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EDEXCEL INTERNATIONAL GCSE MATHS: QUESTIONS BY TOPIC

Powers, Roots, Standard Form & Surds (N3)

International GCSE Mathematics A (4MA1) · Higher tier

89 questions · 315 marks · Mark schemes included

Past papers June 2018 - June 2025 · 3 sub-topics

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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QUESTIONS

89 questions · 315 marks · 3 sub-topics

SUB-TOPIC N3a

POWERS, ROOTS & INDEX LAWS

Sub-topic N3a · 33 questions · 117 marks · lowest tariff first



9 (a) Factorise $x^2 - x - 42$

.....
(2)

(b) Solve the inequality $3x + 15 < 8x + 3$

Show clear algebraic working.

.....
(3)

(Total for Question 9 is 5 marks)

10 Given that $150^x = 1$

(a) write down the value of x .

$x =$
(1)

Given that $3^{-8} \div 3^{-6} = 3^n$

(b) find the value of n .

$n =$
(1)

(Total for Question 10 is 2 marks)



7 $\frac{2^k}{4^n} = 2^x$

Find an expression for x in terms of k and n

$x = \dots\dots\dots$

(Total for Question 7 is 2 marks)

- 8 A cinema increased the cost of an adult ticket by 12%
After the increase, the cost of an adult ticket was £18.20
Work out the cost of an adult ticket before the increase.

£.....

(Total for Question 8 is 3 marks)



12 $3^{\frac{1}{2}} \times 3^{\frac{2}{5}} = 3^m$

(a) Work out the value of m

$$m = \dots\dots\dots (1)$$

$$5^{-10} \div 5^{-4} = 5^n$$

(b) Work out the value of n

$$n = \dots\dots\dots (1)$$

(Total for Question 12 is 2 marks)

13 Expand and simplify $3x(2x - 5)^2$
Show clear algebraic working.

(Total for Question 13 is 3 marks)



12 Solve $2^{-4x} = 32$

$x =$

(Total for Question 12 is 2 marks)

13 Use algebra to show that $0.\dot{3}8\dot{1} = \frac{21}{55}$

(Total for Question 13 is 2 marks)



7 (a) Simplify $(4^{-2})^0$

.....
(1)

$$3^{-14} \times 3^8 = 3^m$$

(b) Find the value of m

$m =$
(1)

(Total for Question 7 is 2 marks)



10 Gemara works as a taxi driver.

Last week, he recorded the following information about the distances he drove.

For the 5 days from Monday to Friday, the mean number of kilometres he drove was 104

For the 7 days from Monday to Sunday, the mean number of kilometres he drove was 127

On Saturday, Gemara drove 132 kilometres.

Work out the number of kilometres he drove on Sunday.

..... kilometres

(Total for Question 10 is 3 marks)

11 Express $\left(\frac{m^6 k^{10}}{25}\right)^{\frac{3}{2}}$ in the form $\frac{m^a k^b}{c}$ where a , b and c are integers to be found.

(Total for Question 11 is 2 marks)



7 $\frac{3^{-2} \times 3^5}{3^{10}} = 3^n$

Find the value of n

$$n = \dots\dots\dots$$

(Total for Question 7 is 2 marks)

- 8 In a sale, all normal prices are reduced by 17%

The sale price of a fridge is 6225 rupees.

Work out the normal price of the fridge.

..... rupees

(Total for Question 8 is 3 marks)



13 The straight line L_1 has equation $y = 6 - 2x$

The straight line L_2 is perpendicular to L_1 and passes through the point $(4, 7)$

Find the coordinates of the point where the line L_2 crosses the x -axis.

(....., ...)

(Total for Question 13 is 4 marks)

14 $128 = 4^{2x} \times 2^x$

Work out the value of x .

$x =$

(Total for Question 14 is 3 marks)



Answer ALL TWENTY SIX questions.

Write your answers in the spaces provided.

You must write down all the stages in your working.

1 (a) Simplify $\frac{x^9}{x^2}$

.....
(1)

(b) Write $\frac{7^8 \times 7^4}{7^3}$ as a single power of 7

.....
(2)

.....
(Total for Question 1 is 3 marks)

2 Change 32.4 m^3 into cm^3

..... cm^3

.....
(Total for Question 2 is 2 marks)



12 Given that $\frac{3^x}{9^{3x}} = 81$

find the value of x .

Show clear algebraic working.

$$x = \dots\dots\dots$$

(Total for Question 12 is 3 marks)

13 Use algebra to show that $0.6\dot{8}\dot{1} = \frac{15}{22}$

(Total for Question 13 is 2 marks)



11 Simplify fully $\left(\frac{9t^4w^9}{18t^6w^{10}}\right)^{-2}$

(Total for Question 11 is 3 marks)

12 15 people were asked how long, in minutes, they had been waiting for a bus.

Here are the results.

2 3 3 4 5 6 6 8 9 10 11 13 14 15 18

Find the interquartile range of these times.

..... minutes

(Total for Question 12 is 2 marks)



14 Simplify fully $\left(\frac{9x^4}{16y^{10}}\right)^{-\frac{1}{2}}$

(Total for Question 14 is 3 marks)

15 (a) Complete the table of values for $y = \frac{1}{x}(x^2 + 4)$

x	0.25	0.5	1	2	4	8
y	16.25					8.5

(2)



24

$$\frac{18 \times (\sqrt{27})^{4n+6}}{6 \times 9^{2n+8}} = 3^x$$

Express x in terms of n

Show your working clearly and simplify your expression.

$x = \dots\dots\dots$

(Total for Question 24 is 3 marks)

TOTAL FOR PAPER IS 100 MARKS



14 Given that $\frac{3^{2n+3}}{3^4} = 3^3 \times 3^{1-2n}$

find the value of n

Show your working clearly.

$$n = \dots\dots\dots$$

(Total for Question 14 is 3 marks)

15 Use algebra to show that $0.7\dot{6}\dot{3} = \frac{42}{55}$

(Total for Question 15 is 2 marks)



15 Simplify fully $\left(\frac{2a^3}{10a^7c^2}\right)^{-3}$

(Total for Question 15 is 3 marks)

16 Make t the subject of the formula $c = \frac{t^2 + 3}{7 - 8t^2}$

(Total for Question 16 is 4 marks)



10 $\frac{8}{2^7} = 2^n$

(a) Find the value of n .

$$n = \dots\dots\dots (2)$$

$$(13^{-6})^4 \times 13^5 = 13^k$$

(b) Find the value of k .

$$k = \dots\dots\dots (2)$$

(Total for Question 10 is 4 marks)



- 8 There are 10 people in a lift.
These 10 people have a mean weight of 79.2 kg.

3 of these people get out of the lift.
These 3 people have a mean weight of 68 kg.

Work out the mean weight of the 7 people left in the lift.

..... kg

(Total for Question 8 is 3 marks)

- 9 (a) Simplify $t^9 \div t^3$

.....
(1)

- (b) Simplify $w^5 \times w^7$

.....
(1)

- (c) Simplify $(5xy^2)^3$

.....
(2)

(Total for Question 9 is 4 marks)



14 (a) Simplify fully $(x^{12}y^8)^{\frac{3}{4}}$

.....
(2)

Given that $3^n = \frac{3^x}{9^y}$

(b) find an expression for n in terms of x and y .

$n =$
(2)

(Total for Question 14 is 4 marks)



3 $\mathcal{E} = \{21, 22, 23, 24, 25, 26, 27, 28, 29, 30\}$

$A = \{22, 24, 26, 28, 30\}$

$B = \{21, 24, 27, 30\}$

(a) List the members of the set

(i) $A \cap B$

(ii) A'

(2)

$C = \{23, 25, 29\}$

(b) Using set notation, find an expression for C in terms of A and B .

(1)

(Total for Question 3 is 3 marks)

4 (a) Simplify $(3k^2)^4$

(2)

(b) Simplify $(21m^4n) \div (3n^{-5})$

(2)

(Total for Question 4 is 4 marks)



11 $\sqrt{2} \times 16 = 2^x$

- (a) Find the value of x .
Show your working clearly.

$$x = \dots\dots\dots (2)$$

$$\frac{(11^{-6})^5}{11^4} = 11^n$$

- (b) Find the value of n .
Show your working clearly.

$$n = \dots\dots\dots (2)$$

(Total for Question 11 is 4 marks)



Answer ALL TWENTY TWO questions.

Write your answers in the spaces provided.

You must write down all the stages in your working.

- 1** (a) Write down the value of m , given that $3^4 \times 3^5 = 3^m$

$m = \dots\dots\dots$
(1)

- (b) Write down the value of n , given that $(5^3)^7 = 5^n$

$n = \dots\dots\dots$
(1)

- (c) Find the value of p , given that $\frac{7^8 \times 7^2}{7^p} = 7^6$

$p = \dots\dots\dots$
(2)

(Total for Question 1 is 4 marks)



- 6 (a) Write down the value of x^0

.....
(1)

Given that $2^{-3} \times 2^9 = 2^n$

- (b) find the value of n

$n =$
(1)

Given that $\frac{7^{206} \times 7^m}{7^{214}} = 7^{-3}$

- (c) find the value of m

$m =$
(2)

(Total for Question 6 is 4 marks)



8 (a) Write 0.000 089 in standard form.

.....
(1)

(b) Write 8.34×10^4 as an ordinary number.

.....
(1)

(Total for Question 8 is 2 marks)

9 (a) Simplify $8 \times (4t)^0$

.....
(1)

$$x^6 \div x^{-5} = x^p$$

(b) Find the value of p

$p =$
(1)

(c) Simplify fully $(2k^2m^4)^3$

.....
(2)

(Total for Question 9 is 4 marks)



- 5 Each time Evie plays a game against her computer, she will win or lose.

For each game, the probability that Evie will win is 0.74

Evie is going to play 300 games against her computer.

Work out an estimate for the number of games that Evie will lose.

(Total for Question 5 is 2 marks)

- 6 (a) Simplify $m^{10} \div m^3$

(1)

$$k^n \times k^4 = k^{12}$$

- (b) Write down the value of n

$$n = \dots\dots\dots$$

(1)

- (c) Simplify $(3x^6y^8)^2$

(2)

(Total for Question 6 is 4 marks)



12 $2^7 \times 4^5 = 4^x$

(a) Calculate the value of x

$x = \dots\dots\dots$
(2)

(b) Simplify fully $(125p^6y^{24})^{\frac{2}{3}}$

$\dots\dots\dots$
(2)

(Total for Question 12 is 4 marks)

13 Robert asked 11 people how many meetings they attended last week.

Here are the results in numerical order.

1 2 4 6 6 8 11 12 13 14 17

Find the interquartile range of the number of meetings.

$\dots\dots\dots$
(Total for Question 13 is 2 marks)



10 (a) Simplify $(2p)^0$ where $p > 0$

.....
(1)

$$y^9 \times y^{-3} = y^n$$

(b) Find the value of n

$n =$
(1)

(c) Simplify fully $(5a^4c^2)^3$

.....
(2)

(Total for Question 10 is 4 marks)



4 $x^5 \times x^7 = x^m$

(a) Find the value of m

$$m = \dots\dots\dots (1)$$

$$y^8 \div y^3 = y^n$$

(b) Find the value of n

$$n = \dots\dots\dots (1)$$

(c) Simplify fully $(5a^4r^2)^3$

$$\dots\dots\dots (2)$$

(Total for Question 4 is 4 marks)

- 5 In a sale, normal prices are reduced by 28%
The sale price of a watch is 198 euros.

Work out the normal price of the watch.

$\dots\dots\dots$ euros

(Total for Question 5 is 3 marks)



23 $\frac{4x^2 - 4x - 120}{5x^2 - 180} \div \frac{x^2 + 5x}{10x^2 + 60x} = p$ where p is an integer.

Find the value of p

Show clear algebraic working.

$$p = \dots\dots\dots$$

(Total for Question 23 is 4 marks)



26 Find the values of n such that

$$\frac{10^{4n} \times 2^{3(n^2-5n)} \times 5^{2(1-2n)}}{20^2} = 1$$

Show clear algebraic working.

(Total for Question 26 is 5 marks)

TOTAL FOR PAPER IS 100 MARKS



24 Given that

$$2^n = 2^{x^2} \times 16^x \times 8$$

and

$$x > 0$$

find an expression for x in terms of n
State any restrictions on n

(Total for Question 24 is 5 marks)



- 6 (a) Write down the value of 5^0

.....
(1)

$$\frac{5^9 \times 5^{-3}}{5^{-2}} = 5^k$$

- (b) Find the value of k

$k =$
(2)

- (c) Simplify fully $(2d^4e^5)^3$

.....
(2)

(Total for Question 6 is 5 marks)



14 (a) Given that $a = 3^x$ and $b = 3^y$

express in terms of a or b or a and b ,

(i) 3^{2x}

(ii) 3^{x+4y}

(iii) 3^{y-1}

(3)

$$a = 3^x \text{ and } b = 3^y$$

$$ab = 2187$$

$$a^2b = 177147$$

(b) Work out the value of x and the value of y .
Show your working clearly.

$$x =$$

$$y =$$

(3)

(Total for Question 14 is 6 marks)



15 (a) $\sqrt{2} \div \frac{8^3}{16^2} = 2^n$

Work out the value of n
Show your working clearly.

$n = \dots\dots\dots$
(3)

- (b) Find 4% of 4.5×10^{157}
Give your answer in standard form.

$\dots\dots\dots$
(3)

(Total for Question 15 is 6 marks)



SUB-TOPIC N3b

STANDARD FORM

Sub-topic N3b · 32 questions · 108 marks · lowest tariff first



7 Here are the first four terms of an arithmetic sequence.

6 10 14 18

(a) Find an expression, in terms of n , for the n th term of this sequence.

.....
(2)

(b) Write down an expression, in terms of n , for the $(n + 1)$ th term of this sequence.

.....
(1)

(Total for Question 7 is 3 marks)

8 (a) Write 1 390 000 in standard form.

.....
(1)

(b) Write 0.005 in standard form.

.....
(1)

(Total for Question 8 is 2 marks)



- 5 (a) Factorise fully $15y^4 + 20uy^3$

.....
(2)

(b) Solve $4 - 3x = \frac{5 - 8x}{4}$

Show clear algebraic working.

$x =$
(3)

(Total for Question 5 is 5 marks)

- 6 (a) Write 2 840 000 000 in standard form.

.....
(1)

- (b) Write 2.5×10^{-4} as an ordinary number.

.....
(1)

(Total for Question 6 is 2 marks)



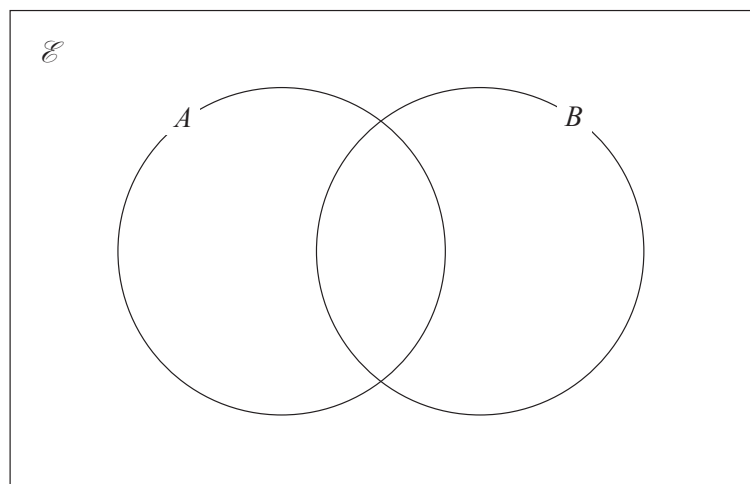
7 $\mathcal{E} = \{4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\}$

$A \cap B = \{5, 10, 15\}$

$B' = \{7, 8, 9, 11, 12, 13, 14\}$

$A' = \{4, 6, 7, 8, 14\}$

Complete the Venn diagram for this information.



(Total for Question 7 is 3 marks)

8

$a = 4.2 \times 10^{-24}$

$b = 3 \times 10^{145}$

Work out the value of $a \times b$

Give your answer in standard form.

(Total for Question 8 is 2 marks)



8 (a) Write 0.000 089 in standard form.

.....
(1)

(b) Write 8.34×10^4 as an ordinary number.

.....
(1)

(Total for Question 8 is 2 marks)

9 (a) Simplify $8 \times (4t)^0$

.....
(1)

$$x^6 \div x^{-5} = x^p$$

(b) Find the value of p

$p =$
(1)

(c) Simplify fully $(2k^2m^4)^3$

.....
(2)

(Total for Question 9 is 4 marks)



- 5 Nancy has some coins with a total value of 85 pence.
She has only 2 pence coins and 5 pence coins.
The ratio

$$\text{number of 2 pence coins} : \text{number of 5 pence coins} = 1 : 3$$

Nancy has more 5 pence coins than 2 pence coins.

How many more?

.....
(Total for Question 5 is 4 marks)

- 6 (a) Write 76000000 in standard form.

.....
(1)

- (b) Write 5.4×10^{-4} as an ordinary number.

.....
(1)

(Total for Question 6 is 2 marks)



13 Here are the numbers of eggs laid by some hens on each of 11 days in June.

9 10 12 15 17 18 19 19 20 25 26

Work out the interquartile range of the numbers of eggs.

.....
(Total for Question 13 is 2 marks)

14 Work out $6.7 \times 10^{135} + 3 \times 10^{134}$

Give your answer in standard form.

.....
(Total for Question 14 is 2 marks)



5 (a) Write 8×10^4 as an ordinary number.

.....
(1)

(b) Work out $(3.5 \times 10^5) \div (7 \times 10^8)$
Give your answer in standard form.

.....
(2)

(Total for Question 5 is 3 marks)



20 $a = 25 \times 10^{14n}$ where n is an integer.

Find an expression, in terms of n , for $a^{\frac{3}{2}}$
Give your answer in standard form.

.....
(Total for Question 20 is 3 marks)



8

$$A = 3^2 \times 5^4 \times 7 \quad B = 3^4 \times 5^3 \times 7 \times 11$$

(a) Find the highest common factor (HCF) of A and B .

.....
(2)

(b) Find the lowest common multiple (LCM) of A and B .

.....
(2)

(Total for Question 8 is 4 marks)

9 (a) Write 840 000 in standard form.

.....
(1)

(b) Work out $(6 \times 10^7) \div (8 \times 10^{-2})$
Give your answer in standard form.

.....
(2)

(Total for Question 9 is 3 marks)



- 6 (a) Write 7.8×10^{-4} as an ordinary number.

