Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
1	Uses $\alpha+\beta=-\frac{b}{a}$ to write $4p=-6$	**M1**	1.1b	TBC
	Solves to find $p=-\frac{3}{2}$	**A1**	1.1b	
	Uses $\alpha\beta=\frac{c}{a}$ to write $3p^2=\frac{30}{k}$	**M1**	1.1b	
	Solves to find $k=\frac{40}{9}$	**A1**	1.1b	
		(4)		
				(4 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
2a	Uses $\alpha+\beta=-\frac{b}{a}$ to write $2\operatorname{Re}(\alpha)=-\frac{m}{5}$	**M1**	2.2a	TBC
	Solves to find $m=-40$	**A1**	1.1b	
		(2)		
b	Uses $\alpha\beta=\frac{c}{a}$ to write $(\operatorname{Re}(\alpha))^2+(\operatorname{Im}(\alpha))^2=\frac{n}{5}$	**M1**	2.2a	
	Solves to find $n=80$ and concludes $n>80$	**A1**	1.1b	
		(2)		
				(4 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
3a	States $\alpha\beta+\beta\gamma+\gamma\alpha=\frac{k}{5}$, $\alpha\beta\gamma=10$ and $\alpha+\beta+\gamma=\frac{11}{5}$	**B1**	1.1b	TBC
		(1)		
b	Deduces that $\alpha^*=1-7i$ is a root.	**M1**	2.2a	
	Finds $\alpha\alpha^*=(1+7i)(1-7i)=50$	**M1**	1.1b	
	Uses $\alpha\beta\gamma=10\Rightarrow\alpha\alpha^*\gamma=10$ to state $\gamma=\frac{1}{5}$	**A1**	1.1b	
		(3)		
c	Uses $\alpha\beta+\beta\gamma+\gamma\alpha=\frac{k}{5}$ to write $50+\frac{1}{5}(1-7i)+\frac{1}{5}(1+7i)=\frac{k}{5}$	**M1**	2.2a	
	Solves to find $k=252$	**A1**	1.1b	
		(2)		
				(6 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
4a	Multiplies the three given roots together and sets the result equal to 52 or −52. For example $(\alpha)\left(\frac{1}{\alpha}\right)\left(\alpha+\frac{13}{\alpha}+46\right)=-52$ or $(\alpha)\left(\frac{1}{\alpha}\right)\left(\alpha+\frac{13}{\alpha}+46\right)=52$ is seen.	**M1**	1.1b	TBC
	Correctly uses $(\alpha)\left(\frac{1}{\alpha}\right)\left(\alpha+\frac{13}{\alpha}+46\right)=52$ to find $\alpha^2-6\alpha+13=0$	**A1**	1.1b	
	Attempts to solve this quadratic using either completing the square or the quadratic formula.	**M1**	3.1a	
	Correctly finds $\alpha=3\pm 2i$	**A1**	1.1b	
	States that the roots of $\mathrm{f}(z)=0$ are $3+2i,\ 3-2i,\ 4$	**A1**	2.2a	
		(5)		
b	Applies the process of finding $-\sum$ (of their three roots found in part (a)) to attempt to find *m*.	**M1**	3.1a	
	Correctly finds $m=-10$	**A1**	1.1b	
	Applies the process of using the pair sums to find the value of *n*. For example, $13+6\gamma=n$ is seen.	**M1**	3.1a	
