Question Number	Scheme	Marks
7.(a)	States or implies that $A = 2\,500$	B1
	$10\,000 = 2500\mathrm{e}^{k\times 8} \Rightarrow 8k = \ln 4 \Rightarrow k = ...$	M1
	$\Rightarrow k = \frac{1}{8}\ln 4$ or awrt 0.1733	A1
		(3)
(b)	$\frac{\mathrm{d}N}{\mathrm{d}t} = 60\,000 \times -0.6\mathrm{e}^{-0.6\times 5} = -1792$ So decrease is 1790	M1, A1
		(2)
(c)	$60\,000\mathrm{e}^{-0.6t} = 2500\mathrm{e}^{0.1733t}$	M1
	$24 = \mathrm{e}^{0.1733t+0.6t} \Rightarrow 0.1733t + 0.6t = \ln 24 \Rightarrow t = ...$	dM1
	$T = 4.11$	A1
		(3)
		8 marks

Notes

(a)

B1 States or implies that $A = 2\,500$. E.g award for $N = 2500\mathrm{e}^{kt}$

M1 Attempts to use $N = A\mathrm{e}^{kt}$ with $t = 8, N = 10\,000$ and their A to set up and solve an equation in k. Correct ln work must be used to solve their equation.
Allow this mark for attempts to find k first by solving simultaneously if they use $t = 1$ for the start of the study: $2500 = A\mathrm{e}^{k}, 10000 = A\mathrm{e}^{8k} \Rightarrow \mathrm{e}^{7k} = 4 \Rightarrow 7k = \ln 4 \Rightarrow k = ...$ but the index and ln work must be correct.

A1 $k =$ awrt 0.1733. Accept the exact value $\frac{1}{8}\ln 4$ and isw after seen.

(b)

M1 $\frac{\mathrm{d}N}{\mathrm{d}t} = C\mathrm{e}^{-0.6\times 5} = ...$ where C is a constant. Condone $60\,000\mathrm{e}^{-0.6t} \rightarrow 60\,000\mathrm{e}^{-0.6t}$ as long as it is clear they think they have found $\frac{\mathrm{d}N}{\mathrm{d}t}$. Must be correct index (not kt).

A1 Awrt 1790 from a correct derivative. Condone awrt -1790

(c)

M1 Sets $60\,000\mathrm{e}^{-0.6t} =$ their $2500\mathrm{e}^{\text{"0.1733"}t}$ May use T or another variable instead. Allow a slip on e.g. the 60000 as 6000. Allow with k in place of their "0.1733" as long as they have a value for k in (a).

dM1 Proceeds to rearrange to $e^{mt} = D$ $(D > 0)$ and applies ln to find t. The ln work must be correct, though there may be slips in the coefficients or index work reaching $e^{mt} = D$ $(D > 0)$. May be implied by a correct answer for their $e^{mt} = D$
Alternatively, takes ln of both sides first and applies correct ln laws to proceed to make t the subject: $\ln\left(60\,000\mathrm{e}^{-0.6t}\right) = \ln\left(2500\mathrm{e}^{0.1733t}\right) \Rightarrow \ln 60000 - 0.6t = \ln 2500 + 0.1733t \Rightarrow t = ...$

A1 awrt 4.11 Must be a value, not an expression in ln terms for this mark.

Note Answer only scores no marks, method must be shown and the dM1 must be achieved in order to access the A mark.

Question Number	Scheme	Marks
8. (a)	$f'(x) = 6(2x+1)^2 e^{-4x} - 4(2x+1)^3 e^{-4x}$	M1 A1
	$= 2(2x+1)^2 e^{-4x}\{3-2(2x+1)\}$	dM1
	$= 2(2x+1)^2(1-4x)e^{-4x}$	A1
		(4)
(b)	Sets $f'(x) = 0 \Rightarrow x = -\frac{1}{2}, \frac{1}{4}$	B1
	Either $f\left("-\frac{1}{2}"\right) = ...$ or $f\left("\frac{1}{4}"\right) = ...$	M1
	Both $\left(-\frac{1}{2}, 0\right)$ and $\left(\frac{1}{4}, \frac{27}{8e}\right)$	A1
		(3)
(c)	$\left(\frac{9}{4}, \frac{27}{e}\right)$	B1ft B1ft
		(2)
		9 marks

Notes

(a)

M1 Attempts the product rule to achieve $P(2x+1)^2 e^{-4x} \pm Q(2x+1)^3 e^{-4x}$
May also be attempted by the quotient rule - equivalent form after e terms cancel.

A1 $f'(x) = 6(2x+1)^2 e^{-4x} - 4(2x+1)^3 e^{-4x}$ which may be unsimplified

dM1 Correctly takes out a common factor of $(2x+1)^2 e^{-4x}$ from their expression with an intermediate step before the final answer. Allow if there are minor slips in the $(2x+1)^2 e^{-4x}$ as a factor (such as $(2x+)^2 e^{-4x}$) if recovered - look for the correct remaining terms in the bracket { }. Allow going from an expanded cubic to a factorised form for this mark:
$e^{-4x}\left(2-24x^2-32x^3\right) \rightarrow 2(2x+1)^2(1-4x)e^{-4x}$.

A1 Achieves $2(2x+1)^2(1-4x)e^{-4x}$ with no incorrect algebra. Accept with the brackets in either order.

(b)

B1 $x = -\frac{1}{2}, \frac{1}{4}$ o.e. Both required.

M1 Attempts to substitute one of $x = \pm\frac{1}{2}, \pm\frac{1}{4}$ into f(x). If substitution not seen may be implied by either of $\left(-\frac{1}{2}, 0\right)$ or $\left(\frac{1}{4}, \frac{27}{8e}\right)$ o.e (accept awrt 1.24 for this mark) or by either of $\left(\frac{1}{2}, \frac{8}{e^2}\right)$ (awrt 1.08) or $\left(-\frac{1}{4}, \frac{e}{8}\right)$ (awrt 0.340) o.e.

A1 For $\left(-\frac{1}{2}, 0\right)$ and $\left(\frac{1}{4}, \frac{27}{8e}\right)$ o.e. must be exact but isw after exact coordinates given.
Allow as x = .., y =… as long as clearly paired.
Allow the M and A marks if seen in part (c) - mark (b) and (c) together.