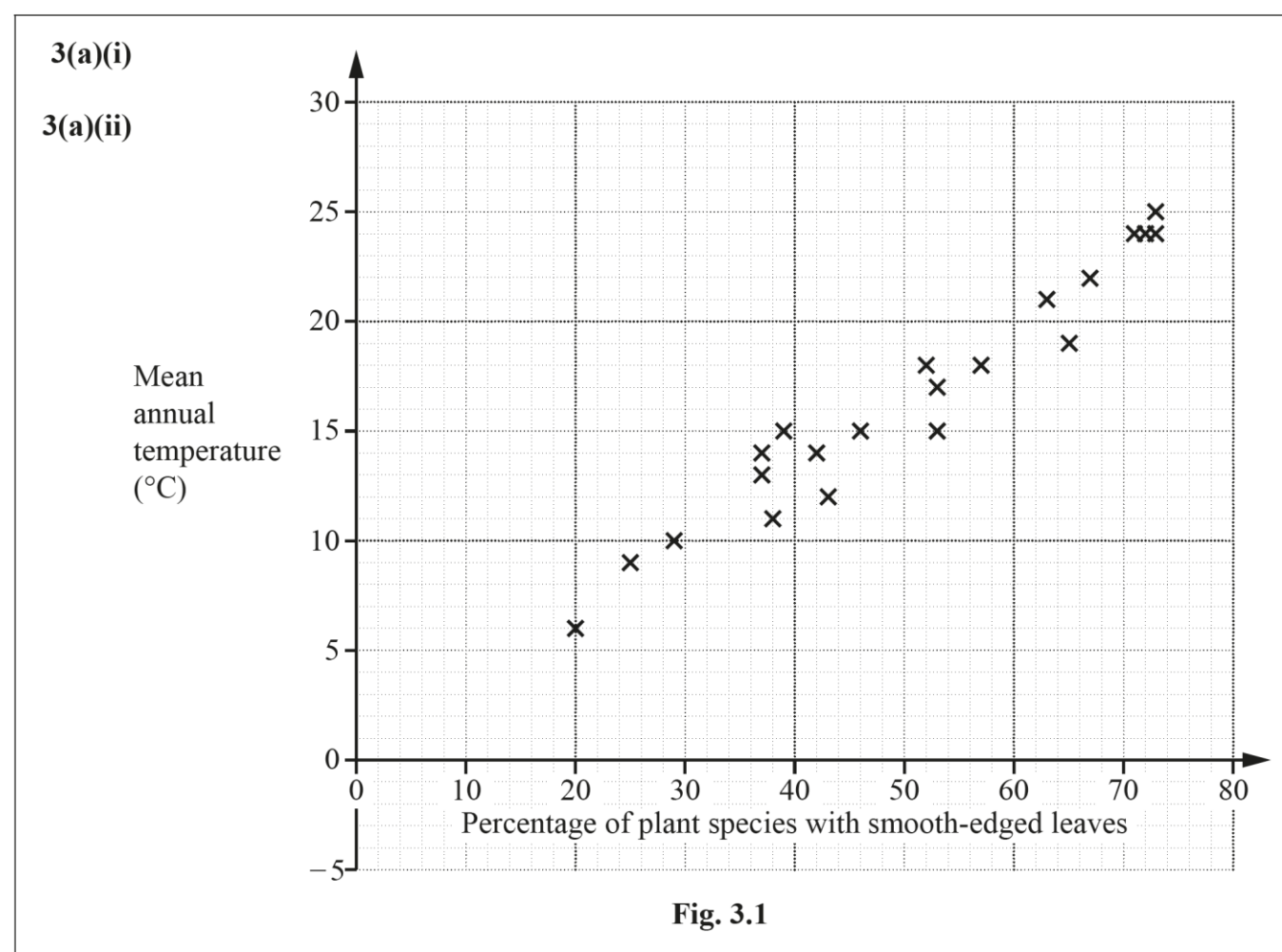
Question 3 (a) (i)

3   **This question refers to article A in the pre-release material, 'Leaves as thermometers'. You can find the article on the Insert accompanying this paper.**

(a)   The scatter diagram in **Fig. 3.1** shows 21 observations of the percentage of species of plants with smooth-edged leaves and the mean annual temperature in various regions around the world.

   (i)   Coca is a region in Ecuador. The mean annual temperature there is 27 °C and 76% of plant species have smooth-edged leaves.

