Question	Scheme	Marks	AOs
4(a)(i)	$x^2+y^2+10x-4y+1=0$		
	$(x+5)^2+(y-2)^2$	M1	1.1b
	Centre $(-5,\ 2)$	A1	1.1b
(a)(ii)	Radius is $\sqrt{28}$	A1	1.1b
		(3)	
(b)	$2+2\sqrt{7}$ or $2-2\sqrt{7}$ seen	B1	2.2a
	$2-2\sqrt{7}<k<2+2\sqrt{7}$	M1	1.1b
	$\left\{k:2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ oe	A1	2.5
		(3)	
			(6 marks)

Notes:

Condone mislabelled parts e.g. labelled as (a), (b) and (c) not (a)(i), (a)(ii), (b)

(a)

M1: Attempts to complete the square by halving both x and y terms.
Award for sight of $(x\pm 5)^2\ldots(y\pm 2)^2$ or $(x\pm5)^2$ and $(y\pm2)^2$ seen separately.
May be implied by a centre of $(\pm5,\ \pm2)$

A1: Correct coordinates $(-5,\ 2)$ or e.g. $x=-5$, $y=2$ and condone e.g. $-5,\ 2$

A1: $\sqrt{28}$ $\left(\text{or } 2\sqrt{7}\right)$

(b)

B1: $2+2\sqrt{7}$ **or** $2-2\sqrt{7}$ seen. Accept $\sqrt{28}$ for $2\sqrt{7}$ throughout this question.

M1: $"2-2\sqrt{7}"<k<"2+2\sqrt{7}"$
Selects the inside interval for **their** endpoints which must come from a correct method condoning slips. Condone use of y for k.
May be seen separately e.g. $"2-2\sqrt{7}"<k,\quad k<"2+2\sqrt{7}"$
Condone e.g. $"2-\sqrt{28}"\leqslant k\leqslant"2+\sqrt{28}"$ and allow inexact e.g.
$"-3.291\ldots"<k<"7.291\ldots"$
An incorrect method would include e.g. $5-2\sqrt{7}<k<5+2\sqrt{7}$ ie using the x coordinate of the centre rather than the y coordinate.

A1: Correct answer in exact form in set notation or interval notation in terms of k.
Allow: $\left\{k:2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}\cap\left\{k:k<2+2\sqrt{7}\right\}$ or
$\left\{2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{2-2\sqrt{7}<k\right\}\cap\left\{k<2+2\sqrt{7}\right\}$ or $\left(2-2\sqrt{7},\ 2+2\sqrt{7}\right)$ or
$\left\{k:2-2\sqrt{7}<k\cap k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}$ and $\left\{k:k<2+2\sqrt{7}\right\}$ but **not**
$\left\{2-2\sqrt{7}<k\right\}\cup\left\{k<2+2\sqrt{7}\right\}$ and **not** $\left[2-2\sqrt{7},\ 2+2\sqrt{7}\right]$ and **not**
$\left\{2-2\sqrt{7}\leqslant k\leqslant 2+2\sqrt{7}\right\}$

(b)	**Alternative 1** (substitutes $y=k$ into the given or their circle equation and uses $b^2-4ac=0$ or $b^2-4ac>0$) Scores in the same way following e.g. $x^2+10x+\left(k^2-4k+1\right)=0,\ 10^2-4\left(k^2-4k+1\right)>0,\ 24+4k-k^2=0$
B1:	$2+2\sqrt{7}$ **or** $2-2\sqrt{7}$ seen. Accept $\sqrt{28}$ for $2\sqrt{7}$ throughout this question.
M1:	$"2-2\sqrt{7}"<k<"2+2\sqrt{7}"$ Selects the inside interval for their endpoints which must come from a correct method condoning slips. Condone use of *y* for *k*. May be seen separately e.g. $"2-2\sqrt{7}"<k,\quad k<"2+2\sqrt{7}"$ Condone e.g. $"2-\sqrt{28}"\leqslant k\leqslant"2+\sqrt{28}"$ and allow inexact e.g. $"-3.291..."<k<"7.291..."$ If when finding their endpoints they make a sign error and obtain e.g. $k^2-4k-24>0$ and then choose the outside region, this scores M1 but it must be consistent with their inequality.
A1:	Correct answer in exact form in set notation or interval notation in terms of *k*. Allow: $\left\{k:2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}\cap\left\{k:k<2+2\sqrt{7}\right\}$ or $\left\{2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{2-2\sqrt{7}<k\right\}\cap\left\{k<2+2\sqrt{7}\right\}$ or $\left(2-2\sqrt{7},\ 2+2\sqrt{7}\right)$ or $\left\{k:2-2\sqrt{7}<k\cap k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}$ and $\left\{k:k<2+2\sqrt{7}\right\}$ but **not** $\left\{2-2\sqrt{7}<k\right\}\cup\left\{k<2+2\sqrt{7}\right\}$ and **not** $\left[2-2\sqrt{7},\ 2+2\sqrt{7}\right]$ and **not** $\left\{2-2\sqrt{7}\leqslant k\leqslant 2+2\sqrt{7}\right\}$
(b)	**Alternative 2** (substitutes $x="-5"$ into the given or their circle equation and solves for *y*) Scores in the same way following e.g. $25+y^2-50-4y+1-0\Rightarrow y^2-4y-24=0\Rightarrow y=$
B1:	$2+2\sqrt{7}$ **or** $2-2\sqrt{7}$ seen. Accept $\sqrt{28}$ for $2\sqrt{7}$ throughout this question.
M1:	$"2-2\sqrt{7}"<k<"2+2\sqrt{7}"$ Selects the inside interval for their endpoints which must come from a correct method condoning slips. Condone use of *y* for *k*. May be seen separately e.g. $"2-2\sqrt{7}"<k,\quad k<"2+2\sqrt{7}"$ Condone e.g. $"2-\sqrt{28}"\leqslant k\leqslant"2+\sqrt{28}"$ and allow inexact e.g. $"-3.291..."<k<"7.291..."$
A1:	Correct answer in exact form in set notation or interval notation in terms of *k*. Allow: $\left\{k:2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}\cap\left\{k:k<2+2\sqrt{7}\right\}$ or $\left\{2-2\sqrt{7}<k<2+2\sqrt{7}\right\}$ or $\left\{2-2\sqrt{7}<k\right\}\cap\left\{k<2+2\sqrt{7}\right\}$ or $\left(2-2\sqrt{7},\ 2+2\sqrt{7}\right)$ or $\left\{k:2-2\sqrt{7}<k\cap k<2+2\sqrt{7}\right\}$ or $\left\{k:2-2\sqrt{7}<k\right\}$ and $\left\{k:k<2+2\sqrt{7}\right\}$ but **not** $\left\{2-2\sqrt{7}<k\right\}\cup\left\{k<2+2\sqrt{7}\right\}$ and **not** $\left[2-2\sqrt{7},\ 2+2\sqrt{7}\right]$ and **not** $\left\{2-2\sqrt{7}\leqslant k\leqslant 2+2\sqrt{7}\right\}$