	Correctly finds $n=37$	**A1**	1.1b	
		(4)		
				(9 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
5a	States or implies that $\gamma = 2-4i$ is a root.	**M1**	2.2a	TBC
	Uses $\alpha+\beta+\gamma+\delta = \alpha+\beta+4 = -\frac{-24}{4}$ to write $\alpha+\beta-2=0$	**A1**	3.1a	
	Uses $\alpha\beta\gamma+\alpha\beta\delta+\alpha\gamma\delta+\beta\gamma\delta = \alpha\beta(2+4i)+\alpha\beta(2-4i)+\alpha(20)+\beta(20) = -\frac{-276}{4}$ to write $4\alpha\beta+20(\alpha+\beta)=69$	**A1**	3.1a	
		(3)		
b	Makes an attempt to solve for α and β, for example $\alpha = 2-\beta$ is substituted into $4\alpha\beta+20(\alpha+\beta)=69$	**M1**	2.2a	
	Forms a quadratic in α or β: $4\alpha^2-8\alpha+29=0$ or $4\beta^2-8\beta+29=0$ or equivalent is seen and attempts to solve the quadratic.	**M1**	3.1a	
	States either $\alpha = 1+\frac{5}{2}i$ or $\beta = 1+\frac{5}{2}i$	**A1**	1.1b	
	States the roots of the equation are: $2+4i,\ 2-4i,\ 1+\frac{5}{2}i,\ 1-\frac{5}{2}i$	**A1**	2.2a	
		(4)		
C	Makes an attempt to use $\alpha\beta\gamma\delta = \frac{n}{a}$ to find n	**M1**	3.1a	
	Finds $n = 580$	**A1**	1.1b	
		(2)		
				(9 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
6a	States $\alpha+\beta+\gamma=-\frac{-6}{3}=2$, $\alpha\beta+\beta\gamma+\gamma\alpha=-\frac{10}{3}$ and $\alpha\beta\gamma=-\frac{-20}{3}=\frac{20}{3}$	B1	1.1b	TBC
		(1)		
bi	Makes an attempt to use $\alpha^4\beta^4\gamma^4=(\alpha\beta\gamma)^4$	M1	3.1a	
	Finds $\alpha^4\beta^4\gamma^4=(\alpha\beta\gamma)^4=\left(\frac{20}{3}\right)^4=\frac{160\,000}{81}$	A1	1.1b	
		(2)		
bii	Makes an attempt to use $\alpha^2+\beta^2+\gamma^2=(\alpha+\beta+\gamma)^2-2(\alpha\beta+\beta\gamma+\gamma\alpha)$	M1	3.1a	
	Finds $\alpha^2+\beta^2+\gamma^2=(\alpha+\beta+\gamma)^2-2(\alpha\beta+\beta\gamma+\gamma\alpha)$ $=(2)^2-2\left(-\frac{10}{3}\right)=\frac{32}{3}$	A1	1.1b	
		(2)		
biii	Makes an attempt to multiply out $(2-\alpha)(2-\beta)(2-\gamma)$	M1	1.1b	
	Finds or states $(2-\alpha)(2-\beta)(2-\gamma)$ $=8-4(\alpha+\beta+\gamma)+2(\alpha\beta+\beta\gamma+\gamma\alpha)-\alpha\beta\gamma$	M1	3.1a	
	Finds $(2-\alpha)(2-\beta)(2-\gamma)=8-4(2)+2\left(-\frac{10}{3}\right)-\frac{20}{3}=-\frac{40}{3}$	A1	1.1b	
		(3)		
				(9 marks)