   Plot this point with a cross on the scatter diagram in **Fig. 3.1**.   **[1]**

Fig. 3.1

A very well answered part, only a very small minority were unsuccessful.

Question 3 (a) (ii)

(ii) Draw a line of best fit by eye on the scatter diagram.   [1]

Most candidates successfully drew a line of best fit within tolerance and with a ruler. The prime source of credit loss was not using a ruler.

Question 3 (a) (iii)

(iii) The straight line model represented by your line of best fit can be used to estimate annual mean temperatures millions of years ago, provided fossilised leaves from that time are available.

In Wyoming, USA, there are large deposits of fossilised leaves. These can be dated using animal bone fossils.

In one site, 55.9 million years old, half of the plants had smooth-edged leaves.

The present mean annual temperature in Wyoming is 7.6 °C.
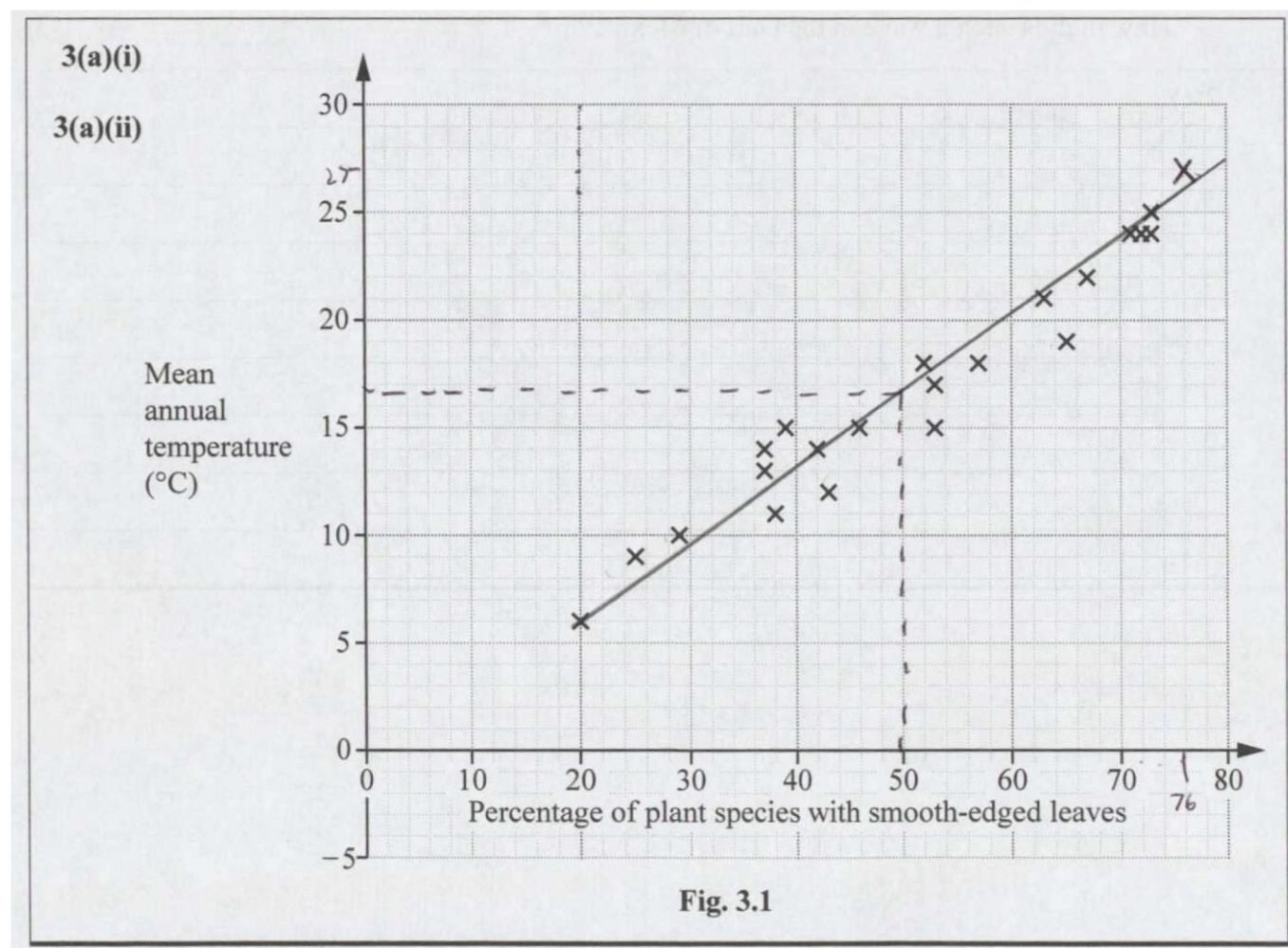
Compare this with the temperature 55.9 million years ago.   [3]

Most candidates gained full credit, set against a very small minority who did not gain any marks. Most errors arose from considering solely the leaves with no reference to the temperature. Using the straight line presented no problems for the great majority. Almost no candidates guessed, based on global warming, that today's temperature would be greater than millions of years ago.