.....
(1)

- (b) Work out $\frac{5.6 \times 10^4 + 7 \times 10^3}{2.8 \times 10^{-3}}$

Give your answer in standard form.

.....
(2)

(Total for Question 6 is 3 marks)

- 7 (a) Expand and simplify $(m - 8)(m + 5)$

.....
(2)

- (b) Factorise fully $5y + 20y^2$

.....
(2)



10 The table shows information about the surface area of each of the world's oceans.

Ocean	Surface area in square kilometres
Pacific	1.56×10^8
Indian	6.86×10^7
Southern	2.03×10^7
Arctic	1.41×10^7
Atlantic	1.06×10^8

- (a) Work out the difference, in square kilometres, between the surface area of the Atlantic Ocean and the surface area of the Indian Ocean.
Give your answer in standard form.

..... square kilometres
(2)

The surface area of the Pacific Ocean is k times the surface area of the Arctic Ocean.

- (b) Work out the value of k .
Give your answer correct to the nearest whole number.

$k =$
(1)

(Total for Question 10 is 3 marks)



- 8 The table gives the length of the coastline, in kilometres, of each of five oceans.

Ocean	Length of coastline (km)
Arctic	4.539×10^4
Atlantic	1.119×10^5
Pacific	1.357×10^5
Indian	6.653×10^4
Southern	1.797×10^4

- (a) Which ocean has the greatest length of coastline?

.....
(1)

- (b) Calculate the difference between the length of the Atlantic Ocean's coastline and the length of the Southern Ocean's coastline.
Give your answer in standard form.

..... km
(2)

(Total for Question 8 is 3 marks)

- 9 Solve $x^2 - 21x + 20 = 0$
Show your working clearly.

.....
(Total for Question 9 is 3 marks)



12 $a = 6 \times 10^{40}$

Work out the value of a^3

Give your answer in standard form.

(Total for Question 12 is 3 marks)



- 10 The table gives information about the population and the total amount of money, in dollars, spent on healthcare for two countries in 2016

Country	Total population	Total spent on healthcare (\$)
Austria	8.7×10^6	4.2×10^{10}
Luxembourg	6.3×10^5	3.7×10^9

Work out how much more was spent **per person** on healthcare in Luxembourg than in Austria.

Give your answer correct to the nearest whole number.

..... dollars

(Total for Question 10 is 3 marks)



..... cm

(Total for Question 8 is 5 marks)

- 9 (a) Write 6.25×10^{-4} as an ordinary number.

.....
(1)

- (b) Work out $(2.4 \times 10^{12}) \div (9.6 \times 10^4)$
Give your answer in standard form.

.....
(2)

(Total for Question 9 is 3 marks)



7 (a) Expand $4x(x - 5)$

.....
(1)

(b) Factorise $y^2 - 9y + 20$

.....
(2)

(Total for Question 7 is 3 marks)

8 (a) Write 5.6×10^{-3} as an ordinary number.

.....
(1)

(b) Work out $\frac{6 \times 10^3}{2.1 \times 10^{-4} + 9 \times 10^{-5}}$

Give your answer in standard form.

.....
(2)

(Total for Question 8 is 3 marks)



- 9 The table gives the amount of rice produced by each of two countries in 2020

Country	Amount of rice (tonnes)
Indonesia	3.5×10^7
Argentina	8.2×10^5

- (a) Write 3.5×10^7 as an ordinary number.

.....
(1)

In 2020, Japan produced 6 780 000 more tonnes of rice than Argentina.

- (b) Work out the amount of rice Japan produced in 2020
Give your answer in standard form.

..... tonnes
(2)

(Total for Question 9 is 3 marks)



9 (a) Write 8.4×10^{-5} as an ordinary number.

.....
(1)

(b) Work out $(6.5 \times 10^{-40}) \times (8 \times 10^{185})$
Give your answer in standard form.

.....
(2)

(Total for Question 9 is 3 marks)



7 The table shows the volumes, in km^3 , of four oceans.

Ocean	Volume (km^3)
Arctic Ocean	1.88×10^7
Atlantic Ocean	3.10×10^8
Indian Ocean	2.64×10^8
Southern Ocean	7.18×10^7

(a) Write 7.18×10^7 as an ordinary number.

(1)

(b) Calculate the total volume of these four oceans.

(2)

km^3

The volume of the South China Sea is $9\,880\,000\text{ km}^3$

(c) Write $9\,880\,000$ in standard form.

(1)

(Total for Question 7 is 4 marks)



- 7 (a) Write 5.7×10^6 as an ordinary number.

.....
(1)

- (b) Write 0.004 in standard form.

.....
(1)

- (c) Work out $\frac{2 \times 10^4 + 3 \times 10^5}{6.4 \times 10^{-2}}$

.....
(2)

(Total for Question 7 is 4 marks)

- 8 On 1st January 2016 Li bought a boat for \$170 000
The value of the boat depreciates by 8% per year.

Work out the value of the boat on 1st January 2019
Give your answer correct to the nearest dollar.

\$

(Total for Question 8 is 3 marks)



- 5 (a) Write 5.7×10^{-3} as an ordinary number.

.....
(1)

- (b) Write 800 000 in standard form.

.....
(1)

- (c) Work out $\frac{3 \times 10^5 - 2.7 \times 10^4}{6 \times 10^{-2}}$

.....
(2)

(Total for Question 5 is 4 marks)

- 6 A rocket travelled 100 km at an average speed of 28 440 km/h.

Work out how long it took the rocket to travel the 100 km.
Give your answer in seconds, correct to the nearest second.

..... seconds

(Total for Question 6 is 3 marks)



3 (a) Write 2.46×10^6 as an ordinary number.

.....
(1)

(b) Write 0.000 74 in standard form.

.....
(1)

(c) Work out $(5.6 \times 10^6) + (2.3 \times 10^5)$

.....
(2)

(Total for Question 3 is 4 marks)



6 (a) Write down the value of y^0

.....
(1)

(b) Work out $\frac{9.6 \times 10^{141} + 6.4 \times 10^{140}}{3.2 \times 10^{16}}$

Give your answer in standard form.

.....
(3)

(Total for Question 6 is 4 marks)



- 8 The table shows the populations of five countries.

Country	Population
China	1.4×10^9
Germany	8.2×10^7
Sweden	9.9×10^6
Fiji	9.1×10^5
Malta	4.3×10^5

- (a) Work out the difference between the population of China and the population of Germany.
Give your answer in standard form.

.....
(2)

Given that

$$\text{population of Fiji} = \frac{1}{k} \times \text{population of Sweden}$$

- (b) work out the value of k .
Give your answer correct to the nearest whole number.

$k =$
(2)

(Total for Question 8 is 4 marks)



8 (a) Write 5×10^4 as an ordinary number.

.....
(1)

(b) Write 0.000 06 in standard form.

.....
(1)

(c) Work out $(4 \times 10^{512}) \div (1.6 \times 10^{700})$
Give your answer in standard form.

.....
(2)

(Total for Question 8 is 4 marks)



- 9 The table gives information about the population, correct to 2 significant figures, of each of five cities in 2018

City	Population (2018)
Ahmedabad	7.7×10^6
Barcelona	5.5×10^6
Chicago	8.8×10^6
Lagos	1.3×10^7
Tokyo	3.7×10^7

- (a) Write 8.8×10^6 as an ordinary number.

.....
(1)

- (b) Which of these cities had the least population in 2018?

.....
(1)

- (c) Work out the difference between the population of Tokyo and the population of Ahmedabad in 2018
Give your answer in standard form correct to 2 significant figures.

.....
(2)

(Total for Question 9 is 4 marks)



- 9 (a) Write 5.87×10^{-4} as an ordinary number.

.....
(1)

- (b) Write 84 000 000 in standard form.

.....
(1)

The number of neurons in a human brain is 8.5×10^{10}
The number of neurons in a monkey brain is 1.47×10^9

The number of neurons in a human brain is $K \times$ the number of neurons in a monkey brain.

- (c) Work out the value of K
Give your answer correct to one decimal place.

$K =$
(2)

(Total for Question 9 is 4 marks)



9 (a) Write 6.04×10^5 as an ordinary number.

.....
(1)

(b) Write 0.00007 in standard form.

.....
(1)

(c) Work out $\frac{7.6 \times 10^{10}}{4 \times 10^5 - 2 \times 10^4}$

Give your answer in standard form.

.....
(2)

(Total for Question 9 is 4 marks)



8 (a) Write 520 million in standard form.

.....
(1)

(b) Write 8.79×10^{-5} as an ordinary number.

.....
(1)

(c) Work out $(5 \times 10^{42}) \times (7 \times 10^{-180})$
Give your answer in standard form.

.....
(2)

(Total for Question 8 is 4 marks)



- 9 A rainwater tank contains 2.4×10^7 raindrops.
The rainwater tank also contains 1.75×10^6 bacteria.

- (a) Work out the number of bacteria per raindrop in the tank.
Give your answer in standard form correct to 2 significant figures.

.....
(3)

A drop of rainwater contains 5.01×10^{21} atoms.

In a drop of rainwater the number of atoms is 3 times the number of molecules.

- (b) Work out the number of molecules in the rainwater tank.
Give your answer in standard form correct to one significant figure.

..... molecules
(2)

(Total for Question 9 is 5 marks)



7 (a) Write 9.32×10^{-5} as an ordinary number.

.....
(1)

(b) Work out $3 \times 10^5 - 6 \times 10^4$
Give your answer in standard form.

.....
(2)

(c) Work out $(3 \times 10^{55}) \times (6 \times 10^{65})$
Give your answer in standard form.

.....
(2)

(Total for Question 7 is 5 marks)



- 11 The table gives the average crowd attendance per match for each of five football clubs for one season.

Football club	Average crowd attendance
Monaco	9.5×10^3
Chelsea	4.2×10^4
Juventus	3.9×10^4
Oxford United	8.3×10^3
Barcelona	7.7×10^4

- (a) Find the difference between the average crowd attendance for Barcelona and the average crowd attendance for Monaco.
Give your answer in standard form.

.....
(2)

Antonio says,

“The average crowd attendance for Chelsea is approximately 50 times that for Oxford United.”

- (b) Is Antonio correct?
You must give a reason for your answer.

.....
(2)

During last season the cost of a ticket to watch Seapron United increased by 15% and then decreased by 8%

- (c) Work out the overall percentage change in the cost of a ticket to watch Seapron United during last season.

..... %
(2)

(Total for Question 11 is 6 marks)



SUB-TOPIC N3c

SURDS

Sub-topic N3c · 24 questions · 90 marks · lowest tariff first



(b) Show that the ratio

total surface area of the cylinder : total surface area of the sphere

is the same as the ratio

volume of the cylinder : volume of the sphere

(3)

(Total for Question 17 is 5 marks)

- 18 Show that $\frac{\sqrt{8}}{\sqrt{8}-2}$ can be written in the form $n + \sqrt{n}$, where n is an integer.
Show your working clearly.

(Total for Question 18 is 3 marks)



16 Show that $\frac{4 + \sqrt{8}}{\sqrt{2} - 1}$ can be written in the form $a + b\sqrt{2}$, where a and b are integers.

Show each stage of your working clearly and give the value of a and the value of b .

(Total for Question 16 is 3 marks)



20 The area of a rectangle is 18 cm^2

The length of the rectangle is $(\sqrt{7} + 1) \text{ cm}$.

Without using a calculator and showing each stage of your working,

find the width of the rectangle.

Give your answer in the form $a\sqrt{b} + c$ where a , b and c are integers.

..... cm

(Total for Question 20 is 3 marks)



(b) Work out an estimate for the number of these plants with a height greater than 40 cm.

.....
(2)

(Total for Question 18 is 5 marks)

19 Without using a calculator, rationalise the denominator of $\frac{6}{3 - \sqrt{7}}$

Simplify your answer.

You must show each stage of your working.

.....
(Total for Question 19 is 3 marks)



(Total for Question 17 is 5 marks)

- 18 Given that $(8 - \sqrt{x})(5 + \sqrt{x}) = y\sqrt{x} + 21$ where x is a prime number and y is an integer, find the value of x and the value of y . Show each stage of your working clearly.

$$x = \dots\dots\dots$$

$$y = \dots\dots\dots$$

(Total for Question 18 is 3 marks)



17 Express $\frac{8}{\sqrt{5}-1}$ in the form $\sqrt{a} + b$ where a and b are integers.

Show each stage of your working clearly.

.....
(Total for Question 17 is 3 marks)



17 Show that $\frac{\sqrt{12}}{\sqrt{3} + 2}$

can be written in the form $a + \sqrt{b}$ where a and b are integers.

(Total for Question 17 is 3 marks)



13 $a = \sqrt{8} + 4$

$$b = \sqrt{8} - 4$$

$(a - b)(a + b)$ can be written in the form $y\sqrt{4y}$

Find the value of y

Show your working clearly.

$y = \dots\dots\dots$

(Total for Question 13 is 3 marks)



- 16 Without using a calculator, show that $\frac{12}{\sqrt{2}-1} - (\sqrt{2})^5 = 2\sqrt{32} + 12$
Show your working clearly.

(Total for Question 16 is 3 marks)



- 16 Show that $\frac{2\sqrt{3}}{\sqrt{3}-1}$ can be written in the form $a + \sqrt{a}$ where a is an integer.

Show your working clearly.

(Total for Question 16 is 3 marks)

- 17 Make x the subject of $y = \sqrt[3]{\frac{6+5x}{x+4}}$

(Total for Question 17 is 4 marks)



17 Show that $\frac{1 + \sqrt{5}}{3 - \sqrt{5}}$ can be written in the form $a + \sqrt{b}$ where a and b are integers.

Show each stage of your working clearly.

(Total for Question 17 is 3 marks)



23 Simplify $\frac{30 \times 25^{2x+7}}{\sqrt{180} \times (\sqrt{5})^{4x+9}}$

Give your answer in the form 5^w where w is an expression in terms of x
Show each stage of your working clearly.

(Total for Question 23 is 3 marks)

Turn over for Question 24



- 16 Show that $\frac{4}{3\sqrt{5} + 7}$ can be written in the form $a - \sqrt{b}$ where a and b are integers.
Show each stage of your working.

(Total for Question 16 is 3 marks)

- 17 Make k the subject of $p = \frac{8k^2 + 5}{7 - 3k^2}$

(Total for Question 17 is 4 marks)



16 (a) Rationalise the denominator of $\frac{a + \sqrt{4b}}{a - \sqrt{4b}}$ where a is an integer and b is a prime number.

Simplify your answer.

(b) Given that $\left(\sqrt{\frac{y}{x}}\right)^{-5} = \frac{x^m}{y^m}$ where $x \neq y$ (3)

find the value of m .

$m =$ (1)

(Total for Question 16 is 4 marks)



21 Express $\frac{3 + \sqrt{8}}{(\sqrt{2} - 1)^2}$ in the form $p + \sqrt{q}$ where p and q are integers.

Show each stage of your working clearly.

(Total for Question 21 is 4 marks)

Turn over for Question 22



18 Solve $\sqrt{3}(x - 2\sqrt{3}) = x + 2\sqrt{3}$

Give your answer in the form $a + b\sqrt{3}$ where a and b are integers.
Show your working clearly.

$x =$

(Total for Question 18 is 4 marks)



17 Given that $8\sqrt{m} + \sqrt{49m} - \sqrt{9m} = k\sqrt{m}$
where k is an integer and m is a prime number,

(a) work out the value of k

$$k = \dots\dots\dots (1)$$

(b) Show that $\frac{5 - \sqrt{18}}{1 - \sqrt{2}}$ can be written in the form $a + b\sqrt{2}$

where a and b are integers.

Show each stage of your working clearly.

(3)

(Total for Question 17 is 4 marks)



23 The diagram shows a cuboid with a square cross section.

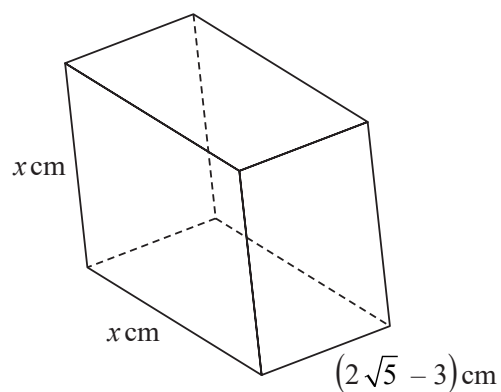


Diagram **NOT**
accurately drawn

The volume of the cuboid is $(13 + 6\sqrt{5}) \text{ cm}^3$

Without using a calculator, find the value of x

Give your answer in the form $a + \sqrt{b}$ where a and b are integers.

Show your working clearly.

$$x = \dots\dots\dots$$

(Total for Question 23 is 4 marks)

Turn over for Question 24



17 (a) $\left(\sqrt[4]{k^{12}}\right)^5 = k^n$

Find the value of n

$$n = \dots\dots\dots (1)$$

(b) Express $\frac{7}{2 - \sqrt{3}}$ in the form $\sqrt{c} + d$ where c and d are integers.

Show your working clearly.

$$\dots\dots\dots (3)$$

(Total for Question 17 is 4 marks)



17 (a) Express $\sqrt{675}$ in the form $n\sqrt{27}$ where n is a positive integer.

.....
(1)

(b) Show that $\frac{5 - \sqrt{2}}{\sqrt{2} - 1}$ can be written in the form $a + b\sqrt{2}$ where a and b are integers.

(3)

(Total for Question 17 is 4 marks)



15 $(\sqrt{3})^5 = k\sqrt{3}$ where k is an integer.

(a) Find the value of k

$$k = \dots\dots\dots (1)$$

(b) Show that $\frac{21}{3 - \sqrt{2}}$ can be written in the form $c + \sqrt{d}$

where c and d are integers.

Show each stage of your working clearly.

(3)

(Total for Question 15 is 4 marks)



- 21 (a) Show that $\sqrt{45} + \sqrt{20} = 5\sqrt{5}$
Show your working clearly.

(2)

- (b) Express $\frac{2}{\sqrt{3}-1}$ in the form $p + \sqrt{q}$
where p and q are integers.
Show your working clearly.

(2)

- (c) Express $x^2 + 6\sqrt{2}x - 1$ in the form $(x + a)^2 + b$
Show your working clearly.

(2)

(Total for Question 21 is 6 marks)



17 (a) Show that $(6 + 2\sqrt{12})^2 = 12(7 + 4\sqrt{3})$

Show each stage of your working.

