Question	Scheme	Marks	AOs
13(a)	$(V=)\pi r^2 h = 400$	B1	1.1b
	$A = 2\pi r^2 + 2\pi rh$	B1	1.1b
	$h = \dfrac{400}{\pi r^2} \Rightarrow A = 2\pi r^2 + 2\pi r\left(\dfrac{400}{\pi r^2}\right)$	M1	1.1b
	$A = 2\pi r^2 + \dfrac{800}{r}$ *	A1*	1.1b
		(4)	
(b)	Attempts to differentiate $A = 2\pi r^2 + \dfrac{800}{r}$ with respect to r $\dfrac{dA}{dr} = 4\pi r - 800r^{-2}$	M1 A1	3.1b 1.1b
	Sets $\dfrac{dA}{dr} = 0 \Rightarrow r^3 = \dfrac{200}{\pi}$	dM1	1.1b
	$\Rightarrow r = \sqrt[3]{\dfrac{200}{\pi}}$ (cm)	A1	1.1b
		(4)	
(c)	Finds $\dfrac{d^2A}{dr^2} = 4\pi + 1600r^{-3}$ at $r = \sqrt[3]{\dfrac{200}{\pi}}$	M1	1.1b
	$\dfrac{d^2A}{dr^2} = (+37.7) > 0$ hence minimum (surface area).	A1ft	2.4
		(2)	
(d)	Substitutes $r = \sqrt[3]{\dfrac{200}{\pi}}$ in $A = 2\pi r^2 + \dfrac{800}{r}$	M1	1.1b
	Minimum surface area = awrt 301 (cm^2)	A1ft	1.1b
		(2)	
			(12 marks)

Notes:

(a)

B1: Correct equation for volume: $\pi r^2 h = 400$

B1: Correct formula for surface area in terms of the radius and height: $A = 2\pi r^2 + 2\pi rh$

M1: Rearranges $\pi r^2 h = 400$ to $h = \dfrac{400}{\pi r^2}$ and substitutes in to h in their formula for the surface area

A1*: cso.

(b)

M1: Attempts to differentiate $A = 2\pi r^2 + \frac{800}{r}$ with respect to r. Look for $\left(\frac{\mathrm{d}A}{\mathrm{d}r} =\right) \ldots r \pm \ldots r^{-2}$

A1: $\left(\frac{\mathrm{d}A}{\mathrm{d}r} =\right) 4\pi r - 800r^{-2}$ Condone $\frac{\mathrm{d}A}{\mathrm{d}r}$ appearing as $\frac{\mathrm{d}y}{\mathrm{d}x}$ or being absent.

dM1: Sets their $\frac{\mathrm{d}A}{\mathrm{d}r} = 0$ and arrives at $r^3 = k, k > 0$. $\frac{\mathrm{d}A}{\mathrm{d}r}$ must have been of the form $\ldots r \pm \ldots r^{-2}$

A1: $r = \sqrt[3]{\frac{200}{\pi}}$ or exact equivalent. Condone omission of units or use of incorrect units. Note $r = 3.99$ to s.f.

(c)

M1: Finds $\frac{\mathrm{d}^2 A}{\mathrm{d}r^2}$ following on from their $\frac{\mathrm{d}A}{\mathrm{d}r}$ (which must be of equivalent difficulty) and attempts to find its value or sign at their r

A1ft: $\frac{\mathrm{d}^2 A}{\mathrm{d}r^2} = (+37.7) > 0$ hence minimum (surface area).

Alternatively, $\frac{\mathrm{d}^2 A}{\mathrm{d}r^2} = 4\pi + 1600r^{-3} > 0$ as +ve + +ve > 0 as $r > 0$.

Requires a correct calculation or expression, a correct statement, and a correct conclusion.

Follow through on their r ($r > 0$) and their $\frac{\mathrm{d}^2 A}{\mathrm{d}r^2}$.

$\frac{\mathrm{d}^2 A}{\mathrm{d}r^2}$ must be used for this mark to meet the demand of the question.

(d)

M1: For a correct method for finding $A =$ from their solution to $\frac{\mathrm{d}A}{\mathrm{d}r} = 0$

May be implied by correct final answer. Do not accept attempts using negative values of r.

A1ft: Minimum surface area = awrt 301 (cm^2) Condone omission of units or use of incorrect units.