Question	Scheme	Marks	AOs
2.	$\{w = x + 3 \Rightarrow\}\ x = w - 3$	B1	3.1a
	$2(w-3)^3 + 6(w-3)^2 - 3(w-3) + 12\ (= 0)$	M1	1.1b
	$2w^3 - 18w^2 + 54w - 54 + 6(w^2 - 6w + 9) - 3w + 9 + 12 (= 0)$		
	$2w^3 - 12w^2 + 15w + 21 = 0$	M1	3.1a
		A1	1.1b
	(So $p = 2$, $q = -12$, $r = 15$ and $s = 21$)	A1	1.1b
		(5)	
ALT 1	$\alpha + \beta + \gamma = -\frac{6}{2} = -3,\ \alpha\beta + \beta\gamma + \alpha\gamma = -\frac{3}{2},\ \alpha\beta\gamma = -\frac{12}{2} = -6$	B1	3.1a
	sum roots $= \alpha + 3 + \beta + 3 + \gamma + 3$	M1	3.1a
	$= \alpha + \beta + \gamma + 9 = -3 + 9 = 6$		
	pair sum $= (\alpha+3)(\beta+3) + (\alpha+3)(\gamma+3) + (\beta+3)(\gamma+3)$		
	$= \alpha\beta + \alpha\gamma + \beta\gamma + 6(\alpha+\beta+\gamma) + 27$		
	$= -\frac{3}{2} + 6 \times -3 + 27 = \frac{15}{2}$		
	product $= (\alpha + 3)(\beta + 3)(\gamma + 3)$		
	$= \alpha\beta\gamma + 3(\alpha\beta + \alpha\gamma + \beta\gamma) + 9(\alpha+\beta+\gamma) + 27$		
	$= -6 + 3 \times -\frac{3}{2} + 9 \times -3 + 27 = -\frac{21}{2}$		
	$w^3 - 6w^2 + \frac{15}{2}w - \left(-\frac{21}{2}\right)\ (= 0)$	M1	1.1b
	$2w^3 - 12w^2 + 15w + 21 = 0$	A1	1.1b
	(So $p = 2$, $q = -12$, $r = 15$ and $s = 21$)	A1	1.1b
		(5)	
			(5 marks)

Notes

	B1	Selects the method of making a connection between x and w by writing $x = w - 3$
	M1	Applies the process of substituting their $x = aw \pm b$ into $2x^3 + 6x^2 - 3x + 12\ (= 0)$ So accept e.g. if $x = \frac{w}{3}$ is used.
	M1	Depends on having attempted substituting either $x = w - 3$ or $x = w + 3$ into the equation. This mark is for manipulating their resulting equation into the form $pw^3 + qw^2 + rw + s\ (= 0)$ ($p \neq 0$). The "= 0" may be implied for this.
See note	**A1**	At least three of p, q, r and s are correct in an equation with integer coefficients. (need not have "= 0")
	A1	Correct final equation, including "=0". Accept integer multiples.
ALT 1	**B1**	Selects the method of giving three correct equations each containing α, β and γ.
	M1	Applies the process of finding sum roots, pair sum and product.
	M1	Applies $w^3 - (\text{their sum roots})w^2 + (\text{their pair sum})w - (\text{their product})\ (= 0)$ Must be correct identities, but if quoted allow slips in substitution, but the "=0" may be implied.
See note	**A1**	At least three of p, q, r and s are correct in an equation with integer coefficients. (need not have "=0")
	A1	Correct final equation, including "=0". Accept multiples with integer coefficients.

Note: may use another variable than w for the first four marks, but the final equation must be in terms of w

Notes: Do not isw the final two A marks – if subsequent division by 2 occurs then mark the final answer.