Question	Scheme	Marks	AOs
12(a)	(Surface area $=$) $2xy+\frac{\pi x^2}{4}$	B1	1.1b
	$2xy+\frac{\pi x^2}{4}=100 \Rightarrow y=\frac{400-\pi x^2}{8x}=\frac{50}{x}-\frac{\pi x}{8}$	M1	3.4
	$\left(P=\right) 2x+4y+\frac{2\pi x}{4}$	B1	1.1b
	$\left(P=\right) 2x+4\left(\frac{400-\pi x^2}{8x}\right)+\frac{2\pi x}{4}$	M1	3.4
	$P=2x+\frac{200}{x}$ *	A1*	2.1
		(5)	
(b)	$\left(\frac{\mathrm{d}P}{\mathrm{d}x}=\right)\ 2-200x^{-2}$	M1 A1	1.1b 1.1b
	$2-200x^{-2}=0 \Rightarrow x=...$	dM1	3.1b
	$x=10$	A1	1.1b
		(4)	
(c)	$\left(\frac{\mathrm{d}^2P}{\mathrm{d}x^2}=\right)"400"x^{-3} \Rightarrow "400"\times 10^{-3}>0$	M1	1.1b
	e.g. $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}(=0.4)>0$ hence minimum (perimeter)	A1	2.4
		(2)	
(d)	e.g. $y=\frac{400-\pi\times"10"^2}{8\times"10"}$	M1	3.4
	e.g. $y=1.07$ (m) so yes this would be suitable	A1	2.2a
		(2)	
			(13 marks)

Notes

(a) **Note that different sections of the perimeter may be completed separately and brought together in a final line. Most marks will only be scored at this point – send to review if unsure.**

B1: Correct expression for the surface area in terms of x and y only (may be in an equivalent form). May be implied by their equation set equal to 100 or their rearranged form.

M1: Sets their expression in x and y equal to 100 and rearranges to make y (or $2y$ or $4y$) the subject. Do not be concerned by the mechanics of their rearrangement. May be implied by further work or can be scored for a different valid substitution into their expression for the perimeter.

B1: Correct expression for the perimeter in terms of x and y (may be in an equivalent form) and may be implied by an expression for the perimeter in terms of x if they have substituted in for their y straight away (which may be incorrect or have been rearranged incorrectly)

M1: Attempts to substitute their y into their perimeter to produce an expression or equation in just x. Condone invisible brackets for this mark. Condone slips provided the intention is clear.

A1*: $P = 2x + \frac{200}{x}$ cso (Condone the omission of $P =$ on the final line if it is seen on an earlier line of working) Allow Perimeter =
Do not withhold this mark if missing/invisible brackets are recovered in their working.

(b)

M1: Attempts to differentiate the given expression for *P* achieving an answer of the form $A \pm Bx^{-2}$
Condone candidates who do not achieve the given answer but their derivative differentiates to the required form to score this mark (and possibly dM1)

A1: $2 - 200x^{-2}$ o.e.

dM1: Sets their derivative of the form $A - Bx^{-2}$, $A \times B > 0$ equal to 0 and rearranges to find a value for *x*. It is dependent on the previous method mark. Condone slips in their rearrangement. May proceed directly to the answer.

A1: 10 cao (provided a correct derivative is seen) ± 10 is A0 isw if they attempt to find *P*

(c) Note that attempts only evaluating the gradient either side of $x = 10$ is M0A0

M1: Finds $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}$ of the form Ax^{-3} o.e. and either considers the sign or evaluates for their positive *x*

A1: Requires

- $\left(\frac{\mathrm{d}^2P}{\mathrm{d}x^2} =\right) 400x^{-3}$ (condone this mark if $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ is written or any other incorrect notation)
- reference to $400x^{-3}$ being > 0 for $x > 0$, or by using either a correct calculation (0.4 o.e.), a correct numerical expression or the algebraic expression and referencing that it is > 0 for $x = 10$
- correct conclusion e.g. hence min, shown, tick, QED
  Condone "minimum value of *x*"

(d)

M1: Either

- substitutes their value of *x* into any of their equations involving *y* or their expression for *y* from part (a) (unless restarted) to find a value for *y*
- uses their value of *x* to find their minimum value of *P* using the given expression for *P*, and then uses their *x* and their *P* to find a value for *y*
- attempts to find the value of *x* when $y = 1$ (allow to be solved directly from a calculator once a three-term quadratic has been formed)
- attempts to find the value of *P* using the given expression for *P*, their value for *x* and $y = 1$

Condone slips provided the intention is clear of their intended method.

A1: awrt 1.1 m and concludes would be suitable (yes is sufficient or a tick)
Note that "yes suitable because e.g. $1.07 > 0$ is A0" (it had to be greater than 1)

If they find the value for *x* when $y = 1$ it requires a correct comparison of awrt 10.1 with 10 so yes suitable

If they find the value of *P* using $x = 10$ and $y = 1$ it requires a correct comparison of awrt 39.7 with 40 so yes suitable