

Question	Scheme	Marks
7(a)	$\left(\cos 3\theta + \sqrt{3} \sin 3\theta\right)^2 = 0 \Rightarrow \cos 3\theta = -\sqrt{3} \sin 3\theta \Rightarrow \tan 3\theta = -\frac{1}{\sqrt{3}}$ $\Rightarrow 3\theta = -\frac{\pi}{6} \text{ or } \frac{5\pi}{6}$ $\Rightarrow m = -\frac{\pi}{18} \quad n = \frac{5\pi}{18}$	M1 A1 A1 [3]
(b)	$V = \pi \int_{-\frac{\pi}{18}}^{\frac{5\pi}{18}} (\cos 3\theta + \sqrt{3} \sin 3\theta) \, d\theta$ $V = \pi \left[\frac{\sin 3\theta}{3} - \frac{\sqrt{3} \cos 3\theta}{3} \right]_{-\frac{\pi}{18}}^{\frac{5\pi}{18}}$ $V = \pi \left[\left(\frac{\sin 3\left(\frac{5\pi}{18}\right)}{3} - \frac{\sqrt{3} \cos 3\left(\frac{5\pi}{18}\right)}{3} \right) - \left(\frac{\sin 3\left(-\frac{\pi}{18}\right)}{3} - \frac{\sqrt{3} \cos 3\left(-\frac{\pi}{18}\right)}{3} \right) \right]$ $V = \frac{4\pi}{3}$	M1 M1 M1 A1 [4]
Total 7 marks		

Part	Mark	Notes
(a)	M1	Sets the equation = 0 and obtains $\tan 3\theta = k$
	A1	Finds at least one correct value of 3θ $3\theta = -\frac{\pi}{6} \text{ or } \frac{5\pi}{6}$ <u>Works in degrees</u> Accept -30° or 150° for this mark. This mark is also implied by one correct solution for m or n in degrees or radians. NB This is an M mark in Epen
	A1	For $m = -\frac{\pi}{18} \quad n = \frac{5\pi}{18}$ which must be in radians. Accept embedded in coordinates. M and n do not need to be identified.

(b)	<p>Working in degrees. Allow working in degrees up to the last M mark.</p>
M1	<p>For a correct statement for the volume of revolution with π and their limits. Allow</p> $V = \pi \int_{-\frac{\pi}{18}}^{\frac{5\pi}{18}} \left(\left[\cos 3\theta + \sqrt{3} \sin 3\theta \right]^{\frac{1}{2}} \right)^2 d\theta \text{ or } V = \pi \int_{-\frac{\pi}{18}}^{\frac{5\pi}{18}} (\cos 3\theta + \sqrt{3} \sin 3\theta) d\theta$ <p>Allow also:</p> $V = \pi \int_{-\frac{\pi}{18}}^{\frac{5\pi}{18}} (\cos 3\theta + \sqrt{3} \sin 3\theta) dx \text{ or even } V = \pi \int_{-\frac{\pi}{18}}^{\frac{5\pi}{18}} (\cos 3\theta + \sqrt{3} \sin 3\theta)$ <p>This mark can be implied by correct further working <u>Working in degrees</u></p> $V = \pi \int_{-10^\circ}^{50^\circ} (\cos 3\theta + \sqrt{3} \sin 3\theta) d\theta$
M1	<p>For an acceptable attempt at integration. Minimally acceptable integration is as follows.</p> $\cos 3\theta \Rightarrow \pm \frac{\sin 3\theta}{3}, \quad \sin 3\theta \Rightarrow \pm \frac{\cos 3\theta}{3}$ <p>Ignore absence or incorrect limits and the absence of π for this mark.</p>
M1	<p>For substitution of the correct limits into their integrated expression the correct way around. This must be a changed expression from the one given. If the integrated expression is correct with correct limits, allow a final volume of $\frac{4\pi}{3}$ seen without explicit substitution. If the final volume is incorrect without evidence of explicit substitution award M0.</p> <p>If the integrated expression is incorrect or the limits are incorrect, explicit substitution must be seen for the award of this mark.</p> <p>Do not allow use of degrees at this stage.</p> <p>Ignore absence of π for this mark.</p>
A1	<p>For the correct volume $(V) = \frac{4\pi}{3}$</p>