OCR
Oxford Cambridge and RSA

Thursday 19 May 2022 – Afternoon

Level 3 Certificate Core Maths B (MEI)

H869/01 Introduction to Quantitative Reasoning

Time allowed: 2 hours

You must have:
- the Insert (inside this document)

You can use:
- a scientific or graphical calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number						Candidate number				

First name(s) ______________________________

Last name ______________________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working.
- Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION
- The total mark for this paper is **72**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

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]**

(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]**

(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]**

1(a)(i)	
1(a)(ii)	
1(a)(iii)	

(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]**

1(a)(iv)	

(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]**

1(b)	

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.

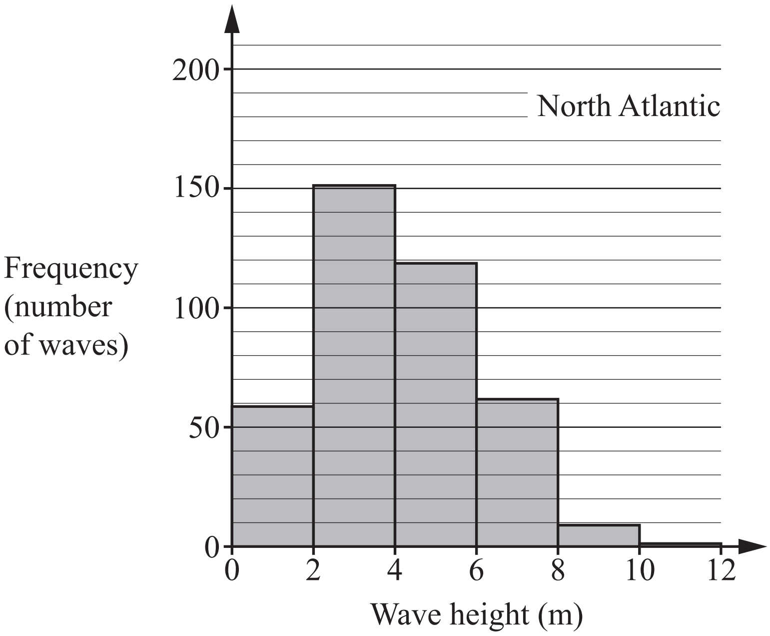

Fig. 2.2

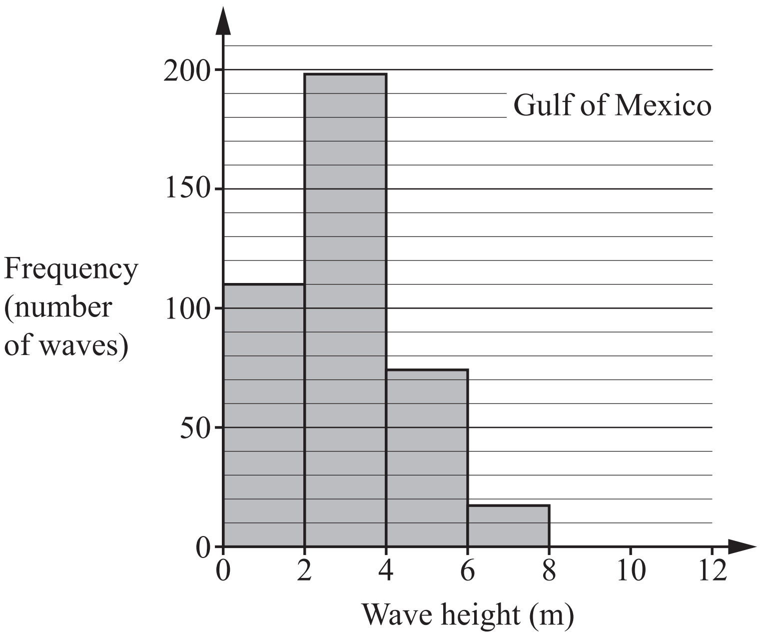

Fig. 2.3

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

2(a)(i)	

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

2(a)(ii)	**Difference:**
	Similarity:

(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	$\le w <$	4	2	55	110
3	4	$\le w <$	8	6	97	582
4	8	$\le w <$	12	10	90	900
5	12	$\le w <$	16	14	43	602
6	16	$\le w <$	20	18	11	198
7	20	$\le w <$	24	22	4	88
8	24	$\le w <$	28	26	0	0
9				Total	300	2480
10						

Fig. 2.4

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

2(b)(i)	

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

2(b)(ii)	

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

2(b)(iii)	

(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]**

2(c)	

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]**

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

3(a)(i)

3(a)(ii)

