| Question Number | Scheme | Marks |
|---|---|---|
| **2(a)** | $(S=)\ 6x^2+6xh+2xh$ | B1 |
| | eg $V=3x^2h=972\Rightarrow h=\dfrac{972}{3x^2}$ or eg $hx=\dfrac{324}{x}$<br>$\Rightarrow (S=)\ 6x^2+8x\left(\dfrac{972}{3x^2}\right)$ or $\Rightarrow (S=)\ 6x^2+8\left(\dfrac{324}{x}\right)$ | M1 |
| | $S=6x^2+\dfrac{2592}{x}$* | A1* |
| | | **(3)** |
| **(b)** | $\left(\dfrac{\mathrm{d}S}{\mathrm{d}x}=\right)12x-\dfrac{2592}{x^2}$ | B1 |
| | | **(1)** |
| **(c)** | $12x-\dfrac{2592}{x^2}=0\Rightarrow 12x^3=2592$<br>$\Rightarrow x=\sqrt[3]{\dfrac{2592}{12}}$ | M1 |
| | $x=6$ | A1 |
| | | **(2)** |
| **(d)** | $\left(\dfrac{\mathrm{d}^2S}{\mathrm{d}x^2}=\right)12+\dfrac{5184}{x^3}$ | B1ft |
| | $\dfrac{\mathrm{d}^2S}{\mathrm{d}x^2}>0$ when $x=6$ so minimum | B1 |
| | | **(2)** |
| **(e)** | $S=6(6)^2+\dfrac{2592}{6}=648\ (\mathrm{cm}^2)$ | B1 |
| | | **(1)** |
| | | **Total 9** |

**(a)**

B1 Correct expression for the surface area in any form.
It may be implied by a correct expression for the surface area in terms of $x$ which is not the given answer.
Once a correct expression is seen then award B1.

M1 Uses the given volume in a dimensionally correct formula to obtain $h$ or $hx$ in terms of $x$ and substitutes into their expression for $S$ of the form $...xh+...x^2$ or equivalent e.g. $...xh+...xh+...x^2$
It may be implied by a correct expression for the surface area in terms of $x$ which is not the given answer.

A1* Achieves the given answer with no errors including bracketing omissions.
As a minimum you must see:

- the separate equation for the volume
- a substitution before seeing the $\dfrac{2592}{x}$ term
- $S=$ in their solution at some point (or e.g. SA = or surface area = or Area=)

Examples:

e.g. $6x^2+6x\left(\frac{324}{x^2}\right)+2x\left(\frac{324}{x^2}\right)$ scores B1M1A0

e.g. $6x^2+8x\left(\frac{972}{3x^2}\right)\Rightarrow S=6x^2+\frac{2592}{x}$ scores B1M1A0 (does not write a separate equation for the volume)

e.g. $3x^2h=972\Rightarrow S=6x^2+6x\left(\frac{324}{x^2}\right)+2x\left(\frac{324}{x^2}\right)$

$=6x^2+\frac{2592}{x}$

scores B1M1A1 (separate equation for the volume, a substitution before seeing the $\frac{2592}{x}$ term and $S$ = seen in their solution at some point.

**(b) Mark (b), (c), (d) and (e) altogether**

B1 $\left(\frac{\mathrm{d}S}{\mathrm{d}x}=\right)12x-\frac{2592}{x^2}$ in any form eg $12x-2592x^{-2}$

**(c)**

M1 Starts from a derivative of the form $Ax-Bx^{-2}$ oe, sets equal to 0 (seen or implied) where $A\times B>0$, and solves via a correct method to find an expression or value for $x=\sqrt[3]{\frac{B}{A}}$ (you may need to check this)

$\sqrt[3]{\frac{2592}{12}}$ scores M1.

Stating 6 without a **correct derivative from (b)** is M0.

M1 6 cao with no incorrect working seen in their method. Withhold this mark if $\pm 6$ seen

Minimum acceptable for full marks is $12x-\frac{2592}{x^2}=0\Rightarrow x=6$

**Note this final mark is only possible from a correct derivative**

**(**Beware of incorrect derivatives leading to the correct value of $x$ e.g. $6x-\frac{1296}{x^2}=0\Rightarrow x=6$ )

**(d)**

B1ft Correct second derivative. Follow through their first derivative of the form $Ax-Bx^{-2}$ so award for $A+\frac{2B}{x^3}$ or equivalent.