Notes

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
7	States $w = 2x - 1 \Rightarrow x = \frac{w+1}{2}$	**B1**	3.1a	TBC
	States $2\left(\frac{w+1}{2}\right)^3 - 4\left(\frac{w+1}{2}\right)^2 + 6\left(\frac{w+1}{2}\right) - 9 = 0$	**M1**	3.1a	
	Makes an attempt to manipulate the equation into the form $aw^3 + bw^2 + cw + d = 0$	**M1**	1.1b	
	At least two of *a*, *b*, *c* or *d* are correct.	**A1**	1.1b	
	Fully correct final equation: $w^3 - w^2 + 7w - 27 = 0$	**A1**	1.1b	
		(5)		
				(5 marks)

Notes

7: Accept an equation that is a multiple of $w^3 - w^2 + 7w - 27 = 0$, most likely $2w^3 - 2w^2 + 14w - 54 = 0$.

See also alternative method for first three marks on next page.

ALTERNATIVE METHOD FOR FIRST THREE MARKS

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
7	States $\alpha+\beta+\gamma=2$, $\alpha\beta+\beta\gamma+\gamma\alpha=3$ and $\alpha\beta\gamma=\frac{9}{2}$	**B1**	3.1a	
	Sum of roots: $(2\alpha-1)+(2\beta-1)+(2\gamma-1)$ $=2(\alpha+\beta+\gamma)-3=2(2)-3=1$ Pair sum: $(2\alpha-1)(2\beta-1)+(2\beta-1)(2\gamma-1)+(2\gamma-1)(2\alpha-1)$ $=4(\alpha\beta+\beta\gamma+\gamma\alpha)-4(\alpha+\beta+\gamma)+3$ $=4(3)-4(2)+3=7$ Product: $(2\alpha-1)(2\beta-1)(2\gamma-1)$ $=8(\alpha\beta\gamma)-4(\alpha\beta+\beta\gamma+\gamma\alpha)+2(\alpha+\beta+\gamma)-1$ $=8\left(\frac{9}{2}\right)-4(3)+2(2)-1=27$	**M1**	3.1a	
	Applies: w^3 – (their sum roots)w^2 + (their pair sum)w – their product = 0	**M1**	1.1b	

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
8	States $w = 2x \Rightarrow x = \frac{w}{2}$	B1	3.1a	TBC
	States $2\left(\frac{w}{2}\right)^4 - 6\left(\frac{w}{2}\right)^2 + 16\left(\frac{w}{2}\right) - 1 = 0$	M1	3.1a	
	Makes an attempt to manipulate the equation into the form $pw^4 + qw^3 + rw^2 + sw + t = 0$.	M1	1.1b	
	At least two of p, q, r, s and t are correct.	A1	1.1b	
	Fully correct final equation: $w^4 - 12w^2 + 64w - 8 = 0$	A1	1.1b	
		(5)		
				(5 marks)

Notes

See also alternative method for first three marks on next page.

ALTERNATIVE METHOD FOR FIRST THREE MARKS

Q	Scheme	Marks	AOs	Pearson Progression Step and Progress descriptor
8	States $\alpha+\beta+\gamma+\delta=0$, $\alpha\beta+\beta\gamma+\gamma\alpha+\gamma\delta+\alpha\delta+\beta\delta=-3$, $\alpha\beta\gamma+\alpha\beta\delta+\alpha\gamma\delta+\beta\gamma\delta=-8$ and $\alpha\beta\gamma\delta=-\frac{1}{2}$	**B1**	3.1a	TBC
	Sum of roots: $2\alpha+2\beta+2\gamma+2\delta=0$ Pair sum: $(2\alpha)(2\beta)+(2\beta)(2\gamma)+(2\gamma)(2\alpha)+\ldots$ $\ldots+(2\gamma)(2\delta)+(2\alpha)(2\delta)+(2\beta)(2\delta)$ $=4(\alpha\beta+\beta\gamma+\gamma\alpha+\gamma\delta+\alpha\delta+\beta\delta)$ $=4(-3)=-12$ Triple sum: $(2\alpha)(2\beta)(2\gamma)+(2\alpha)(2\beta)(2\delta)+\ldots$ $\ldots+(2\alpha)(2\gamma)(2\delta)+(2\beta)(2\gamma)(2\delta)$ $=8(\alpha\beta\gamma+\alpha\beta\delta+\alpha\gamma\delta+\beta\gamma\delta)$ $=8(-8)=-64$ Product: $(2\alpha)(2\beta)(2\gamma)2(\delta)=16(\alpha\beta\gamma\delta)=16\left(-\frac{1}{2}\right)=-8$	**M1**	3.1a	
	Applies: w^4 – (their sum roots)w^3 + (their pair sum)w^2 – (their triple sum)w + their product = 0	**M1**	1.1b	