(3)

(b) Simplify fully $\left(\frac{27a^{12}}{t^{15}}\right)^{-\frac{2}{3}}$

(3)

(Total for Question 17 is 6 marks)



19 (a) Simplify $8^2 \times \sqrt[3]{4^6}$

Give your answer in the form 2^a where a is an integer.

Show each stage of your working clearly.

.....
(3)

Given that $n^{\left(-\frac{4}{5}\right)} = \left(\frac{1}{2}\right)^4$ where $n > 0$

(b) find the value of n .

$n =$
(4)

(Total for Question 19 is 7 marks)



MARK SCHEMES

official mark schemes, in the same order as the questions



9	(a)		2	M1 for $(x \pm 6)(x \pm 7)$
		$(x + 6)(x - 7)$		A1 for $(x + 6)(x - 7)$ or $(x - 7)(x + 6)$ isw roots given if candidate solves the quadratic = 0
	(b)	$3x - 8x < 3 - 15$ or $15 - 3 < 8x - 3x$	3	M1 accept as equation or with the wrong inequality sign.
		$-5x < -12$ or $12 < 5x$		M1 accept as equation or with the wrong inequality sign.
		$x > 2.4$		A1 Accept $2.4 < x$ or $x > \frac{12}{5}$ oe allow $(-\infty, 2.4)$ award M1 M1 A0 for 2.4 with = sign or no inequality or incorrect inequality sign.
Total 5 marks				
10	(a)	0	1	B1 condone 150^0
	(b)	-2	1	B1 condone 3^{-2}
Total 2 marks				
11	See appendix 1		3	M1 for $y = x$ correctly drawn solid or dashed line accepted
				M1 indep for $x = 4$ and $y = -2$ correctly drawn solid or dashed line accepted
		Correct region identified		A1 for correct region identified region may be shaded or left unshaded Condone missing label if region is clear and no contradictory labels
Total 3 marks				

(d)		$5cd^2(2c^2 + 3d^2)$	2	B2 for $5cd^2(2c^2 + 3d^2)$ B1 for a correct partial factorisation eg $5(2c^3d^2 + 3cd^4)$ or $cd^2(10c^2 + 15d^2)$ or $5d^2(2c^3 + 3cd^2)$ or $5c(2c^2d^2 + 3d^4)$ $5cd(2c^2d + 3d^3)$ etc or $5cd^2$ (a 2 term expression with just one error)
Total 8 marks				
7	$(4^n =)(2^2)^n$ or $(4^n =)2^{2n}$ oe eg $2^k \div 2^{2n} = 2^x$ or $2^k = 4^{\frac{1}{2}k}$ and $2^x = 4^{\frac{1}{2}x}$ oe eg $\frac{4^{\frac{1}{2}k}}{4^n} = 4^{\frac{1}{2}x}$		2	M1 for writing 4^n as $(2^2)^n$ or 2^{2n} or for writing each term in terms of 4 ie $2^k = 4^{\frac{1}{2}k}$ and $2^x = 4^{\frac{1}{2}x}$ If these things are seen in working, award this mark even if followed by incorrect working – if not a choice of methods
		$k - 2n$		A1 allow 2^{k-2n}
Total 2 marks				

11		$2x + y \leq 6$ $2y \leq 5x + 1$ $3y + 2x \geq 4$	3	B3 oe for all three correct (B2 oe for any two correct) (B1 oe for any one correct) $2x + y \leq 6$ equivalent to $y \leq -2x + 6$ oe $2y \leq 5x + 1$ equivalent to $y \leq 2.5x + 0.5$ oe $3y + 2x \geq 4$ equivalent to $y \geq -\frac{2}{3}x + \frac{4}{3}$ oe Allow the following inequalities $2x + y < 6$ oe $2y < 5x + 1$ oe $3y + 2x > 4$ oe
Total 3 marks				

12	(a)		$\frac{9}{10}$	1	B1 oe
	(b)		-6	1	B1
Total 2 marks					



12	$2^{-4x} = 2^5$ or $-4x = 5$ or $-\frac{4}{5}x = 1$ oe		2	M1
	Correct answer scores full marks (unless from obvious incorrect working)	$-\frac{5}{4}$		A1 oe allow eg $\frac{5}{-4}$
				Total 2 marks



6	(a)	$7 \times 5 \times 14 (= 490)$ oe or $7 \times 14 (= 98)$ and $400 \div 5 (= 80)$		4	M1 for working out the pay per week or pay per day
		"490" – 400 (= 90) or "98" – "80" (= 18) or "98" $\div$ "80" oe or "490" $\div$ 400 oe or 1.225 oe			M1
		$\frac{90}{400} (\times 100) (= 0.225)$ oe or $\frac{18}{80} (\times 100) (= 0.225)$ oe or $\frac{98}{80} \times 100 (= 122.5)$ oe or $\frac{490}{400} \times 100 (= 122.5)$ oe or "1.225" – 1 (= 0.225)			M1 dep on M2
		Correct answer scores full marks (unless from obvious incorrect working)	22.5		A1 oe allow 23% with M3 awarded
	(b)	E.g. $1 - 0.06 (= 0.94)$ or $100(\%) - 6(\%) (= 94(\%))$ or $\frac{23\,030}{94} (= 245)$ oe		3	M1
		E.g. $23\,030 \div "0.94"$ or $23\,030 \div "94" \times 100$ or $23\,030 \times 100 \div "94"$ or "245" $\times 100$			M1
		Correct answer scores full marks (unless from obvious incorrect working)	24 500		A1
					Total 7 marks



7	(a)		1	1	B1 cao
	(b)		-6	1	B1 Allow 3^{-6}
					Total 2 marks

8	(a)	$-4x > 17 - 9$ or $-4x > 8$ or $9 - 17 > 4x$ or $-8 > 4x$ or $\frac{9}{4} - x > \frac{17}{4}$ oe or $-\frac{9}{4} + x < -\frac{17}{4}$ oe		2	M1 for a correct first step Condone = rather than > or any other sign for this mark.
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	$x < -2$		A1 oe eg $-2 > x$ (sight of correct answer in working space and just $(x =) -2$ on answer line gains M1 only)
	(b)		$y \geq 2$ $x \leq 6$ $y \leq x$	3	B3 for all 3 correct Allow $2 \leq y, 6 \geq x$ and $x \geq y$ B2 for 2 correct B1 for 1 correct Allow < and > signs SCB2: $y \leq 2, y \geq x$ and $x \geq 6$ (for all 3) Allow < and > signs
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>			Total 5 marks



11		$\frac{m^9 k^{15}}{125}$	2	B2 oe for all 3 correct eg $125^{-1} m^9 k^{15}$ or $\frac{1}{125} m^9 k^{15}$ Accept $a = 9$, $b = 15$ and $c = 125$ B1 for a quotient in the form of $\frac{m^p k^q}{r}$ or a product in the form $r^{-1} m^p k^q$ where 2 from p or q or r are correct eg $\frac{m^9 k^{15}}{25}$ or $125 m^9 k^{15}$ Allow $m^9 k^{15}$ or $\frac{m^9}{125}$ or $125^{-1} m^9$ or $\frac{k^{15}}{125}$ or $125^{-1} k^{15}$ so long as not added to any other terms Accept two from $a = 9$ or $b = 15$ or $c = 125$ Accept $y 125^{-1} m^9 k^{15}$ or $\frac{y m^9 k^{15}}{125}$ where y is constant
Total 2 marks				

12	(a)	D	1	B1 allow d
	(b)	C	1	B1 allow c
	(c)	B	1	B1 allow b
Total 3 marks				



4	(a)(i)		1, 2, 3, 5, 6, 7	1	B1	in any order with no repeats
	(a)(ii)		4, 5, 7, 8, 9, 10	1	B1	in any order with no repeats
	(b)	eg 1. 2 (or 3 or 2 and 3) is in both sets oe 2. A and B have 2 (or 3 or 2 and 3) oe 3. 2 (or 3 or 2 and 3) is common oe 4. 2 (or 3 or 2 and 3) is in the intersection oe 5. $A \cap B = \{2, 3\}$ oe or $A \cap B = \{2\}$ oe or $A \cap B = \{3\}$ oe 6. They share 2 (or 3 or 2 and 3) oe 7. As 2 and/or 3 are factors of 6 and also prime numbers oe Allow sector for set This is not an exhaustive list	2 (or 3 or 2 and 3) is a member of A and B	1	B1	for identifying the element 2 or 3 or 2 and 3 with a correct explanation to show they know the meaning of intersection and empty set If students mention a number that is common, it must be correct
	(c)		1, 5, 6, 7	2	B2	for 1, 5, 6, 7 (B1 for three correct values with no more than one incorrect or for four correct values with no more than one incorrect)
						Total 5 marks

5	$\sqrt{81}(=9)$ or 9 or $9 \times 9 (=81)$		4	M1 for method to find the length of the side of the square (may be seen on the diagram)
	$4 \times "9" (=36)$ oe			M1 for the perimeter of the square (the first M mark can be implied by 36)
	eg $\pi \times "9" (=28.2(743\dots))$ or 9π			M1 for a correct expression for the circumference for using $2\pi r$ or πD (the first M mark can be implied by 28.2(743\dots) rounded or truncated to 1 dp or by 9π)
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	64.3		A1 accept 64.26 – 64.3
Total 4 marks				

6 (a)	eg $2f = 12f - 51$ or $\frac{f}{3} = \frac{4}{2}f - \frac{17}{2}$ or $\frac{f}{3} = 2f - \frac{17}{2}$ or $0.3f = 2f - 8.5$ or $f = 6f - \frac{51}{2}$ or $f = 6f - 25.5$ or $17 = 4f - \frac{2}{3}f$ or $17 = 4f - 0.6f$ or $17 = 4f - 0.7f$ or $\frac{2}{3}f - 4f = -17$ or $0.6f - 4f = -17$ or $0.7f - 4f = -17$	3	M1 for a correct first step – multiplying both sides by 3 correctly and expanding to find $2f = 12f - 51$ or $2f = -51 + 12f$ or writing the RHS as 2 terms each over 2 (Allow decimals to 1dp or better – rounded or truncated)
	eg $-10f = -51$ or $10f = 51$ or $\frac{5f}{3} = \frac{17}{2}$ or $5f = \frac{51}{2}$ or $17 = \frac{10f}{3}$ or $3.3f = 17$ or $-\frac{10f}{3} = -17$ or $-3.3f = -17$		M1 for a correct 2 term equation in the form $af = b$ ft the following equations only $2f = 12f - 17$ oe $2f = 4f - 51$ oe $6f = 12f - 51$ oe (Allow decimals to 1dp or better – rounded or truncated)
	Working required	$\frac{51}{10}$	A1 (dep on at least M1) oe



6	(b)		1	1	B1
	(c)		$3a^3h^4$	2	B2 for $3a^3h^4$ oe B1 for a product in the form ka^ph^q where 2 from k , p or q are correct (allow multiplication signs) eg $5a^3h^4$ or $\frac{12a^3h^4}{4}$ (Allow $3a^3$ or a^3h^4 or $3h^4$ as long as not added to any other term)
	(d)		$4x^3y(5x^2 + 3y^3)$	2	B2 for $4x^3y(5x^2 + 3y^3)$ B1 for any correct factorisation with at least a 2 term factor outside the bracket eg $2x^3y(10x^2 + 6y^3)$ or $x^3y(20x^2 + 12y^3)$ or $2x(10x^4y + 6x^2y^4)$ or $4y(5x^5 + 3x^3y^3)$ or $4x^3(5x^2y + 3y^4)$ etc or the correct highest common factor and a 2 term expression with at most one incorrect term eg $4x^3y(5x^2 + \dots)$ or $4x^3y(\dots + 3y^3)$
Total 8 marks					

7	eg 3^3 or $(3^{-2}) \times 3^{-5}$ or $\frac{3^3}{(3^{10})}$ or $\frac{(3^5)}{3^{12}}$ or $\frac{(3^{-2})}{3^5}$ or $3^{-12}(\times 3^5)$ oe or $-2 + 5 - 10$ oe or $-12 + 5$ oe or $3 - 10$ oe		2	M1 for a correct application of an index rule as a first step or a correct calculation for n
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	-7		A1 Allow 3^{-7}
Total 2 marks				



Question	Working	Answer	Mark	Notes
14	$2^7 = 4^{2x} \times 2^x$ or $128 = (2^2)^{2x} \times 2^x$	1.4	3	M1 Replacing 128 by 2^7 or 4 by 2^2
	$7 = 2(2x) + x$			M1
				A1 oe
				Total 3 marks

15	(i)	19	1	B1
	(ii)	5	1	B1
	(iii)	29	1	B1
				Total 3 marks

International GCSE Maths				
Apart from Questions 3, 7b, 12, 17, 20, 22 the correct answer, unless clearly obtained by an incorrect method, should be taken to imply a correct method				
Q	Working	Answer	Mark	Notes
1 (a)		x^7	1	B1
(b)	eg $7^8 \times 7^4 = 7^{12}$ or $7^8 \div 7^3 = 7^5$ or $7^5 \times 7^4 = 7^9$ or $7^4 \div 7^3 = 7$ or $7^8 \times 7 = 7^{12}$ or $7^{12} \div 7^3 = 7^{12-3}$		2	M1 for one correct step – must be written as a power of 7
		7^9		A1 for 7^9
Total 3 marks				
2	32.4×100^3		2	M1 for 32.4×100^3 oe
		32 400 000		A1 for 32 400 000 accept 3.24×10^7
Total 2 marks				



11	a		$4e^{10}$	2	B2 (B1 for $4e^k$ or ke^{10})
	b	A correct first step eg $\frac{y^{-4}}{2^{-4}}$ or $\left(\frac{y^4}{16}\right)^{-1}$ or $\frac{y^{-4}}{0.0625}$ or $\left(\frac{2}{y}\right)^4$ or $\frac{16}{y^4}$ or $\left(\frac{1}{y/2}\right)^4$ or $\frac{1}{\left(\frac{y}{2}\right)^4}$			M1 or for $16y^p$ where $p \neq -4$
			$16y^{-4}$	2	A1
	c	eg $12 \times \frac{4x-2}{3} - 12 \times \frac{5-3x}{4} = 12 \times 6$ or eg $4(4x-2) - 3(5-3x) = 12 \times 6$ or eg $\frac{4(4x-2)}{12} - \frac{3(5-3x)}{12} (=6)$ or eg $\frac{4(4x-2)-3(5-3x)}{12} (=6)$ oe			M1 for clear intention to multiply all terms by 12 or a multiple of 12 or to express LHS as two fractions over 12 or a multiple of 12 or as a single fraction with a denominator of 12 or a multiple of 12 (if expanded numerator, allow one sign error)
		eg $16x - 8 - 15 + 9x = 6 \times 12$			M1 expanding brackets and multiplying both sides by denominator with no more than one sign error
		eg $16x + 9x = 72 + 8 + 15$			M1 for correct rearrangement of a correct equation with terms in x isolated
			3.8	4	A1 oe, award full marks for a correct answer if at least M1 scored
					Total 8 marks



12	$3^4 = \frac{3^x}{9^{3x}}$ or $81 = \frac{3^x}{(3^2)^{3x}}$	$9^2 = \frac{3^x}{9^{3x}}$ or $81 = \frac{(9^{0.5})^x}{9^{3x}}$			M1 replacing 81 with 3^4 or 9^{3x} with $(3^2)^{3x}$ (or 3^{6x}) or replacing 81 with 9^2 or 3^x with $(9^{0.5})^x$ (in an equation)
	eg $4 + 6x = x$ or $4 = x - 2(3x)$ oe	eg $2 = 0.5x - 3x$ oe			M1 a correct equation using powers
			-0.8	3	A1 oe, dep on at least M1
					Total 3 marks

13	e.g. $x = 0.6\bar{8}1$ and $100x = 68.1\bar{8}$ or $10x = 6.8\bar{1}$ and $1000x = 681.8\bar{1}$			M1 e.g. two decimals that when subtracted give a finite decimal (must show understanding of recurring figures by 'dot' or at least 2 lots of 18 or 81 after the decimal point). Algebra required, use of any letter.
	$99x = 67.5, x = \frac{67.5}{99} = \frac{15}{22}$ or $990x = 675, x = \frac{675}{990} = \frac{15}{22}$ oe	show	2	A1 dep for completing the 'show that' arriving at given answer from correct working.
				Total 2 marks

11		(definition of part: there are 3 parts: one part is the number, one part the letter t and one part the letter w Definition of terms: there are 6 terms: 2 number terms, 2 terms in t and 2 terms in w)		3	M1 indep	Fully correct cancellation of any two parts of their fraction at any stage of working
					M1 indep	correctly apply the negative power to the whole of their bracket (all parts or all terms) or correctly square all parts or terms of their bracket or correctly apply the negative power AND square of at least two parts (maybe 4 terms) of their bracket
			$4t^4w^2$		A1	Allow $(2t^2w)^2$ after the correct answer
		ALTERNATIVE				
			$4t^4w^2$	3	M2	2 correct terms (M1 for 1 correct term)
					A1	Allow $(2t^2w)^2$ after the correct answer
Total 3 marks						

12		$13 - 4$		2	M1	For selecting 4 and 13
			9		A1	
Total 2 marks						



Question	Working	Answer	Mark	Notes
14		$\frac{4y^5}{3x^2}$	3	B3 Accept $\frac{4}{3}x^{-2}y^5$ or $\frac{4x^{-2}y^5}{3}$ or $1.\dot{3}x^{-2}y^5$ oe NB: Must see 4 and 3 and not $16^{\frac{1}{2}}$ or $9^{\frac{1}{2}}$ or $16^{-\frac{1}{2}}$ or $9^{-\frac{1}{2}}$ (allow use of 1.3[33..])
				If not B3 then B2 for 2 of: correct fraction ($\frac{4}{3}$ or $1.\dot{3}$)(allow use of 1.3[33..]) or x term correct (x^2 on denominator or x^{-2} on numerator) or y term correct (y^5 on numerator or y^{-5} on denominator)
				If not B2 then B1 for 1 of : correct fraction or x term correct or y term correct or for one of applying negative power to at least 3 out of 4 of 9, x^4 , 16, y^{10} or applying square root to at least 3 out of 4 of 9, x^4 , 16, y^{10} eg at least 3 of the 4 parts of $\frac{16y^{10}}{9x^4}$ or $\frac{16x^{-4}}{9y^{-10}}$ or $\frac{\frac{1}{9}x^{-4}}{\frac{1}{16}y^{-10}}$ or $\frac{3x^2}{4y^5}$ oe
				Total 3 marks

