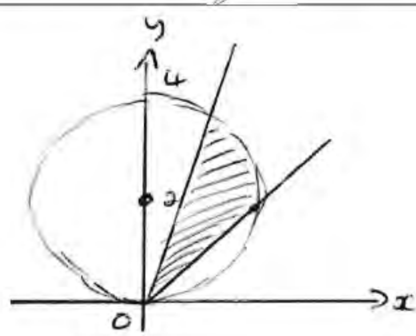
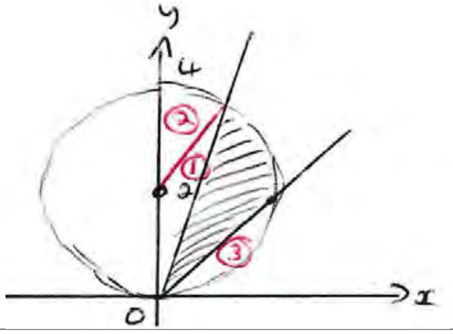
Question	Scheme	Marks	AOs
8(i)	$\lvert z\rvert=\sqrt{6^2+6^2}=\ldots\ 6\sqrt{2}$ or $\sqrt{72}$ and $\arg\ z=\tan^{-1}\left(\frac{6}{6}\right)=\ldots\left\{\frac{\pi}{4}\right\}$ Can be implied by $r=6\sqrt{2}e^{\frac{\pi}{4}i}$	M1 A1	3.1a 1.1b
	Adding multiplies of $\frac{2\pi}{5}$ to their argument $z=6\sqrt{2}e^{\frac{\pi}{4}i}\times e^{\frac{2\pi k}{5}i}$ or $z=6\sqrt{2}\left[\cos\left(\frac{\pi}{4}+\frac{2\pi k}{5}\right)+i\sin\left(\frac{\pi}{4}+\frac{2\pi k}{5}\right)\right]$	M1	1.1b
	$z=re^{\left(\theta+\frac{2\pi}{5}\right)i},\ re^{\left(\theta+\frac{4\pi}{5}\right)i},\ re^{\left(\theta+\frac{6\pi}{5}\right)i},\ re^{\left(\theta+\frac{8\pi}{5}\right)i}$ o.e. or $z=re^{\left(\theta+\frac{2\pi}{5}\right)i},\ re^{\left(\theta-\frac{2\pi}{5}\right)i},\ re^{\left(\theta-\frac{6\pi}{5}\right)i},\ re^{\left(\theta-\frac{8\pi}{5}\right)i}$ o.e.	A1ft	1.1b
	$z=6\sqrt{2}e^{\frac{13\pi}{20}i},\ 6\sqrt{2}e^{\frac{21\pi}{20}i},\ 6\sqrt{2}e^{\frac{29\pi}{20}i},\ 6\sqrt{2}e^{\frac{37\pi}{20}i}$ o.e. or $z=6\sqrt{2}e^{\frac{13\pi}{20}i},\ 6\sqrt{2}e^{-\frac{19\pi}{20}i},\ 6\sqrt{2}e^{-\frac{11\pi}{20}i},\ 6\sqrt{2}e^{-\frac{3\pi}{20}i}$ o.e.	A1	1.1b
		(5)	
(ii)(a)	Circle centre (0, 2) and radius 2 or  with the point on the origin	B1	1.1b
	Fully correct 	B1	1.1b
		(2)	
(ii)(b)	area $=\frac{1}{2}\int_{\frac{\pi}{4}}^{\frac{\pi}{3}} 4\sin\theta\ ^2\ d\theta$ or area $=\frac{1}{2}\int_{\frac{\pi}{4}}^{\frac{\pi}{3}} \alpha\sin\theta\ ^2\ d\theta$	M1	3.1a
	Uses $\sin^2\theta=\frac{1}{2}-\frac{1}{2}\cos 2\theta$ and integrates to the form $A\theta+B\sin 2\theta$ area $=8\int_{\frac{\pi}{4}}^{\frac{\pi}{3}}\sin^2\theta\ d\theta=4\int_{\frac{\pi}{4}}^{\frac{\pi}{3}}1-\cos 2\theta\ d\theta=4\theta-2\sin 2\theta$	M1	3.1a
	Uses the limits of $\frac{\pi}{4}$ and $\frac{\pi}{3}$ and subtracts the correct way around $\left[4\left(\frac{\pi}{3}\right)-2\sin\left(\frac{2\pi}{3}\right)\right]-\left[4\left(\frac{\pi}{4}\right)-2\sin\left(\frac{2\pi}{4}\right)\right]$	M1	1.1b

