Question	Scheme	Marks
3(a)	$675 = \dfrac{\theta r^2}{2} \Rightarrow \theta = \dfrac{675\times 2}{r^2} = \dfrac{1350}{r^2}$	M1
	$P = 2r + r\theta \Rightarrow P = 2r + r\left(\dfrac{1350}{r^2}\right) \Rightarrow P = 2r + \dfrac{1350}{r}$	M1A1 cso [3]
(b)	$\dfrac{dP}{dr} = 2 - \dfrac{1350}{r^2}$	M1
	$2 - \dfrac{1350}{r^2} = 0 \Rightarrow r = 15\sqrt{3}$ or $\sqrt{675}$	M1A1
	$P = 2\times 15\sqrt{3} + \dfrac{1350}{15\sqrt{3}} = 60\sqrt{3}$	M1A1 [5]
(c)	$\dfrac{d^2P}{dr^2} = \dfrac{2700}{r^3}$ $\quad r > 0 \Rightarrow \dfrac{d^2P}{dr^2} > 0 \Rightarrow$ minimum	M1A1ft [2]
		Total 10 marks

Part	Mark	Notes
(a)	**Note:** Accept any variable for P in this part of the question for the first two M marks **only** , even no variable as long as it is clear it is the perimeter.	
	M1	Applies the **correct** formula for the area of a sector with 675 cm^2 and attempts to rearrange to find an expression for θ, r or $r\theta$ Minimally acceptable expression: $\theta = \dfrac{k}{r^2}, r = \dfrac{k}{\theta r}$ or $\theta r = \dfrac{k}{r}$
	M1	Applies the **correct** formula for the perimeter of a sector and substitutes their expression for θ provided it is as a minimum of the form $\theta = \dfrac{k}{r^2}$ Minimally acceptable expression: $P = 2r + \dfrac{k}{r}$ where k is an integer
	A1	For a fully correct expression for P with no errors seen. You must see $P =$ …….
	ALT – uses the formula $A = \dfrac{1}{2}rS$ where S is the arc length. S is very popular!	
	M1	Applies the **correct** formula for the area of a sector and rearranges to find an expression for S. $675 = \dfrac{rS}{2} \Rightarrow S = \dfrac{1350}{r}$ minimally acceptable $S = \dfrac{k}{r}$
	M1	Applies the correct formula for the perimeter of a sector. $P = 2r + S \Rightarrow P = 2r + \dfrac{1350}{r}$ minimally acceptable $P = 2r + \dfrac{k}{r}$
	A1	For a fully correct expression for P with no errors seen. You must see $P =$ …….

	ALT 2 – works in degrees	
	M1	Applies a **correct** formula for the area of a sector in degrees and attempts to find an expression for θ $675 = \frac{\theta}{360} \times \pi r^2 \Rightarrow \theta = \frac{675 \times 360}{\pi r^2} = \frac{243000}{\pi r^2}$ Min: $\theta = \frac{K}{\pi r^2}$
	M1	Applies a **correct** formula for the perimeter of a sector and substitutes their expression for θ $P = 2r + \frac{\theta}{360} \times 2\pi r\left(\frac{243000}{\pi r^2}\right) \Rightarrow P = 2r + \frac{1350}{r}$ Min: $P = 2r + \frac{K}{r}$ **Do not accept solution with a mix of degrees and radians.**
	A1	For a fully correct expression for P with no errors seen. You must see $P =$ …….
(b)	M1	**NB:** Allow poor notation here, even $\frac{\mathrm{d}y}{\mathrm{d}x}$ or nothing at all. For attempting to differentiate the **given** expression for P The minimally acceptable expression for the derivate is $\frac{\mathrm{d}P}{\mathrm{d}r} = 2 - \frac{Q}{r^2}$ where Q is a **positive** integer.
	M1	For setting their differentiated expression = 0 finding a value for r This is a simple equation to solve. Go through their working checking that it is correct. Do not award this mark for incorrect processing.
	A1	For $r = 15\sqrt{3}$ oe [An approximate value is $r = 25.98$….]
	NB: Award the next 2 marks if they appear in part (b) only	
	M1	For substituting their value for r into the given expression for P Only allow this mark if: • They use the correct r and obtain the correct perimeter. • They use an incorrect r provided it is a positive value and **show explicit substitution**
	A1	For the correct final answer in exact form. There is no follow through here.
(c)	**NB: Award the next two marks if they appear in part (c) only.**	
	M1	Finds the second derivative. The minimally acceptable expression for the second derivative is $\frac{\mathrm{d}^2P}{\mathrm{d}r^2} = \frac{X}{r^3}$ where x is an integer. (The value for $\frac{\mathrm{d}^2P}{\mathrm{d}r^2}$ is awrt 0.15) If they test $\frac{\mathrm{d}P}{\mathrm{d}r}$ around the minimum point – send to Review. If they test P either side – score M0A0
	A1ft	For a correct conclusion. FT their 2nd derivative provided it is of the form $\frac{\mathrm{d}^2P}{\mathrm{d}r^2} = \frac{X}{r^3}$ r must be positive and if they find a value for $\frac{\mathrm{d}^2P}{\mathrm{d}r^2}$ then substitution **must** be seen unless they use $15\sqrt{3}$ and obtain awrt 0.15