Question	Scheme		Marks	AOs
1 (a)	$\log_{10} h = 2.25 - 0.235\log_{10} m$ $\Rightarrow h = 10^{2.25-0.235\log_{10} m}$ $\Rightarrow h = 10^{2.25} \times m^{-0.235}$	$h = pm^q$ $\Rightarrow \log_{10} h = \log_{10} p + \log_{10} m^q$ $\Rightarrow \log_{10} h = \log_{10} p + q\log_{10} m$	M1	1.1b
	Either one of $p = 10^{2.25}$ $q = -0.235$	Or either one of $\log_{10} p = 2.25$ $q = -0.235$	A1	1.1b
	$\Rightarrow p = 178$ and $q = -0.235$		A1	2.2a
			(3)	
(b)	$h = "178" \times 5^{"-0.235"}$	$\log_{10} h = "2.25" - "0.235" \log_{10} 5$	M1	3.1b
	$h = 122$	$h = 122$	A1	1.1b
	Reasonably accurate (to 2 sf) so suitable		A1ft	3.2b
			(3)	
(c)	"p" would be the (resting) heart rate (in bpm) of a mammal with a mass of 1 kg		B1	3.4
			(1)	
			(7 marks)	

Notes

(a)

M1: Establishes a link between $h = pm^q$ and $\log_{10} h = 2.25 - 0.235\log_{10} m$.
May be implied by a correct equation in p or q

A1: For a correct equation in p or q

A1: $p = 178$ and $q = -0.235$

(b)

M1: Uses either model to set up an equation in h (or m)

A1: h = awrt 122. Condone h = awrt 122 bpm

A1ft: Comments on the suitability of the model. Follow through on their answer.

Requires a comment consistent with their answer from using the model.

E.g. It is a suitable model as it is only “3” bpm away from the real value ✓
Do not allow an argument stating that it should be the same.
It is an unsuitable model as “122” bpm is not equal to 119 bpm ✗

(c)

B1: "p" would be the (resting) heart rate of a mammal with a mass of 1 kg

Question	Scheme	Marks	AOs
2(a)	$p = 10^{0.5}$ (or $\log_{10} p = 0.5$) or $q = 10^{0.03}$ (or $\log_{10} q = 0.03$)	M1	1.1b
	$p =$ awrt 3.162 or $q =$ awrt 1.072	A1	1.1b
	$p = 10^{0.5}$ (or $\log_{10} p = 0.5$) and $q = 10^{0.03}$ (or $\log_{10} q = 0.03$)	dM1	3.1a
	$A = 3.162 \times 1.072^t$	A1	3.3
		(4)	
(b)(i)	The initial mass (in kg) of algae (in the pond).	B1	3.4
(b)(ii)	The ratio of algae from one week to the next.	B1	3.4
		(2)	
(c)(i)	5.5 kg	B1	2.2a
(c)(ii)	$4 = "3.162" \times "1.072"^t$ or $\log_{10} 4 = 0.03t + 0.5$	M1	3.4
	awrt 3.4 (weeks)	A1	1.1b
		(3)	
(d)	• The model predicts unlimited growth. • The weather may affect the rate of growth	B1	3.5b
		(1)	
			(10 marks)

Notes

(a)

M1: A correct equation in p **or** q. May be implied by a correct value for p or q. Also score for rearranging the equation to the form $A = 10^{0.5} ... 10^{0.03t}$

A1: For p = awrt 3.162 or q = awrt 1.072. May be embedded within the equation.

dM1: Correct equations in p **and** q. Also score for rearranging the equation to the form $A = 10^{0.5} \times 10^{0.03t}$

A1: Complete equation with p = awrt 3.162 and q = awrt 1.072. **Must be seen in (a)**
If p and q are just stated but the equation is not written with the values embedded then withhold this mark.
Withhold the final mark if the correct values for p and q result from incorrect working such as $A = 10^{0.5} + 10^{0.03t} \Rightarrow A = 3.162 \times 1.072^t$.
If p and q are stated the wrong way round, take the stated equation as their final answer and isw.

