Question	Scheme	Marks	AOs
9(a)	$t=0,\ \theta=80 \Rightarrow A=59$	B1	2.2a
	$t=40,\ \theta=33 \Rightarrow 33=21+59\mathrm{e}^{-40k} \Rightarrow \mathrm{e}^{-40k}=\dfrac{12}{59}$ $\Rightarrow -40k=\ln\left(\dfrac{12}{59}\right) \Rightarrow k=\ldots$	M1	3.1b
	$\Rightarrow k=-\dfrac{1}{40}\ln\left(\dfrac{12}{59}\right) \quad (=0.0398)$	A1	1.1b
	$\theta=21+59\mathrm{e}^{-0.0398t}$	A1	3.3
		(4)	
(b)	$t=20 \Rightarrow \theta=21+59\mathrm{e}^{-20\times0.0398}=\ldots(47.6)$	M1	3.4
	This suggests that the model is appropriate because $47.6\approx48$	A1ft	3.5a
		(2)	
(b) Alt	$\theta=48 \Rightarrow 48=21+59\mathrm{e}^{-20\times0.0398} \Rightarrow \mathrm{e}^{-0.0398t}=\dfrac{27}{69} \Rightarrow t=\ldots(19.6)$	M1	3.4
	This suggests that the model is appropriate because $19.6\approx20$	A1ft	3.5a
		(2)	
(c)	$\theta=21+59\mathrm{e}^{-0.0398t} \Rightarrow \dfrac{\mathrm{d}\theta}{\mathrm{d}t}=-0.0398\times59\mathrm{e}^{-0.0398t}=\ldots$	B1ft	2.2a
	$\Rightarrow \dfrac{\mathrm{d}\theta}{\mathrm{d}t}=-0.0398\times59\mathrm{e}^{-0.0398\times20}=\ldots$	M1	1.1b
	Decreasing at a rate of $1.06\,^\circ\mathrm{C}$ per minute	A1	3.2a
		(3)	
			(9 marks)

Notes

(a)
B1: Uses $t=0,\ \theta=80$ to deduce the correct value for A
M1: Uses the given equation for the model and $t=40,\ \theta=33$ and correct log work to establish a value for k
A1: Correct value for k (exact or awrt 0.0398)
A1: Correct **equation** (allow exact k or awrt 0.0398)
(b)
M1: Uses the model with their values to find the temperature after 20 minutes
A1ft: Compares their value with 48 and makes a correct interpretation
Alt:
M1: Uses the model with their values to find t when $\theta=48$
A1ft: Compares their value with 20 and makes a correct interpretation
(c)
B1ft: Deduces the correct derivative. Follow through their values.
M1: Substitutes $t=20$ into an expression of the form $\beta\mathrm{e}^{-kt}$ to establish the required rate.
A1: Correct rate including units