Question Number	Scheme	Marks
4 (a)(i)	e.g. $f(-3) = 13-9-(k-3)^2 = 4-(k-3)^2$ and states when $k=5, f(-3)=0$	B1*
(a)(ii)	Uses $f(-3)=0 \Rightarrow (k-3)^2 = 4 \Rightarrow k = (5), 1$	M1A1 **(3)**
(b)(i)	$13+3x+(x+2)(x+5)^2 = 13+3x+(x+2)(x^2+10x+25) = 13+3x+x^3+....$	M1
	$= x^3+12x^2+48x+63$	A1
	Hence $f(x) = (x+3)(x^2+9x+21)$	dM1A1 **(4)**
(b)(ii)	e.g. Attempts "b^2-4ac" for their $(x^2+9x+21)$	M1
	e.g. $b^2-4ac=-3<0 \Rightarrow (x^2+9x+21)$ has no roots and hence $f(x)=0$ has one solution, -3	A1 **(2)**
		(9 marks)

(a) Mark (a) parts (i) and (ii) together

(i)

B1*: Either sets $f(-3)=0$ and states or shows $k=5$, or finds $f(-3)$ and states or shows that when $k=5, f(-3)=0$ Must be *k* not *x*. **The "=0" must be seen somewhere it cannot be implied.**

May be found at the same time as the other possible value for *k* which is fine as we mark both parts together. Allow the root to be stated once a correct equation in *k* only is formed.

May see e.g. $-k^2+6k-5=0 \Rightarrow k=5$

A conclusion referring to $k=5$ is only required if $k=5$ is used in their solution by setting $f(-3)=0$

e.g. $13-9-(k-3)^2 \Rightarrow 13-9-(2)^2=0$ "so $k=5$" or if they attempt to divide the cubic by $x+3$ with $k=5$ substituted to reach a remainder of 0

Allow a preamble followed by a minimal conclusion e.g. proven, shown, tick QED is condoned.

(ii)

M1: Sets up and attempts to solve a quadratic in *k* using a correct valid method (they cannot just state the roots):

e.g. $4-(-3+k)^2=0 \Rightarrow (-3+k)^2=4 \Rightarrow -3+k=\pm 2 \Rightarrow k=5,1$

e.g. $4-(-3+k)^2=0 \Rightarrow k^2-6k+5=0 \Rightarrow (k-5)(k-1)=0 \Rightarrow k=5,1$

(may use the quadratic formula)

Do not allow this mark to be scored for poor attempts at multiplying out the brackets i.e.

$(k-3)^2=4 \Rightarrow k^2-9=4 \Rightarrow k=...$

The "= 0" may be implied.

A1: $k=1$ following M1. Condone $-k^2+6k-5=0\Rightarrow(k-5)(k-1)=0\Rightarrow k=5,1$ but just stating the roots scores M0A0. Condone use of x instead of k for this mark.

Note: There may be other more long winded methods requiring a lot of algebraic manipulation. e.g. look out for attempts at algebraic division and setting the remainder equal to 0.

If you see an approach which you may think deserves credit then send to review.

(b) Mark (b) parts (i) and (ii) together

(b)(i) Note that work seen in (a) must be used in (b) to score

M1: Attempts to multiply out the expression with $k = 5$ to form a 4-term cubic expression Ax^3+Bx^2+Cx+D where $A,B,C,D\neq 0$. Condone algebraic slips including $(x+5)^2=x^2+25$

A1: $x^3+12x^2+48x+63$ (which must be simplified)

dM1:Attempts to divide their cubic by $(x+3)$ to achieve a quadratic factor. It is dependent on the previous method mark.

Look for two correct terms for their cubic (allow $\pm$).
e.g. first and last terms are correct (allow $\pm$) if done by inspection

A1: Correct factorisation $(\mathrm{f}(x)=)\ (x+3)(x^2+9x+21)$ Must be written as a product. Condone missing trailing bracket. Ignore if = 0 is seen

(b)(ii)

M1: Attempts to show that their three-term quadratic "$(x^2+9x+21)$" does not have any roots:

- **Attempts the discriminant**
  e.g. $b^2-4ac=81-4\times1\times21\ \left(=-3\right)$ (may be embedded in the quadratic formula)
- **Attempts to use the quadratic formula**
  e.g. $\left(x=\right)\dfrac{-9\pm\sqrt{9^2-4\times1\times21}}{2}$ but do not allow directly from a calculator $\dfrac{-9\pm\sqrt{3}i}{2}$
- **Attempts to complete the square**
  e.g. $x^2+9x+21=\left(x+\dfrac{9}{2}\right)^2+\ldots\quad\left(=\left(x+\dfrac{9}{2}\right)^2-\dfrac{81}{4}+21\right)$
- **Uses calculus to find the turning point**
  e.g. $\dfrac{\mathrm{d}(x^2+9x+21)}{\mathrm{d}x}=2x+9=0\Rightarrow x=-\dfrac{9}{2}\Rightarrow y=\ldots$

Note that any attempts using the discriminant or quadratic formula must have the values embedded in the correct places (may be partially evaluated) to score M1

A1: **Dependent on a correct** $x^2+9x+21$

Fully correct argument that requires:

- Fully correct work
- A justification depending on strategy and no incorrect reasoning seen
- A conclusion which refers to $(x=)-3$ is a root or the only solution comes from $x+3=0$ (allow $(x=)-3$ to have been stated in their working somewhere which is not the value of the discriminant)

Note be careful not to award this mark if the only reference to -3 is the value of the discriminant

Examples on the next page – Note we must see working before they proceed to a correct root or minimum value – see M1 for guidance