Exemplar 2

3(a)(i)

3(a)(ii)

Fig. 3.1

3(a)(iii)	The temperature 55.a million years ago was just under 17.°C, around 16-8°C, So compared to now it was is a this around 9°C colder. now then it was. back then.

The candidate successfully answered parts (i) and (ii) enabling a concise response for part (iii).
Full credit was given for all three parts. Note that the candidate has shown exactly how they have used the line of best fit.

Question 3 (b)

(b) Fossil dating always has some uncertainty.
It is established that dinosaurs became extinct 65.95 ± 0.04 million years ago.

A dinosaur bone has been dated as 65.3 ± 0.9 million years old.

Is this figure consistent with the extinction date for dinosaurs? **[3]**

> All but a few candidates were successful in finding the error bands of at least one of the dates. However, using the error bands was found challenging and only around 2 in 5 were able to correctly say that the figures were consistent. Only a small minority used a number line to support their response.

Question 4 (a) (i)

4 **This question refers to article B in the pre-release material, 'Centre pivot irrigation'. You can find the article on the Insert accompanying this paper.**

(a) Centre pivot irrigation is used in square fields. A basic system can only irrigate the circular region shown in **Fig. 4.1** (which is part of **Fig. B.3** in the pre-release material).
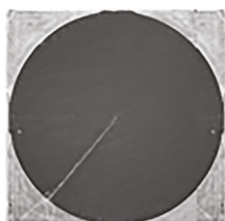
Fig. 4.1

A circle of radius r metres is surrounded by a square of side $2r$ metres.

(i) Find the total area of the four regions that are inside the square but outside the circle. (This is the area not irrigated.) **[1]**

> Candidates were very reluctant to employ algebra in either part (i) or part (ii). In fact, most candidates did not gain credit in part (i) and almost no candidates were successful in part (ii). A common error by those attempting to use algebra was to assume "$2r \times 2r = 2r^2$" or "$(2r)^2 = 2r^2$", instead of $4r^2$.

Question 4 (a) (ii)

(ii) Show that this area is $(100 - 25\pi)\%$ of the area of the square. **[2]**

> Partial credit was available to those who worked consistently with a specifically sized square and corresponding circle, following this through from their result in part (a)(i).

Question 4 (b)

(b) The radius of the irrigated circle in a centre pivot irrigation system is 400 m.

Calculate the area which is irrigated.
Give your answer in m^2 correct to **2** sf.   **[3]**

A large majority of candidates were successful in calculating the irrigated area. Most problems arose in rounding these areas correct to 2 sf. A very common wrong response was "502 000" – the result of not understanding that a trapped zero is a significant figure. A very small minority made the error of using the formula for the circumference of a circle.

Question 4 (c)

(c) 1 mm of rain falls evenly onto 1 m^2 of ground (see **Fig. 4.2**).
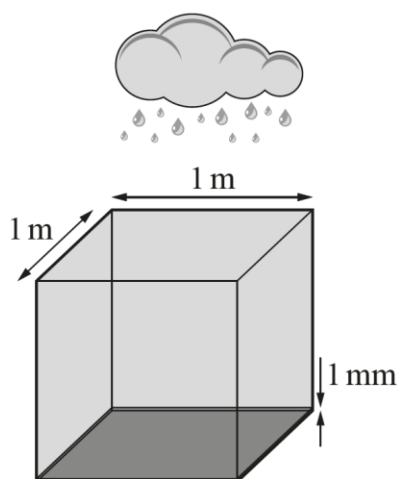
Fig. 4.2

Show that this is 1 litre of water (1 litre $= 1000\,\text{cm}^3$).   **[1]**

Just over half the candidates were successful. This ranged from about a third of lower attainers to just over three quarters of higher attainers. It was clear that a significant minority were not secure converting between the various metric measures of both length and volume. There were a few muddled calculations which in the final step were divided by a number such that the result was 1000, but with no obvious rationale.