24	eg $\frac{2 \times 3 \times 3 \times (3^2)^{4n+6}}{2 \times 3 \times 3^{2(2n+8)}}$ or $\frac{3 \times 3^{\frac{3}{2}(4n+6)}}{3^{2(2n+8)}}$ $\sqrt{27}$ to be changed to a power of 3 and not $3\sqrt{3}$ unless recovered		3	M1 For 2 of: - writing 18 as 2×3^2 oe and 6 as 2×3 OR cancelling 6 & 18 fully - writing $\sqrt{27}$ as $3^{\frac{3}{2}}$ or $3 \times 3^{\frac{1}{2}}$ OR $(\sqrt{27})^{4n+6}$ as $(3^3)^{2n+3}$ or 3^{6n+9} - writing 9 as 3^2 OR 9^{2n+8} as $3^{2(2n+8)}$ or 3^{4n+16}
	eg $\frac{3 \times 3^{6n+9}}{3^{4n+16}}$ or $\frac{3^{6n+10}}{3^{4n+16}}$ or $\frac{3 \times 3^{1.5(4n+6)}}{3^{2(2n+8)}}$ or $\frac{3^2 \times 3^{6n+9}}{3 \times 3^{4n+16}}$ or $\frac{3^{6n+11}}{3^{4n+17}}$ oe or eg $3^{6n+11} = 3^x \times 3^{4n+17}$ oe			M1 For a correct expression or equation using only powers of 3 (powers of 3 but not necessarily a single power)
		$2n - 6$		A1 oe eg $2(n - 3)$ dep on M1
Total 3 marks				

14	eg $3^{2n+3-4} (= 3^3 \times 3^{1-2n})$ or $3^{2n-1} (= 3^3 \times 3^{1-2n})$ or $(3^{2n+3} =) 3^7 \times 3^{1-2n}$ or $\left(\frac{3^{2n+3}}{3^4}\right) 3^{4-2n}$ or $(3^{2n+3} =) 3^3 \times 3^{5-2n}$ or $\frac{3^{2n}}{3^4} = 3^{1-2n}$ (division by 3^3) <i>This is not an exhaustive list</i> or $2n + 3 - 4 (= \dots)$ or $(\dots =) 3 + 1 - 2n$ or $2n - 1 (= \dots)$ or $(\dots =) 4 - 2n$ (no other options for this)		3	M1 For one rule of indices used to correctly combine two or more of the given expressions (do not need part in brackets) <i>(must include algebra)</i> or For one of the 4 expressions shown, providing it is clear that they apply to the LHS or to the RHS
	eg $3^{2n+3-4} = 3^{3+1-2n}$ or $3^{2n+3} = 3^{8-2n}$ or $3^{2n-1} = 3^{4-2n}$ or $2n + 3 - 4 = 3 + 1 - 2n$ oe eg $2n - 1 = 4 - 2n$			M1 A correct single power of 3 on both sides or a correct equation in n without indices (some students may go straight to this and gain M2)
	Working required	$\frac{5}{4}$		A1 oe dep on M1
				Total 3 marks

Question	Working	Answer	Mark	Notes
14 (a)		B	1	B1 cao
(b)		C	1	B1 cao
Total 2 marks				

Question	Working	Answer	Mark	Notes
15		$125a^{12}c^6$	3	B3 for $125a^{12}c^6$ oe eg $\frac{125a^{12}}{c^{-6}}$ or $\frac{125c^6}{a^{-12}}$ or $\frac{125}{a^{-12}c^{-6}}$ or $\frac{a^{12}}{125^{-1}c^{-6}}$ or $\frac{1}{125^{-1}a^{-12}c^{-6}}$ or $\frac{a^{12}c^6}{125^{-1}}$ B2 for 2 correct terms (Allow eg $125a^{12}$ or $125c^6$ or $ka^{12}c^6$ as long as not added to any other terms) B1 for one correct term (allow eg a^{12} or $a^{-12}c^6$ or $\frac{1}{125^{-1}}$ or $\frac{1000a^{21}c^6}{8a^9}$ as long as not added to any other terms)
Total 3 marks				



Question	Working	Answer	Mark	Notes
9	eg $7x + 7y = 105$ – $5x + 5y = 75$ + $7x - 5y = 3$ $7x - 5y = 3$		3	M1 Correct method to eliminate x or y: coefficients of x or y the same and correct operation to eliminate selected variable (condone any one arithmetic error in multiplication) or writing x or y in terms of the other variable and correctly substituting
	$7(15 - y) - 5y = 3$ or $7x - 5(15 - x) = 3$ oe			M1 dep Correct method to find second variable using their value from a correct method to find first variable or for repeating above method to find second variable
	"6.5" + y = 15 or x + "8.5" = 15 or $7 \times \text{"6.5"} - 5y = 3$ or $7x - 5 \times \text{"8.5"} = 3$			A1oe dep on first M1
		x = 6.5, y = 8.5		Total 3 marks
10 (a)	$\frac{2^3}{2^7}$ or $2^3 \times 2^{-7}$ or $\frac{1}{2^4}$ or $\frac{1}{16}$ and $16 = 2^4$		2	M1
		–4		A1 Accept 2^{-4}
(b)	$13^{-24} \times 13^5$		2	M1 for 13^{-24} or for $k = -6 \times 4 + 5$
		–19		A1 Accept 13^{-19}
				Total 4 marks
11	$V = \frac{4}{3} \times \pi \times 1.5^3$ (= 14.1(37)... or $\frac{9}{2} \pi$)		3	M1 Correct expression for volume.
	$D = \frac{109.6}{\frac{4}{3} \pi \times 1.5^3}$ oe			M1 dep
		7.75		A1 7.75 – 7.78
				Total 3 marks



8	$10 \times 79.2 (= 792)$ or $3 \times 68 (= 204)$		3	M1
	$(10 \times 79.2 - 3 \times 68) \div 7$			M1
		84		A1
				Total 3 marks

9	(a)	t^6	1	B1
	(b)	w^{12}	1	B1
	(c)	$125x^3y^6$	2	B2
				(B1) for 2 correct terms as part of a product
				Total 4 marks

10	$22 \times 60 \times 60 (= 79\,200)$ oe or $22 \div 1000 (= 0.022)$ oe		3	M1 for converting from m/s to m/h or from m to km	M2 for 22×3.6 oe
	$22 \times 60 \times 60 \div 1000$ oe			M1 for a complete method	
		79.2		A1 oe, dep on at least M1	
				Total 3 marks	

Question		Working	Answer	Mark	Notes
12		$\sin 32 = \frac{BD}{3.1}$ oe ($BD \Rightarrow 3.1 \times \sin 32 (= 1.6427\dots)$)	2.21	5	M1 A correct calculation involving BD
		$\cos 42 = \frac{3.1 \sin 32}{AB}$ oe or $\frac{AB}{\sin 90} = \frac{3.1 \sin 32}{\sin 48}$ oe		M1 Accept 1.6 or better	
		$AB = \frac{3.1 \sin 32}{\cos 42}$ or $AB = \frac{3.1 \sin 32}{\sin 48}$		M1 Dep or ($AD \Rightarrow$) "1.6.. x tan 42 (= 1.479)"	
				M1 Or ($AB \Rightarrow$) $\sqrt{1.479^2 + 1.6427^2}$	
				A1 2.21053... (Accept 2.2 $\rightarrow$ 2.22)	
					Total 5 marks
13	(a)	Plotting points from table at ends of interval (40, 6), (50, 20), (60, 56), (70, 84), (80,95), (90, 100)	Correct cf diagram	2	M1 $\pm 1/2$ sq (at least 5 points plotted correctly) Or <u>all</u> points plotted consistently within each interval at the correct heights Accept cf graph which is not joined to (30,0)
		Points joined with curve or line segments		A1	
	(b)	Use of graph at 50	58 – 59	2	M1 Use of graph at 50 walkers A1 No working shown and answer is within 58 – 59 award M1A1
	(c)	86 or 87 or 88 indicated on graph or stated 100 – "86" or 100 – "87" or 100 – "88"	$\frac{12}{100}$ oe $\frac{13}{100}$ oe $\frac{14}{100}$	3	M1 Use of their graph at 72 minutes M1 Dep e.g. 12, 13 or 14 walkers A1 0.12 $\rightarrow$ 0.14 inc, oe
					Total 7 marks
14	(a)	x^3y^6	x^3y^6	2	B1B1 Allow B1 if $(x^3y^2)^3$ or $(x^{36}y^{24})^{0.25}$ seen on answer line
	(b)	$3^n = \frac{3^x}{3^{2y}}$	$n = x - 2y$	2	M1 for a correct first step e.g. 3^{2y} or 3^{-2y}
					A1
					Total 4 marks

3	(a) (i)		24, 30	1	B1	No repeats, omissions or extra values
	(ii)		21, 23, 25, 27, 29	1	B1	No repeats, omissions or extra values
	(b)		$(A \cup B)'$ or $A' \cap B'$	1	B1	or $(B \cup A)'$ or $B' \cap A'$
Total 3 marks						
4	(a)		$81k^8$	2	B2	B1 for 81 or k^8 seen in their final answer.
	(b)		$7m^4n^6$	2	B2	B1 for $7m^4$ or n^6 in a product with no other terms in m or n
Total 4 marks						
5	(a)	vertices at $(-9, 6)$ $(-9, 9)$ $(-3, 9)$ $(-6, 6)$	Shape in correct position	2	B2	B1 for congruent shape in correct orientation but wrong position or quadrilateral with 2 or 3 vertices correct.
	(b)	vertices at $(7, 3)$ $(10, 6)$ $(13, 6)$ $(13, 3)$	Shape in correct position	1	B1	
	(c)		enlargement scale factor 2 centre $(-3, 3)$	3	B1 B1 B1	for enlargement, enlarge, etc so long as no mention of rotation, reflection or translation, flip, move etc. SF 2, double, two times etc. $(-3, 3)$ stated. Accept about, from etc. with no mention of line, or column vector.
Total 6 marks						

11	(a)	$2^{\frac{1}{2}} \times 2^4$ or eg $2 \times (2^4)^2 = (2^x)^2$ or $2^9 = 2^{2x}$		2	M1 for a correct expression in powers of 2 that is equivalent to 2^x eg $2^{\frac{1}{2}} \times 2^4$ or for showing $\sqrt{2} = 2^{\frac{1}{2}}$ and $16 = 2^4$ or for writing the equation in powers of 2 eg $2 \times (2^4)^2 = (2^x)^2$ or $2^9 = 2^{2x}$
		<i>Working required</i>	$\frac{9}{2}$		A1 or 4.5 or 4½ dependent on M1
	(b)	$\frac{11^{-30}}{11^4}$ or $-30 - 4 = n$ or $-30 = n + 4$ oe		2	M1 For $(11^{-6})^5$ written as 11^{-30} in the equation or $(11^{-6})^5 = 11^{-30}$ shown in working or a correct equation with indices only (no marks for $3.914... \times 10^{-36}$)
	<i>Working required</i>	-34	A1 dep on M1 (as we have asked for working)		
Total 4 marks					

12		$\frac{50}{360} \times \pi \times 7 \times 2$ oe eg $\frac{14\pi}{36} \times 5$ or "43.98..." $\div 360 \times 50$ oe		2	M1 Students may use π or 3.14, 3.142 or $\frac{22}{7}$
		Working not required, so correct answer scores full marks (unless from obvious incorrect working)	6.1		A1 Accept answers in the range 6.05 – 6.2
					Total 2 marks

International GCSE Maths				
Apart from Questions 2, 5, 7, 12c, 17, 18 and 19 the correct answer, unless clearly obtained by an incorrect method, should be taken to imply a correct method				
Q	Working	Answer	Mark	Notes
1 (a)		9	1	B1 allow 3^3
(b)		21	1	B1 allow 5^{21}
(c)	$8 + 2 - p = 6$ oe eg $8 + 2 = 6 + p$ or $7^{8+2-p} = 7^6$ oe		2	M1 (or embedded eg $8 + 2 = 10$, $10 - 4 = 6$)
	Correct answer scores full marks (unless from obvious incorrect working)	4		A1 allow 7^4
				Total 4 marks

6	(a)		1	1	B1
	(b)		6	1	B1
	(c)	$206 + m - 214 = -3$ oe or $\frac{7^{-3} \times 7^{214}}{7^{206}}$ or $\frac{7^{211}}{7^{206}}$ oe		2	M1 allow $7^{206+m-214} = 7^{-3}$ oe (must be in the form $7^x = 7^y$ where x and y are correct expressions)
			5		A1 accept 7^5
					Total 4 marks

7	$1.4 = \frac{72}{(\text{area})}$ oe		4	M1
	$(\text{area} =) \frac{72}{1.4} (= \frac{360}{7} = 51.4\dots)$ oe			M1 (51.4 or better)
	"51.4..." $\times 18$ or $r = \sqrt{\frac{"51.4\dots"}{\pi}} (= 4.046\dots)$ and $\pi \times "4.046" \times 18$			M1 allow use of πr^2 to find the radius and then using $\pi r^2 h$ to find the volume
		926		A1 Allow 925 – 928
				Total 4 marks

8	(a)	8.9×10^{-5}	1	B1
	(b)	83 400	1	B1
				Total 2 marks

9	(a)	8	1	B1
	(b)	11	1	B1 accept x^{11}
	(c)	$8k^6m^{12}$	2	B2 for all correct B1 for two correct from 8 or k^6 or m^{12}
				Total 4 marks



5	eg $0.74 \times 300 (= 222)$ or $1 - 0.74 (= 0.26)$ seen or $\frac{78}{300}$		2	M1 for a method to work out an estimate for the number of games Evie will win or the probability that Evie will lose or an answer of $\frac{78}{300}$
	Correct answer scores full marks (unless from obvious incorrect working)	78		A1 cao
Total 2 marks				

6	(a)	m^7	1	B1
	(b)	8	1	B1 Allow k^8
	(c)	$9x^{12}y^{16}$	2	B2 B1 for a product in the form $ax^p y^q$ where 2 from a , p or q are correct eg $3x^{12}y^{16}$ (Allow $9x^{12}$ or $9y^{16}$ or $x^{12}y^{16}$ so as long as not added to any other terms)
Total 4 marks				

7	(a)	$4x^2 - 20x$	1	B1 $or -20x + 4x^2$
	(b)	$(y \pm 5)(y \pm 4)$ or $(5 \pm y)(4 \pm y)$ or $y(y - 4) - 5(y - 4)$ or $y(y - 5) - 4(y - 5)$	2	M1 for $(y \pm 5)(y \pm 4)$ or $(5 \pm y)(4 \pm y)$ or for $(y + a)(y + b)$ where $ab = 20$ or $a + b = -9$
	Correct answer scores full marks (unless from obvious incorrect working)	$(y - 5)(y - 4)$		A1 oe Allow any letter for y Accept $(5 - y)(4 - y)$
Total 3 marks				

Question	Working	Answer	Mark	Notes
12 (a)	$2^7 \times (2^2)^5 = (2^2)^x$ oe eg $2^7 \times 2^{10} = 2^{2x}$ or $\left(4^{\frac{1}{2}}\right)^7 \times 4^5 = (4)^x$ oe or LHS written as 2^{17}		2	M1 writing $4^{\frac{1}{2}}$ and 4^1 as powers of 2 or or writing 2^7 as $4^{3.5}$ oe or writing (LHS) $2^7 \times 4^5$ as 2^{17}
	<i>Working not required, so correct answer scores full marks (unless from obvious incorrect working)</i>	8.5		A1 oe $\frac{17}{2}$, $8\frac{1}{2}$, allow $4^{8.5}$ oe
(b)		$25p^4y^{16}$	2	B2 (award B1 for 2 parts correct must be 25 and not 5^2)
Total 4 marks				



7	(a)(i)		23, 24, 27, 29, 30, 31, 33	1	B1 in any order with no repeats
	(a)(ii)		27, 33	1	B1 in any order with no repeats
	(b)	eg 1. Yes, no members/numbers/values in common 2. Yes, nothing in common 3. Yes, no common members/numbers/values 4. Yes, they share no common members/numbers/values 5. Yes, there is not the same members/numbers/values in both sets 6. Yes, there is no intersection or there is nothing in B and C 7. Yes, as there are no members/numbers/values the same (in B and C) 8. Yes, no members/numbers/values in B are in C or vice versa 9. Yes, there are no members/numbers in B that are multiples of 3 10. Yes, there are no members/numbers/values in that empty set 11. Yes, 23, 29, 31 not in C 12. Yes, 24, 27, 30, 33 are not in B Allow sector for set This is not an exhaustive list Allow element(s) for members/numbers/values	Yes, there are no multiples of 3 in set B	1	B1 for Yes and a statement which indicates correct meanings of intersection and empty set. If no box is ticked, then the 'Yes' must be stated in the answer
	(c)		23, 25, 29, 31	2	B2 for the four correct numbers and no additions (B1 for three correct values with no more than one incorrect or for four correct values with no more than one incorrect)
Total 5 marks					

3	eg $360 - (148 + 50) (= 162)$ or $180 - 50 (= 130)$ or $180 - 148 (= 32)$		4	M1	for method to interior angle of the polygon or start to the method of finding the exterior angle of the polygon	
	eg $180 - "162" (= 18)$ or $148 - "130" (= 18)$ or $50 - "32" (= 18)$	eg $180(n - 2) = "162"n$ or $180(n - 2) \div n = "162"$		M1	for method to find the exterior angle or for setting up an equation using sum of interior angles formula	
	eg $360 \div "18"$	eg $(n =) 360 \div (180 - "162")$		M1	for a complete method	
	Working required			20	A1	dep on M1
Total 4 marks						

4	(a)	12	1	B1 accept x^{12}
	(b)	5	1	B1 accept y^5
	(c)	$125a^{12}r^6$	2	B2 for $125a^{12}r^6$ (B1 for a product in the form $ka^p r^q$ where 2 from k , p or q are correct eg $5a^{12}r^6$ Allow $125a^{12}$ or $125r^6$ or $a^{12}r^6$ so as long as not added to any other terms)
	Total 4 marks			

5	eg $1 - 0.28 (= 0.72)$ oe or $0.72x = 198$ or $100(\%) - 28(\%) (= 72(\%))$ or $\frac{198}{72} (= 2.75)$ oe		3	M1 for a correct first step
	eg $(x =) 198 \div "0.72"$ oe or $198 \div "72" \times 100$ oe or $"2.75" \times 100$			M1 for a complete method
	Correct answer scores full marks (unless from obvious incorrect working)	275		A1 cao
				Total 3 marks