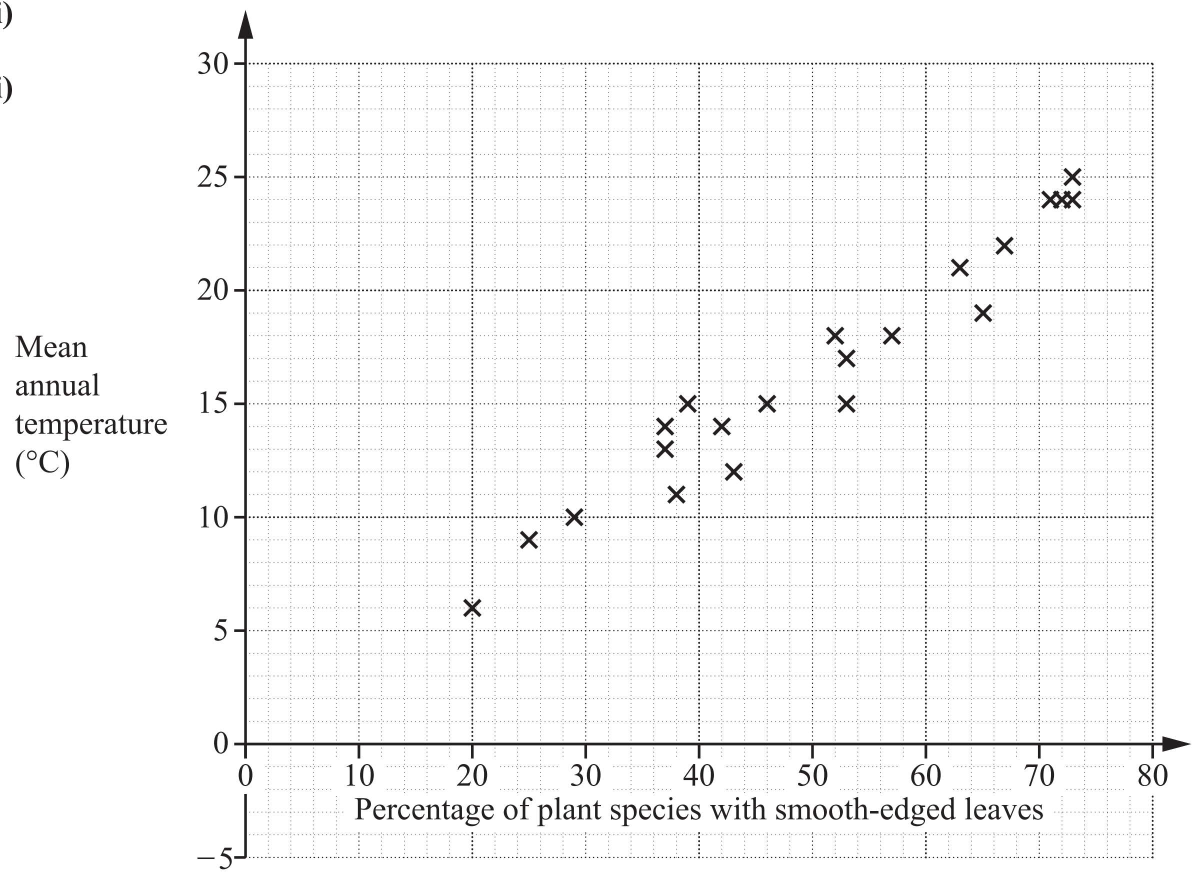

Fig. 3.1

(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]**

3(a)(iii)	

(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]**

3(b)	

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).

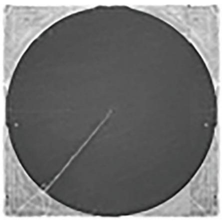

Fig. 4.1

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]**

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

4(a)(i)	

4(a)(ii)	

(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]**

4(b)	

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

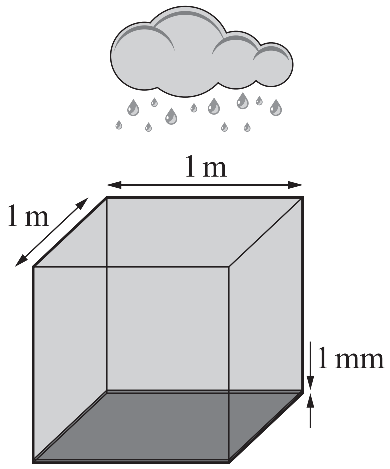

Fig. 4.2

Show that this is 1 litre of water (1 litre = 1000 cm^3). **[1]**

4(c)	

(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]**

4(d)	

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)**
Bananas	12
Beans	11
Eggplant	11
Grapes	7
Melon	10

Crop	**Water needed (mm per day)**
Nuts	10
Peppers	10
Potatoes	11
Squash	9
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]**

4(e)	

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

  $V = \frac{3600N}{T}$ 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]**

5(a)(i)	

(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]**

5(a)(ii)	

(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.