	Area = $\frac{\pi}{3}-\sqrt{3}+2$	A1	1.1b
		(4)	
	Alternative 		
	Finds either the areas 1 or 2 Area 1 $=\frac{1}{2}\times 2^2\times\sin\left(\frac{2\pi}{3}\right)\left\{=\sqrt{3}\right\}$ Area 2 $=\frac{1}{2}\times 2^2\times\frac{\pi}{3}\left\{=\frac{2\pi}{3}\right\}$	M1	1.1b
	A complete method to find area 3 Area 3 $=\frac{1}{4}\pi\times 2^2-\frac{1}{2}\times 2^2\left\{=\pi-2\right\}$	M1	3.1a
	A complete method to find the required area Shaded area $=$ Area of semi circle $-$ area 1 $-$ area 2 $-$ area 3 $=\left[\frac{1}{2}\pi\times 2^2\right]-\left[\frac{1}{2}\times 2^2\times\sin\left(\frac{2\pi}{3}\right)\right]-\left[\frac{1}{2}\times 2^2\times\frac{\pi}{3}\right]-\left[\frac{1}{4}\pi\times 2^2-\frac{1}{2}\times 2^2\right]$ $=2\pi-\sqrt{3}-\frac{2\pi}{3}-(\pi-2)$ Or Shaded area $=$ Area of sector $-$ area 1 $-$ area 3 $=\left[\frac{1}{2}\times 4\times\left(\frac{2\pi}{3}\right)\right]-\left[\frac{1}{2}\times 2^2\times\sin\left(\frac{2\pi}{3}\right)\right]-\left[\frac{1}{4}\pi\times 2^2-\frac{1}{2}\times 2^2\right]$ $=\frac{4\pi}{3}-\sqrt{3}-(\pi-2)$	M1	3.1a
	Area = $\frac{\pi}{3}-\sqrt{3}+2$	A1	1.1b
		(4)	
			(11 marks)

Notes:

(i)

M1: Finds the modulus and argument of z

A1: Correct modulus and argument of z

M1: Uses a correct method to find to all the other 4 vertices of the pentagon. Must be doing the equivalent of adding/ subtracting multiplies of $\frac{2\pi}{5}$ to the argument.

A1ft: All 4 vertices following through on their modulus and argument. Does not need to be simplified for this mark.

A1: All 4 vertices correct in the required form

(ii)(a)

B1: Circle centre (0, 2) and radius 2 or  with the vertex on the origin.

B1: Fully correct region shaded.

(ii) (b)

M1: Writes the required area using polar coordinates

M1: Uses $\sin^2\theta = \frac{1}{2} - \frac{1}{2}\cos 2\theta$ and integrates to the form $A\theta + B\sin 2\theta$

M1: Uses the limits of $\frac{\pi}{4}$ and $\frac{\pi}{3}$ and subtracts the correct way around. Must be some attempt at

$\text{area} = \frac{1}{2}\int \alpha\sin\theta\ {}^2\ \mathrm{d}\theta$ and integration.

A1: Correct exact area $= \frac{\pi}{3} - \sqrt{3} + 2$

Alternative

M1: Finds either area 1 or area 2

M1: A complete method to find the area 3

M1: A complete method to find the required area = Area of semi circle − area 1 − area 2 − area 3 or = Area of sector − area 1 − area 3

A1: Correct exact area $= \frac{\pi}{3} - \sqrt{3} + 2$