(b)
(i)
B1: Must reference mass of algae and relating to initially/at the start/beginning
Examples of acceptable answers:
The mass of algae originally (in the pond)
p is the mass of algae when $t = 0$
Examples of answers we would not accept
p is how much algae there is at the beginning
The relationship between algae and number of weeks

(ii)

B1: Must reference the rate of change/multiplier and the time frame eg per week/every week/each week.

Examples of acceptable answers:
q is the rate at which the mass of algae increases for every week
The amount of algae increases by 7.2% each week (condone amount for mass in ii)
The proportional increase in mass of the algae each week

Examples of answers we would not accept:
q is how much algae will increase when t increases by 1
The amount that grows per unit of time
The rate at which the mass of algae in the small pond increases after t number of weeks
The rate in which the algae mass increases

(c)

B1: cao (including units)

M1: Setting up a correct equation to find t using the given equation or their part (a)
Substitution of $A = 4$ into their equation for A or the given equation is sufficient for this mark.

A1: awrt 3.4 (weeks). Accept any acceptable method (including trial and improvement)
Condone lack of units. isw if they subsequently convert to weeks and days. Allow awrt 3.5 (weeks) following p = awrt 3.16 and q = awrt 1.07.
An answer of only awrt 3.4 is M1A1, but an answer of 4 (weeks) with no working is M0A0

(d)

B1: Any reason why the rate of change, growth or the mass of algae might change or why the model in not realistic.
Be generous with the awarding of this mark as long as the answer has engaged with the context of the problem or the model

Examples of acceptable answers:
Seasonal changes (which would affect the growth rate)
Overcrowding (as it is a small pond)
Algae may stop growing (the model predicts unlimited growth)
Algae may die / be removed / eaten (so the rate of growth may not continue at the same rate)

Examples of answers we would not accept:
There could be other factors that affect the amount of algae (too vague)
The mass of algae might change

Question	Scheme	Marks	AOs
3(a)(i)	$\log_3\left(\frac{x}{9}\right)=\log_3 x-\log_3 9=p-2$	B1	1.2
(ii)	$\log_3\left(\sqrt{x}\right)=\frac{1}{2}p$	B1	1.1b
		(2)	
(b)	$2\log_3\left(\frac{x}{9}\right)+3\log_3\left(\sqrt{x}\right)=-11\Rightarrow 2p-4+\frac{3}{2}p=-11\Rightarrow p=...$	M1	1.1b
	$p=-2$	A1	1.1b
	$\log_3 x=-2\Rightarrow x=3^{-2}$	M1	1.1b
	$x=\frac{1}{9}$	A1	1.1b
		(4)	
	Alternative for (b) not using (a):		
	$2\log_3\left(\frac{x}{9}\right)+3\log_3\left(\sqrt{x}\right)=-11\Rightarrow\log_3\left(\frac{x}{9}\right)^2+\log_3\left(\sqrt{x}\right)^3=-11$ $\Rightarrow\log_3\frac{x^{\frac{7}{2}}}{81}=-11$	M1	1.1b
	$\Rightarrow\frac{x^{\frac{7}{2}}}{81}=3^{-11}$ or equivalent eg $x^{\frac{7}{2}}=3^{-7}$	A1	1.1b
	$x^{\frac{7}{2}}=81\times3^{-11}\Rightarrow x^{\frac{7}{2}}=3^4\times3^{-11}=3^{-7}\Rightarrow x=\left(3^{-7}\right)^{\frac{2}{7}}=3^{-2}$	M1	1.1b
	$x=\frac{1}{9}$	A1	1.1b
		(6 marks)	

Notes

(a)(i)

B1: Recalls the subtraction law of logs and so obtains $p-2$

(a)(ii)

B1: $\frac{1}{2}p$ oe

(b) ***Be aware this should be solved by non-calculator methods***

M1: Uses their results from part (a) to form a linear equation in p and attempts to solve leading to a value for p. Allow slips in their rearrangement when solving. Allow a misread forming the equation equal to 11 instead of -11

A1: Correct value for p

M1: Uses $\log_3 x=p\Rightarrow x=3^p$ following through on what they consider to be their p. It must be a value rather than p

A1: $(x =) \frac{1}{9}$ cao with correct working seen. Must be this fraction. Do not penalise invisible brackets as long as the intention is clear.