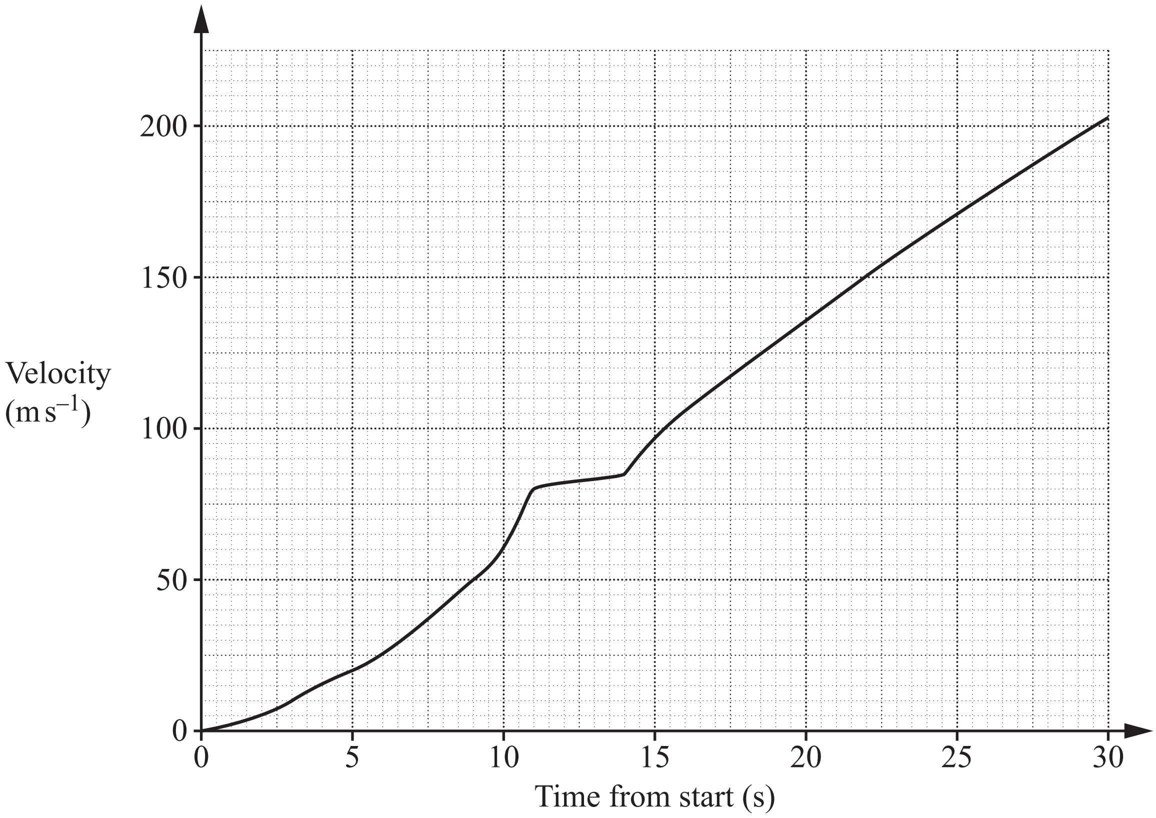

Fig. 5.1

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

5(b)(i)	

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

5(b)(ii)	

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

5(b)(iii)	

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

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

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

5(c)	

(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**.

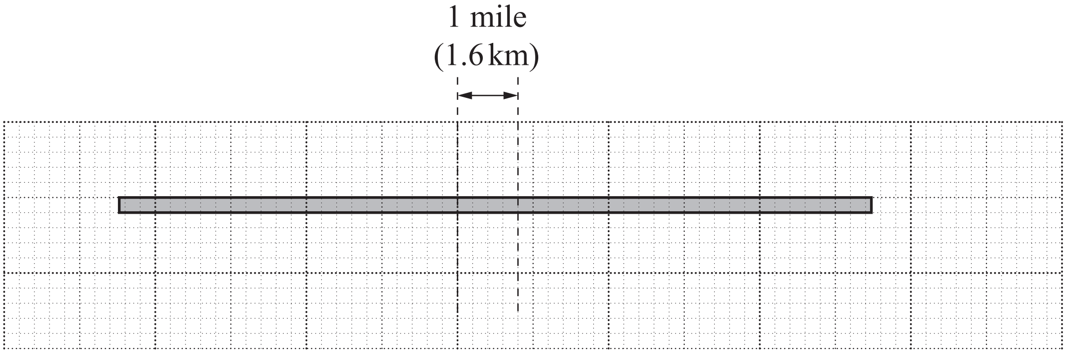

Fig. 5.2

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

5(d)	

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.

