Question Number	Scheme	Notes	Marks
6(a)	$\frac{\mathrm{d}x}{\mathrm{d}\theta}=\begin{cases}a(1-\cos\theta)\\ \text{or}\\ a-a\cos\theta\end{cases}$ **or** $\frac{\mathrm{d}y}{\mathrm{d}\theta}=a\sin\theta$	At least **one** correct derivative	B1
	$a^2(1-\cos\theta)^2+(a\sin\theta)^2$ $=a^2(1-2\cos\theta+\cos^2\theta+\sin^2\theta)$ $=2a^2(1-\cos\theta)$	Squares and adds their derivatives and uses $\cos^2\theta+\sin^2\theta=1$ to obtain an expression in $\cos\theta$ only (not $\cos^2\theta$) Could be implied	M1
	$=2a^2\left(1-\left(1-2\sin^2\left(\frac{\theta}{2}\right)\right)\right)=4a^2\sin^2\frac{\theta}{2}$	**d**M1: Replaces $\cos\theta$ with ±1 $\pm2\sin^2\frac{\theta}{2}$ or equivalent trig work (sign errors only on identities) to obtain an expression in $\sin^2\frac{\theta}{2}$ only **Requires previous M mark.** Can be implied. A1: Achieves $4a^2\sin^2\frac{\theta}{2}$ or $k = 4$ from correct work	**d**M1 A1
			(4)
(b)	S.A. $=(2\pi)\int y\sqrt{\left\{\left(\frac{\mathrm{d}x}{\mathrm{d}\theta}\right)^2+\left(\frac{\mathrm{d}y}{\mathrm{d}\theta}\right)^2\right\}}\,\mathrm{d}\theta$ $=(2\pi)\int_{(0)}^{(2\pi)}a(1-\cos\theta)\left(2a\sin\frac{\theta}{2}\right)\mathrm{d}\theta$	Applies $y\sqrt{\left\{\left(\frac{\mathrm{d}x}{\mathrm{d}\theta}\right)^2+\left(\frac{\mathrm{d}y}{\mathrm{d}\theta}\right)^2\right\}}$ with their $ka^2\sin^2\frac{\theta}{2}$ and square roots. The result of the square root may be incorrect but must be of the form $p\sin\frac{\theta}{2}$ Allow a slip replacing y but they must not have used x, $\frac{\mathrm{d}x}{\mathrm{d}\theta}$ or $\frac{\mathrm{d}y}{\mathrm{d}\theta}$ for y Allow the letter k or an invented value. 2π may be absent or wrong. Integral not required.	M1
	$=(2\pi)2a^2\int_{(0)}^{(2\pi)}\left(\sin\frac{\theta}{2}-\sin\frac{\theta}{2}\cos\theta\right)\mathrm{d}\theta$ $\Rightarrow(2\pi)2a^2\int_{(0)}^{(2\pi)}\left(\sin\frac{\theta}{2}-\sin\frac{\theta}{2}\left(2\cos^2\frac{\theta}{2}-1\right)\right)\mathrm{d}\theta$ or e.g., $\Rightarrow(2\pi)2a^2\int_{(0)}^{(2\pi)}2\sin^3\frac{\theta}{2}\,\mathrm{d}\theta$	Uses trig identity/identities (condoning sign errors) to obtain an expression with arguments of $\frac{\theta}{2}$ only. Allow the letter k or an invented value. 2π may be absent or wrong. Integral not required. **Dependent on previous M mark.**	**d**M1
	Scheme continues...		

Question Number	Scheme	Notes	Marks
6(b) **cont.**	$\left(=(2\pi)4a^2\int_{(0)}^{(2\pi)}\left(\sin\frac{\theta}{2}-\sin\frac{\theta}{2}\cos^2\frac{\theta}{2}\right)\mathrm{d}\theta\right)$ $S=8\pi a^2\left[-2\cos\frac{\theta}{2}+\frac{2}{3}\cos^3\frac{\theta}{2}\right]_{(0)}^{(2\pi)}$ or e.g., $\pi a^2\left[-16\cos\frac{\theta}{2}+\frac{16}{3}\cos^3\frac{\theta}{2}\right]_{(0)}^{(2\pi)}$	A correct expression for the surface area ignoring limits ft their numerical *k*, i.e., $S=2k\pi a^2\left[-2\cos\frac{\theta}{2}+\frac{2}{3}\cos^3\frac{\theta}{2}\right]_{(0)}^{(2\pi)}$ oe If they integrate in a piecemeal fashion, award this mark if they have a correct expression for their *k* when integration is completed – any partial evaluations must be correct for their *k*	A1ft
	$=8\pi a^2\left[\left(-2\cos\frac{2\pi}{2}+\frac{2}{3}\cos^3\frac{2\pi}{2}\right)-\left(-2\cos 0+\frac{2}{3}\cos^3 0\right)\right]$	Substitutes correct limits and attempts to subtract either way round following a completed attempt at integration with a numerical *k*. **Requires previous M marks** and must have used 2π. Look for evidence of correct limit substitution and subtraction. There may be slips but insist on limits being applied on all integrations if they have been carried out separately. Algebraic results of integration must be seen	**dd**M1
	$=\frac{64}{3}\pi a^2$	Correct exact answer. Accept equivalent fractions.	A1
	All marks available regardless of how *k* = 4 was obtained		**(5)**
			Total 9
	Other integration methods: Allow the second M mark to be available before any attempt at integration is made. Otherwise the second M is only awarded if they **complete** integration without any loss of the required forms (i.e., sign and coefficient errors only and just sign errors only with any trig identities). The first A (ft) mark is for a fully correct expression ignoring limits for their *k*. The last two marks are the same as the main scheme. For information: Applying parts to $\int\sin\frac{\theta}{2}\cos\theta\,\mathrm{d}\theta$ gives $\frac{2}{3}\left(\cos\frac{\theta}{2}+2\sin\frac{\theta}{2}\right)$ Using addition formulae: $\int\sin\frac{\theta}{2}\cos\theta\,\mathrm{d}\theta=\frac{1}{2}\int\left(\sin\frac{3\theta}{2}-\sin\frac{\theta}{2}\right)\mathrm{d}\theta=\frac{1}{2}\left(2\cos\frac{\theta}{2}-\frac{2}{3}\cos\frac{3\theta}{2}\right)$		