Question Number	Scheme	Notes	Marks
6(a)	area of $R = \frac{1}{2}\int_0^{\pi} r^2 \mathrm{d}\theta = \frac{1}{2}\int_0^{\pi} \left(k - 2\cos\theta\right)^2 \mathrm{d}\theta = \frac{1}{2}\int_0^{\pi} \left(k^2 - 4k\cos\theta + 4\cos^2\theta\right)\mathrm{d}\theta$		**M1**
	$= \frac{1}{2}\int_0^{\pi} \left(k^2 - 4k\cos\theta + 4\left(\frac{1}{2}\cos 2\theta + \frac{1}{2}\right)\right)\mathrm{d}\theta$	Uses $\cos^2\theta = \pm\frac{1}{2}\cos 2\theta \pm \frac{1}{2}$	**M1**
	$= \frac{1}{2}\int_0^{\pi} \left(k^2 + 2 - 4k\cos\theta + 2\cos 2\theta\right)\mathrm{d}\theta$ $= \frac{1}{2}\left[\left(k^2+2\right)\theta - 4k\sin\theta + \sin 2\theta\right]_0^{\pi}$	Integrates to obtain expression of the correct form	**M1**
	$\frac{1}{2}\left(k^2+2\right)\pi = \left(4+\sqrt{5}\right)\pi$ $k^2 + 2 = 8 + 2\sqrt{5} \Rightarrow k^2 = 6 + 2\sqrt{5}$ *	Reaches $k^2 = 6 + 2\sqrt{5}$ with sufficient work and no errors seen	**A1***
			(4)
(b)	$x = r\cos\theta \Rightarrow x = \left(1+\sqrt{5}\right)\cos\theta - 2\cos^2\theta$	Uses $x = r\cos\theta$	**M1**
	$\frac{\mathrm{d}x}{\mathrm{d}\theta} = -\left(1+\sqrt{5}\right)\sin\theta + 4\cos\theta\sin\theta$	Differentiates to the correct form (oe)	**M1**
	$\sin\theta\left(4\cos\theta - \left(1+\sqrt{5}\right)\right) = 0 \Rightarrow \cos\theta = \frac{1+\sqrt{5}}{4}$	Sets = 0 and solves to obtain a valid value for $\cos\theta$ consistent with their derivative (oe).	**ddM1**
	$\theta = \frac{\pi}{5}$	Correct value for θ. Allow awrt 0.628	**A1**
	$\left\{r = 1 + \sqrt{5} - \frac{1}{2} - \frac{1}{2}\sqrt{5} \Rightarrow\right\}$ $r = \frac{1}{2} + \frac{1}{2}\sqrt{5}$ or $\frac{1}{2}\left(1+\sqrt{5}\right)$	Correct exact value for r or awrt 1.62 and no others points.	**A1**
			(5)
			Total 9

Further notes

(a)

M1: Uses $\frac{1}{2}\int r^2 \mathrm{d}\theta$ and expands to expression of the correct form. Condone missing the middle k

2nd M: Applies a suitable attempt at the double angle formula to the integrand (may be in separate working) to achieve an integrable form. Does not have to be within integrand.

Final A: Sufficient working must be shown. There must be a step with the substitution of limits carried out (allow bottom limit zero to be implied) and trig terms evaluated (allow if the sine terms are not seen), set equal to the given area and either expansion or cancellation of π before the final answer. Watch out for cases where the k is missing in the middle term of expansion, which score 1110.

(b)

First M Must be applied to curve, so r must be substituted, but allow with use of k rather than a value or awrt 3.23. Condone a copy error when substituting for r.

Second M Allow attempts to differentiate either $x = r\cos\theta$ or $y = r\sin\theta$ for this mark. Form of derivative must be correct in either case. For $x = r\cos\theta$ may get $A\sin\theta + B\sin 2\theta$. For $y = r\sin\theta$ they should get $\frac{\mathrm{d}y}{\mathrm{d}\theta} = A\cos\theta + B\cos 2\theta$ or $A\cos\theta + B(\cos^2\theta \pm \sin^2\theta)$ (oe). May use k or awrt 3.23 for k.

ddM Must have scored both previous M marks, so must be using $x = r\cos\theta$. Value found should be consistent up to sign errors when rearranging with their derivative. May be in terms of k.

Note they e.g. may use double angle formula to get $\cos 2\theta = \frac{2\sqrt{5}-2}{8}$ – allow up to sign error as before.

A marks, accept answers rounding to 3 s.f. or alternative exact forms. Accept $\frac{1}{2}\sqrt{6+2\sqrt{5}}$ for r