Question Number	Scheme	Notes	Marks
3.	(i) $z^* - 3z = \dfrac{5\text{i}}{3-\text{i}}$; (ii) $w = -4+5\text{i}$, (b) $\arg(w+k) = \dfrac{\pi}{2}$, (c) $\lvert w+c\text{i}\rvert = 4\sqrt{5}$		
(i) **Way 1**	$\{z^* - 3z = \}\ (a-\text{i}b) - 3(a+\text{i}b)$	Left hand side $= (a-\text{i}b) - 3(a+\text{i}b)$ Can be implied by e.g. $-2a-4b\text{i}$ **Note:** Can be seen (or implied) anywhere in their solution	B1
	$\ldots\ldots = \dfrac{5\text{i}}{(3-\text{i})}\dfrac{(3+\text{i})}{(3+\text{i})}$	Multiplies numerator **and** denominator of the right-hand side by $3+\text{i}$ or $-3-\text{i}$	M1
	$\ldots\ldots = \dfrac{15\text{i}-5}{10}$	Applies $\text{i}^2 = -1$ to give right-hand side $= \dfrac{15\text{i}-5}{10}$ or equivalent	A1
	So, $-2a-4b\text{i} = -\dfrac{1}{2}+\dfrac{3}{2}\text{i}$ $\Rightarrow a = \dfrac{1}{4},\ b = -\dfrac{3}{8}\ \Rightarrow z = \dfrac{1}{4}-\dfrac{3}{8}\text{i}$	**dependent on the previous B and M marks** Equates either real parts or imaginary parts to give at least one of $a = \ldots$ or $b = \ldots$	ddM1
		$z = \dfrac{1}{4}-\dfrac{3}{8}\text{i}$ **or** $z = 0.25-0.375\text{i}$ **or** $z = \dfrac{1}{4}+\left(-\dfrac{3}{8}\text{i}\right)$	A1
			(5)
(i) **Way 2**	$\{z^* - 3z = \}\ (a-\text{i}b) - 3(a+\text{i}b)$	Left hand side $= (a-\text{i}b) - 3(a+\text{i}b)$ Can be implied by e.g. $-2a-4b\text{i}$ **Note:** Can be seen (or implied) anywhere in their solution	B1
	$(-2a-4b\text{i})(3-\text{i}) = \ldots\ldots$	Multiplies their $(-2a-4b\text{i})$ by $(3-\text{i})$	M1
	$-6a+2a\text{i}-12b\text{i}-4b = \ldots\ldots$	Applies $\text{i}^2 = -1$ to give left-hand side $= -6a+2a\text{i}-12b\text{i}-4b$ or equivalent	A1
	So, $(-6a-4b)+(2a-12b)\text{i} = 5\text{i}$ gives $-6a-4b = 0,\ 2a-12b = 5$ $\Rightarrow a = \dfrac{1}{4},\ b = -\dfrac{3}{8}\ \Rightarrow z = \dfrac{1}{4}-\dfrac{3}{8}\text{i}$	**dependent on the previous B and M marks** Equates **both** real parts and imaginary parts and solves simultaneously to give at least one of $a = \ldots$ or $b = \ldots$	ddM1
		$z = \dfrac{1}{4}-\dfrac{3}{8}\text{i}$ **or** $z = 0.25-0.375\text{i}$ **or** $z = \dfrac{60}{240}-\dfrac{15}{40}\text{i}$	A1
			(5)
(ii)(a)	e.g. $\arg w = \pi - \tan^{-1}\left(\frac{5}{4}\right)$ or $= \frac{\pi}{2} + \tan^{-1}\left(\frac{4}{5}\right)$ or $= -\pi - \tan^{-1}\left(\frac{5}{4}\right)$	Uses trigonometry to find an expression for $\arg w$ so that $\arg w$ is in the range $(1.58\ldots, 3.14\ldots)$ or $(90°, 180°)$ or $(-4.71\ldots, -3.15\ldots)$ or $(-270°, -180°)$	M1
	$\arg w = \pi - 0.896055\ldots = 2.245537\ldots$ $\{= 2.25\ (2\text{ dp})\}$ or $\arg w = -\pi - 0.896055\ldots = -4.037648\ldots$ $\{= -4.04\ (2\text{ dp})\}$	awrt 2.25 **or** awrt -4.04 **or** awrt 8.53 **or** awrt -10.32	A1
