Question Number	Scheme	Notes	Marks
6.	$12x^2-3x+4=0$ has roots α, β		
(a)	$\alpha+\beta=\frac{3}{12}$ or $\frac{1}{4}$, $\alpha\beta=\frac{4}{12}$ or $\frac{1}{3}$	**Both** $\alpha+\beta=\frac{3}{12}$ or $\frac{1}{4}$ **and** $\alpha\beta=\frac{4}{12}$ or $\frac{1}{3}$, seen or implied	B1
	$\frac{2}{\alpha}+\frac{2}{\beta}=\frac{2\beta+2\alpha}{\alpha\beta}$	**States or uses** $\frac{2}{\alpha}+\frac{2}{\beta}=\frac{2\beta+2\alpha}{\alpha\beta}$ or $\frac{2(\alpha+\beta)}{\alpha\beta}$	M1
	$=\frac{2\left(\frac{3}{12}\right)}{\left(\frac{4}{12}\right)}=\frac{3}{2}$	**dependent on BOTH previous marks being awarded** $\frac{3}{2}$ or $\frac{6}{4}$ or 1.5 **from correct working**	A1 **cso cao**
			(3)
(b)	Sum $=\frac{2}{\alpha}-\beta+\frac{2}{\beta}-\alpha$ $=\frac{2}{\alpha}+\frac{2}{\beta}-(\alpha+\beta)$ $=\frac{3}{2}-\frac{1}{4}=\frac{5}{4}$	Uses at least one of their $\frac{2}{\alpha}+\frac{2}{\beta}$ or their $(\alpha+\beta)$ in an attempt to find a **numerical value** for the sum of $\left(\frac{2}{\alpha}-\beta\right)$ and $\left(\frac{2}{\beta}-\alpha\right)$	M1
		Correct sum of $\frac{5}{4}$ or $\frac{15}{12}$ or 1.25 which can be implied	A1
	Product $=\left(\frac{2}{\alpha}-\beta\right)\left(\frac{2}{\beta}-\alpha\right)$ $=\frac{4}{\alpha\beta}-2-2+\alpha\beta$ $=\frac{4}{\left(\frac{1}{3}\right)}-2-2+\frac{1}{3}=\frac{25}{3}$	Expands $\left(\frac{2}{\alpha}-\beta\right)\left(\frac{2}{\beta}-\alpha\right)$ to give $\frac{P}{\alpha\beta}+Q+R\alpha\beta$; $P, Q, R\neq 0$ and uses their $\alpha\beta$ at least once in an attempt to find a **numerical value** for the product of $\left(\frac{2}{\alpha}-\beta\right)$ and $\left(\frac{2}{\beta}-\alpha\right)$	M1
		Correct product of $\frac{25}{3}$ or $8\frac{1}{3}$ or $8.\dot{3}$ or $\frac{100}{12}$	A1
	$x^2-\frac{5}{4}x+\frac{25}{3}=0$	Applies $x^2-(\text{sum})x+\text{product}$ (can be implied), where sum and product are numerical values. **Note:** "$=0$" is not required for this mark	M1
	$12x^2-15x+100=0$	***Any integer multiple*** of $12x^2-15x+100=0$, including the "$=0$"	A1 **cso**
			(6)
			9

Question 6 Notes

6. (a)	**Note**	Writing down $\alpha, \beta=\frac{3+\sqrt{183}\,\mathrm{i}}{24}, \frac{3-\sqrt{183}\,\mathrm{i}}{24}$ and then stating $\alpha+\beta=\frac{1}{4}$, $\alpha\beta=\frac{1}{3}$ **or** applying $\alpha+\beta=\frac{3+\sqrt{183}\,\mathrm{i}}{24}+\frac{3-\sqrt{183}\,\mathrm{i}}{24}=\frac{1}{4}$ and $\alpha\beta=\left(\frac{3+\sqrt{183}\,\mathrm{i}}{24}\right)\left(\frac{3-\sqrt{183}\,\mathrm{i}}{24}\right)=\frac{1}{3}$ scores B0
	Note	Those candidates who then apply $\alpha+\beta=\frac{4}{5}$, $\alpha\beta=\frac{3}{5}$, having written down/applied $\alpha, \beta=\frac{3+\sqrt{183}\,\mathrm{i}}{24}, \frac{3-\sqrt{183}\,\mathrm{i}}{24}$, can only score the M mark in part (a) for $\frac{2}{\alpha}+\frac{2}{\beta}=\frac{2\beta+2\alpha}{\alpha\beta}$
	Note	Give B0 M0 A0 for $\frac{2}{\alpha}+\frac{2}{\beta}=\frac{2}{\left(\frac{3+\sqrt{183}\,\mathrm{i}}{24}\right)}+\frac{2}{\left(\frac{3-\sqrt{183}\,\mathrm{i}}{24}\right)}=\frac{3}{2}$

