Question Number	Scheme	Marks
9(a)	$\frac{\mathrm{d}\theta}{\mathrm{d}t}=-k(\theta+15)\Rightarrow\int\frac{\mathrm{d}\theta}{\theta+15}=\int-k\,\mathrm{d}t$ **OR** $\frac{\mathrm{d}t}{\mathrm{d}\theta}=\frac{1}{-k(\theta+15)}$ $\Rightarrow\ln(\theta+15)=-kt(+c)$ o.e. $\Rightarrow t=-\frac{1}{k}\ln(\theta+15)+c$	M1A1
	$t=0,\theta=21\Rightarrow c=.....(\text{e.g.},c=\ln 36)$	M1
	$\ln(\theta+15)=-kt+\ln 36$ $\Rightarrow\theta+15=\mathrm{e}^{-kt+\ln 36}$ **OR** $\ln(\theta+15)=-kt+\ln 36$ $\Rightarrow\left[\ln(\theta+15)-\ln 36=-kt\right]$ $\Rightarrow\ln\left(\frac{\theta+15}{36}\right)=-kt\Rightarrow\theta=36\mathrm{e}^{-kt}-15$	M1
	$\theta=36\mathrm{e}^{-kt}-15$	A1
		(5)
(b)	$12.9=36\mathrm{e}^{-20k}-15\Rightarrow\mathrm{e}^{-20k}=\frac{31}{40}\Rightarrow-20k=\ln\frac{31}{40}\Rightarrow k=...$	M1
	$k=0.0127$	A1
		(2)
(c)	$t=60\Rightarrow\theta='36'\mathrm{e}^{-60\times'0.0127'}-'15'$	M1
	$=1.8\left(^{\circ}\mathrm{C}\right)$	A1
		(2)
		Total 9

Notes

(a)

M1: Separates the variables **and** integrates to obtain $...\ln(\theta+15)=...kt(+c)$ (or equivalent) with or without a constant of integration.

A1: Correct equation with or without a constant of integration.

If they do not have a constant of integration the following 3 marks are not available

M1: States or uses $t=0$ and $\theta=21$ to find a value for "c" . Do not be concerned by the rearrangement as long as a value of c is found.

M1: Rearranges using correct application of log processing to make θ the subject

A1: Correct equation

(b)

M1: Sets their θ = 12.9, substitutes t = 20 into their expression which is minimally of the form $\theta=\alpha\mathrm{e}^{-kt}\pm\beta$ where α can equal 1 and rearranges **using correct explicit log work** to find k.

For the award of this mark their $'\frac{31}{40}'$ must be a positive number.

A1: Awrt 0.0127

(c)

M1: Substitutes t = 60 and their k into their $\theta=36\mathrm{e}^{-kt}-15$ which must be minimally of the form $\theta=\alpha\mathrm{e}^{-kt}-\beta$

Unless the final answer is correct coming from a correct equation, substitution of 60 must be explicit.

A1:	Awrt $1.8\left(^{\circ}\mathrm{C}\right)$ A correct answer coming a correct expression implies A1 Units are not required, but if the units are incorrect score A0.

Question Number	Scheme	Marks
10(a)	$\theta=\frac{\pi}{3}\Rightarrow x=8\cos\frac{\pi}{3}=4,\ y=5\sin\frac{2\pi}{3}=\frac{5\sqrt{3}}{2}$	B1
	$x=8\cos\theta\Rightarrow\frac{\mathrm{d}x}{\mathrm{d}\theta}=-8\sin\theta \qquad y=5\sin2\theta\Rightarrow\frac{\mathrm{d}y}{\mathrm{d}\theta}=10\cos2\theta$ $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{d}y}{\mathrm{d}\theta}\div\frac{\mathrm{d}x}{\mathrm{d}\theta}=\frac{10\cos2\theta}{-8\sin\theta}=\frac{10\cos\frac{2\pi}{3}}{-8\sin\frac{\pi}{3}}=\ldots\left(\frac{5\sqrt{3}}{12}\right)$	M1
	$y-\frac{5\sqrt{3}}{2}=-\frac{4\sqrt{3}}{5}(x-4)$	M1
	$y=-\frac{4\sqrt{3}}{5}x+\frac{57\sqrt{3}}{10}$	A1
		(4)
(b)	$\int y\,\mathrm{d}x=\int y\frac{\mathrm{d}x}{\mathrm{d}\theta}(\mathrm{d}\theta)=\int5\sin2\theta\times-8\sin\theta(\mathrm{d}\theta)$	M1
	$\int y\,\mathrm{d}x=\int y\frac{\mathrm{d}x}{\mathrm{d}\theta}(\mathrm{d}\theta)=\int5(2\sin\theta\cos\theta)\times-8\sin\theta\ (\ \mathrm{d}\theta)=\pm80\int\sin^2\theta\cos\theta\ (\mathrm{d}\theta)$	M1
	$=\left(-\frac{80}{3}\right)\sin^3\theta+c$	M1
	$0=-\frac{4\sqrt{3}}{5}x+\frac{57\sqrt{3}}{10}\Rightarrow x=\ldots\frac{57}{8}$ and $\mathrm{A}_{\Delta}=\frac{1}{2}\left(\frac{57}{8}-4\right)\times\frac{5\sqrt{3}}{2}=\left(\frac{125\sqrt{3}}{32}\right)$	M1
	$\pm\frac{80}{3}\left[\sin^3\theta\right]_{\frac{\pi}{2}}^{\frac{\pi}{3}}$ or $\pm\frac{80}{3}\left[\sin^3\theta\right]_{\frac{\pi}{3}}^{\frac{\pi}{2}}=\frac{80}{3}\left(1-\frac{3\sqrt{3}}{8}\right)$	M1
	Total area $=\frac{80}{3}-\frac{195\sqrt{3}}{32}$	A1
		(6)
		Total 10

Notes

NB: If you see attempts to answer this question using a Cartesian equation please send to Review.

(a)

B1: Correct coordinates for P stated or implied by working.

M1: Attempts $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{d}y}{\mathrm{d}\theta}\div\frac{\mathrm{d}x}{\mathrm{d}\theta}$ at $\theta=\frac{\pi}{3}$

Minimally required differentiation is: $\cos\theta\Rightarrow\beta\sin\theta \quad \sin2\theta\Rightarrow\alpha\cos2\theta \quad \frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{d}y}{\mathrm{d}\theta}\div\frac{\mathrm{d}x}{\mathrm{d}\theta}$

M1: Attempts to find the equation of the normal at $\theta=\frac{\pi}{3}$

A1: Correct equation in the required form.

(b)