B1 Fully correct justification with a conclusion (or preamble with eg tick/QED etc) following fully correct work to find $\frac{\mathrm{d}^2S}{\mathrm{d}x^2}$. They must either:

- substitute $x=6$ into $12+\frac{5184}{x^3}$ (if evaluated achieving 36) and state e.g. $(36)>0$ oe **hence minimum**

- justifiy that as $x > 0$ or $x = 6$ then $12 + \frac{5184}{x^3} > 0$ (or $\frac{\mathrm{d}^2S}{\mathrm{d}x^2} > 0$) **hence minimum**.

**Note this final mark is only possible if $x = 6$ is found correctly in (c) from a correct derivative.**

**(e)**

B1 648 $\text{cm}^2$ (condone lack of units/incorrect units) provided this has come from $x = 6$

Note e.g. $x = -12$ leading to 648 is B0

| Question Number | Scheme | Marks |
|---|---|---|
| **3(a)** | $\left(2+\frac{kx}{8}\right)^7 = 2^7 + \binom{7}{1}2^6\left(\frac{kx}{8}\right) + \binom{7}{2}2^5\left(\frac{kx}{8}\right)^2 + \binom{7}{3}2^4\left(\frac{kx}{8}\right)^3 + ...$ | M1 |
| | $= 128 + 56kx + \frac{21}{2}k^2x^2 + \frac{35}{32}k^3x^3 + ...$ | B1A1A1 |
| | | **(4)** |
| **(b)** | $\frac{35}{32}k^3 - \frac{21}{2}k^2 = \frac{21}{2}k^2 - 56k$ | M1 |
| | $5k^2 - 96k + 256 = 0 \Rightarrow k = ...$ | dM1 |
| | $k = 16, \frac{16}{5}$ | A1 |
| | | **(3)** |
| | | **Total 7** |

**(a)**

M1 Attempts the binomial expansion **up to at least the third term** with an acceptable structure for either the **3rd or 4th term**. The correct binomial coefficient (allowing alternative notation) must be combined with the correct power of *x* and the correct power of 2 (oe) but condone if brackets are missing. Condone errors on the first or second term.
M0 for descending powers.
Alternatively writes e.g. $\left(2+\frac{kx}{8}\right)^7 = 2^7\left(1+\frac{kx}{16}\right)^7 = 2^7\left(1+\frac{7}{16}kx+\frac{7\times6}{2}\left(\frac{kx}{16}\right)^2+\frac{7\times6\times5}{6}\left(\frac{kx}{16}\right)^3\right)$ which can also score M1 for the expansion up to at least the third term with an acceptable structure for either the **3rd or 4th term**. They do not have to multiply out the brackets for this mark but the $2^7$ cannot be omitted unless it is later recovered. Condone errors on the first or second term.
Condone missing brackets.

B1 $128+56kx$. May be listed but must be simplified. Allow $128\left(1+\frac{7}{16}kx+...\right)$ if the $2^7$ is taken out first.

A1 $\frac{21}{2}k^2x^2$ **or** $\frac{35}{32}k^3x^3$. May be listed, **does not need to be simplified**, but the binomial coefficients must be numerical. Accept $\frac{21}{2}(kx)^2$ **or** $\frac{35}{32}(kx)^3$ oe e.g. $10.5(kx)^2$ or $1.09375(kx)^3$ for this mark only. Common acceptable terms seen are $\frac{672}{64}(kx)^2$, $\frac{560}{512}(kx)^3$

A1 $\frac{21}{2}k^2x^2$ **and** $\frac{35}{32}k^3x^3$ or exact simplified equivalent e.g. $10.5k^2x^2$ **and** $1.09375k^3x^3$. May be listed but must have $k^nx^n$ terms.

**Note:** isw after correct terms are seen if they try to divide or multiply through or set = 0

**(b)**