

Question	Scheme	Marks	AOs
8(a)	$25 = \frac{200}{5+k} \Rightarrow k = \dots$	M1	3.4
	$M = \frac{200}{5+3e^{-0.15t}}$	A1	3.3
		(2)	
(b)	$35 = \frac{200}{5+3e^{-0.15T}} \Rightarrow 175 + 105e^{-0.15T} = 200 \Rightarrow 105e^{-0.15T} = 25$	M1	3.4
	$105e^{-0.15T} = 25 \Rightarrow e^{-0.15T} = \frac{5}{21} \Rightarrow T = -\frac{20}{3} \ln \frac{5}{21}$	dM1	1.1b
	$T = 9.57$	A1	1.1b
		(3)	

Notes

(a)	M1: Uses the equation for the model and sets $M = 25$ and $t = 0$ and solves for k. You do not need to check their processing to find k. May be implied by $k = 3$. A1: Correct equation. Allow correct equivalents e.g. $M(5 + 3e^{-0.15t}) = 200$ The equation must be seen but if it does not appear in (a) allow this to score if the correct equation appears later but not the equation with values substituted. A correct equation implies both marks. Is w once a correct equation is seen.
(b)	Note that this part can be solved entirely using a calculator which is not acceptable. Allow the use of t (or any other letter) for T. M1: Uses the equation for the model with their k and sets $= 35$ and proceeds to the form $\alpha e^{\pm 0.15T} = \beta$ or equivalent. Condone one of α or β being negative for this mark and condone the use of the letter k for this mark e.g. allow $35ke^{-0.15T} = 25$ dM1: Uses correct log work to solve an equation of the form $\alpha e^{\pm 0.15T} = \beta$ where $\alpha\beta > 0$ leading to a value for T. They cannot proceed directly to a value for T without some intermediate working seen e.g. $T = -\frac{20}{3} \ln \frac{5}{21}$ or $T = \frac{20}{3} \ln \frac{21}{5}$ or e.g. $105e^{-0.15T} = 25 \Rightarrow -0.15T = -1.435... \Rightarrow T = ...$ as the correct log work is implied by the $-0.15T = -1.435...$ As a minimum allow correct log work to be implied e.g. $"105"e^{-0.15T} = "25" \Rightarrow e^{-0.15T} = \frac{"25"}{"105"} \Rightarrow T = "9.57"$ (You may need to check their T on your calculator to 2sf or truncated for their $\frac{25}{105}$) Condone slips as long as the log work is correct e.g. $105e^{-0.15T} = 25 \Rightarrow -0.15T = -1.435... \Rightarrow T = -0.15 \times -1.435 = ...$ Do not allow this mark if the equation is unsolvable e.g. $\alpha e^{\pm 0.15T} = \beta$ where $\alpha\beta < 0$ Depends on the first method mark. A1: For awrt 9.57 with working seen. Units are not required and if any are given they can be ignored so just look for awrt 9.57 and isw e.g. if they subsequently convert this to minutes and seconds.

Note that $105e^{-0.15T} = 25 \Rightarrow T = 9.57$ scores M1dM0A0 as there is no intermediate stage.

8(c)	$(L =) 40$	B1	2.2a
	Since e.g. As $t \rightarrow \infty$, $e^{-0.15t} \rightarrow 0$	B1	2.4
		(2)	

(7 marks)

Notes

Note that both marks in (c) do **not** require a value for k and if they do have a value of k it does not need to be correct.

B1: Correct value. Note that units are not required and if any are given (correct or incorrect) they can be ignored. The “ $L =$ ” is not required so just look for the value.

Allow e.g. < 40 or $,, 40$ and allow $39.\dot{9}$ with a clear dot over the 9 but not e.g. $39.999\dots$
Do **not** condone e.g. $L > 40$

B1: Must follow a limiting value in the range $[39.9, 40]$

Correct explanation for the limiting value that needs to convey that the exponential term is negligible/small/zero when t is large.

The minimum requirement is to explain that as t becomes large, $e^{-0.15t}$ tends to 0 or e.g. $ke^{-0.15t}$ tends to 0. Condone e.g. $e^{-0.15t}$ gets smaller and smaller or e.g. $e^{-\infty} = 0$ if t is large. Condone e.g. if t is large $e^{-0.15t}$ is/becomes 0 oe

Note that e.g. “because $\frac{200}{5 + "3" \times 0} = 40$ ” without an explanation is B1B0

Note that e.g. $t \rightarrow \infty, (e^{-0.15t} \rightarrow 0) \Rightarrow M \rightarrow \frac{200}{5} = 40$ scores B1B1

Note that e.g. “as $t \rightarrow \infty, 5 + ke^{-0.15t} \rightarrow 5 \Rightarrow M \rightarrow \frac{200}{5} = 40$ ” scores B1B1

Do not allow e.g. “because it is the asymptote” without any reference to as t becomes large, $e^{-0.15t}$ tends to 0

Do not accept substituting a large numerical value for t as a reason why the limit is 40

There must be no contradictory or incorrect statements e.g. “because when t is large e is large”

Once you have the sufficient evidence to award the second B1 mark, do not deduct it if they subsequently provide extra information that isn’t needed or is irrelevant or is incorrect as long as it is not a clear contradiction of their argument.

Note that B0B1 is possible.