Question 4 (d)

(d) 1 mm of rainfall falls uniformly over a circle of radius 400 m.

Calculate the volume of water involved. Give your answer in m^3, using the results from parts **(b)** and **(c)** $(1\, m^3 = 1000$ litres$)$. **[2]**

Most candidates did not gain credit. Almost 1 in 5 candidates did not attempt to answer the question. This was despite the instruction to use the results from parts (b) and (c). A lack of understanding of units was shown in a significant minority of cases. Some of these could perhaps have been reduced had candidates put the relevant units after each calculation thereby guiding them to focus on what the results meant in terms of the problem asked.

Question 4 (e)

Centre pivot irrigation allows farming in deserts, providing water wells can be drilled. The tables in **Fig. 4.3** show how many millimetres of water are needed each day in the desert conditions, during peak growth for some popular crops.

Crop	Water needed (mm per day)		Crop	Water needed (mm per day)
Bananas	12		Nuts	10
Beans	11		Peppers	10
Eggplant	11		Potatoes	11
Grapes	7		Squash	9
Melon	10		Tomatoes	11

Fig. 4.3

(e) How many m^3 of water would be needed per day to grow potatoes during peak growth on a single 400 m radius irrigated circle? **[2]**

A large majority of candidates gained no credit for this part and only about a quarter gained full credit. Partial credit was available but it was sometimes impossible to give due to the unordered presentation of working. A small minority divided by 11 instead of multiplying by 11, indicative of misunderstanding the situation.

Question 5 (a) (i)

5   **This question refers to article C in the pre-release material, 'Land speed record'. You can find the article on the Insert accompanying this paper.**

(a)   In 1935 the car Bluebird took a **total** of 23.91 seconds to cover the measured mile in both run directions. This gave a mean speed of 301.129 mph for the 2 miles, making it the first car to achieve an average speed of over 300 mph.

- The mean speed, V mph, needed to cover 1 mile in T seconds is given by

$$V = \frac{3600\,N}{T} \text{ with } N = 1.$$

- The first run took 11.83 seconds, giving a mean speed of 304.311 mph.
- The second run took 12.08 seconds.

(i)   Calculate the mean speed for the second run.   **[2]**

A large majority were successful, and most were able to successfully substitute into the given formula. However, many truncated or rounded their answers prematurely, despite the pre-release stating that speeds in world land speed records are correct to 3 dp.

Question 5 (a) (ii)

(ii)   Determine whether the official mean speed of 301.129 mph corresponds to the mean of run 1's speed and run 2's speed.
(You will need your answer to part **(i)**.)   **[2]**

A minority were successful. A very small but significant minority did not realise that they needed to calculate the mean and tried to compare the mean given by the first and second times separately. There was some evident confusion in a few cases as to what was meant by "corresponds to".

Question 5 (b) (i)