23	$\frac{4(x-6)(x+5)}{5(x-6)(x+6)} \div \frac{x(x+5)}{10x(x+6)} (= p) \text{ or }$ $\frac{4(x-6)(x+5)}{5(x-6)(x+6)} \times \frac{10x(x+6)}{x(x+5)} (= p)$ or 2 from $4(x-6)(x+5)$ or $5(x-6)(x+6)$ or $x(x+5)$ or $10x(x+6)$		4	M1 for factorising 2 or 3 of the quadratics fully – could be implied by 2 factors cancelled correctly NB factors must be in the form $(ax + b)$ NB Substitution of values of x into the given equation is not an acceptable algebraic method
	$\frac{4(x-6)(x+5)}{5(x-6)(x+6)} \div \frac{x(x+5)}{10x(x+6)} (= p) \text{ or }$ $\frac{4(x-6)(x+5)}{5(x-6)(x+6)} \times \frac{10x(x+6)}{x(x+5)} (= p)$ or $4(x-6)(x+5)$ and $5(x-6)(x+6)$ and $x(x+5)$ and $10x(x+6)$			M1 for factorising all of the quadratics fully – could be implied by 2 factors cancelled correctly NB factors must be in the form $(ax + b)$
	$\frac{4x^2 - 4x - 120}{5x^2 - 180} \times \frac{10x^2 + 60x}{x^2 + 5x} (= p)$			M1 for inverting the 2nd fraction (this mark can be awarded at any time and may be awarded with incorrect factorisation if meaning is clear)
	<i>Working required</i>	8		A1 oe dep on M3
				Total 4 marks
ALT	$\frac{40x^4 + 200x^3 - 1440x^2 - 7200x}{5x^4 + 25x^3 - 180x^2 - 900x}$			M3 for a correct expression (no errors)
		8		A1 oe dep on M3

Q	Working	Answer	Mark	Notes
26	For one of: $10^{4n} = (5 \times 2)^{4n}$ or $5^{4n} \times 2^{4n}$ or oe $20^2 = (5 \times 2^2)^2$ or $5^2 \times 2^4$ or $5^2 \times 2^2 \times 2^2$ or cancelling 5^2 on numerator with 20^2 to get 16 or 2^4		5	M1 for writing 10^{4n} correctly as a product of 5 and 2 to the power $4n$ oe or writing 20^2 correctly as a product of 5 and 2^2 to the power 2 oe or cancelling 5^2 on numerator with 20^2 to get 16 or 2^4
	for getting numerator to the stage (this scores M1M1) $2^{4n} \times 2^{3n^2-15n} \times 5^2$ oe eg $2^{3n^2-11n} \times 5^{-4n+4n+2}$ oe or for two of $10^{4n} = (5 \times 2)^{4n}$ or $5^{4n} \times 2^{4n}$ or oe $20^2 = (5 \times 2^2)^2$ or $5^2 \times 2^4$ or $5^2 \times 2^2 \times 2^2$ or cancelling 5^2 on numerator with 20^2 to get 16 or 2^4 or getting the numerator to the stage			M1
	$\frac{2^{4n} \times 2^{3n^2} \times 2^{-15n}}{2^4} [= 1 \text{ or } 2^0]$ or $2^{4n} \times 2^{3n^2} \times 2^{-15n} = 2^4$ oe			M1 For writing the equation in powers of 2 only
	$3n^2 - 11n - 4 [= 0]$			A1 Correct quadratic equation dep on M1
	<i>working required</i>	$-\frac{1}{3}, 4$		A1 Both answers required dep on M1
				Total 5 marks



24	2^3 and 2^{4n} or $(2^4)^n$		5	M1 for writing 16^x and 8 as a power of 2 (or all as powers of 4, 8 or 16)
	$n = x^2 + 4x + 3$ oe or $x^2 + 4x + 3 - n = 0$			A1 for writing n in terms of x correct expression implies first M1
	$(n =)(x + 2)^2 - 2^2$ oe or $(x =) - 2 \pm \sqrt{n+1}$ $(x =) \frac{-4 \pm \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe			M1 for a correct first step in completing the square or using the quadratic formula correctly ft their 3 term quadratic
	$(x =) - 2 + \sqrt{n+1}$ oe or $(x =) \frac{-4 + \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe			A1 for correctly rearranging to make x the subject (must be positive square root)
	Correct answer scores full marks (unless from obvious incorrect working)	$(x =) - 2 + \sqrt{n+1}$ and $n > 3$		A1 must be positive square root Accept $(x =) \sqrt{n+1} - 2$ oe and $3 < n$ Accept $(x =) \frac{-4 + \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe and $n > 3$ or $3 < n$
Total 5 marks				



24 ALT	$4^{\frac{1}{2}n}, 4^{\frac{1}{2}x^2}, 4^{2x}$ and $4^{\frac{3}{2}}$	$8^{\frac{1}{3}n}, 8^{\frac{1}{3}x^2}$ and $8^{\frac{4}{3}x}$	$16^{\frac{1}{4}n}, 16^{\frac{1}{4}x^2}$ and $16^{\frac{3}{4}}$		5	M1 for all as powers of 4 or 8 or 16
	$n = x^2 + 4x + 3$ oe or $x^2 + 4x + 3 - n = 0$					A1 for writing n in terms of x correct expression implies first M1
	$(n =)(x + 2)^2 - 2^2$ oe or $(x =) - 2 \pm \sqrt{n+1}$ $(x =) \frac{-4 \pm \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe					M1 for a correct first step in completing the square or using the quadratic formula correctly ft their 3 term quadratic
	$(x =) - 2 + \sqrt{n+1}$ oe or $(x =) \frac{-4 + \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe					A1 for correctly rearranging to make x the subject (must be positive square root)
	Correct answer scores full marks (unless from obvious incorrect working)			$(x =) - 2 + \sqrt{n+1}$ and $n > 3$		A1 must be positive square root Accept $(x =) \sqrt{n+1} - 2$ oe and $3 < n$ Accept $(x =) \frac{-4 + \sqrt{4^2 - 4 \times 1 \times (3-n)}}{2}$ oe and $n > 3$ or $3 < n$
						Total 5 marks



5	(a)		Vertices at (2, 5) (2, 8) (3, 6) (3, 7)	2	B2 for correct shape in correct position (B1 for correct orientation of shape but wrong position or for 3 out of 4 vertices correct or for $y = x$ drawn)
	(b)		Vertices at (5, 3) (5, 7) (7, 7) (9, 3)	2	B2 for correct shape in correct position (B1 for correct size and orientation of shape but wrong position or for 3 out of 4 vertices correct)
					Total 4 marks

6	(a)		1	1	B1 cao
	(b)	eg $(5^3 \div 5^3 =) 5^6$ or $(5^3, 5^{-2} =) 5^{11}$ or $(5^{-3}, 5^{-2} =) 5^{-1}$ or $(5^k \div 5^{-2} =) 5^{k+2}$ or $9 - 3 = k - 2$ oe or $9 - 3 = -2$ or $9 - 3 + 2$ <i>Correct answer scores full marks (unless from obvious incorrect working)</i>	8	2	M1 for one correct application of an index rule (must be seen in powers of 5) this could be after an initial mistake – working will need to be clearly seen or for forming a correct equation in the indices alone or for a complete method for the value of k
	(c)		$8d^{12}e^{15}$	2	B2 for a correct answer (B1 for answer of the form $kd^m e^n$ where at least two of $k = 8$, $m = 12$ and $n = 15$ are correct)
					Total 5 marks



Question	Working	Answer	Mark	Notes
12	0, 4, 6, 9, 17, 21, 32, 42, 51, 69, 102	45	3	M1 for identifying 6 or 51 from ordered list or attempt to find 3 rd and 9 th seen (from an ordered list) M1 for identifying 6 and 51 A1 for 45
13	$1 + 0.65 + 1.22 (=2.87)$ or $100 + 65 + 122 (=287)$ $861 \div 2.87$ or $(861 \div 287) \times 100$ oe	300	3	M1 oe Note: $861 \div 3 = 287$ is M0 M1 A1
14	(a)(i) (ii) (iii) (b) $177\ 147 \div 2187 (= 81)$ or $a = 81$ $2187 \div 81 (= 27)$ or $b = 27$	a^2 ab^4 $\frac{1}{3}b$ $x = 4, y = 3$	1 1 1 3	B1 B1 B1oe M1 or $x + y = 7$, M1 $2x + y = 11$ A1 $x = 4$ and $y = 3$

15	(a)	$\sqrt{2} = 2^{\frac{1}{2}}$ or $8^3 = 2^9$ or $16^{\frac{3}{2}} = 2^6$		3	M1 for one of $\sqrt{2} = 2^{\frac{1}{2}}$ or $8^3 = 2^9$ or $16^{\frac{3}{2}} = 2^6$
					M1 for all of $\sqrt{2} = 2^{\frac{1}{2}}$ and $8^3 = 2^9$ and $16^{\frac{3}{2}} = 2^6$ OR $2^{\frac{1}{2}} \div 2^3$
		<i>Working required</i>	-2.5		A1 oe, dep on M1
	(b)	$0.04 \times 4.5 \times 10^{157}$ oe		3	M1
		$4 \times 10^{-2} \times 4.5 \times 10^{157} (= 18 \times 10^{155})$ or 0.18×10^{157} oe			M1
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	1.8×10^{156}		A1 SCB1 for $18 \times 10^{156} = 1.8 \times 10^{157}$ or $18 \times 10^{157} = 1.8 \times 10^{158}$
Total 6 marks					

16	(a)		6	1	B1
	(b)		36	1	B1
	(c)		15	1	B1
Total 3 marks					

7	(a)		$4n + 2$	2	M1 for $4n + k$ (k may be 0 or absent) oe
					A1 oe e.g $6 + (n - 1)4$
	(b)		$4n + 6$	1	B1 oe ft part (a) providing M1 in part (a) is awarded e.g $4(n + 1) + 2$
					Total 3 marks

8	(a)		1.39×10^6	1	B1
	(b)		5×10^{-3}	1	B1
					Total 2 marks

9		$2.5 - 0.6 = 1.9$	2 hours 51 minutes	4	M1
		$3 \times 12 \times "1.9" (= 68.4)$			M1 for using length $\times$ width $\times$ height to find a volume
		$"68.4" \times 1000 \div 400$ (= 171 minutes)			M1 for their volume $\times 1000 \div 400$
					A1
					Total 4 marks
		Alternative scheme			
		$250 - 60 = 190$	2 hours 51 minutes	4	M1
		$300 \times 1200 \times "190" (= 6.84 \times 10^7)$			M1 for using length $\times$ width $\times$ height to find a volume
		$"6.84 \times 10^7" \div 10^6 \times 1000 \div 400$ (= 171 minutes)			M1 for their volume $\div 10^6 \times 1000 \div 400$
					A1
					Total 4 marks

5	(a)		$5y^3(3y + 4u)$	2	B2 for $5y^3(3y + 4u)$ (B1 for $5y(3y^3 + 4uy^2)$ or $5y^2(3y^2 + 4uy)$ or $y^2(15y^2 + 20uy)$ or $y^3(15y + 20u)$ or $5y^3(\dots)$ where there is only one mistake in the brackets)
	(b)	$4 \times (4 - 3x) = 5 - 8x$ oe or $16 - 12x = 5 - 8x$ oe or $4 - 3x = \frac{5}{4} - 2x$ oe		3	M1 for removal of fraction in a correct equation
		e.g. $16 - 5 = 12x - 8x$ or $11 = 4x$ oe or $4 - \frac{5}{4} = 3x - 2x$			M1 for terms in x on one side and numbers on the other side in an equation, allow correct rearrangement of their equation in the form $ax + b = cx + d$
			2.75		A1 (dep on M1) oe e.g. $2\frac{3}{4}$ or $\frac{11}{4}$
Total 5 marks					

6	(a)		2.84×10^9	1	B1
	(b)		0.000 25	1	B1
Total 2 marks					



8	$12.6 \times 10^{(-24+145)}$ or 12.6×10^{121} or 1.26×10^n		2	M1
		1.26×10^{122}		A1 allow 1.3×10^{122}
				Total 2 marks

9	$17.5^2 - 14^2 (= 110.25)$		4	M1 or for use of cosine rule to find one of the angles eg $28^2 = 17.5^2 + 17.5^2 - 2 \times 17.5 \times 17.5 \times \cos A$ or eg $\cos B = \frac{14}{17.5}$
	$\sqrt{17.5^2 - 14^2} (= 10.5)$			M1 or for rearranging the cosine rule to eg $\cos A = \frac{17.5^2 + 17.5^2 - 28^2}{2 \times 17.5 \times 17.5}$ ($A = 106.26\dots$) or eg $B = \cos^{-1}(\frac{14}{17.5})$ ($= 36.86\dots$)
	$0.5 \times 28 \times "10.5"$ oe			M1 or for $0.5 \times 17.5 \times 17.5 \times \sin 106.26\dots$ oe eg $0.5 \times 17.5 \times 28 \times \sin 36.86\dots$ [clear use of Heron's formula: M1 for $S = 0.5(17.5 + 17.5 + 28)(=31.5)$ M2 for $\sqrt{31.5("31.5"-17.5)^2 ("31.5"- 28)}$ oe]
		147		A1 accept awrt 147
				Total 4 marks



6	(a)		7.6×10^7	1	B1
	(b)		0.000 54	1	B1
Total 2 marks					

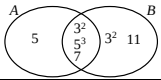
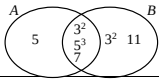
7	$DCO = 90$ (or right (angle)) or $DAO = 90$ (or right (angle)) Could also be awarded for $CAO + CAD = 90$ or $DAC + CAO = 90$		3	M1 may be marked on diagram – also allow right angle 'square' symbol on diagram	M2 implied by $360 - 90 - 90 - 48$ or $360 - 228$
	Obtuse $AOC = 360 - 90 - 90 - 48 (= 132)$ oe or Obtuse $AOC = 2(180 - (0.5 \times 48) - 90) (= 132)$ or Obtuse $AOC = 180 - "24" - "24"$ or $180 - 48$ (if working with $\triangle DAC$ and $\triangle OAC$) or Reflex $AOC = 90 + 90 + 48$			M1 dep on M1 being awarded may be marked on diagram	
	Correct answer scores full marks (unless from obvious incorrect working)	228		A1 SC if no other marks awarded 132 gains B1	
Total 3 marks					

14	eg 0.3×10^{135} or 67×10^{134} or $(6.7 + 0.3) \times 10^{135}$ or 70×10^{134} or 0.7×10^{136} or 7×10^n $n \neq 135$		2	M1
	<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	7×10^{135}		A1
				Total 2 marks



Question	Working	Answer	Mark	Notes
5 a		80 000	1	B1
b	$0.5 \times 10^{5-8}$ or 0.0005 or 5×10^9 or 5.0×10^9	5×10^{-4}	2	M1 A1 for 5×10^{-4} or 5.0×10^{-4} SC : B1 for $\frac{1}{2000}$ or $\frac{1}{2 \times 10^3}$
6	$9.7^2 + 3.5^2 (=106.34)$ $\sqrt{9.7^2 + 3.5^2}$ or $\sqrt{106.34}$ (=10.3...) $\pi \times "10.3..."$ or $2 \times \pi \times \frac{"10.3..."}{2}$	32.4	4	M1 M1 M1 A1 M1 for the use of MN and a correct angle (70.1... or 70.2, 19.8...) in a correct trig statement eg $\cos 70.2 = \frac{3.5}{MN}$ M1 for a complete method to find MN eg $MN = \frac{3.5}{\cos 70.2}$ (=10.3...) dep on M2 for answer in range 32.3 – 32.41

					Total 6 marks
19	$a + 24d = 44.5$		5	M1	oe
	$\frac{30}{2}(2a + (30 - 1)d) = 765$ oe, eg $(15(2a + 29d) = 765), (2a + 29d = 51)$, etc			M1	oe (may be simplified)
	e.g. $2(44.5 - 24d) + 29d = 51$ oe or $2a + 48d = 89$ $2a + 29d = 51$ oe			M1	dep on M2, a complete method to eliminate one variable, allow one arithmetic error
		26.5		A2	dep on M2, oe
				(A1)	dep on M2. If not A2, award A1 for $a = -3.5$ or $d = 2$
					Total 5 marks
20	125 or 10^{21n}		3	M1	
	125×10^{21n}			M1	
		$1.25 \times 10^{21n+2}$		A1	
					Total 3 marks

Question	Working	Answer	Mark	Notes
8	(a)		2	M1 3 ² × 5 ³ × 7 oe or correct Venn diagram
	(b)		2	M1 3 ⁴ × 5 ⁴ × 7 × 11 oe or correct Venn diagram
		7875		A1
		3 898 125		A1
Total 4 marks				
9	(a)	8.4 × 10 ⁵	1	B1
	(b)	$\frac{600000000}{0.08}$ or 750000000 oe (e.g. 0.75 × 10 ⁹)	2	M1 M1 for 60000000 or 0.08
		7.5 × 10 ⁸		A1
Total 3 marks				
10		150000 × 0.82 ³	3	M2 If not M2 then M1 for 1st year e.g. 150000 × 0.82 (= 123000) or 150000 × 0.18 (= 27000) SC B1 for 150000 × 1.18 (= 177000) or 150000 × 1.18 ³ (= 246454.8) or 150000 × 0.54 (= 81000) or 150000 × 0.46 (= 69000) Accept 82705.2
		82705		A1
Total 3 marks				
11		Gradient = (-)4 ÷ 2 oe	3	M1 Correct method to work out the gradient (±) accept 4 ÷ 2 oe or "m" = 2
		y = -2x - 1 oe		A2 If not A2 then A1 for L = -2x - 1 or -2x - 1 or y = 2x - 1 or y = -2x + c
Total 3 marks				

5		$120 \div (3 + 5) (= 15)$ '15' $\times 3 (= 45)$ or '15' $\times 5 (= 75)$		6	M1 M1	M2 for $\frac{3}{8} \times 120 (= 45)$ or $\frac{5}{8} \times 120 (= 75)$ oe
		'45' $\div 3 (= 15)$ or '45' $\div 3 \times 2 (= 30)$			M1	
		'75' $\times \frac{16}{25} (= 48)$ or '75' $\times \frac{9}{25} (= 27)$			M1	
		E.g. ('45' $\div 3 \times 2$) + ('75' $\times \frac{9}{25}$) oe or '27' + '30' or ('75' – '48') + ('45' – '15')			M1 for a complete method	
			57		A1	
						Total 6 marks