Alternative:

M1: Correct use of log rules to achieve an equation of the form $\log_3 ... = \log_3 ...$ or $\log_3 ... = \text{a number}$ (typically -11). Condone arithmetical slips.

A1: Correct equation with logs removed.

M1: Uses inverse operations to find x. Condone slips but look for proceeding from $x^{\frac{a}{b}} = ... \Rightarrow x = ...^{\frac{b}{a}}$ where they have to deal with a fractional power.

A1: $(x =) \frac{1}{9}$ cao with correct working seen. Must be this fraction. Do not penalise invisible brackets as long as the intention is clear.

Question	Scheme	Marks	AOs
4	$2\log_5(3x-2)-\log_5 x=2$		
	Uses one correct law e.g. $2\log_5(3x-2)\to\log_5(3x-2)^2$ **or** $2\to\log_5 25$ **or** $\log_5 ...=2\to ...=5^2$	B1	1.1a
	Uses two correct log laws: either $2\log_5(3x-2)\to\log_5(3x-2)^2$ **and** $2\to\log_5 25$ or $2\log_5(3x-2)-\log_5 x\to\log_5\dfrac{(3x-2)^2}{x}$ leading to an equation without logs	M1	3.1a
	Correct equation without logs, usually $\dfrac{(3x-2)^2}{x}=25$	A1	1.1b
	$\dfrac{(3x-2)^2}{x}=25\Rightarrow 9x^2-37x+4=0\Rightarrow(9x-1)(x-4)=0\Rightarrow x=...$	dM1	1.1b
	$x=4$ only	A1 cso	3.2a
		(5)	
		(5 marks)	

Notes:

B1: Uses one correct log law. The base does not need to be seen for this mark.
This mark is independent of any other errors they make.

M1: This can be awarded for the overall strategy leading to an equation in x **not involving logs**.
It requires the correct use of two log laws as in the main scheme to reach an equation in x
This mark may **not** be awarded for correct application of two laws following incorrect log work, but numerical slips are condoned.

A1: For a correct unsimplified equation with logs removed and **no incorrect work seen.**
Ignore any incorrect simplification of their equation.

Allow recovery on missing brackets, e.g., $\log_5\dfrac{3x-2^2}{x}=2\to\dfrac{9x^2-12x+4}{x}=25$

Correct equations are likely to be $\dfrac{(3x-2)^2}{x}=25$ or, e.g., $(3x-2)^2=25x$ but you might see

$9x-12+\dfrac{4}{x}=25$ Sight of a correct equation does **not** imply either the previous M1 or the A1.

Note: $\dfrac{\log_5(3x-2)^2}{\log_5 x}=2\to\dfrac{(3x-2)^2}{x}=25$ may be seen and scores B1M0A0.

dM1: For a correct method to solve their equation, **via a 3TQ set = 0**
The 3TQ may be solved by calculator - you may need to check their value(s).

	Can be implied by one correct value for their 3TQ set = 0 correct to 1d.p.
A1:	cso $x=4$ only.
	If $x=\frac{1}{9}$ is also given it must be rejected. $x=0$ might also be seen and must be rejected.
	Ignore any reasoning for rejecting any values.
	Note that calculators can solve the equation at any stage and so full log work must be shown leading to a 3TQ set = 0.

Question	Scheme	Marks	AOs
5	$\log_3(12y+5)-\log_3(1-3y)=2 \Rightarrow \log_3\dfrac{12y+5}{1-3y}=2$ or e.g. $2=\log_3 9$	B1 M1 on EPEN	1.1b
	$\log_3\dfrac{12y+5}{1-3y}=2 \Rightarrow \dfrac{12y+5}{1-3y}=3^2 \Rightarrow 9-27y=12y+5 \Rightarrow y=...$ or e.g. $\log_3(12y+5)=\log_3\left(3^2(1-3y)\right) \Rightarrow (12y+5)=3^2(1-3y) \Rightarrow y=...$	M1	2.1
	$y=\dfrac{4}{39}$	A1	1.1b
		(3)	
			(3 marks)

Notes

B1(M1 on EPEN): Applies at least one addition or subtraction law of logs correctly.
Can also be awarded for using $2=\log_3 9$. This may be implied by e.g.
$\log_3 ...=2 \Rightarrow ...=9$

M1: A rigorous argument with no incorrect working to remove the log or logs correctly and obtain a <u>correct</u> equation in any form **and** solve for y.