(b) The chart in **Fig. 5.1** shows the first 30 seconds of a journey from a standing start by the high-speed Bloodhound SSC based on an actual test run.
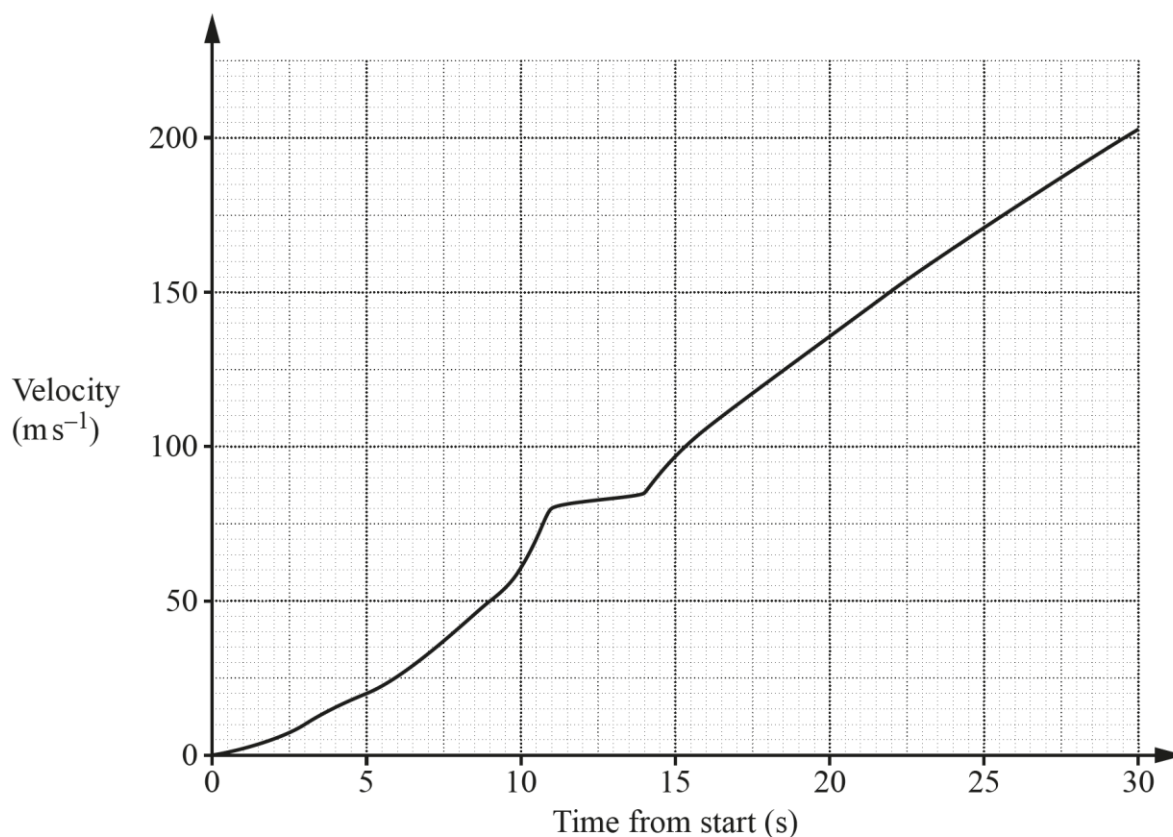

Fig. 5.1

    (i) Write down the velocity of Bloodhound SSC, in $m\,s^{-1}$, after 10 seconds.   **[1]**

A large majority were successful. Incorrect responses included "61ms⁻¹" and "70ms⁻¹" as might be expected but also some others which appeared not to have a logical explanation.

Question 5 (b) (ii)

    (ii) State whether the acceleration of the Bloodhound SSC is constant over the first 10 seconds. Explain your answer.   **[2]**

About half of the candidates were successful and responded with at least "no, not a straight line". Many others got involved with calculations which were rarely correct. There were also instances of insecurity as to the actual meaning of acceleration.

Question 5 (b) (iii)

(iii) Calculate Bloodhound's acceleration between 10 and 11 seconds after starting.   **[2]**

Only a very small minority of candidates gained full credit, however a larger proportion gained some partial credit, usually as a result of a correct numerical response with incorrect units, usually ms^{-1}.

Question 5 (c)

(c) Calculate the time taken on a single run of 1 mile to give an average speed of 1000 mph.

Use the formula $V = \dfrac{3600\,N}{T}$ with $N = 1$

where V is the average speed, in mph, needed to cover 1 mile in T seconds.   **[2]**

Full credit was achieved by most candidates, with a small minority not gaining any credit.

Question 5 (d)

(d) The measured mile (1.6 km) together with the track used by Bloodhound SSC is illustrated in the scale drawing in **Fig. 5.2**.
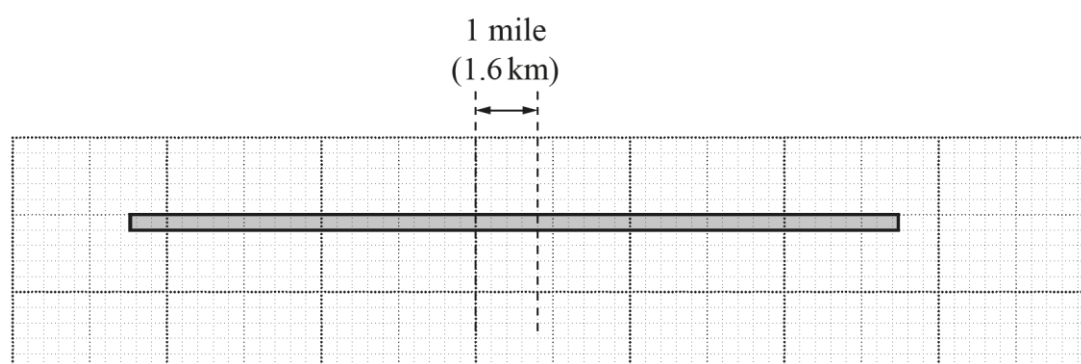
1 mile
(1.6 km)

Fig. 5.2

Work out the length of the track.
Give your answer in kilometres and assume that 1 mile is exactly 1.6 kilometres.   **[2]**

The majority gained full credit, with a small minority not gaining any credit. A common error was to assume the grid to be a centimetre grid. It was possible that partial credit may, on occasion, have been lost because of lack of working to provide sufficient evidence.

