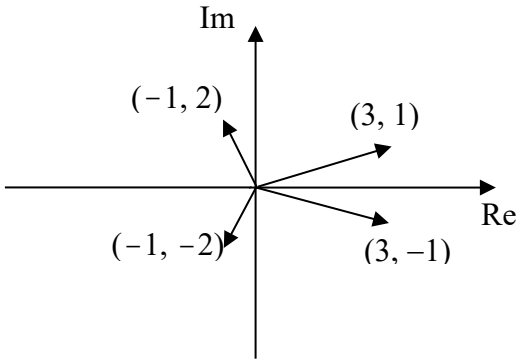
Question Number	Scheme	Notes	Marks
3	$f(z) = z^4 + az^3 + bz^2 + cz + d$		
(a)	$(z =) 3 - i$ or $(z =) -1 + 2i$		B1
	$(z =) 3 - i$ and $(z =) -1 + 2i$		B1
			(2)
(b)		$3 \pm i$ correctly plotted with vectors or dots or crosses etc. or $-1 \pm 2i$ correctly plotted with vectors or dots or crosses etc.	B1
		All 4 correct roots correctly plotted with scaling approximately correct (e.g. (-1, 2) higher than (3, 1), etc.) There should be approximate symmetry about the real axis, but be generous	B1
			(2)
(c)	$z = 3 \pm i \Rightarrow (z - (3 + i))(z - (3 - i)) = ...$ or $z = -1 \pm 2i \Rightarrow (z - (-1 + 2i))(z - (-1 - 2i)) = ...$	Correct strategy to find at least one quadratic factor. Throughout this part ignore the use of x (or other variable) instead of z	M1
	$z^2 - 6z + 10$ or $z^2 + 2z + 5$	One correct quadratic	A1
	$z^2 - 6z + 10$ and $z^2 + 2z + 5$	Both correct	A1
	$(z^2 - 6z + 10)(z^2 + 2z + 5) = ...$	Attempts product of their two <u>3-term</u> quadratic factors... no 'missing terms' in the expansion	M1
	$a = -4, b = 3, c = -10, d = 50$ or $f(z) = z^4 - 4z^3 + 3z^2 - 10z + 50$	All correct values or correct quartic	A1
			(5)
			Total 9

(c) **Way 2**	$(z-(3+\mathrm{i}))(z-(-1\pm 2i))=\cdots$ or $(z-(3-\mathrm{i}))(z-(-1\pm 2\mathrm{i}))=\cdots$	Correct strategy to find at least one quadratic factor. Throughout this part ignore the use of x (or other variable) instead of z	M1
	$z^2+z(-2+\mathrm{i})+(-1-7\mathrm{i})$ (i) or $z^2+z(-2-\mathrm{i})+(-1+7\mathrm{i})$ (ii) or $z^2+z(-2+3\mathrm{i})+(-5-5\mathrm{i})$ (iii) or $z^2+z(-2-3\mathrm{i})+(-5+5\mathrm{i})$ (iv)	One correct quadratic	A1
	(i) and (ii) correct or (iii) and (iv) correct	A correct pair	A1
	e,g $[z^2+z(-2+i)+(-1-7i)]\times$ $[z^2+z(-2-\mathrm{i})+(-1+7\mathrm{i})]$ =...	Attempts product of their two <u>3-term</u> quadratic factors... no 'missing terms' in the expansion	M1
	$a=-4, b=3, c=-10, d=50$ or $\mathrm{f}(z)=z^4-4z^3+3z^2-10z+50$	All correct values or correct quartic	A1

(c) **Way 3**	$\sum\propto=(3+\mathrm{i})+(3-\mathrm{i})+(-1-2\mathrm{i})+(-1+2\mathrm{i})$ =.. or $\alpha\beta\gamma\delta=(3+\mathrm{i})(3-\mathrm{i})(-1-2\mathrm{i})(-1+2\mathrm{i})$ = ..	Attempts one of these	M1
	a = - 4 or d = 50		A1
	Both a = - 4 and d = 50		A1
	$\sum\alpha\beta$ = ... and $\sum\alpha\beta\gamma$ = ...	Attempts $\sum\alpha\beta$ (all 6 terms) and $\sum\alpha\beta\gamma$ (all 4 terms)	M1
	$a=-4, b=3, c=-10, d=50$ or $\mathrm{f}(z)=z^4-4z^3+3z^2-10z+50$	All correct values or correct quartic	A1

(c) **Way 4**	$(3+\mathrm{i})^4+a(3+\mathrm{i})^3+b(3+\mathrm{i})^2+c(3+\mathrm{i})+d=0$ (.....) + (.....) i = 0	Substitutes one of the roots into the given quartic and fully multiplies out	M1
	$(28+18a+8b+3c+d)+\mathrm{i}(96+26a+6b+c)$ or $(-7+11a-3b-c+d)+\mathrm{i}(-24+2a+4b-2c)$	One correct expansion	A1
	$(28+18a+8b+3c+d)+\mathrm{i}(96+26a+6b+c)$ and $(-7+11a-3b-c+d)+\mathrm{i}(-24+2a+4b-2c)$	Obtains a second correct expansion using another root.	A1
	$(28+18a+8b+3c+d)=0$, etc leading to $a=$, $b=$, $c=$, $d=$	Solves 4 simultaneous equation to find values of a, b, c and d	M1
	$a=-4, b=3, c=-10, d=50$ or $\mathrm{f}(z)=z^4-4z^3+3z^2-10z+50$	All correct values or correct quartic	A1