6	(a)		0.000 78	1	B1
	(b)	22 500 000 oe e.g. 22.5×10^6 or 2.25×10^n $n \neq 7$		2	M1
			2.25×10^7		A1
					Total 3 marks

Question	Working	Answer	Mark	Notes
8	$20\,000 \times 0.81^3$ oe			M2 M1 for $20\,000 \times 0.81$ oe (= 16 200) or $20\,000 \times 1.19$ oe (= 23 800) or $20\,000 \times 1.19^3$ oe (= 33 703.18)
		10 629		A1 Accept 10 628 → 10 629
Total 3 marks				
9	$30 = \frac{27}{1.2x}$		3	M1 Or for $\frac{27}{30}$ (= 0.9)
	$1.2x = \frac{27}{30}$ or $36x = 27$ or $22.5 \div 30$			M1
		0.75 oe		A1
Total 3 marks				
10 (a)		3.74×10^7	2	B2 B1 for 37 400 000 (oe but not in standard form) or 3.74×10^n ($n \neq 7$) or 3.7×10^7 or 3.8×10^7
(b)		11	1	B1 Allow 11 → 11.1
Total 3 marks				
11 (a)		-1, 0, 1, 2, 3, 4	2	B2 B1 for -2, -1, 0, 1, 2, 3, 4 or -1, 0, 1, 2, 3
(b)		$y \leq 6$ oe $x + y \geq 5$ oe $y \geq x - 3$ oe	2	B2 for 3 correct inequalities B1 for 2 correct inequalities SC B2 for $y \geq 6$ oe and $x + y \leq 5$ oe and $y \leq x - 3$ oe (In all cases allow < in place of ≤, and > in place of ≥)
Total 4 marks				



8	(a)		Pacific	1	B1	Accept 1.357×10^5
	(b)	$1.119 \times 10^5 - 1.797 \times 10^4$		2	M1	Accept 111 900 – 17 970 oe or 93 930 or –93 930
			$9.393(0) \times 10^4$		A1	Accept $(\pm) 9.393(0) \times 10^4$ or $(\pm) 9.39 \times 10^4$ or $(\pm) 9.4 \times 10^4$
						Total 3 marks

9	eg $(x \pm 20)(x \pm 1)$	$\frac{-(-21) \pm \sqrt{(-21)^2 - 4 \times 1 \times 20}}{2 \times 1}$ or $\left(x - \frac{21}{2}\right)^2 - \left(\frac{21}{2}\right)^2 + 20 = 0$		3	M1	If factorising, allow brackets which expanded give 2 out of 3 terms correct – if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{21 \pm \sqrt{441 - 80}}{2}$ or eg $\left(x - \frac{21}{2}\right)^2 - \frac{361}{4} = 0$ oe
	$(x - 20)(x - 1)$	eg $\frac{21 \pm \sqrt{441 - 80}}{2}$ or $\frac{21 \pm \sqrt{361}}{2}$ or $\frac{21 \pm 19}{2}$ or $x = \pm \sqrt{\frac{361}{4}} + \frac{21}{2}$ oe			M1	dep on M1 for correct factorisation, or a correct expression for x if completing the square. or a correct substitution into quadratic formula with some processing.
			1, 20		A1	for both correct values, dep on 1st M1 with no incorrect working.
						Total 3 marks

12	216 or 2.16 or 10^{120} or 10^{122} or $6^3 \times 10^{40 \times 3}$		3	M1 or for digits 216
	216×10^{120} oe or or 2.16×10^n where $n \neq 122$			M1
		2.16×10^{122}		A1
				Total 3 marks
13		$x \geq -1$	1	B1 oe condone > in place of $\geq$
		$y \geq x$	1	B1 oe condone > in place of $\geq$
		$x + 2y \leq 8$	1	B1 oe condone < in place of $\leq$
				SCB1 if all inequalities reversed
				Total 3 marks
14	$12 \times \tan 5 (=1.05)$ or $\tan 5 = \frac{y}{12}$ or $12 \tan 5$ or $\tan 85 = \frac{12}{y}$ or $\frac{12}{\tan 85}$ $\frac{y}{\sin 5} = \frac{12}{\sin 85}$ oe or $(y =) 1.04986\dots$ oe		3	M1 oe correct expression using tan or the sine rule or $\sqrt{\left(\frac{12}{\cos 5}\right)^2 - 12^2} (= 1.04986\dots)$
	$(AB \Rightarrow) 2.6 + "1.05"$ oe			M1
		3.65		A1 allow awrt 3.65
				Total 3 marks
15	5 5 7 8 10 12 13 14 16 21 23		3	M1 For ordering the numbers Allow one error or omission in the list.
	16 & 7 identified for LQ and UQ			M1 For identifying 16 and 7 – may also have identified the median (12)
		9		A1
				Total 3 marks



10	$(4.2 \times 10^{10}) \div (8.7 \times 10^6) (= 4827.58\dots)$ or $(3.7 \times 10^9) \div (6.3 \times 10^5) (= 5873.01\dots)$ or $42\,000\,000\,000 \div 8\,700\,000 (= 4827.58\dots)$ or $3\,700\,000\,000 \div 630\,000 (= 5873.01\dots)$		3	M1
	$'5873.01\dots' - '4827.58\dots' (= 1045.42\dots)$ or $\frac{42000000000}{8700000} - \frac{3700000000}{630000}$			M1 dep on M1
		1045		A1 Answer in range 1045 – 1045.5 or 1.045×10^3 to 1.0455×10^3
				Total 3 marks

8	$\cos 50 = \frac{18}{(AB)}$ or $\sin 40 = \frac{18}{(AB)}$ or $\frac{(AB)}{\sin 90} = \frac{18}{\sin 40}$		5	M1	M2 for $(AB =) \sqrt{18^2 + (18 \tan 50)^2}$ oe (= 28.0030...) or 28
	$(AB =) \frac{18}{\cos 50}$ (= 28.0030...) oe or 28 or $(AB =) \frac{18}{\sin 40}$ (= 28.0030...) oe or 28			M1	
	$\frac{1}{2} \times \pi \times$ "28.0030..." (= 43.9...) oe or 44 $\pi \times$ "28.0030..." (= 87.9...) oe or 88			M1 for use of πd or $\frac{1}{2} \pi d$ oe Allow any value of $AB > 18$ if M2 not scored	
	"28..." + "43.9..." (= 71.9900...) or "28" + "44"			M1ft from previous M1 Allow <i>their d</i> + <i>their</i> $\frac{1}{2} \pi d$	
	<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	72		A1 awrt 72	
				Total 5 marks	

9	(a)	0.000 625	1	B1	
	(b)	25 000 000 oe e.g. 25×10^6 or 0.25×10^8 or $2.5 \times 10^n \quad n \neq 7$	2	M1	
	<i>Correct answer scores full marks (unless from obvious incorrect working)</i>			A1	
				Total 3 marks	



8	(a)		0.0056	1	B1
	(b)	20 000 000 oe eg 20×10^6 or 0.2×10^8 or 2×10^n $n \neq 7$ or $\frac{6 \times 10^{(3+5)}}{21+9}$ or $\frac{6 \times 10^8}{30}$ or $\frac{6 \times 10^3}{3 \times 10^{-4}}$ or $\frac{6000}{0.0003}$ or $\frac{6000}{3 \times 10^{-4}}$		2	M1
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	2×10^7		A1
					Total 3 marks

9	$0.12 \times 700\,000$ oe (= 84 000) or $0.88 \times 700\,000$ oe (= 616 000) or $700\,000 \times 0.88^2$ oe (= 542 080)		3	M1 for finding 12% or 88% of 700 000	M2 for $700\,000 \times 0.88^3$ or $700\,000 \times 0.88^4$ (= 419 786.75)
	$0.88 \times "616\,000"$ oe (= 542 080) and $0.88 \times "542\,080"$ oe (= 477 030.4)			M1 for completing method to find the value of the car	
	<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	477 030		A1 accept 477 030 – 477 031	
				SC: if no other marks gained award M1 for $0.36 \times 700\,000$ oe or 252 000 or $0.64 \times 700\,000$ oe or 448 000 accept (1 – 0.12) as equivalent to 0.88 throughout	
					Total 3 marks

9	(a)		0.000 084	1	B1 cao
	(b)	52×10^{145} or 5.2×10^n or $p \times 10^{146}$ where $1 \leq p < 10$		2	M1
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	5.2×10^{146}		A1
					Total 3 marks



Question	Working	Answer	Mark	Notes
6	(a)	(6),2,(0),(0),(2),6	1	B1 For both entries correct
	(b)	(0, 6), (1, 2), (2, 0), (3, 0), (4, 2), (5, 6)		M1 for at least 5 points plotted correctly (ft their table)
		Correct curve	2	A1 for a correct curve
	(c)	$x^2 - 5x + 6 = x - 1$		M1 or for $y = x - 1$
7		1.6 and 4.4	3	M1 for $y = x - 1$ drawn
	(a)	71 800 000	1	A1 dep on M2 ft from their graph in (b) if at least 1 mark scored in (b)
	(b)	Eg $1.88 \times 10^7 + 3.10 \times 10^8 + 2.64 \times 10^8 + 7.18 \times 10^7$ or $18\,800\,000 + 310\,000\,000 + 264\,000\,000 + 71\,800\,000$ with at least 3 numbers correct		M1 for a complete method or for digits 6646
		6.646×10^8 oe	2	A1 for 6.646×10^8 oe eg 664 600 000
	(c)	9.88×10^6	1	B1

7	(a)		5 700 000	1	B1
	(b)		4×10^{-3}	1	B1
	(c)		5 000 000 or 5×10^6 oe	2	B2 If not B2 then award B1 for 320000 or 3.2×10^5 oe or 5×10^n oe where $n \neq 6$
					Total 4 marks

8		$0.08 \times 170\,000 (=13600)$ or $0.92 \times 170\,000$ (=156400)		3	M1 oe eg $170\,000 \div 12.5$	M2 for $170\,000 \times 0.92^3$
		e.g. $0.92 \times (0.92 \times "156400")$			M1 (dep)for a complete method	
			132377		A1 or 132376.96	
					(SCB2 for $170\,000 \times 0.92^4 (=121786.(810))$ (SCB1 for $170\,000 \times 0.24 (=40\,800)$ or $170\,000 \times 0.76 (=129\,200)$ or $170\,000 \times 1.08 (=183\,600)$ or $170\,000 \times 1.08^3 (=214151)$ or an answer of 129 200 or an answer of 214 151 – 214151.1(0))	
					Total 3 marks	

5	(a)	0.0057	1	B1
	(b)	8×10^5	1	B1
	(c)	$\frac{273000}{6 \times 10^{-2}}$	2	M1 for 273 000 or digits 455
		4 550 000		A1 for 4 550 000 or 4.55×10^6 oe
Total 4 marks				
6		$100 \div 28\,440 (= 0.0035\dots)$ or $28\,440 \div (60 \times 60) (= 7.9)$	3	M1
		$'0.0035\dots' \times 60 \times 60$ or $100 \div '7.9'$		M1
		13		A1 for 12.65 – 13
				Total 3 marks



3	(a)	2 460 000	1	B1	accept 2,460,000 or 246 0000
	(b)	7.4×10^{-4}	1	B1	
	(c)		2	M1	for correct value not in standard form e.g. 58.3×10^5 or 583×10^4 or 0.583×10^7 oe
		5 830 000		A1	5 830 000 or 5.83×10^6 do not isw.
Total 4 marks					

4			3	M1	for one of - 5 numbers with a median of 8 - 5 numbers with a mode of 5 - 5 numbers with a range of 10 - 5 numbers with a sum of 45
				M1	for two of - 5 numbers with a median of 8 - 5 numbers with a mode of 5 - 5 numbers with a range of 10 - 5 numbers with a sum of 45
		5, 5, 8, 12, 15		A1	Note: The numbers can be in any order SC If no marks awarded, give B1 for 8 in the middle cell, not contradicted.
Total 3 marks					



6	(a)		1	1	B1
	(b)	$3 \times 10^{125} + 2 \times 10^{124}$ or digits 1024 $\times 10^8$ oe		3	M1
		32×10^{124} or $3 \times 10^{125} + 0.2 \times 10^{125}$ or $30 \times 10^{124} + 2 \times 10^{124}$			M1 oe 'correct' answer in incorrect form.
			3.2×10^{125}		A1
Total 4 marks					

7		$5 \times 398 (= 1990)$ or $6 \times 401 (= 2406)$		3	M1 Correct total for 5 or for 6 cocoa pods
		"2406" – "1990"			M1 (M2 for $398 + 6 \times 3$ or $401 + 5 \times 3$)
			416		A1
Total 3 marks					



8	(a)	$1.4 \times 10^9 - 8.2 \times 10^7$ or $1.4 \times 10^9 - 0.082 \times 10^9$ or $140 \times 10^7 - 8.2 \times 10^7$ (= 131.8×10^7)		2	M1 or for 1 318 000 000 oe but not in standard form eg 1318×10^6 or 1.318×10^n where $n \neq 9$
		<i>Working not required, so correct answer scores full marks (unless from obvious incorrect working)</i>	1.318×10^9		A1 Allow 1.32×10^9 or 1.3×10^9
	(b)	$\frac{9.9 \times 10^6}{9.1 \times 10^5}$ oe		2	M1
		<i>Working not required, so correct answer scores full marks (unless from obvious incorrect working)</i>	11		A1 allow 10.8 – 11 (inclusive) SC: if M1 not scored, award B1 for an answer of $\frac{1}{11}$ allow 10.8 – 11 for the denominator
Total 4 marks					



7	$220 \div 80 (= 2.75 \text{ or } \frac{11}{4})$ oe			M1 for a method to find the time from B to C
	$72 \times \frac{50}{60} (= 60)$ oe			M1 for a method to find the distance from C to D Allow 0.83(333...) to 2 dp truncated or rounded
	$\frac{245 + 220 + "60"}{2.5 + "2.75" + \frac{50}{60}} \left(= \frac{525}{\frac{73}{12}} \right)$ oe			M1 for a complete method to find the average speed for entire journey 0.83(333...) to 2 dp truncated or rounded 6.0(8333...) to 2 sf truncated or rounded
		86.3		A1 for 86.3 – 86.4
				Total 4 marks

8	(a)	50 000	1	B1
	(b)	6×10^{-5}	1	B1
	(c)	$2.5 \times 10^{512-700}$ or 2.5×10^n or 0.25×10^{-187} or $p \times 10^{-188}$ where $1 \leq p < 10$	2	M1
		2.5×10^{-188}		A1
				Total 4 marks

9	(a)	x^9	1	B1 cao
	(b)	$64y^6$	2	B2 for $64y^6$ (B1 for ky^6 where $k \neq 64$ or $64y^m$ where $m \neq 6$)
	(c)	$(n \pm 3)(n \pm 4)$	2	M1 for $(n \pm 3)(n \pm 4)$ or $(n + a)(n + b)$ where $ab = 12$ or $a + b = -7$ Condone use of a different letter to n
		$(n - 3)(n - 4)$		A1
				Total 5 marks

9	(a)		8 800 000	1	B1
	(b)		Barcelona	1	B1 accept 5.5×10^6
	(c)	$3.7 \times 10^7 - 7.7 \times 10^6$ or 29 300 000 oe or 37 000 000 – 7 700 000 or 29 000 000 oe or $0.29(3) \times 10^8$ or $29(.3) \times 10^6$		2	M1 allow $2.9(3) \times 10^n$ ($n \neq 7$)
			2.9×10^7		A1 accept -2.9×10^7 accept 2.93×10^7 or -2.93×10^7
					Total 4 marks



9	(a)		0.000 587	1	B1 allow 0.000 587(000...) or .000 587
	(b)		8.4×10^7	1	B1 allow $8.4(000...) \times 10^7$
	(c)	$8.5 \times 10^{10} \div 1.47 \times 10^9 (= \frac{8500}{147})$ or $85\,000\,000\,000 \div 1\,470\,000\,000 (= \frac{8500}{147})$		2	M1
		<i>Working not required, so correct answer scores full marks (unless from obvious incorrect working)</i>	57.8		A1 oe eg 5.78×10 awrt 57.8 allow 58 or 5.8×10 with correct working seen
					Total 4 marks

9	(a)		604 000	1	B1
	(b)		7×10^{-5}	1	B1
	(c)	380 000 or 3.8×10^5 or 38×10^4 oe		2	M1
		<i>Working not required, so correct answer scores full marks (unless from obvious incorrect working)</i>	2×10^5		A1 Accept 2.0×10^5 or 2.00×10^5 etc Accept a dot or a comma for a multiplication sign eg $2, 10^5$ $2. 10^5$ SC B1 for 200 000 or 20×10^4 or 0.2×10^6 oe or 2×10^n where $n \neq 5$ when given as a final answer (not for incorrect simplification of the denominator)
					Total 4 marks



7	$3892 = \pi \times 8^2 \times h$ or $\pi \times 8^2 (= 64\pi = 201\dots)$		3	M1 allow use of 3.14... or $\frac{22}{7}$ for π
	$(h =) \frac{3892}{\pi \times 8^2}$ oe eg $3892 \div 64 = 60.8\dots$ and $60.8\dots \div \pi$			M1 allow use of 3.14... or $\frac{22}{7}$ for π
	Correct answer scores full marks (unless from obvious incorrect working)	19.4		A1 allow 19.3 – 19.4
				Total 3 marks

8	(a)	5.2×10^8	1	B1
	(b)	0.000 087 9	1	B1
	(c)	35×10^{-138} or $3.5 \times 10 \times 10^{-138}$ or 3.5×10^n where $n \neq -137$	2	M1
	Correct answer scores full marks (unless from obvious incorrect working)	3.5×10^{-137}		A1
				Total 4 marks



8	(a)		1	1	B1
	(b)(i)	$(x \pm 4)(x \pm 9) (= 0)$		2	M1 or $(x + a)(x + b)$ where $ab = -36$ or $a + b = -5$
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	$(x + 4)(x - 9)$		A1 (isw if they also solve the equation in this part)
	(ii)	<i>Answers must fit from (b)(i)</i>	-4 and 9	1	B1 ft Answer must fit from their $(x + p)(x + q)$ in (b)(i) Award B0 for -4 and 9 if no marks scored in (i)
					Total 4 marks