Question 6 (a) (i)

6   The zloty is the Polish unit of currency. Like all currencies its value, or exchange rate, compared with other currencies is changing all the time.

(a)   The graph in **Fig. 6.1** shows how many zloty could be bought from a supermarket for £1 for each day in April 2021.
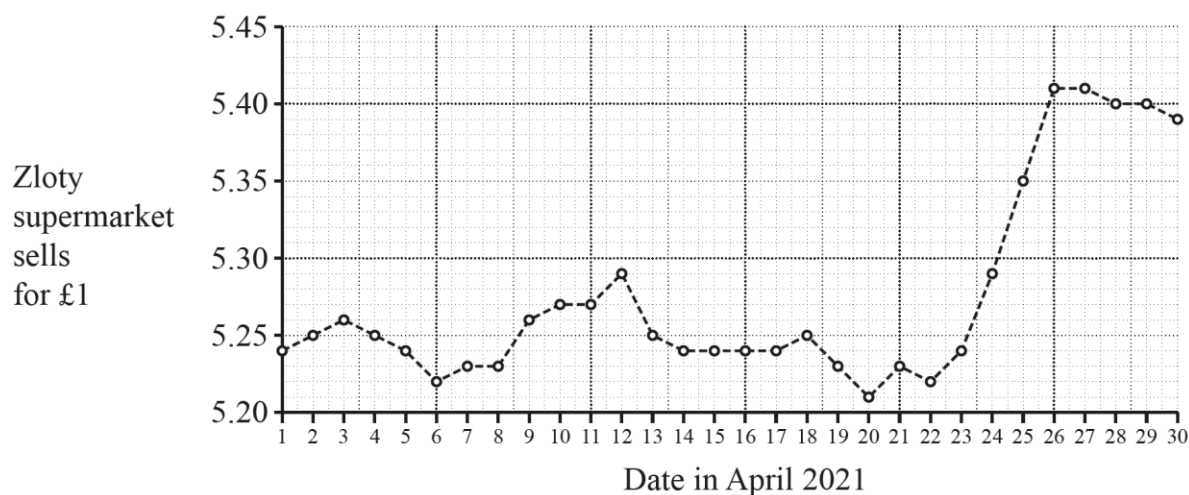
Fig. 6.1

(i)   How many zloty was the supermarket selling for £1 on 10 April 2021?   **[1]**

This was answered with confidence by most candidates of all attainment levels. Popular errors were "5.25" or "5.26", originating from careless reading of the scale.

Question 6 (a) (ii)

(ii)   For how many days was the supermarket selling more than 5.30 zloty for £1?   **[1]**

Only a very small minority were unsuccessful. A relatively common error was "24 days", most likely the result of misinterpreting the question as meaning "less than 5.30 zloty for £1".

Question 6 (a) (iii)

(iii) On which day in April was it most expensive to buy zloty? **[1]**

A minority of candidates found this part a challenge. As might have been expected, a common error was "April 26", the result of not considering the difference between selling and buying currency. Nevertheless, most candidates were successful.

Misconception

? Candidates' responses to questions on buying and selling currency suggests this as an area of uncertainty. Further practice is needed in selecting the rate, deciding on the operation (multiplication or division) and appreciating the magnitude of their answer.

Question 6 (b) (i)

(b) A family is to visit friends in Warsaw, Poland.
They decide to change £1000 into zloty all at once at their bank.

(i) **Fig. 6.2** shows the buying and selling rates in their bank on that day.

Currency	We sell at	We buy at
Euro	1.11	1.32
US dollar	1.34	1.57
Zloty (Poland)	5.27	5.46

Fig. 6.2

How many zloty do the family get for £1000? **[2]**

Most candidates gained credit. A common error was to calculate "1000 ÷ 5.46" or, less frequently, "1000 ÷ 5.27" rather than "1000 × 5.27" suggesting an insecure grasp of currency conversion.