A1: Correct **exact** value. Allow equivalent fractions.

<u>Guidance on how to mark particular cases:</u>

$$\log_3(12y+5)-\log_3(1-3y)=2 \Rightarrow \frac{\log_3(12y+5)}{\log_3(1-3y)}=2$$
$$\Rightarrow \frac{12y+5}{1-3y}=3^2 \Rightarrow 9-27y=12y+5 \Rightarrow y=\frac{4}{39}$$

B1M0A0

$$\log_3(12y+5)-\log_3(1-3y)=2 \Rightarrow \frac{\log_3(12y+5)}{\log_3(1-3y)}=2 \Rightarrow \log_3\frac{12y+5}{1-3y}=2$$
$$\Rightarrow \frac{12y+5}{1-3y}=3^2 \Rightarrow 9-27y=12y+5 \Rightarrow y=\frac{4}{39}$$

B1M0A0

$$\log_3(12y+5)-\log_3(1-3y)=2 \Rightarrow \frac{12y+5}{1-3y}=3^2 \Rightarrow 9-27y=12y+5 \Rightarrow y=\frac{4}{39}$$

B1M1A1

Question	Scheme	Marks	AOs
6(a)	$T = al^b \Rightarrow \log_{10} T = \log_{10} a + \log_{10} l^b$	M1	2.1
	$\Rightarrow \log_{10} T = \log_{10} a + b\log_{10} l$ * or $\Rightarrow \log_{10} T = b\log_{10} l + \log_{10} a$ *	A1*	1.1b
		(2)	
(b)	$b = 0.495$ or $b = \dfrac{45}{91}$	B1	2.2a
	$0 = "0.495" \times -0.7 + \log_{10} a \Rightarrow a = 10^{0.346...}$ or $0.45 = "0.495" \times 0.21 + \log_{10} a \Rightarrow a = 10^{0.346...}$	M1	3.1a
	$T = 2.22l^{0.495}$	A1	3.3
		(3)	
(c)	The time taken for one swing of a pendulum of length 1 m	B1	3.2a
		(1)	
			(6 marks)

Notes

(a)

M1: Takes logs of both sides and shows the addition law.

Implied by $T = al^b \Rightarrow \log_{10} a + \log_{10} l^b$

A1*: Uses the power law to obtain the given equation with no errors. Allow the bases to be missing in the working but they must be present in the final answer.
Also allow *t* rather than *T* and *A* rather than *a*.

Allow working backwards e.g.

$$\log_{10} T = b\log_{10} l + \log_{10} a \Rightarrow \log_{10} T = \log_{10} l^b + \log_{10} a$$

$$\Rightarrow \log_{10} T = \log_{10} al^b \Rightarrow T = al^b \, *$$

M1: Uses the given answer and uses the power law and addition law correctly

A1: Reaches the given equation with no errors as above

(b)

B1: Deduces the correct value for *b* (Allow awrt 0.495 or $\dfrac{45}{91}$)

M1: Correct strategy to find the value of *a*.
E.g. substitutes one of the given points and their value for *b* into $\log_{10} T = \log_{10} a + b\log_{10} l$ and uses correct log work to identify the value of *a*. Allow slips in rearranging their equation but must be correct log work to find *a*.
Alternatively finds the equation of the straight line and equates the constant to $\log_{10} a$ and uses correct log work to identify the value of *a*.
E.g. $y - 0.45 = "0.495"(x - 0.21) \Rightarrow y = "0.495"x + 0.346 \Rightarrow a = 10^{0.346} = ...$

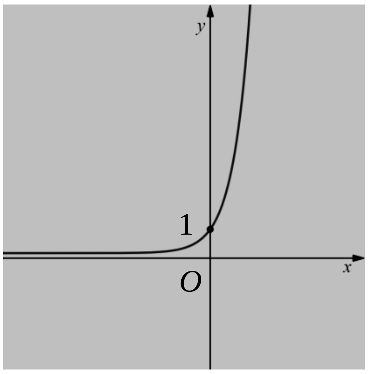
A1: Complete equation $T = 2.22l^{0.495}$ or $T = 2.22l^{\frac{45}{91}}$

(Allow awrt 2.22 and awrt 0.495 or $\dfrac{45}{91}$)

Must see the <u>equation</u> not just correct values as it is a requirement of the question.