9	(a)	$1.75 \times 10^6 \div 2.4 \times 10^7$ or $1\,750\,000 \div 24\,000\,000$ oe eg $\frac{1.75}{24}$		3	M1
		0.0729(16...) or 0.072 or 0.073 or for $\frac{7}{96}$ or 7.29(16...) % or 7.2% or 7.3%			A1
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	7.3×10^{-2}		A1 accept 7.3×10^{-2} or better (7.29(16....) $\times 10^{-2}$)
	(b)	$2.4 \times 10^7 \times 5.01 \times 10^{21} \div 3$ oe		2	M1
		<i>Correct answer scores full marks (unless from obvious incorrect working)</i>	4×10^{28}		A1 accept 4×10^{28} , 4.0×10^{28} , 4.01×10^{28} , 4.008×10^{28}
					Total 5 marks

6	eg $4x + 8y = 60$ or $3x + 6y = 45$ $- 4x - 6y = 4$ $+ 4x - 6y = 4$ $(14y = 56)$ $(7x = 49)$		3	M1	Correct method to eliminate x or y : coefficients of x or y the same and correct operator to eliminate selected variable (condone any one arithmetic error in multiplication) or correctly writing x or y in terms of the other variable and correctly substituting.
	eg $4x - 6\left(\frac{15-x}{2}\right) = 4$ or $4(15-2y) - 6y = 4$ oe			M1	dep correct method to find second variable using their value from a correct method to find first variable or for repeating above method to find second variable.
	eg $x + 2 \times 4 = 15$ or $7 + 2 \times y = 15$			A1	dep on M1
	Working required	$x = 7, y = 4$			Total 3 marks
7	(a)	0.000 0932	1	B1	
	(b)	2.4×10^5	2	B2	If not B2, then B1 for 240 000 or 24×10^4 oe or 2.4×10^a $a \neq 5$
	(c)	1.8×10^{121}	2	B2	If not B2, then B1 for 18×10^{120} or 1.8×10^b $b \neq 121$
					Total 5 marks



11	(a)	$\pm(7.7 \times 10^4 - 9.5 \times 10^3)$ or $\pm(7.7 \times 10^4 - 0.95 \times 10^4)$ or $\pm(77\,000 - 9\,500)$ or $\pm 67\,500$ oe			M1 for clearly subtracting the correct values
			6.75×10^4	2	A1 allow -6.75×10^4 allow $\pm 6.8 \times 10^4$
	(b)	$(8.3 \times 10^3) \times 50 (= 415\,000 \text{ or } 4.15 \times 10^5)$ or $(4.2 \times 10^4) \div 50 (= 840 \text{ or } 8.4 \times 10^2)$ or $(4.2 \times 10^4) \div (8.3 \times 10^3) (= 5(.060\dots))$			M1 for a relevant calculation
			No supported by correct comparable figures in the same form	2	A1 for NO and 415 000 and 42 000 or NO and 4.15×10^5 NO and 840 and 8 300 or NO and 8.4×10^2 NO and 5(.060...)
	(c)	$1.15 \times 0.92 (= 1.058)$ oe or 105.8 $\frac{n \times 1.15 \times 0.92}{n}$ where n is a number or variable e.g. $\frac{200 \times 1.15 \times 0.92}{200}$			M1 condone $x \times 1.15 \times 0.92$ oe
			5.8	2	A1 NB. -5.8 (M1A0) decrease of 5.8% (M1A0)

Question	Working		Answer	Mark	Notes
18	$\frac{\sqrt{8}}{\sqrt{8}-2} \times \frac{\sqrt{8}+2}{\sqrt{8}+2}$ $\frac{\sqrt{8}(\sqrt{8}+2)}{8-4} = \frac{8+2\sqrt{8}}{4} = \frac{8+4\sqrt{2}}{4}$ $= 2 + \sqrt{2}$		Shown	3	M1 or $\frac{2\sqrt{2}}{2\sqrt{2}-2}$ or $\frac{\sqrt{2}}{\sqrt{2}-1}$ M1 or $\frac{\sqrt{2}}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$ A1 (dep on M2) Conclusion - need not state the value of n
19	Angle $BCE = 73^\circ$ Angle $DEB = 73^\circ$ and Angle $DCB = 180 - 73 (=107^\circ)$ Angle $DCE = 34^\circ$ eg <u>Alternate segment</u> theorem Opposite angles of a <u>cyclic quadrilateral</u> sum to 180° <u>Alternate angles</u> are equal Angles in the <u>Same segment</u> are equal <u>Angles</u> in a <u>triangle</u> sum to 180	Angle $BDE = 73^\circ$ Angle $DEB = 73^\circ$ and Angle $DBE = 180 - 73 \times 2 (=34^\circ)$	34	5	M1 angles may be written on the diagram M1 A1 B2 for a full set of reasons relevant to their method (B1 for at least one relevant circle theorem)

16		$\frac{4+\sqrt{8}}{\sqrt{2}-1} \times \frac{(\sqrt{2}+1)}{(\sqrt{2}+1)}$			M1 for rationalising the denominator by multiplying numerator and denominator by $\sqrt{2}+1$ (or $-\sqrt{2}-1$) condone missing brackets
		e.g., $\frac{4\sqrt{2}+4+\sqrt{8}\sqrt{2}+\sqrt{8}}{2-1}$ or $\frac{4\sqrt{2}+4+4+\sqrt{8}}{2-1}$ or $\frac{4\sqrt{2}+4+\sqrt{16}+\sqrt{8}}{2-1}$ or $= 4\sqrt{2}+4+4+\sqrt{8}$ oe			M1 (dep) for expansion of numerator with at least 3 terms correct oe Using $-\sqrt{2}-1$ e.g. $\frac{-4\sqrt{2}-4-\sqrt{8}\sqrt{2}-\sqrt{8}}{-2+1}$ or $\frac{-4\sqrt{2}-4-4-\sqrt{8}}{-2+1}$ or $\frac{-4\sqrt{2}-4-\sqrt{16}-\sqrt{8}}{-2+1}$
			$8+6\sqrt{2}$	3	A1 (dep on M2) or for stating $a=8$ and $b=6$
					Total 3 marks

20	$\frac{18}{\sqrt{7}+1} \times \frac{\sqrt{7}-1}{\sqrt{7}-1}$		3	M1 for $\frac{18}{\sqrt{7}+1} \times \frac{\sqrt{7}-1}{\sqrt{7}-1}$
	eg $\frac{18(\sqrt{7}-1)}{7-1}$			M1 Dep on M1 for a correct numerator and multiplying out the denominator to $7-1$ or 6
	$3\sqrt{7}-3$	$3\sqrt{7}-3$		A1 Dep on M2 Allow $3(\sqrt{7}-1)$
				Total 3 marks

21	(a)(i)	(0, 6)	2	B1
	(iii)	(2, 6)		B1
	(b)		2	M1 for applying one of the transformations to the equation
	eg $(x-4)^2 + 3(x-4) + 4$ oe or eg $(x+\frac{3}{2}-4)^2 - \frac{9}{4} + 4$ oe or eg $x^2 + 3x + 10$ oe or eg $(x+\frac{3}{2})^2 - \frac{9}{4} + 4 + 6$ oe eg $y-6 = x^2 + 3x + 4$			
		$y = (x-4)^2 + 3(x-4) + 10$ or $y = (x+\frac{3}{2}-4)^2 - \frac{9}{4} + 4 + 6$		A1 oe eg $y = (x-\frac{5}{2})^2 + \frac{31}{4}$ or $y = x^2 - 5x + 14$ oe
				Total 4 marks



19	$\frac{6}{3-\sqrt{7}} \times \frac{3+\sqrt{7}}{3+\sqrt{7}}$ or $\frac{6}{3-\sqrt{7}} \times \frac{-3-\sqrt{7}}{-3-\sqrt{7}}$			M1
	$\frac{6(3+\sqrt{7})}{3^2-7}$ or $\frac{6(3+\sqrt{7})}{2}$ or $\frac{6(-3-\sqrt{7})}{-3^2+7}$ or $\frac{6(-3-\sqrt{7})}{-2}$			M1 (numerator may be expanded or denominator may be 4 terms which need to be all correct)
		$9+3\sqrt{7}$	3	A1 dep on M2 for $9+3\sqrt{7}$ or $3(3+\sqrt{7})$ from correct working
Total 3 marks				

20	$\sqrt{\frac{300}{108}}$ or $\sqrt{\frac{108}{300}}$ or $\sqrt{\frac{25}{9}}$ oe or $\sqrt{\frac{9}{25}}$ oe or $\left(\frac{300}{108}\right)^3 = \left(\frac{V}{135}\right)^2$ oe			M1 for a correct linear scale factor (fraction or ratio) or for the use of $\left(\frac{A_1}{A_2}\right)^3 = \left(\frac{V_1}{V_2}\right)^2$
	$135 \times \left(\sqrt{\frac{300}{108}}\right)^3$ oe or $\sqrt{\frac{300^3}{108^3}} \times 135^2$ or $\sqrt{390625}$			M1
		625	3	A1
Total 3 marks				



17	e.g. $(V =) \frac{1}{2} \left(\frac{4}{3} \pi x^3 \right) + \pi x^2 (20 - 4x)$ or $(V =) \frac{2}{3} \pi x^3 + 20\pi x^2 - 4\pi x^3$		5	M1 for a correct expression
	e.g. $\frac{1}{3} \pi y = \frac{1}{2} \left(\frac{4}{3} \pi x^3 \right) + \pi x^2 (20 - 4x)$ or $\frac{1}{3} \pi y = \frac{2}{3} \pi x^3 + 20\pi x^2 - 4\pi x^3$			M1 for a correct equation
	$y = 60x^2 - 10x^3$ oe			A1 for writing y in terms of x
	e.g. $\left(\frac{dy}{dx} = \right) 120x - 30x^2 = 0$ oe			M1 for differentiating their $ax^2 + bx^3$ and equating to 0
		320		A1 (dep on M3) cao
Total 5 marks				
18	e.g. $40 + 8\sqrt{x} - 5\sqrt{x} - \sqrt{x}\sqrt{x}$ or $40 + 8\sqrt{x} - 5\sqrt{x} - (\sqrt{x})^2$ or $40 + 8\sqrt{x} - 5\sqrt{x} - x$ or $40 + 3\sqrt{x} - x$		3	M1 for a correct expansion with at least 3 out of 4 terms correct oe or all 3 terms correct
		$x = 19$		A1 (dep on M1) for $x = 19$
		$y = 3$		B1 for $y = 3$
Total 3 marks				

17	$\left(\frac{8}{\sqrt{5}-1}\right) \times \frac{\sqrt{5}+1}{\sqrt{5}+1}$ or $\frac{8(\sqrt{5}+1)}{4} \text{ or } \frac{8\sqrt{5}+8}{4} \text{ oe}$		3	M1 for rationalising the denominator – award for seeing intention to multiply by $\frac{\sqrt{5}+1}{\sqrt{5}+1}$ or $\frac{-\sqrt{5}-1}{-\sqrt{5}-1}$
	Working required	$2\sqrt{5}+2$		A1 from correct working
		$\sqrt{20}+2$		B1ft for $k\sqrt{5}+c = \sqrt{5k^2}+c$ where $5k^2$ is a single integer Accept $a = 20$ and $b = 2$
Total 3 marks				

17	eg $\frac{\sqrt{12}}{\sqrt{3}+2} \times \frac{\sqrt{3}-2}{\sqrt{3}-2}$		3	M1 rationalise denominator – award for seeing multiplication by $\frac{\sqrt{3}-2}{\sqrt{3}-2}$ or $\frac{-\sqrt{3}+2}{-\sqrt{3}+2}$
	eg $\frac{(\sqrt{36}-2\sqrt{12})}{3-4}$ or $\frac{6-2\sqrt{12}}{-1}$ or $-6+2\sqrt{12}$ or $\frac{6-4\sqrt{3}}{-1}$ or $-6+4\sqrt{3}$			M1 dep M1 correctly simplifying numerator and denominator. (denominator could be $3-4$ or -1)
		$-6+\sqrt{48}$		A1 dep M2 must be in correct form (including $\sqrt{48}$) allow $a = -6$ and $b = 48$
				Total 3 marks

13	$\sqrt{8} + 4 - (\sqrt{8} - 4) (= 8)$ and $\sqrt{8} + 4 + (\sqrt{8} - 4) (= 2\sqrt{8} = 4\sqrt{2})$	$(a + b)(a - b) = a^2 - b^2$ and $(\sqrt{8} + 4)^2 - (\sqrt{8} - 4)^2$	3	M1 for correct substitutions into expression for $a + b$ and $a - b$ or expand the expression to get $a^2 - b^2$ and substitute into this expression.
	$(\sqrt{8})^2 - (\sqrt{8} - 4)^2$ or $\sqrt{2048}$ or $16\sqrt{8}$ or $32\sqrt{2}$ or $8\sqrt{32}$ or $8\sqrt{8 \times 4}$ oe			M1 (dep M1)
		8		A1 (dep both M marks)
				Total 3 marks



16	$\frac{12}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$ or $\frac{12}{\sqrt{2}-1} \times \frac{-\sqrt{2}-1}{-\sqrt{2}-1}$ and $4\sqrt{2}$ or $2\sqrt{8}$ or $\sqrt{32}$ oe		3	M1 for showing a correct method for rationalising the denominator and dealing with $(\sqrt{2})^5$
	E.g. $12\sqrt{2}+12-4\sqrt{2}$ or $8\sqrt{2}+12$ $12\sqrt{2}+12-2\sqrt{8}$ or $12\sqrt{2}+12-\sqrt{32}$ oe			M1 dep expression must be in surd form
	E.g. $12\sqrt{2}(+12)-4\sqrt{2}=8\sqrt{2}(+12)=2\sqrt{4^2 \times 2}(+12)=2\sqrt{32}(+12)$ or $12\sqrt{2}(+12)-2\sqrt{8}=6\sqrt{8}(+12)-2\sqrt{8}=4\sqrt{8}(+12)=2\sqrt{4 \times 8}(+12)=2\sqrt{32}(+12)$ or $12\sqrt{2}(+12)-\sqrt{32}=3\sqrt{4^2 \times 2}(+12)-\sqrt{32}=2\sqrt{32}(+12)$ oe Note $8\sqrt{2}=2\sqrt{4^2 \times 2}$ or $2\sqrt{16 \times 2}$ or $\sqrt{32 \times 4}$ or $\sqrt{64 \times 2}$ $12\sqrt{2}=3\sqrt{4^2 \times 2}$ or $3\sqrt{16 \times 2}$ or $\sqrt{32 \times 9}$	Shown		A1 dep on M2 for showing working to given answer (they may dismiss the +12 and just deal with the surd part for this stage)
				Total 3 marks



16	$\frac{2\sqrt{3}}{\sqrt{3}-1} \times \frac{\sqrt{3}+1}{\sqrt{3}+1}$ or $\frac{2\sqrt{3}}{\sqrt{3}-1} \times \frac{-\sqrt{3}-1}{-\sqrt{3}-1}$		3	M1 for explicitly multiplying the numerator and the denominator by $\sqrt{3}+1$ or $-\sqrt{3}-1$
	$\frac{2 \times 3 + 2\sqrt{3}}{3-1}$ or $\frac{6+2\sqrt{3}}{3-1}$ or $\frac{6+2\sqrt{3}}{2}$ oe $\frac{-2 \times 3 - 2\sqrt{3}}{-3+1}$ or $\frac{-6-2\sqrt{3}}{-3+1}$ or $\frac{-6-2\sqrt{3}}{-2}$ oe			M1 dep on M1 (numerator expanded for 2 terms which need to be all correct and denominator may be 4 terms which need to be all correct)
	Working required	$3 + \sqrt{3}$		A1 allow $\sqrt{3}+3$ (dep on M2)
				Total 3 marks



17	$\frac{1+\sqrt{5}}{3-\sqrt{5}} \times \frac{3+\sqrt{5}}{3+\sqrt{5}}$ oe or $\frac{1+\sqrt{5}}{3-\sqrt{5}} \times \frac{-3-\sqrt{5}}{-3-\sqrt{5}}$ oe		3	M1 for rationalising the denominator by multiplying numerator and denominator by $3+\sqrt{5}$ (or $-3-\sqrt{5}$)
	$\frac{3+\sqrt{5}+3\sqrt{5}+\sqrt{5}\sqrt{5}}{9+3\sqrt{5}-3\sqrt{5}-\sqrt{5}\sqrt{5}}$ oe or $\frac{3+\sqrt{5}+3\sqrt{5}+\sqrt{5}\sqrt{5}}{9-\sqrt{5}\sqrt{5}}$ oe or $\frac{3+\sqrt{5}+3\sqrt{5}+5}{9+3\sqrt{5}-3\sqrt{5}-5}$ oe or $\frac{8+\sqrt{5}+3\sqrt{5}}{9-5}$ oe or $\frac{3+4\sqrt{5}+5}{9-5}$ oe or $\frac{8+4\sqrt{5}}{4}$			M1 numerator correctly expanded and may be simplified to at least 2 terms and denominator correctly expanded and may be simplified to 1 term
	Working required	$2+\sqrt{5}$		A1 for $2+\sqrt{5}$ from correct working dep on M2
				Total 3 marks



23	For 2 of $30 = 5 \times 6$ or $30 = 5 \times 2 \times 3$ oe (for numerator) or $\sqrt{180} = 6\sqrt{5}$ oe or $\sqrt{180} = 2 \times 3 \times \sqrt{5}$ (for denominator) or $25^{2x+7} = (5^2)^{2x+7}$ or $5^{2(2x+7)}$ oe or $(\sqrt{5})^{4x+9} = \left(5^{\frac{1}{2}}\right)^{4x+9}$ or $5^{\frac{1}{2}(4x+9)}$ oe or $\frac{30}{\sqrt{180}} = \sqrt{5}$ oe or 5^{4x+15} as the numerator or 5^{2x+5} as the denominator		3	M1 or 5^{4x+15} as the numerator or 5^{2x+5} as the denominator or $30 = 5 \times 6$ or $30 = 5 \times 2 \times 3$ oe or $\sqrt{180} = 6\sqrt{5}$ oe or $\sqrt{180} = 2 \times 3 \times \sqrt{5}$ or $25^{2x+7} = (5^2)^{2x+7}$ or $5^{2(2x+7)}$ oe or $(\sqrt{5})^{4x+9} = \left(5^{\frac{1}{2}}\right)^{4x+9}$ or $5^{\frac{1}{2}(4x+9)}$ oe or
	$\frac{6 \times 5 \times 5^{4x+14}}{6 \times 5^{0.5} \times 5^{2x+4.5}}$ oe eg $\frac{5^{4x+15}}{5^{2x+5}}$ or $\frac{\sqrt{5}^{8x+30}}{\sqrt{5}^{4x+10}}$ oe or $\frac{25^{2x+7.5}}{25^{x+2.5}}$ oe			M1 Correct expression in terms of 6 (or 2 and 3) and 5 with indices Some cancellation could have taken place or fully correct with $\sqrt{5}$ and powers or 25 and powers
	working required	5^{2x+10}		A1 dep on M2 allow $w = 2x + 10$
				Total 3 marks

