Question	Scheme	Marks	AOs
10 (a)	265 thousand	B1	3.4
		(1)	
(b)	Attempts $\frac{\mathrm{d}N_b}{\mathrm{d}t} = 11\mathrm{e}^{0\,05t}$	M1	1.1b
	Substitutes $t = 10$ into their $\frac{\mathrm{d}N_b}{\mathrm{d}t}$	M1	3.4
	$\frac{\mathrm{d}N_b}{\mathrm{d}t} =$ awrt 18.1 which is approximately 18 thousand per year *	A1*	2.1
		(3)	
(c)	Sets $45 + 220\,\mathrm{e}^{0\,05t} = 10 + 800\,\mathrm{e}^{-0\,05t} \Rightarrow 220\,\mathrm{e}^{0\,05t} + 35 - 800\,\mathrm{e}^{-0\,05t} = 0$	M1	3.1b
	Correct quadratic equation $\Rightarrow 220\left(\mathrm{e}^{0\,05t}\right)^2 + 35\mathrm{e}^{0\,05t} - 800 = 0$	A1	1.1b
	$\mathrm{e}^{0\,05t} = 1.829, \left(-1.988\right) \Rightarrow 0.05t = \ln(1.829)$	M1	2.1
	$T = 12.08$	A1	1.1b
		(4)	
			(8 marks)
Notes:			

(a) May be seen in the question so watch out.

B1: Accept 265 thousand or 265 000 or equivalent such as 265 k but not just 265.

(b)

M1: Differentiates to a form $k\,\mathrm{e}^{0\,05t}$, $k > 0, k \neq 220$. Do not be too concerned about the lhs.

M1: Substitutes $t = 10$ into a changed function that was formed from an attempt at differentiation.

The left hand side must have implied differentiation. E.g. Rate = , N', $\frac{dN_b}{dt}$, $\frac{dN}{dt}$ or even $\frac{\mathrm{d}y}{\mathrm{d}x}$

A1*: Full and complete proof that requires

- some correct lhs seen at some point. E.g. "Rate = , " $\frac{dN_b}{dt}$, $\frac{dN}{dt}$ but condone N'.
- an intermediate line/answer of either $11\mathrm{e}^{0\,05\times10}$ or awrt 18.1 before a minimal conclusion which must be referencing the 18 000 or 18 thousand

(c)

M1: Attempts to set both equations equal to each other and simplify the constant terms.

Look for $220\,e^{0\,05t} + 35 = 800\,e^{-0\,05t}$ o.e but condone slips

It is also possible to set $\frac{N-45}{220} = \left(e^{0\,05t} = \right) \frac{800}{N-10}$ and form an equation in N

A1: Correct quadratic form.

Look for $220\left(e^{0\,05t}\right)^2 + 35e^{0\,05t} - 800 = 0$ or $220\,e^{0\,1t} + 35e^{0\,05t} - 800 = 0$ but allow with terms in different order such as $220\,e^{0\,1t} + 35e^{0\,05t} = 800$

FYI the equation in N is $N^2 - 55N - 175550 = 0$

M1: Full attempt to find the value of t (or a constant multiple of t)

This involves the key step of recognising and solving a 3TQ in $e^{0\,05t}$ followed by the use of lns.

If the answers to the quadratic just appear (from a calculator) you will need to check.

Accuracy should be to 3sf.

You may see different variables used such as x

$x = e^{0\,05t}$, $220\,e^{0\,1t} + 35e^{0\,05t} = 800 \Rightarrow 220x^2 + 35x = 800 \Rightarrow x = 1.82... \Rightarrow t = 20\ln 1.82...$

Allow use of calculator for solving the quadratic and for $e^{0\,05t} = 1.82.. \Rightarrow t = 12.08$

Via the N route it will involve substituting the positive solution to their quadratic into either equation to find a value for t/T using same rules as above.

A1: AWRT 12.08

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Answers with limited or no working in (b) and (c)

(b) A derivative in the correct form must be seen

(c) Candidates who state $45 + 220\,e^{0\,05t} = 10 + 800\,e^{-0\,05t}$ followed by awrt 12.08 (presumably from using num-solv on their calculators) can score SC 1100. Rubric on the front of the paper states that "Answers without working may not gain full credit" so we demand a method in this part.

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