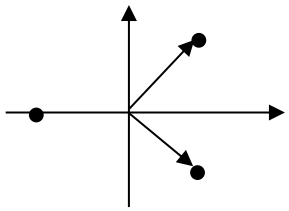
Question	Scheme	Marks
	$f(z) = 4z^3 + pz^2 - 24z + 108$, -3 a root.	
3(a)	$f(-3) = 0 \Rightarrow 4(-3)^3 + p(-3)^2 - 24(-3) + 108 = 0 \Rightarrow p = ...$	**M1**
	$p = -8$	**A1**
		(2)
(b)	$4z^3 - 8z^2 - 24z + 108 = (z+3)(4z^2 + ...z + 36)$	**M1**
	$= (z+3)(4z^2 - 20z + 36)$	**A1**
	$4z^2 - 20z + 36 = 0 \Rightarrow z = \dfrac{20 \pm \sqrt{400 - 4\times4\times36}}{8} = ...$	**dM1**
	Roots are $-3, \dfrac{5 \pm i\sqrt{11}}{2}$	**A1**
		(4)
(c)	e.g. Product of complex roots is $\dfrac{36}{4} = 9$, so modulus is $\sqrt{"9"}$ or Modulus is $\sqrt{\left(\dfrac{5}{2}\right)^2 + \left(\dfrac{\sqrt{11}}{2}\right)^2}$	**M1**
	Hence modulus is 3	**A1**
		(2)
(d)	 Complex conjugate pair in correct quadrant for their roots	**M1**
	All three roots correctly positioned.	**A1**
		(2)
		(10 marks)

Notes:

Mark the question as a whole - do not be concerned part labelling.

(a)

M1: A complete method to find the value of *p*. Use of the factor theorem is most direct, look for setting f(−3) = 0 and solving for *p*. May attempt to factor out $(z+3)$ and compare coefficients, e.g.

$f(z) = 4z^3 + pz^2 - 24z + 108 = (z+3)(4z^2 + bz + 36) \Rightarrow 3b + 36 = -24, 12 + b = p \Rightarrow b = .., p = \ldots$ or may attempt long division and set remainder equal to zero to find p or variations on these.

A1: For $p = -8$

(b)

Note: Allow marks in (b) for work seen in (a) e.g. via attempts in (a) by long division.

M1: Correct strategy to find a quadratic factor. If factorising, look for correct first and last terms. May use long division, in which case look for the correct first term and attempt to use it - may have been seen in (a).

Question instructs use of algebra so an algebraic method must be seen.

A1: Correct quadratic factor - may have been seen in (a).

dM1: Uses the quadratic formula or completing the square or calculator to find the roots of their quadratic factor (allow for attempts at a quadratic factor via long division which had non-zero remainder). If a calculator is used (no method shown), there must be at least one correct **complex** root for their equation. Factorisation is M0.

A1: Correct roots in simplest form. All three should be included at some point in the solution in (b).

(c)

M1: Any correct method to find the modulus of the complex roots. Most likely to see Pythagoras, but some may deduce from product of roots. They must have complex roots to score the marks in (c).

A1: Modulus 3 only. If -3 is also given as a modulus then score A0.

(d)

Note: Allow the marks in (d) if the i's were missing in their roots in (b) but they clearly mean the correct complex roots on their diagram.

M1: Plots the complex roots as a conjugate pair in the correct quadrants for their roots.

A1: Fully correct diagram with one root on the negative real axis, and the other as a complex pair of roughly the same length in quadrants 1 and 4.