(c)

B1: Correct interpretation

Question	Scheme		Marks	AOs
7(a)		Correct shape or correct intercept – see notes	B1	1.2
		Fully correct – see notes	B1	1.1b
			(2)	
(b)	$4^x = 100 \Rightarrow x = \log_4 100$ or e.g. $x\log 4 = \log 100 \Rightarrow x = \frac{\log 100}{\log 4}$		M1	1.1b
	$\Rightarrow (x =)$ awrt 3.32		A1	1.1b
			(2)	
				(4 marks)

Notes:

Note that B0B1 is not possible in part (a)

(a) **Axes do not need to be labelled. No sketch is no marks.**

B1: Correct shape or correct intercept.

Shape: A positive exponential curve in quadrants 1 and 2 only, passing through a point on the positive y-axis. Must "level out" in quadrant 2 but not necessarily asymptotic to the x-axis and allow if the curve bends up slightly for $x < 0$ but do not allow a clear "U" shape. It must not clearly "stop" on the x-axis to the left of the y-axis.

OR

Intercept: The intercept can be marked as 1 or (0, 1) or $y = 1$ or (1, 0) as long as it is in the correct place. May also be seen away from the sketch but must be seen as (0, 1) or possibly these coordinates in a table but it must correspond to the sketch. If there is any ambiguity, the sketch takes precedence.

B1: Fully correct.

Shape: A positive exponential curve in quadrants 1 and 2 only, passing through a point on the positive y-axis. The curve must appear to be asymptotic to the x-axis **and it must level out at least half way below the intercept**. Allow if the curve bends up slightly for $x < 0$ but do not allow a clear "U" shape. The curve must not bend back on itself on the rhs of the y-axis. There must be no suggestion that the curve approaches another horizontal asymptote other than the x-axis e.g. a horizontal dotted line that the curve approaches.

AND

Intercept: As above

See practice items and below for some examples:

(b)

M1: Uses logs in an attempt to solve the equation. E.g. takes log base 4 and obtains $x = \log_4 100$

Alternatively takes logs (any base) to obtain $x\log 4 = \log 100$ and proceeds to $x = \frac{\log 100}{\log 4}$

Allow if this subsequently becomes e.g. log 25 as long as $\frac{\log 100}{\log 4}$ is seen **but**

$x\log 4 = \log 100 \Rightarrow x = \log 25$ or $x\log 4 = \log 100 \Rightarrow x = \log 100 - \log 4$ scores M0

A1: awrt 3.32 . A correct answer only of awrt 3.32 scores M1A1

Note that a common incorrect answer is x = 3.218875… and comes from ln 25 or ln 100 – ln4 and unless $x = \frac{\ln 100}{\ln 4}$ is seen previously, this scores M0A0

Question	Scheme	Marks	AOs
8(a)	$\frac{1}{2}a$	B1	2.2a
		(1)	
(b)	$\log_2 x(x+8) \Rightarrow \log_2 x + \log_2(x+8)$	M1	1.2
	$= a+b$	A1	2.2a
		(2)	
(c)	e.g. $8+\frac{64}{x}=\frac{8x+64}{x}$	B1	1.1b
	$\log_2 \frac{8}{x}(x+8) = 3-\log_2 x+\log_2(x+8)$	M1	1.1b
	$3+b-a$	A1	2.2a
		(3)	
			(6 marks)

Notes

Condone omission of base 2 in all parts. If they work in any other base then send to review.