Question 6 (b) (ii)

(ii) The airline company flying to Warsaw ceases trading a month later, so the trip is cancelled. The family changes all their zloty back into £s. **Fig. 6.3** shows the new rates in their bank.

Currency	We sell at	We buy at
Euro	1.15	1.37
US dollar	1.42	1.66
Zloty (Poland)	5.31	5.44

Fig. 6.3

How much do the family lose of their original £1000? **[3]**

A large majority gained full credit. A number were able to gain partial credit. A noticeable error was to calculate the correct money received after changing the zloty back into £s but omitting to use this to calculate the financial loss to the family.

Question 7 (a)

7 **This question refers to article D in the pre-release material, 'Near-Earth Objects'. You can find the article on the Insert accompanying this paper.**

(a) A megaton (Mt) is equivalent to 4.2×10^{15} J (joules) of energy.

Just over two billion years ago the Earth was hit by a very large asteroid. It is estimated that the energy of the impact was 2×10^{25} J.

Convert 2×10^{25} J to megatons (Mt).
Give your answer in standard form correct to **1** sf. **[2]**

About two thirds gained at least partial credit. There were instances of candidates working through the whole calculation in normal number format correctly but not gaining the final mark which asked for the answer in standard form correct to 1 sf. Rounding incorrectly to 1 sf was not uncommon with "4.8×10^9" or "4.9×10^9" among the most common incorrect final answers.

Question 7 (b) (i)

(b) The risk from an NEO can be assessed by calculations based on observation and modelling. Details of four NEOs are given in **Fig. 7.1**.

NEO name	Year of nearest approach	Probability of impact	Diameter (m)	Impact energy (Mt)
2007 DX40	2030	6.2E–05	40	3.9E+00
2012 QD8	2042	6.5E–06	80	4.8E+01
2017 WT28	2083	1.5E–04	8	1.3E–02
1950 DA	2880	1.0E–04	1600	1.0E+04

Fig. 7.1

    (i) Which NEO in **Fig. 7.1** has the greatest chance of impacting the Earth? **[1]**

Most candidates found this too challenging. The most common incorrect response was "1950DA", although most of the NEOs were represented. There was a strong impression that candidates were not familiar with numbers expressed in standard form in the format of spreadsheets (or some scientific calculators).

Assessment for learning
It may be helpful for candidates to have an experience of using standard form in spreadsheet format – perhaps to check calculations. Ranking them would also be a useful exercise.

Question 7 (b) (ii)

    (ii) Use the figures in **Fig. 7.1** to determine whether the impact energy of an NEO is proportional to its diameter. **[3]**

This was a challenging question with over a quarter of candidates not attempting (the highest amount for any of the questions on the paper). A very large number of candidates did not get any credit. Some attempted conclusions without providing supporting calculations. When attempts were made to use ratio in any form it was not always used consistently. As in part (b)(i), it appeared there were problems working with standard form in the format used in the question.

Exemplar 3

7(b)(ii)	1×10^4 M̶ t /1600 m $= 6.25$
	1.3×10^{-2} /8 m $= 0.001625$
	4.8×10^1 /8 cm $= 0.6$
	3.9×10^0 /40 m $= 0.0975$
	yes they're proportional

A good start has been made and a clear attempt to calculate the ratio of impact energy to diameter for all 4 NEOs, credit was given for this. Dealing with the calculator/spreadsheet number format of the impact energies presented no problems. Unfortunately, the conclusion is incorrect.

Question 7 (b) (iii)

(iii) Use **Fig. 7.2** to find the Torino scale number for NEO 1950 DA.   **[1]**

7(b)(iii)

The Torino scale (0 to 10)