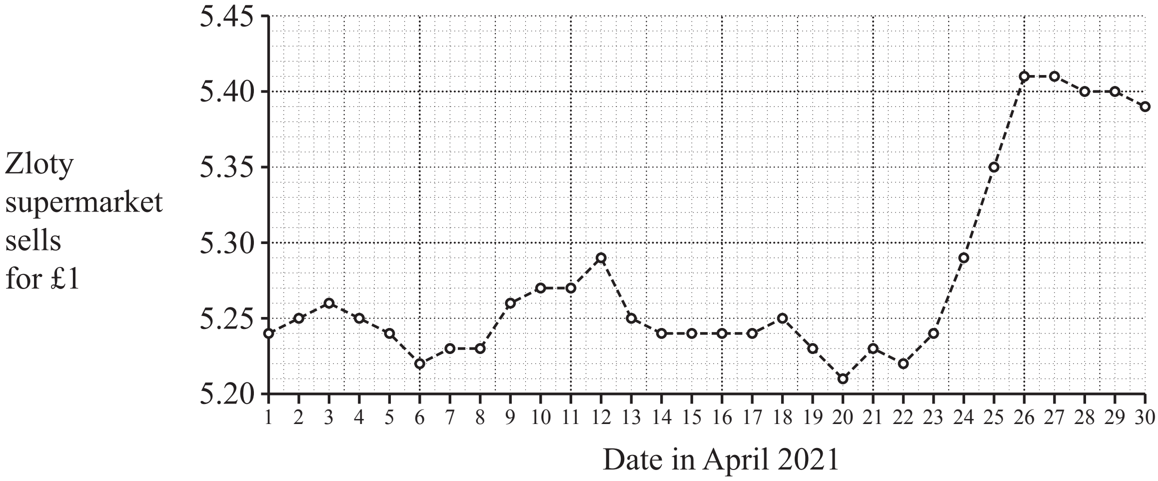

Fig. 6.1

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

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

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

6(a)(i)	
6(a)(ii)	
6(a)(iii)	

(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]**

(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]**

6(b)(i)	
6(b)(ii)	

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]**

7(a)	

(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]**

7(b)(i)	

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

7(b)(ii)	

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

7(b)(iii)	

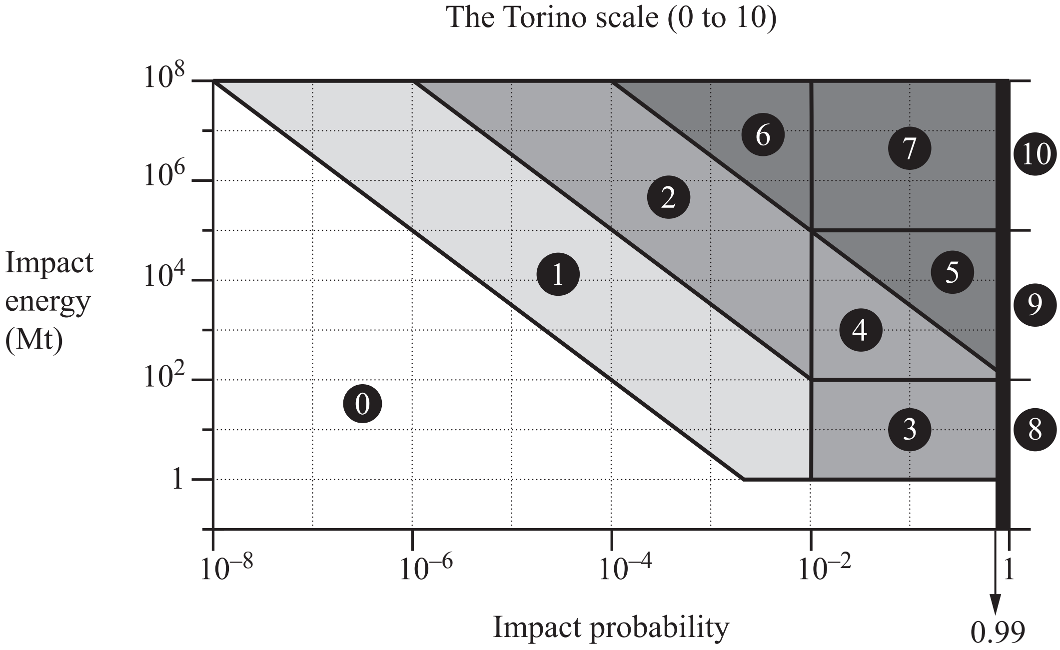

Fig. 7.2

(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]**

7(c)	

(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]**

7(d)	

END OF QUESTION PAPER