Question	Scheme	Marks	AOs
12(a)	$\theta = 22 + 64e^{-\frac{3}{32}t}$, $t \geqslant 0$		
	$t = 0 \Rightarrow \theta = 86°C$	B1	3.4
		(1)	
(b)	Attempts to differentiate $\theta = 22 + 64e^{-\frac{3}{32}t}$ with respect to t $\frac{d\theta}{dt} = -6e^{-\frac{3}{32}t}$	M1	3.1b
	$\frac{d\theta}{dt} = -6e^{-\frac{3}{32}(10)}$	dM1	3.4
	2.35 (°C/minute)	A1	1.1b
		(3)	
(c)	$22 + 64e^{-\frac{3}{32}t} = 40$ $e^{-\frac{3}{32}t} = \frac{9}{32}$ or $22 + 64e^{-\frac{3}{32}t} = 40$ $e^{-\frac{3}{32}t} = \frac{19}{32}$	M1	1.1b
	$t_1 = 13.53$ $t_2 = 5.56$	A1	1.1b
	$T = t_1 - t_2 = 13.53 - 5.56$	dM1	1.1b
	7.97 minutes $= 7$ minutes 58 seconds	A1	1.1b
		(4)	
(d)	$20.8°C$ is below the lower limit $22°C$ and so the model is inaccurate (for large values of t).	B1	3.5a
		(1)	
(e)	Increase the coefficient of t (but keep it below 0).	B1	3.5c
		(1)	
			(10 marks)

Notes:

(a)

B1: Uses the model to state that the initial temperature is $86°C$. Units required.

(b)

M1: Attempts to differentiate $\theta = 22 + 64e^{-\frac{3}{32}t}$ with respect to t. Look for $64e^{-\frac{3}{32}t} \rightarrow ke^{-\frac{3}{32}t}$.

dM1: Substitutes $t = 10$ into their $\frac{d\theta}{dt}$

A1: awrt 2.35 (2.3496…)

(c)

M1: Attempts to solve $22+64e^{-\frac{3}{32}t}=40$ or $22+64e^{-\frac{3}{32}t}=60$ as far as $e^{-\frac{3}{32}t}=k,\ k>0$

A1: awrt 13.5 or 5.6

dM1: Solves both $22+64e^{-\frac{3}{32}t}=40$ and $22+64e^{-\frac{3}{32}t}=60$ with correct use of logarithms to arrive at two values for t and subtracts either way round.

A1: 7 minutes 58 seconds or 478 seconds.

(d)

B1: States that the model is inaccurate (for large values of t) and provides a valid justification.

e.g., $20.8°C$ is lower than the room temperature which is not possible.

Alternatively, attempt to solve $22+64e^{-\frac{3}{32}t}=20.8$ as far as $64e^{-\frac{3}{32}t}=k,\ k<0$ and state no solutions.

Do not allow simply "there is an asymptote at $22°C$" without explanation that the model will not drop lower than this.

Substituting $t=120$ and suggesting that 22 is close or not close to 20.8 is not acceptable.

(e)

B1: Decrease the $\frac{3}{32}$ or increase $-\frac{3}{32}$ (or the coefficient of t).

There is no need to mention limiting the coefficient at 0.