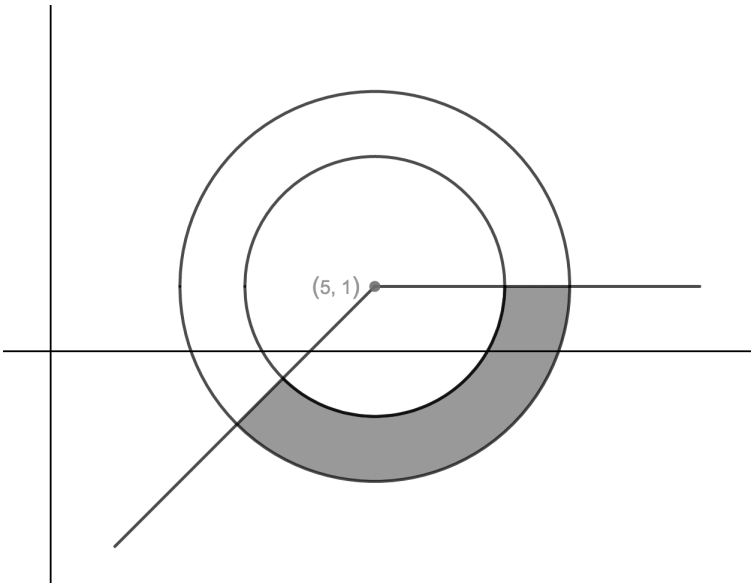
Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
1a	Concentric circles (see Notes) Half-lines (see Notes)  	**M1** **A1** **M1** **A1** **A1**	1.1b 1.1b 1.1b 1.1b 2.2a	6th Understand and use a wide range of regions in the Argand diagram
		(5)		
1b	Area $R = \frac{\frac{3\pi}{4}}{2\pi}(\pi(3)^2 - \pi(2)^2)$ oe $\frac{15\pi}{8}$ or $1\frac{7}{8}\pi$ or $1.875\,\pi$	**B1** **B1**	3.1a 1.1b	6th Understand and use a wide range of regions in the Argand diagram
		(2)		
1c	Maximum value of arg z_1 = arctan $\left(\frac{'1'}{'7'}\right)$ 0.142 (0.141897...)	**M1** **A1**	2.2a 1.1b	6th Understand and use a wide range of regions in the Argand diagram
		(2)		
				(9 marks)

Notes

1a **M1:** Any two concentric circles

A1: Accurate sketch of circles centred at (5,1)

M1: Any two half-lines from a common point

A1: Accurate sketch of half-lines from (5,1)

A1: Fully correct diagram

1b **B1:** A correct unsimplified expression for the area of region R or the value of k (could be implied)

B1: Correct area in correct form

Allow both these marks to be scored if the circles and half-lines are at an incorrect centre

1c **M1:** A correct method to find the argument of their $z_1 = a + bi$ with $a, b \neq 0$. Accept $\arctan\left(\frac{b}{a}\right)$

A1: awrt 0.142

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
2a	$z = x + \text{i}y \Rightarrow \lvert x + \text{i}y - 3 + 6\text{i}\rvert = \sqrt{2}\lvert x + \text{i}y\rvert$	**M1**	2.1	5th Understand and use a wide range of loci in the Argand diagram
	$\lvert(x-3) + \text{i}(y+6)\rvert = \sqrt{2}\lvert x + \text{i}y\rvert$ $(x-3)^2 + (y+6)^2 = 2(x^2 + y^2)$	**M1**	1.1b	
	$x^2 - 6x + 9 + y^2 + 12\text{y} + 36 = 2x^2 + 2y^2$ $x^2 + y^2 + 6x - 12y - 36 = 0$	**M1**	1.1b	
	$(x+3)^2 - 9 + (y-6)^2 - 36 - 36 = 0$	**M1**	2.1	
	$(x+3)^2 + (y-6)^2 = 81$ which is a circle	**A1***	2.2a	
		(5)		
2b	$z - z^* = 8\text{i} \Rightarrow x + \text{i}y - (x - \text{i}y) = 8\text{i}$ $2\text{i}y = 8\text{i}$	**M1**	3.1a	5th Understand and use a wide range of loci in the Argand diagram
	$y = 4$	**A1**	1.1b	
	$(x+3)^2 + (4-6)^2 = 81$ $(x+3)^2 = 77$ $x = -3 \pm \sqrt{77}$	**M1**	3.1a	
	$\text{Re}(z) = -3 \pm \sqrt{77}$	**A1**	1.1b	
		(4)		
				(9 marks)

Notes

2a **M1:** Substitutes $z = x + iy$ into given equation

M1: Collects real and imaginary parts on LHS and uses correct method to remove moduli

M1: Expands and simplifies to obtain equation of a circle with x^2 and y^2 coefficients of 1

M1: Completes the square on both quadratic parts in x and y

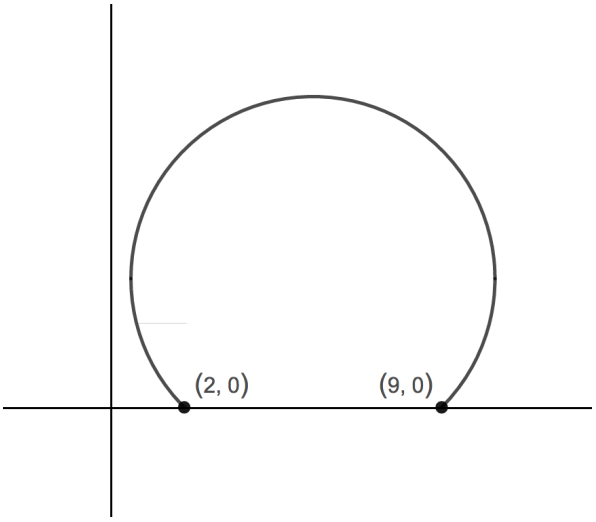
A1*: Achieves given answer with no errors

2b **M1:** Substitutes $z = x + iy$ and $z^* = x - iy$

A1: Obtains $y = 4$

M1: Substitutes y value into circle equation and solves quadratic as scheme or by formula to reach $x = ...$

A1: Both correct exact answers

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress Descriptor
3a	Arc of a circle or circle (see Notes) (2,0) and (9,0) – see Notes  	**M1** **M1** **A1**	1.1b 1.1b 1.1b	5th Understand and use a wide range of loci in the Argand diagram
		(3)		
3b	Centre C is $\left(\frac{11}{2},\frac{7}{2}\right)$ $r=\sqrt{2\left(\frac{7}{2}\right)^2}=\frac{7\sqrt{2}}{2}$ $OC=\sqrt{\left(\frac{11}{2}\right)^2+\left(\frac{7}{2}\right)^2}=\frac{\sqrt{170}}{2}$ $\lvert z\rvert_{\min}=\frac{\sqrt{170}}{2}-\frac{7\sqrt{2}}{2}$ $\lvert z\rvert_{\min}=\frac{\sqrt{170}-7\sqrt{2}}{2}$	**B1** **M1** **M1** **A1**	3.1a 3.1a 3.1a 1.1b	5th Understand and use a wide range of loci in the Argand diagram
		(4)		
				(7 marks)

Notes

3a **M1:** An arc of a circle or circle in any position

M1: An arc of a circle or circle that touches or passes through (2, 0) and (9, 0)

A1: Fully correct diagram (major arc)

3b **B1:** Correct centre seen or used anywhere

M1: Correct method for radius (could be trig)

M1: Their OC – their r

A1: Correct exact answer oe

Correct work in 3b where arc in 3a is below real axis can score **B0 M1 A1 A1**