16	$\frac{4}{3\sqrt{5}+7} \cdot \frac{3\sqrt{5}-7}{3\sqrt{5}-7}$ or $\frac{4}{3\sqrt{5}+7} \cdot \frac{-3\sqrt{5}+7}{-3\sqrt{5}+7}$ oe		3	M1 for multiplying the numerator and denominator by $3\sqrt{5}-7$ or $-3\sqrt{5}+7$ (may be implied)
	eg $\frac{4(3\sqrt{5}-7)}{45-21\sqrt{5}+21\sqrt{5}-49}$ or $\frac{4(3\sqrt{5}-7)}{45-7^2}$ or $\frac{12\sqrt{5}-28}{45-21\sqrt{5}+21\sqrt{5}-49}$ or $\frac{12\sqrt{5}-28}{45-7^2}$ or $\frac{4(3\sqrt{5}-7)}{45-49}$ or $\frac{4(3\sqrt{5}-7)}{-4}$ or $\frac{12\sqrt{5}-28}{45-49}$ or $\frac{12\sqrt{5}-28}{-4}$			M1 for expanding the denominator in a correct fraction denominator may be 4 terms which all need to be correct $\frac{4}{3\sqrt{5}+7} \cdot \frac{3\sqrt{5}-7}{3\sqrt{5}-7} = 7 - 3\sqrt{5}$ scores M1M0 Implies the 1 st mark
	Working required	$7 - \sqrt{45}$		A1 dep on M2 SCB1 for answer $7 - \sqrt{45}$ with no method marks awarded SCB2 for $7 - \sqrt{45}$ if you would award the 1 st M1 but not the 2 nd M1 (total 2 marks)
				Total 3 marks

Question	Working	Answer	Mark	Notes
16 (a)	Eg $\frac{a + \sqrt{4b}}{a - \sqrt{4b}} \times \frac{a + \sqrt{4b}}{a + \sqrt{4b}}$ or $\frac{a + 2\sqrt{b}}{a - 2\sqrt{b}} \times \frac{a + 2\sqrt{b}}{a + 2\sqrt{b}}$ or $\frac{(a + 2\sqrt{b})^2}{(a + 2\sqrt{b})(a - 2\sqrt{b})}$ Eg $\frac{(a + \sqrt{4b})(a + \sqrt{4b})}{a^2 - 4b}$			M1 For multiplying the numerator and denominator by $a + \sqrt{4b}$ or $a + 2\sqrt{b}$ M1 dep on M1 for correctly simplified denominator A1 for $\frac{a^2 + 4a\sqrt{b} + 4b}{a^2 - 4b}$ or $\frac{(a + 2\sqrt{b})^2}{a^2 - 4b}$
(b)		$\frac{a^2 + 4a\sqrt{b} + 4b}{a^2 - 4b}$ 2.5 oe	3 1	B1

21	$(\sqrt{2}-1)^2 = 2 - \sqrt{2} - \sqrt{2} + 1 (= 3 - 2\sqrt{2})$	$\frac{(3+\sqrt{8})}{(\sqrt{2}-1)^2} \times \frac{(\sqrt{2}+1)^2}{(\sqrt{2}+1)^2}$	4	M1	expand the denominator (accept $2 - 2\sqrt{2} + 1$ - must see expansion) OR method to rationalise using $(\sqrt{2}+1)^2$
	$\frac{(3+\sqrt{8})}{(3-2\sqrt{2})} \times \frac{(3+2\sqrt{2})}{(3+2\sqrt{2})}$	$(\sqrt{2}-1)^2 = 2 - \sqrt{2} - \sqrt{2} + 1 (= 3 - 2\sqrt{2})$ or $(\sqrt{2}+1)^2 = 2 + \sqrt{2} + \sqrt{2} + 1 (= 3 + 2\sqrt{2})$ or $(\sqrt{2}-1)(\sqrt{2}+1) = 2 - \sqrt{2} + \sqrt{2} - 1 (= 1)$		M1	oe ft $3 - 2\sqrt{2}$ method to rationalise OR expansion of $(\sqrt{2}-1)^2$ (accept $2 - 2\sqrt{2} + 1$) or $(\sqrt{2}+1)^2$ (accept $2 + 2\sqrt{2} + 1$) or $(\sqrt{2}-1)(\sqrt{2}+1)$
	eg $\frac{9+6\sqrt{2}+3\sqrt{8}+8}{9-6\sqrt{2}+6\sqrt{2}-8}$ or $\frac{9+12\sqrt{2}+8}{9-8}$ or $\frac{9+6\sqrt{2}+3\sqrt{8}+8}{1}$ or $\frac{9+12\sqrt{2}+8}{1}$			M1	dep on 2nd M1 correct expansion of brackets
		$17 + \sqrt{288}$		A1	or $p = 17, q = 288$ answer from fully correct working with intermediate steps of working seen
					Total 4 marks

18	$\sqrt{3}x - x = 6 + 2\sqrt{3}$ oe or $x - x\sqrt{3} = -6 - 2\sqrt{3}$ (allow $-2\sqrt{9}$ or $-2(\sqrt{3})^2$ for -6 or $2\sqrt{9}$ or $2(\sqrt{3})^2$ for 6)		4	M1	expanding bracket and collecting terms. Condone one error
	$(x =) \frac{6+2\sqrt{3}}{\sqrt{3}-1}$ oe eg $\frac{-6-2\sqrt{3}}{1-\sqrt{3}}$			A1	oe must be a correct fraction with irrational numerator and denominator
	$(x =) \frac{(6+2\sqrt{3}) \times (\sqrt{3}+1)}{(\sqrt{3}-1) \times (\sqrt{3}+1)}$ or $\frac{(6+2\sqrt{3})(\sqrt{3}+1)}{2}$ oe or $\frac{(6+2\sqrt{3}) \times (-1-\sqrt{3})}{(-1+\sqrt{3}) \times (-1-\sqrt{3})}$ oe or $\frac{(-6-2\sqrt{3})(1+\sqrt{3})}{(1-\sqrt{3})(1+\sqrt{3})}$ oe			M1	(indep) Multiplying the numerator and denominator of their fraction by $\sqrt{3}+1$ oe or showing 2 or -2 as the denominator and multiplying the numerator by $\sqrt{3}+1$ oe or rationalising their denominator, so long as it is of the form $p+q\sqrt{3}$ where p and q are non zero integers (condone missing brackets provided meaning is clear)
	Working required	$6+4\sqrt{3}$		A1	dep on M1A1M1 with no errors seen
					Total 4 marks

Question	Working	Answer	Mark	Notes
17 (a)		12	1	B1
(b)	$\frac{5-\sqrt{18}}{1-\sqrt{2}} \times \frac{1+\sqrt{2}}{1+\sqrt{2}}$ or $\frac{5-\sqrt{18}}{1-\sqrt{2}} \times \frac{-1-\sqrt{2}}{-1-\sqrt{2}}$ oe		3	M1 Multiplying numerator and denominator by $1+\sqrt{2}$
	$\frac{5-\sqrt{36}+5\sqrt{2}-\sqrt{18}}{1+\sqrt{2}-\sqrt{2}-2}$ or $\frac{5-6-3\sqrt{2}+5\sqrt{2}}{-1}$ or $\frac{-5+6+3\sqrt{2}-5\sqrt{2}}{1}$ oe NB: allow $\sqrt{18}$ or $3\sqrt{2}$ $\sqrt{36}$ or 6 or $\sqrt{6}\sqrt{6}$			M1 Showing correct expansions (not necessarily as a fraction)
	working required	$1-2\sqrt{2}$		A1 dep on M2 (ie all stages of working must be shown convincingly) or for stating $a = 1$ and $b = -2$
				Total 4 marks



23	$(x^2 =) \frac{13+6\sqrt{5}}{2\sqrt{5}-3}$		4	M1 expression for x^2
	$\frac{13+6\sqrt{5}}{2\sqrt{5}-3} \times \frac{2\sqrt{5}+3}{2\sqrt{5}+3}$ or $\frac{13+6\sqrt{5}}{2\sqrt{5}-3} \times \frac{-2\sqrt{5}-3}{-2\sqrt{5}-3}$			M1 dep on previous M1 showing a correct product to rationalise the denominator (must be correct x^2)
	eg $\frac{13+6\sqrt{5}}{2\sqrt{5}-3} \times \frac{2\sqrt{5}+3}{2\sqrt{5}+3} = \frac{99+44\sqrt{5}}{11}$ or eg $\frac{13+6\sqrt{5}}{2\sqrt{5}-3} \times \frac{2\sqrt{5}+3}{2\sqrt{5}+3} = \frac{26\sqrt{5}+39+60+18\sqrt{5}}{20-9}$ or eg $\frac{13+6\sqrt{5}}{2\sqrt{5}-3} \times \frac{2\sqrt{5}+3}{2\sqrt{5}+3} = \frac{26\sqrt{5}+39+12(\sqrt{5})^2+18\sqrt{5}}{(2\sqrt{5})^2-3^2}$			M1 dep on previous M1 continuing the expansion of the product on the numerator and denominator – maybe one of these forms or a combination of forms
	Working required	$2+\sqrt{5}$		A1 dep on M3 accept $a=2, b=5$
				Total 4 marks

17	(a)		15	1	B1 accept k^{15}
	(b)	eg $\frac{7(2+\sqrt{3})}{(2-\sqrt{3})(2+\sqrt{3})}$ or $\frac{7(-2-\sqrt{3})}{(2-\sqrt{3})(-2-\sqrt{3})}$		3	M1 for multiplying the numerator and denominator of the fraction by $2+\sqrt{3}$ or $-2-\sqrt{3}$
		eg $\frac{14+7\sqrt{3}}{4+2\sqrt{3}-2\sqrt{3}-3}$ or $\frac{14+7\sqrt{3}}{4-3}$ or $\frac{14+7\sqrt{3}}{1}$ or $\frac{-14-7\sqrt{3}}{-4-2\sqrt{3}+2\sqrt{3}+3}$ or $\frac{-14-7\sqrt{3}}{-4+3}$ or $\frac{-14-7\sqrt{3}}{-1}$			M1 dep on previous M1
		Working required	$\sqrt{147} + 14$		A1 dep on M2 SCB1 for $\sqrt{147} + 14$ gained with no method marks awarded SCB2 for $\sqrt{147} + 14$ gained with 1 st M1 awarded
					Total 4 marks



17	(a)		$5\sqrt{27}$	1	B1 Allow $n = 5$ Do not accept 5 by itself
	(b)	$\frac{5-\sqrt{2}}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$ or $\frac{5-\sqrt{2}}{\sqrt{2}-1} \times \frac{-\sqrt{2}-1}{-\sqrt{2}-1}$		3	M1 for rationalising the denominator by multiplying numerator and denominator by $\sqrt{2}+1$ or $-\sqrt{2}-1$
		eg $\frac{5\sqrt{2}+5-2-\sqrt{2}}{2-1}$ oe or $\frac{5\sqrt{2}+5-2-\sqrt{2}}{\sqrt{4}+\sqrt{2}-\sqrt{2}-1}$ oe or $5\sqrt{2}+5-2-\sqrt{2}$			M1 (numerator must be expanded to 4 terms, denominator may be 4 terms which need to be all correct) Accept 1 in the denominator without working
		Working required	$3+4\sqrt{2}$		A1 or for stating $a = 3$ and $b = 4$ dep on M2
					Total 4 marks

15	(a)		9	1	B1	allow $9\sqrt{3}$
	(b)	$\frac{21}{3-\sqrt{2}} \times \frac{3+\sqrt{2}}{3+\sqrt{2}}$ or $\frac{21}{3-\sqrt{2}} \times \frac{-3-\sqrt{2}}{-3-\sqrt{2}}$		3	M1	for explicitly multiplying the numerator and the denominator by $3+\sqrt{2}$ or $-3-\sqrt{2}$
		eg $\frac{21(3+\sqrt{2})}{9-3\sqrt{2}+3\sqrt{2}-2}$ or $\frac{21(3+\sqrt{2})}{3^2-2}$ or $\frac{21(3+\sqrt{2})}{9-2}$ or $\frac{21(3+\sqrt{2})}{7}$ or $\frac{63+21\sqrt{2}}{9-2}$ or $\frac{63+21\sqrt{2}}{7}$			M1	dep on M1 (denominator may be 4 terms which all need to be correct) $\frac{21}{3-\sqrt{2}} \times \frac{3+\sqrt{2}}{3+\sqrt{2}} = 9+3\sqrt{2}$ scores M1M0
		Working required	$9+\sqrt{18}$		A1	dep on M2 SCB1 for $9+\sqrt{18}$ gained with no method marks awarded SCB2 for $9+\sqrt{18}$ gained if you would award 1 st M1 but not 2 nd M1 (total 2 marks)
						Total 4 marks

16	(a)		6	1	B1	cao
	(b)	$9-\sqrt{4x^2} (<0)$		3	M1	for substituting $g(x)$ in $f(x)$, allow incorrect inequality sign or = sign
		eg $9-2x (<0)$ or $9 < 2x$ or $81 < 4x^2$ or $9^2 < 4x^2$			M1	for removing the square root, allow incorrect inequality sign or = sign
		Working required	$x > \frac{9}{2}$		A1	(dep on M1) oe eg $x > 4.5$, $\frac{9}{2} < x$, $4.5 < x$
						Total 4 marks



Question	Working	Answer	Mark	Notes
21 (a)	$\sqrt{9 \times 5}$ and $\sqrt{4 \times 5}$		2	M1 or for $45 = 3 \times 3 \times 5$ and $20 = 2 \times 2 \times 5$
		$5\sqrt{5}$ shown		A1 dep on M1 cao with sight of $3\sqrt{5} + 2\sqrt{5}$ but we must see where these come from
(b)	$\frac{2}{\sqrt{3}-1} \times \frac{\sqrt{3}+1}{\sqrt{3}+1}$ or $\frac{2(\sqrt{3}+1)}{3-1}$ or $\frac{2\sqrt{3}+2}{2}$		2	M1 Rationalise denominator – award for seeing multiplication by $\frac{\sqrt{3}+1}{\sqrt{3}+1}$
oe		$1 + \sqrt{3}$		or $\frac{-\sqrt{3}-1}{-\sqrt{3}-1}$ A1 dep on M1
(c)	$(x + 3\sqrt{2})^2 - (3\sqrt{2})^2 - 1$		2	M1 or $(x + 3\sqrt{2})^2 - 18 - 1$ or for $a = 3\sqrt{2}$ or $b = -19$
		$(x + 3\sqrt{2})^2 - 19$		A1
				Total 6 marks

17	(a)	$6 \times 6 + 6 \times 2\sqrt{12} + 6 \times 2\sqrt{12} + (2 \times \sqrt{12})^2$ or $36 + 12\sqrt{12} + 12\sqrt{12} + 4\sqrt{12}\sqrt{12}$ or $36 + 12\sqrt{12} + 12\sqrt{12} + (4 \times 12)$ or $36 + 24\sqrt{3} + 24\sqrt{3} + 48$ or $36 + 2 \times 24\sqrt{3} + 48$ or $36 + 6 \times 2 \times 2\sqrt{12} + 48$ $84 + 48\sqrt{3}$		3	M1 for correct expansion of brackets showing four terms (need not be simplified) or for the use of $(a + b)^2 = a^2 + 2ab + b^2$ or for showing or stating $\sqrt{12} = 2\sqrt{3}$ oe
					M1 (dep on M1)
			Shown		A1 for fully correct working leading to given expression

17	(b)	E.g. $\left(\frac{3a^4}{t^5}\right)^{-2}$ or $\left(\frac{t^{15}}{27a^{12}}\right)^{\frac{2}{3}}$ or $\left(\frac{729a^{24}}{t^{30}}\right)^{-\frac{1}{3}}$		3	M1 for one of cube rooting or inverting or squaring or $\frac{ka^{-8}}{t^{-10}}$ where k is an integer $\neq 0$
		E.g. $\left(\frac{9a^8}{t^{10}}\right)^{-1}$ or $\frac{3^{-2}a^{-8}}{t^{-10}}$ or $\frac{1}{9}\frac{a^{-8}}{t^{-10}}$ or $\left(\frac{t^5}{3a^4}\right)^2$ or $\left(\frac{t^{30}}{729a^{24}}\right)^{\frac{1}{3}}$ or $\frac{a^{-8}}{9t^{-10}}$			M1 for two of cube rooting or inverting or squaring or $\frac{t^{10}}{ka^8}$ where k is an integer $\neq 0$
			$\frac{t^{10}}{9a^8}$		A1 Allow $\frac{t^{10}a^{-8}}{9}$ or $\frac{1}{9}t^{10}a^{-8}$
					Total 6 marks



19	(a)	eg $(2^3)^2 \times \sqrt[3]{(2^2)^6}$ or $(2^3)^2 \times (4)^{\frac{6}{3}}$ or $4^3 \times 4^2$ or 2^6 or 2^4 seen or $2^6 \times 16$ or 64×4^2 or $8^2 \times 4^2$ or $8^2 \times 16$ or 64×16		3	M1 a correct first stage.
		$2^6 \times (2^{12})^{\frac{1}{3}}$ or 1024 or 32^2 or 4^5 or $2^6 \times 2^4$			M1 dep on 1st M mark.
			2^{10}		A1 dependent on first M1 isw if 2^{10} seen but then 10 given as answer.
	(b)	$(n^{\frac{4}{5}} =) \frac{1}{16}$ or 0.0625 oe	eg $\left(n^{-\frac{1}{5}}\right)^4 = \left(\frac{1}{2}\right)^4$	4	M1 for sight of $\frac{1}{16}$ oe, even if raised to an incorrect power. or for algebraic approach, separating out the 4, or 5 or -1 in the power
	$(n =) 16^{\frac{5}{4}}$ or $0.0625^{\frac{5}{4}}$ oe $(n =) 2^5$ or $\sqrt[4]{1048576}$ oe or $\frac{1}{0.0625^{\frac{5}{4}}}$ or $\left(\frac{1}{16}\right)^{\frac{5}{4}}$	eg $(n =) \left(\frac{1}{2}\right)^{-5}$	M2 for a correct expression for n (M1 for one correct algebraic stage eg $n^{-\frac{1}{5}} = \frac{1}{2}$)		
			32		A1
					Total 7 marks