(a)

B1: $\frac{1}{2}a$ or $\frac{a}{2}$ or $0.5a$ isw

(b)

M1: Takes a factor of x out of the bracket to achieve $\log_2 x(x+8)$ and attempts to apply the addition law of logs, usually leading to $\log_2 x+\log_2(x+8)$. Condone missing brackets or omission of base 2. May be implied by a correct answer. Allow this mark to be scored if they write $\log_2 x+\log_2 x+\log_2 8$ (an answer of $2a+3$ can score M1A0)
$\log_2 x\times\log_2(x+8)$ on its own is M0 but allow the mark to be scored if they proceed to $a+b$

A1: $a+b$ or simplified equivalent (a correct answer with no incorrect log work seen scores M1A1) isw
Note $\log_2 x\times\log_2(x+8)=a+b$ is M1A0 (allow the answer to imply the correct method but withhold the final mark)

(c)

B1: Writes $8+\frac{64}{x}$ as a single fraction e.g. $\frac{8x+64}{x}$ or $\frac{8}{x}(x+8)$ or $8x^{-1}(x+8)$ or $8\left(\frac{x^2+8x}{x^2}\right)$ which may be implied by later work e.g. $\log_2 8-\log_2 x+\log_2(x+8)$

M1: Attempts to apply the laws of logs, uses $\log_2 8=3$ and proceeds to $3\pm\log_2 x\pm\log_2(x+8)$ (or equivalent since $\pm\log_2 x$ may appear as $\pm\log_2\frac{1}{x}$ or $\pm\log_2 x^{-1}$)
May be implied by $3\pm b\pm a$ and condone invisible brackets around $x+8$ and condone the omission of base 2.
Note that if they write $\log_2(x+8)$ as $\log_2 x+\log_2 8$ this is M0

A1: $3+b-a$ or simplified equivalent (a correct answer with no incorrect log work seen is B1M1A1) isw
Note $\log_2\frac{8}{x}(x+8)=3\div\log_2 x\times\log_2(x+8)\Rightarrow 3-a+b$ is B1M1A0 (allow the answer to imply the correct method but withhold the final mark)

Note: You may see attempts to work backwards to the answer. If these do not result in the correct answer but you think they are creditworthy then send to review.

Question	Scheme	Marks	AOs
9(a)	$\log_{10} V = 3 \Rightarrow V = 10^3$	M1	1.1b
	$(V =)$ £1000	A1	3.4
		(2)	
(b)	e.g. $(\log_{10} b =) \dfrac{2.79-3}{10-0} = -0.021$ **or** $\log_{10} V = 3 - 0.021t$ **or** $10^{2.79} = "1000"b^{10}$	M1	1.1b
	e.g. $b = 10^{-0.021}$ $(= 0.952796....)$ **or** $V = 10^3 \times 10^{-0.021t}$ **or** $b = \sqrt[10]{"0.61659..."}$	M1	3.1b
	$V = 1000 \times 0.953^t$	A1ft	3.3
		(3)	
(c)	e.g. $V = 1000 \times "0.953"^{24}$ $(= £315)$ or e.g. $\log_{10} V = 3 - "0.021" \times 24 \Rightarrow V = ...(= £313)$	M1	3.4
	which is close (to £320) so it is a suitable model	A1	3.2b
		(2)	
			(7 marks)

Notes

(a)

M1: Sets $\log_{10} V = 3$ and attempts to find a value for *a* or an expression for *V* when $t = 0$. Score for sight of 10^3 or implied by the correct answer.
There may be more complicated routes to finding the initial value. e.g. finding a complete equation such as $\left(\log_{10} V = 3 + \dfrac{2.79-3}{10} t \Rightarrow \log_{10} V = 3 \Rightarrow V = \right) 10^3$
This mark can also be scored for the equation $V = 10^3 \times 10^{"-0.021"t}$ or $V = 1000 \times (....)^t$ but not $V = 10^{3-"0.021"t}$ (the 10^3 has not been split up from $10^{"-0.021"t}$)

A1: £1000 cao (including units) do not accept £10^3

(b) Mark (b) and (c) together. Note work seen in (a) must be used in (b) to score

M1: Either

- finds the gradient between the two points. Score for the expression $\dfrac{2.79-3}{10-0}$ o.e. e.g. -0.021
  Do not condone sign slips for this mark. May be implied by later work such as sight of $10^{-0.021}$.
- finds the equation for $\log_{10} V$ in terms of *t* e.g. $\log_{10} V = 3 - "0.021"t$ which may be unsimplified.
- forms the equation $10^{2.79} (= 616.5...) = "1000"b^{10}$ o.e. such as $2.79 = 3 + 10\log b$