	{**Note:** $\arg w = 128.6598\ldots°$ or $-231.3401\ldots°$ is M1 A0}		**(2)**
(b)	$\{\arg(-4+5\text{i}+k) = \frac{\pi}{2} \Rightarrow -4+k = 0 \Rightarrow\}\ k = 4$	$k = 4$	B1
			(1)
(c)	$\lvert -4+5\text{i}+c\text{i}\rvert = 4\sqrt{5}$ $\Rightarrow \lvert -4+(5+c)\text{i}\rvert = 4\sqrt{5}$ $\Rightarrow (-4)^2+(5+c)^2 = (4\sqrt{5})^2$	Squares and adds the real and imaginary parts of $w+c\text{i}$ and sets equal to either $(4\sqrt{5})^2$ or $4\sqrt{5}$	M1
		$(-4)^2+(5+c)^2 = (4\sqrt{5})^2$ o.e. Allow the equivalent result $\sqrt{(-4)^2+(5+c)^2} = 4\sqrt{5}$	A1
	$16+(5+c)^2 = 80 \Rightarrow (5+c)^2 = 64 \Rightarrow c = \ldots$ **or** $16+(5+c)^2 = 80 \Rightarrow c^2+10c-39 = 0$ $\Rightarrow (c+13)(c-3) = 0 \Rightarrow c = \ldots$	**dependent on the previous M mark** Solves their quadratic in c to give $c = \ldots$	dM1
	$c = -13,\ 3$	$c = -13,\ 3$	A1
			(4)
			12

	Question 3 Notes	
3. (i)	**Note**	Allow alternative ways of defining z. E.g. $z = x + \mathrm{i}y$ and $z^* = x - \mathrm{i}y$ with $x \equiv a$ and $y \equiv b$
	Note	Give final A0 for defining $z = a + \mathrm{i}b$, finding $a = \frac{1}{4}$, $b = -\frac{3}{8}$ but not stating $z = \frac{1}{4} - \frac{3}{8}\mathrm{i}$
	Note	**Alternative:** Some may define $z = x - \mathrm{i}y$ and $z^* = x + \mathrm{i}y$ This gives $\{z^* - 3z = \}\ (x + \mathrm{i}y) - 3(x - \mathrm{i}y) = -2x + 4y\mathrm{i}$ So, $-2x + 4y\mathrm{i} = -\frac{1}{2} + \frac{3}{2}\mathrm{i} \Rightarrow x = \frac{1}{4},\ y = \frac{3}{8} \Rightarrow z = \frac{1}{4} - \frac{3}{8}\mathrm{i}$
(ii) (a)	**Note**	Allow M1 (implied) for awrt 2.2, awrt -3.8, truncated -4.0, awrt $129°$, truncated $128°$ or awrt $-231°$
(ii) (c)	**Note**	$\lvert -4 + (5 + c)\mathrm{i}\rvert = 4\sqrt{5} \Rightarrow (-4)^2 - (5 + c)^2 = (4\sqrt{5})^2$ unless recovered is 1st M0
	Note	$\lvert -4 + (5 + c)\mathrm{i}\rvert = 4\sqrt{5} \Rightarrow -16 + (5 + c)^2 = (4\sqrt{5})^2$ unless recovered is 1st M0
	Note	$\lvert -4 + 5\mathrm{i} + c\mathrm{i}\rvert = 4\sqrt{5} \Rightarrow (-4)^2 + (5)^2 + c^2 = (4\sqrt{5})^2$ unless recovered is 1st M0
	Note	If a 3TQ is formed in c then a correct method (e.g. factorising, applying the quadratic formula, completing the square or calculator) of solving a 3TQ is required to give $c = ...$
	Note	Give dM1 for using a calculator to write down at least one correct root for their 3TQ
	Note	Having achieved a correct $16 + 25 + 10c + c^2 = 80$ give final dM1 A1 marks for writing down $c = -13,\ 3$ from no working.
	Note	Give final A0 for either • $c = -13,\ 3 \Rightarrow c = 3$ • $c = -13,\ 3 \Rightarrow c = -13$ • $c = 3,\ c = -13$ (reject) • $c = 3$ (reject), $c = -13$