Question	Scheme	Marks	AOs
13 (a)	$\sum_{n=1}^{11}\ln(p^n) = \ln p + \ln p^2 + \ln p^3 + \ldots + \ln p^{11}$ $= \ln p + 2\ln p + 3\ln p + \ldots + 11\ln p$ $= \frac{11}{2}(2\ln p + (11-1)\ln p)$ or $\frac{1}{2}(11)(12)\ln p$	M1	3.1a
	$= 66\ln p \qquad \{k = 66\}$	A1	1.1b
		(2)	
(b)	$S = \sum_{n=1}^{11}\ln(8p^n) = \ln 8p + \ln 8p^2 + \ln 8p^3 + \ldots + \ln 8p^{11}$ $= 11\ln 8 + 66\ln p$	M1	1.1b
	e.g. • $11\ln 8 + 66\ln p = 11\ln 2^3 + 66\ln p = 33\ln 2 + 66\ln p$ $= 33(\ln 2 + 2\ln p) = 33(\ln 2 + \ln p^2) = 33\ln(2p^2)$ * • $11\ln 8 + 66\ln p = 11\ln 2^3 + 66\ln p = 33\ln 2 + 66\ln p$ $= \ln(2^{33}p^{66}) = \ln\left((2p^2)^{33}\right) = 33\ln(2p^2)$ *	A1*	2.1
		(2)	
(c)	$S < 0 \Rightarrow 33\ln(2p^2) < 0 \Rightarrow \ln(2p^2) < 0$		
	so either $0 < 2p^2 < 1$ or $2p^2 < 1$	M1	2.2a
	$\Rightarrow p^2 < \frac{1}{2}$ and $p > 0 \Rightarrow 0 < p < \frac{1}{\sqrt{2}}$		
	In set notation, e.g. $\left\{p : 0 < p < \frac{1}{\sqrt{2}}\right\}$	A1	2.5
		(2)	
			(6 marks)

Question 13 Notes:	
(a)	
M1:	Attempts to find $\sum_{n=1}^{11} \ln(p^n)$ by using a complete strategy of • applying the power law of logarithms followed by either • applying the correct formula for the sum to n terms of an arithmetic series • applying the correct formula $\frac{1}{2}n(n+1)\ln p$ • summing the individual terms to give $66\ln p$
A1:	$66\ln p$ from correct working
(b)	
M1:	Deduces S or $\sum_{n=1}^{11} \ln(8p^n) = 11\ln 8 +$ (their answer to part (a))
A1*:	and produces a logical argument to correctly show that $S = 33\ln(2p^2)$ with no errors seen
(c)	
M1:	Applies $S < 0$ to give $\ln(2p^2) < 0$ and deduces {e.g. by considering the graph of $y = \ln x$ } that either • $0 < 2p^2 < 1$ • $2p^2 < 1$
A1:	Correct answer using set notation. E.g. • $\left\{p: 0 < p < \frac{1}{\sqrt{2}}\right\}$ • $\left\{p: 0 < p < \frac{\sqrt{2}}{2}\right\}$ • $\{p: p > 0\} \cap \left\{p: p < \frac{1}{\sqrt{2}}\right\}$ • $\{p: p > 0\} \cap \left\{p: p < \frac{\sqrt{2}}{2}\right\}$