M1: Attempts to find the value or an expression for *b* using their gradient or their equation
Score for either:

- the expression $10^{"-0.021"}$ o.e such as $10^{\frac{2.79-3}{10-0}}$ or may be implied by a correct value using their gradient. You may need to check this on your calculator.
- correctly proceeding from $\log_{10} V = 3 - "0.021"t$ to $V = 10^{3-"0.021"t}$ and splitting this into $V = 10^3 \times 10^{-"0.021"t}$

- attempting to equate coefficients:

$$\log_{10} V = \log_{10} a + (\log_{10} b)t \Leftrightarrow \log_{10} V = 3 - "0.021"t \Rightarrow \log_{10} b = "-0.021" \Rightarrow b = 10^{"-0.021"}$$

- using their equation $10^{2.79} = "1000"b^{10}$ or $2.79 = "3" + 10\log b$ and proceeding to e.g. $b = \sqrt[10]{"0.61659..."}$ or $b = 10^{"-0.021"}$

A1ft: Complete correct equation, follow through on their "1000" so score for $V = "1000" \times (\text{awrt } 0.953)^t$ or accept $V = "10^3" \times (\text{awrt } 0.953)^t$. Just stating the values of *a* and *b* is A0ft, but if the equation is written in (c) before substituting in $t = 24$ then this mark can be awarded.

(c) Mark (b) and (c) together

M1: A full and valid attempt to:

- either substitute $t = 24$ into their model of the form $V = ab^t$ where *a* is positive and finds a value for *V*
- or substitutes $t = 24$ into their model of the form $\log_{10} V = p + qt$ where *p* is positive and finds a value for *V* (if they only proceed as far as $\log_{10} V$ they would also have to find the value of $\log_{10} 320$)
- or substitutes $V = 320$ into their $V = 1000 \times 0.953^t$ o.e. and finds a value for *t*

(to enable the candidate to compare real life data with that of the model.)
Do not be too concerned with the mechanics of the solution but they must be attempting to find two values which can be compared (e.g. usually 320 and a value for *V*, but they could proceed to find $\log_{10} 320$ and compare with $\log_{10} V = 2.496$ when $t = 24$, or a value for *t* to compare with $t = 24$)
In cases with no working you will need to check the calculation.

A1: Compares their awrt £313-£315 with £320 or their awrt $t = 23.5 - 23.7$ with $t = 24$ or $\log_{10} 320 = 2.505...$ with 2.496 and makes a valid conclusion with a reason.
For this mark you require:

- correct calculations (if using percentage error allow this to be rounded to compare awrt £313-£315 with £320 then it will be in the range (1.4, 2.4). For £314.94 this is $= \text{awrt}\, 1.6\%$)
- a reason such as "the values are close", "the values are similar", "the values are approximately equal". Allow use of "$\approx$". Allow the calculation of the % error as reason.
- a statement that it is a "good" or "accurate" model or similar wording.

Note: Condone as a minimum e.g. "£314.94 and £320 so good model" (we accept the two values being stated here as a comparison that they are similar)

Do not allow incorrect statements such as the model is incorrect as it does not give £320.
Do not allow just "the model gives an underestimate of the true value" (does not comment sufficiently on whether the model is reliable)
Do not allow comments suggesting that the model is not reliable.
Note using the full value for *b* leads to 313.3285724…

Question	Scheme	Marks	AOs
10(a)	Uses one correct log law e.g. $\log_2(x+3)+\log_2(x+10)=\log_2(x+3)(x+10)$ $2=\log_2 4,\ \ 2\log_2 x=\log_2 x^2$	M1	1.1b
	$(x+3)(x+10)=4x^2$ oe	dM1	2.1
	$\Rightarrow 3x^2-13x-30=0$ *	A1*	1.1b
		(3)	
(b)(i)	$(x=)\ 6,\ -\frac{5}{3}$	B1	1.1b
(ii)	$x\neq -\frac{5}{3}$ because $\log_{(2)}\left(-\frac{5}{3}\right)$ is not real	B1	2.4
		(2)	
			(5 marks)

Notes

(a)