Strategy	Correct work examples	Justification examples	Conclusion examples
Via discriminant	$b^2-4ac=-3$	$-3<0$ -3 so no (real) roots but NOT $-3\neq 0$ so no roots	so "-3 is the only (real) root" / "only solution comes from $x+3=0$" / "only one solution" (provided $x=-3$ has been stated somewhere in their solution) [**Note be careful not to award this mark if the only reference to -3 is the value of the discriminant**]
Via using the quadratic formula	$x=\frac{-9\pm\sqrt{3}i}{2}$ or $x=\frac{-9\pm\sqrt{-3}}{2}$	$-3<0$ / which is not possible / complex roots o.e. / cannot square root a negative / no (real) roots	
Via completing the square	$\left(x+\frac{9}{2}\right)^2+\frac{3}{4}$ or $\left(x+\frac{9}{2}\right)^2+\frac{3}{4}=0\Rightarrow$ $\left(x+\frac{9}{2}\right)^2=-\frac{3}{4}$	which has a minimum value of $\frac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis $-\frac{3}{4}<0$ / cannot square root a negative / no (real) roots	
Via calculus	$x=-\frac{9}{2}\Rightarrow y=\frac{3}{4}$	which has a minimum value of $\frac{3}{4}$ / minimum (of the positive quadratic) is above the x-axis	

Condone $81-84<0$ as a justification that the quadratic has no real roots

Note condone the conclusion -3 is the only (real) solution (instead of (real) root). If $(x+3)$ is described as a root or -3 is described as a factor this scores A0

Question Number	Scheme	Marks
5. (i)	$\log_a x + \log_a 3 = \log_a 27 - 1 \Rightarrow \log_a \frac{3x}{27} = -1$	M1A1
	$\Rightarrow \frac{3x}{27} = a^{-1}$	dM1
	$\Rightarrow x = 9a^{-1}$ or $x = \frac{9}{a}$	A1 **(4)**
(ii)	$p^2 - 7p + 12 = 0$ and attempt to solve to give $p =$ or $\log_5 y =$	M1
	p (or $\log_5 y$) = 3 or 4	B1
	$y = 5^3$ or 5^4	M1
	y = 125 and 625	A1 **(4)**
		8 marks

(i)

M1: Uses sum or difference of logs correctly to combine at least two of the original terms e.g. $\log_a 3x$
May be implied by e.g. $\log_a 9$ or a correct equation not in terms of logs which is not the correct answer.
Condone no base written.

A1: Uses correct log work to obtain a correct simplified equation where either

- the log terms have been collected on one side of an equation $\log_a \frac{3x}{27} = -1$ e.g.
- the equation is simplified to e.g. $\log 3ax = \log 27$ or e.g. $\log_a 3x = \log_a \frac{27}{a}$

Base a does not need to be written. May be implied by an equation with no logs which is not the final answer.

dM1: Removes logs correctly from an equation of the form $\log ... = \log ...$ or $\log ... = ...$ and proceeds to a in terms of x or x in terms of a. May be implied by an equation with no logs which is not the final answer.

It is dependent on the previous method mark.

A1: Correct simplified answer

(ii) Note on epen this is M1A1M1A1 but we are marking this M1B1M1A1

M1: Attempts to solve the quadratic in $\log_5 y$ (or may use another variable) by either factorising, completing the square or using the quadratic formula (usual rules apply). They cannot just state the roots.

B1: Obtains both 3 and 4

M1: Finds a value for y by either $y = 5^{"3"}$ or $y = 5^{"4"}$. We must see this expression for at least one of their y values otherwise M0A0.

A1: 125 and 625 (and no others) **provided all previous marks have been scored.**

Question Number	Scheme	Marks
6(a)	$(x\pm3)^2+(y\pm7)^2\pm\ldots=\ldots$	M1
	Centre = $(3,7)$	A1
		(2)
(b)	Attempts $(\pm3)^2+(\pm7)^2\pm32$	M1
	Radius = $3\sqrt{10}$	A1
		(2)
(c)	Uses radius $<3\Rightarrow9+49-k<9$ or uses radius $>0\Rightarrow9+49-k>0$	M1
	$k>49$ or $k<58$	A1
	Uses radius $<3\Rightarrow9+49-k<9$ and uses radius >0 $\Rightarrow9+49-k>0$	dM1
	$49<k<58$ oe (see notes)	A1
		(4)
		(8 marks)

(a)

M1: Attempts to complete the square. Accept $(x\pm3)^2+(y\pm7)^2\pm\ldots=\ldots$ as evidence.
Also score for $(\pm3,\pm7)$

A1: $(3,7)$ which may be given separately $x=3,\ y=7$
Condone missing brackets provided the intention is clear.

(b)

M1: Attempts to find r or r^2. Look for $(\pm3)^2+(\pm7)^2\pm32$ or $\sqrt{(\pm3)^2+(\pm7)^2\pm32}$. Ignore labelling.
May be implied by sight of ±90 or e.g. $\pm58\pm32$

A1: Radius = $3\sqrt{10}$ or exact equivalent such as $\sqrt{90}$ Isw. Decimal answers only score A0. Do not accept $\pm$

(c) **Condone use of strict or inclusive inequalities for any of the marks in this part**

M1: Uses the fact that the radius must be less than 3 (or „ 3) **or** uses the fact that the radius is > 0 or …0 to form a correct inequality. Do not allow sign slips.

A1: Either $k>49$ or $k<58$ (ignore the other part of the inequality if written as e.g. $0<k<58$. Allow use of inclusive inequality.

dM1: Uses the fact that the radius must be less than 3 (or „ 3) **and** uses the fact that the radius is > 0 (or …0) to form two correct inequalities (or may be combined). Do not allow sign slips. It is dependent on the previous method mark.