	Question 6 Notes Continued	
6. (a)	**Note**	Give B0 M1 A0 for $\frac{2}{\alpha}+\frac{2}{\beta}=\frac{2\beta+2\alpha}{\alpha\beta}=\frac{2\left(\frac{3-\sqrt{183}\,\mathrm{i}}{24}\right)+2\left(\frac{3+\sqrt{183}\,\mathrm{i}}{24}\right)}{\left(\frac{3+\sqrt{183}\,\mathrm{i}}{24}\right)\left(\frac{3-\sqrt{183}\,\mathrm{i}}{24}\right)}=\frac{3}{2}$
	Note	Allow B1 for both $\mathrm{S}=\frac{1}{4}$ **and** $\mathrm{P}=\frac{1}{3}$ or for both $\sum=\frac{1}{4}$ **and** $\prod=\frac{1}{3}$
(b)	**Note**	A correct method leading to $a=12,\ b=-15,\ c=100$ without writing a final answer of $12x^2-15x+100=0$ is final M1A0
	Note	Using $\frac{3+\sqrt{183}\,\mathrm{i}}{24},\frac{3-\sqrt{183}\,\mathrm{i}}{24}$ ***explicitly*** to find the sum and product of $\left(\frac{2}{\alpha}-\beta\right)$ and $\left(\frac{2}{\beta}-\alpha\right)$ to give $x^2-\frac{5}{4}x+\frac{25}{3}=0\Rightarrow 12x^2-15x+100=0$ scores M0 A0 M0 A0 M1A0 in part (b)
	Note	Using $\frac{3+\sqrt{183}\,\mathrm{i}}{24},\frac{3-\sqrt{183}\,\mathrm{i}}{24}$ to find $\alpha+\beta=\frac{1}{4},\ \alpha\beta=\frac{1}{3},\ \frac{2}{\alpha}+\frac{2}{\beta}=\frac{3}{2}$ **and applying** $\left\{\alpha+\beta=\frac{1}{4},\right\}\ \alpha\beta=\frac{1}{3},\ \frac{2}{\alpha}+\frac{2}{\beta}=\frac{3}{2}$ can potentially score full marks in part (b). E.g. Score M1 A1 M1 A1 M1 A1 for • Sum = $=\frac{2}{\alpha}-\beta+\frac{2}{\beta}-\alpha=\frac{2}{\alpha}+\frac{2}{\beta}-(\alpha+\beta)=\frac{3}{2}-\frac{1}{4}=\frac{5}{4}$ • Product = $\left(\frac{2}{\alpha}-\beta\right)\left(\frac{2}{\beta}-\alpha\right)=\frac{4}{\alpha\beta}-2-2+\alpha\beta=\frac{4}{\left(\frac{1}{3}\right)}-2-2+\frac{1}{3}=\frac{25}{3}$ • $x^2-\frac{5}{4}x+\frac{25}{3}=0\Rightarrow 12x^2-15x+100=0$
	Note	**<u>Alternative method for finding the sum</u>** Sum = $\frac{2}{\alpha}-\beta+\frac{2}{\beta}-\alpha=\frac{2\beta-\alpha\beta^2+2\alpha-\alpha^2\beta}{\alpha\beta}=\frac{2(\alpha+\beta)-\alpha\beta(\beta+\alpha)}{\alpha\beta}$ $=\frac{2(\frac{1}{4})-(\frac{1}{3})(\frac{1}{4})}{(\frac{1}{3})}=\frac{\frac{1}{2}-\frac{1}{12}}{\frac{1}{3}}=\frac{\frac{5}{12}}{\frac{1}{3}}=\frac{15}{12}=\frac{5}{4}$
	Note	**<u>Alternative method for finding the product</u>** Product = $\left(\frac{2}{\alpha}-\beta\right)\left(\frac{2}{\beta}-\alpha\right)$ $=\frac{(\alpha\beta-2)^2}{\alpha\beta}=\frac{((\frac{1}{3})-2)^2}{(\frac{1}{3})}$ $=\frac{\frac{25}{9}}{(\frac{1}{3})}=\frac{25}{3}$
		Expands $\left(\frac{2}{\alpha}-\beta\right)\left(\frac{2}{\beta}-\alpha\right)$ to give $\frac{(\alpha\beta-2)^2}{\alpha\beta}$ and uses their $\alpha\beta$ at least once in an attempt to find a **numerical value** for the product of $\left(\frac{2}{\alpha}-\beta\right)$ and $\left(\frac{2}{\beta}-\alpha\right)$ — M1
		Correct product of $\frac{25}{3}$ or $8\frac{1}{3}$ or $8.\dot{3}$ — A1