M1: Uses one correct log law. The base does not need to be seen for this mark.
This mark is independent of any other errors they make.
Examples: $\log_2(x+3)+\log_2(x+10)=\log_2(x+3)(x+10)$, $2=\log_2 4$, $2\log_2 x=\log_2 x^2$

dM1: <u>Fully correct work</u> leading to a <u>correct</u> equation not containing logs that is not the printed answer. **Depends on the first mark.** Condone a spurious base e.g. 10 or e, so long as the log work is otherwise correct (i.e., they recover the base 2).
Examples (depending on their method): $(x+3)(x+10)=4x^2$, $\frac{(x+3)(x+10)}{x^2}=4$, $\frac{x+3}{x^2}=\frac{4}{x+10}$
or $1+\frac{13}{x}+\frac{30}{x^2}=4$
Allow recovery from invisible brackets but **not** from incorrect work e.g.

$$\log_2(x+3)+\log_2(x+10)=2+2\log_2 x\Rightarrow \log_2(x+3)(x+10)-\log_2 x^2=\log_2 4$$

$$\Rightarrow \frac{\log_2(x+3)(x+10)}{\log_2 x^2}=\log_2 4\Rightarrow \frac{(x+3)(x+10)}{x^2}=4$$

This scores M1dM0A0

A1*: Obtains $3x^2-13x-30=0$ with no processing errors but condone a spurious base e.g. 10 or e, so long as the log work is otherwise correct (i.e., they recover the base 2) and allow recovery from invisible brackets.

Note the following alternative which can follow the main scheme:

$\log_2(x+3)+\log_2(x+10)=2+2\log_2 x=2+\log_2 x^2$ **M1**

$2^{\log_2(x+3)+\log_2(x+10)}=2^{2+\log_2 x^2}\Rightarrow 2^{\log_2(x+3)}\times 2^{\log_2(x+10)}=2^2\times 2^{\log_2 x^2}\Rightarrow (x+3)(x+10)=4x^2$ **dM1**

$\Rightarrow 3x^2-13x-30=0$ * **A1**

<u>**Special Cases:**</u>

1. $(x+3)(x+10)=4x^2$ with no working leading to the correct answer scores **M1dM1A0**

2. $\log_2(x+3)+\log_2(x+10)=2+2\log_2 x\Rightarrow 2^{\log_2(x+3)+\log_2(x+10)}=2^{2+2\log_2 x}\Rightarrow (x+3)(x+10)=4x^2$

$\Rightarrow 3x^2-13x-30=0$ *

Also scores **M1(implied)dM1A0** (lack of working)

(b)(i)

B1: Both values correct: $(x=)\ 6,\ -\frac{5}{3}$

(b)(ii)

B1: e.g. $(x \neq) -\frac{5}{3}$ and $\log_{(2)}\left(-\frac{5}{3}\right)$ is not real

This mark requires the identification of the **correct** negative root **and** an acceptable explanation.

For the identification of the root allow e.g. $x \neq -\frac{5}{3},\ x = -\frac{5}{3},\ -\frac{5}{3}$ etc. as long as it is clear they have identified the correct value. Requires the correct negative root $\left(-\frac{5}{3}\right)$ but the other may not be 6 but must be positive.

Some examples for the explanation:

- you get $\log_{(2)}\left(-\frac{5}{3}\right)$ which is not possible
- $\log -\frac{5}{3}$ is not possible, can't be found, gives a math error, is not real, is undefined
- if $\left\{k = \log_2\left(-\frac{5}{3}\right),\right\}\ 2^k = -\frac{5}{3}$ which is not possible
- you get log of a negative number
- negative numbers can't be "logged"
- log of negative does not work

Do not allow e.g.

- you can't have a negative log, logs can't be negative (unless clarified further)
- "you get a math error" in isolation
- a log cannot have a negative value
- logs cannot be negative
- $-\frac{5}{3}$ is not a valid input (unless clarified further)
- "it doesn't work in the logs"
- log graph isn't negative
- log graph does not cross negative x–axis
- x is only positive & negative answer does not work

Allow an implied correct answer if they say e.g. 6 is the root because $\log_{(2)}\left(-\frac{5}{3}\right)$ is not possible