Question Number	Scheme	Notes	Marks
6(a)	$x = r\cos\theta = \cos\theta\left(\sqrt{3}+\tan\theta\right)$	Uses $x = r\cos\theta$	**M1**
	$x = \sqrt{3}\cos\theta + \sin\theta \Rightarrow \dfrac{\mathrm{d}x}{\mathrm{d}\theta} = \cos\theta - \sqrt{3}\sin\theta = 0$ or $\dfrac{\mathrm{d}x}{\mathrm{d}\theta} = \cos\theta\sec^2\theta - \sin\theta\tan\theta - \sqrt{3}\sin\theta = 0$	Obtains correct form for $\dfrac{\mathrm{d}x}{\mathrm{d}\theta}$ and sets equal to 0. May use product rule on $\cos\theta\tan\theta$	**dM1**
	$\dfrac{\sin\theta}{\cos\theta} = \tan\theta = \dfrac{1}{\sqrt{3}} \Rightarrow \theta = \dfrac{\pi}{6}$	$\theta = \dfrac{\pi}{6}$	**A1**
	$r = \sqrt{3} + \tan\dfrac{\pi}{6} = \sqrt{3} + \dfrac{\sqrt{3}}{3} = \dfrac{4\sqrt{3}}{3}$	$r = \dfrac{4\sqrt{3}}{3}$ or $\dfrac{4}{\sqrt{3}}$	**A1**
			(4)
(b)	$\dfrac{1}{2}\int r^2\mathrm{d}\theta = \dfrac{1}{2}\int\left(\sqrt{3}+\tan\theta\right)^2\mathrm{d}\theta = \ldots$	Uses $\dfrac{1}{2}\int r^2\mathrm{d}\theta$ and attempts to expands the bracket (accept with just two terms). The $\dfrac{1}{2}$ may be seen later.	**M1**
	$\int \ldots\tan^2\theta\ \mathrm{d}\theta \rightarrow \int \ldots \pm 1 \pm \sec^2\theta\ \mathrm{d}\theta$	Applies $\tan^2\theta = \pm\sec^2\theta \pm 1$ to the integral (Note: could use parts to integrate – see notes below.)	**M1**
	$\int \ldots\sec^2\theta\ \mathrm{d}\theta \rightarrow \ldots\tan\theta$	Correct attempt to integrate $\sec^2\theta$ to $k\tan\theta$ (see notes for attempts via parts). Depends on previous M	**dM1**
	$\int \ldots\tan\theta\ \mathrm{d}\theta \rightarrow \ldots\ln\cos\theta$ or $\ldots\ln\sec\theta$	Correct attempt to integrate $\tan\theta$ to $k\ln\cos\theta$ (oe) within their expression.	**M1**
	$= \left\{\dfrac{1}{2}\right\}\int\left(3 + 2\sqrt{3}\tan\theta + \tan^2\theta\right)\mathrm{d}\theta =$ $= \left\{\dfrac{1}{2}\right\}\left(2\theta - 2\sqrt{3}\ln\cos\theta + \tan\theta\right)$ or $\theta + \sqrt{3}\ln\sec\theta + \dfrac{1}{2}\tan\theta$ (oe)	Fully correct integration of $\int r^2\mathrm{d}\theta$ with or without the $\dfrac{1}{2}$ *see notes for an Alt	**A1**
	sector area $= \dfrac{1}{2}\times\left("\dfrac{4\sqrt{3}}{3}"\right)^2\times"\dfrac{\pi}{6}"$	Correct ft expression for sector	**B1ft**
	$\dfrac{4\pi}{9} - \left[\left(\dfrac{\pi}{6} - \sqrt{3}\ln\cos\dfrac{\pi}{6} + \dfrac{1}{2}\tan\dfrac{\pi}{6}\right) - \left(0 - 0 + 0\right)\right]$	Their sector – their integration from an attempt at $\dfrac{1}{2}\int r^2\mathrm{d}\theta$ with their limit applied appropriately	**M1**
	$= \dfrac{4\pi}{9} - \dfrac{\pi}{6} + \sqrt{3}\ln\dfrac{\sqrt{3}}{2} - \dfrac{\sqrt{3}}{6}$ $= \dfrac{5}{18}\pi + \dfrac{\sqrt{3}}{2}\left(\ln\dfrac{3}{4} - \dfrac{1}{3}\right)$	Correct answer in the correct form	**A1**
			(8)
			Total 12

Additional Notes:
(b)

NB Some candidates have learned $\int \tan^2\theta\,\mathrm{d}\theta = \tan\theta - \theta$ and so do not show the "$\sec^2\theta - 1$" step. Score M1 for $\tan^2\theta \to \pm\tan\theta \pm \theta$ and dM1 for $\tan^2\theta \to \tan\theta - \theta$ in such cases.

Use of parts for the integral:

$$\int \tan^2\theta\,\mathrm{d}\theta = \int \sin\theta \frac{\sin\theta}{\cos^2\theta}\,\mathrm{d}\theta = \sin\theta\frac{1}{\pm\cos\theta} - \int \pm\cos\theta\frac{1}{\pm\cos\theta}\,\mathrm{d}\theta \quad \text{M1}$$

$$= \pm\tan\theta \pm \theta \qquad \text{dM1}$$

Or

$$\int \tan^2\theta\,\mathrm{d}\theta = \int \sin^2\theta\sec^2\theta\,\mathrm{d}\theta = \sin^2\theta\tan\theta - \int 2\sin\theta\cos\theta\tan\theta\,\mathrm{d}\theta \quad \text{M1}$$

$$= \sin^2\theta\tan\theta - \int 1 - \cos 2\theta\,\mathrm{d}\theta = \sin^2\theta\tan\theta - \theta + \frac{1}{2}\sin 2\theta \qquad \text{dM1}$$

Any variations mark similarly as M1 for first stage of parts applied (allowing for sign errors in trig terms), dM1 for fully integrating as long as the first stage of parts achieves an integral that can be achieved more easily. Watch for the alternate form in the second case.

The B1ft may arise from attempts to use polar areas but must reach a correct expression for the area to access the mark: $\left\{\frac{1}{2}\int_0^{"\frac{\pi}{6}"}\left(\frac{"4\sqrt{3}"}{2}\right)^2\mathrm{d}\theta = \right\}\frac{1}{2}\left(\left(\frac{"4\sqrt{3}"}{2}\right)^2 \times "\frac{\pi}{6}"\right) - (0)$

For the M mark for limits, the "-0" for the lower limit may be implied (no need to see it). If no method is shown and only values given from calculator usage, then allow b.o.d. that substitution was correct as long as the correct limits were associated with the integral.