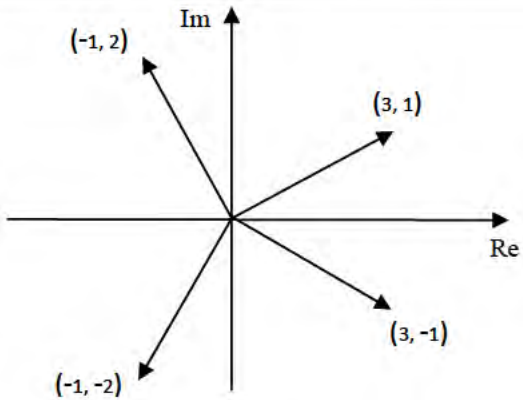
Question	Scheme	Marks	AOs
1(a)	$z=-1-2\text{i}$ or $z=3+\text{i}$	M1	1.2
	$z=-1-2\text{i}$ and $z=3+\text{i}$	A1	1.1b
		B1	1.1b
		B1	1.1b
		(4)	
(b) **Way 1**	$(z-(-1+2\text{i}))(z-(-1-2\text{i}))=\ldots$ or $(z-(3+\text{i}))(z-(3-\text{i}))=\ldots$	$\text{f}(z)=(z-(-1+2\text{i}))(z-(-1-2\text{i}))$ $(z-(3+\text{i}))(z-(3-\text{i}))=\ldots$	M1	3.1a
	z^2+2z+5 or $z^2-6z+10$	e.g. $\text{f}(z)=(z^2+2z+5)(\ldots)$	A1	1.1b
	z^2+2z+5 and $z^2-6z+10$	$\text{f}(z)=(z^3+z^2(-1-\text{i})+z(-1+2\text{i})-15-5\text{i})(\ldots)$	A1	1.1b
	$\text{f}(z)=(z^2+2z+5)(z^2-6z+10)$	Expands the brackets to forms a quartic	M1	3.1a
	$\text{f}(z)=z^4-4z^3+3z^2-10z+50$ or States $a=-4, b=3, c=-10, d=50$		A1	1.1b
			(5)	

Question	Scheme	Marks	AOs
Way 2	$\text{sum roots} = \alpha + \beta + \gamma + \delta = (-1+2\text{i}) + (-1-2\text{i}) + (3+\text{i}) + (3-\text{i}) = \ldots$	M1	3.1a
	$\text{pair sum} = \alpha\beta + \alpha\gamma + \alpha\delta + \beta\gamma + \beta\delta + \gamma\delta$ $= (-1+2\text{i})(-1-2\text{i}) + (-1+2\text{i})(3-\text{i}) + (-1+2\text{i})(3+\text{i}) + (-1-2\text{i})(3-\text{i})$ $+ (-1-2\text{i})(3+\text{i}) + (3+\text{i})(3-\text{i}) = \ldots$		
	$\text{triple sum} = \alpha\beta\gamma + \alpha\beta\delta + \beta\gamma\delta + \alpha\gamma\delta$ $= (-1+2\text{i})(-1-2\text{i})(3-\text{i}) + (-1+2\text{i})(-1-2\text{i})(3+\text{i}) + (-1+2\text{i})(3+\text{i})(3-\text{i})$ $+ (-1-2\text{i})(3+\text{i})(3-\text{i}) = \ldots$		
	$\text{Product} = \alpha\beta\gamma\delta = (-1+2\text{i})(-1-2\text{i})(3-\text{i})(3+\text{i}) = \ldots$		
	sum = 4, pair sum = 3, triple sum = 10 and product = 50	A1 A1	1.1b 1.1b
	$a = -(\text{their sum roots}) = -4$ $b = +(\text{their pair sum}) = 3$ $c = -(\text{triple sum}) = -10$ $d = +(\text{product}) = 50$	M1 A1	3.1a 1.1b
		(5)	
Way 3	$\text{f}(z) = (-1+2\text{i})^4 + a(-1+2\text{i})^3 + b(-1+2\text{i})^2 + c(-1+2\text{i}) + d = 0$ $\text{f}(z) = (3+\text{i})^4 + a(3+\text{i})^3 + b(3+\text{i})^2 + c(3+\text{i}) + d = 0$	M1	3.1a
	Leading to $-7+11a-3b-c+d=0 \qquad 24-2a-4b+2c=0$ $28+18a+8b+3c+d=0 \qquad 96+26a+6b+c=0$	A1 A1	1.1b 1.1b
	Solves their simultaneous equation to find a value for one of the constants	M1	3.1a
	$a=-4, b=3, c=-10, d=50$	A1	1.1b
		(5)	
			(9 marks)

Notes

(a)

M1: Identifies at least one correct complex conjugate as another root (can be seen/implied by Argand diagram)

A1: Both complex conjugate roots identified correctly (can be seen/implied by Argand diagram)

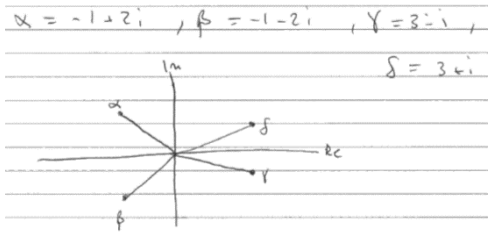
For the next two marks allow either a cross, dot or line drawn where the end point is labelled with the correct coordinate, corresponding complex number or clearly plotted with correct numbers labelled on the axis or indication of the correct coordinates by use of scale markers. Condone (3, i) etc. The axes do not need to be labelled with Re and Im.

B1: One complex conjugate pair correctly plotted.

B1: Both complex conjugate pair correctly plotted. The $3\pm i$ must be closer to the real axes than the $-1\pm 2i$

If there is no indication of the coordinates, scale or complex numbers on the Argand diagram this is B0 B0.

Do accept correct labelling e.g.



(b)

<u>Way 1</u>

M1: Correct strategy for forming at least one of the quadratic factors. Follow through their roots.

A1: At least one correct simplified quadratic factor.

A1: Both simplified quadratic factors correct or a correct simplified cubic factor

M1: A complete strategy to find values for *a*, *b*, *c* and *d* e.g. uses their quadratic factors or cubic and linear factor to form a quartic.

A1: Correct quartic in terms of *z* or correct values for *a*, *b*, *c* and *d* stated.

<u>Way 2</u>

M1: Correct strategy for finding at least three of the sum roots, pair sum, triple sum and product. Follow through their roots. This can be implied by at least three correct values for the sum roots, pair sum, triple sum and product with no working shown. If the calculations are not shown for the sums and product and they have at least two incorrect values this is M0.

A1: At least two correct values for the sum roots, pair sum, triple sum or product.

A1: All correct values for the sum, pair sum, triple sum and product.

M1: Must have real values of *a*, *b* , *c* and *d* and use *a* = −their sum roots, *b* = their pair sum, *c* = −their triple sum and *d* = their product.

A1: Correct quartic in terms of *z* or correct values for *a*, *b*, *c* and *d* stated.

<u>Way 3</u>

M1: Substitutes two roots into $f(z) = 0$ and equates coefficients to form 4 equations

A1: At least two correct equations.

A1: All four correct equations

M1: Solve their four equation (using calculator) to find at least one value. This will need checking if incorrect equations used.
A1: Correct quartic in terms of z or correct values for a, b, c and d stated.

Note: Correct answer only will score 5/5