Fig. 7.2
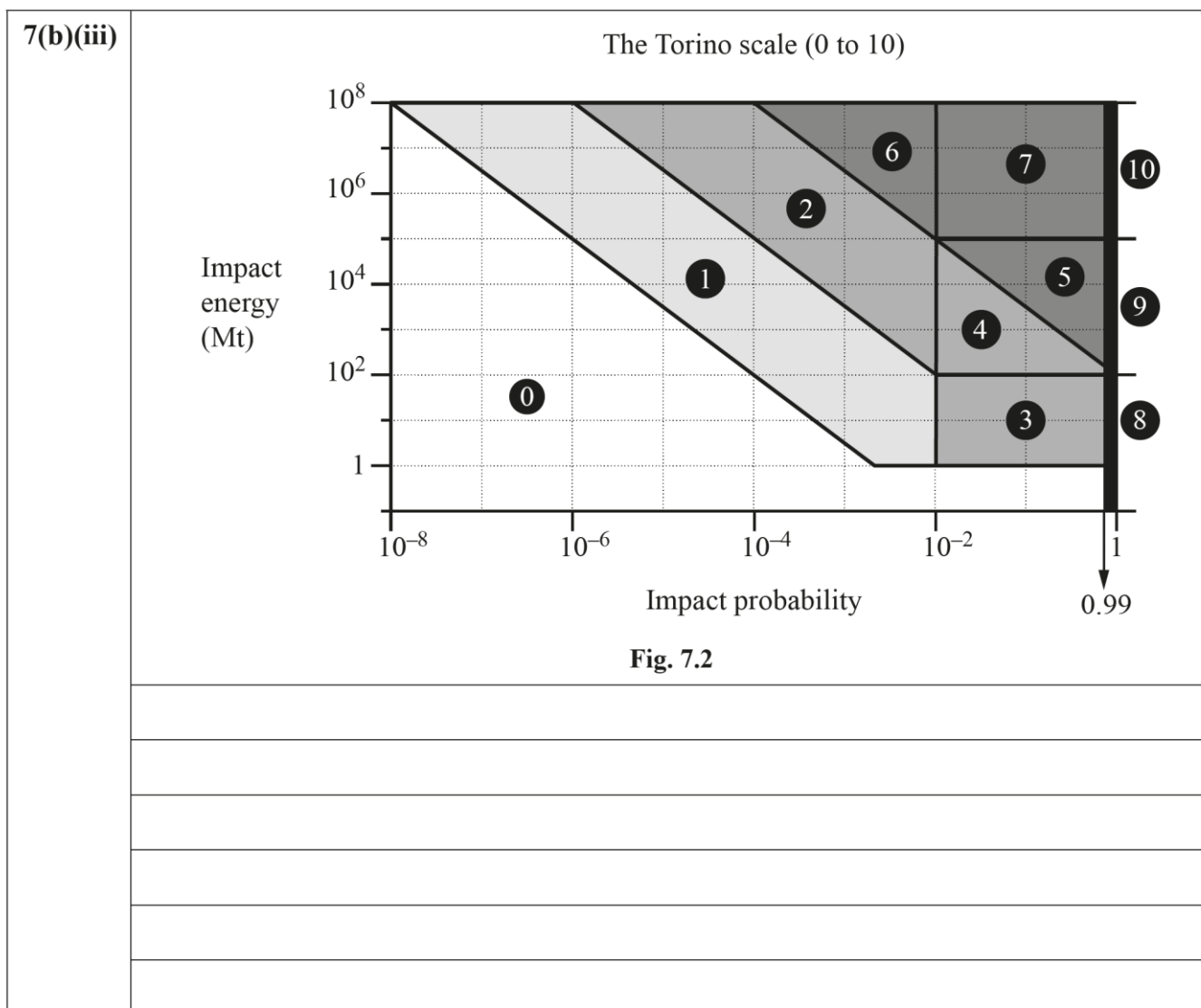
A large majority answered this question successfully.

Non-linear scales – especially logarithmic ones

This topic has proved challenging in the past. The one presented here is probably the simplest possible, but candidates need experience with scales involving non-integer powers.

Question 7 (c)

(c) Geologists can date the craters resulting from NEOs impacting Earth.
They estimate that an impact by a 1 km or greater diameter NEO occurs about once every 100 000 years.

Use this figure to give the probability, as a decimal, of such an event in a year.   **[1]**

Most candidates were successful here. However, a small but noticeable minority did not gain credit as a result of expressing the answer with % added i.e., 0.00001%.

Question 7 (d)

(d) Estimate the value of this calculation which models the impact energy, in Mt, of a 950 m diameter NEO. Do **not** use a calculator.

$$\frac{\pi \times 1.01 \times 10^5 \times 0.95^3}{3}$$

Show all the approximations in your working.   **[2]**

About a third of candidates gained full credit with just under another third gaining partial credit. A small minority attempted the full calculation rather than an estimation. Of the numbers that needed to be approximated π was the greatest challenge by some margin.

Practice with approximate calculations

Making approximations and checking numerical calculations is a useful skill in real-life. Candidates need to realise that other numbers can be approximated such as π or even π^2. Getting a sense for appropriate approximations can only come from practice.

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