$b^2-4ac=0 \Rightarrow (18k-20)^2-4(4-k^2)\times(-56)=0 \Rightarrow 100k^2-720k+1296=0 \Rightarrow k=...$

(allow two values for *k* from a quadratic)

In each method do not be too concerned by their use of $=, \geqslant, \leqslant, >, <$ throughout their working. Condone arithmetical slips.

A1 $(k=)$ 3.6 oe

Question Number	Scheme	Marks
6(a)	$(\mathrm{f}'(x)=) 5(x^2-2)\times\frac{1}{2}\times 4\times(4x+9)^{-\frac{1}{2}}+10x(4x+9)^{\frac{1}{2}}$ $(\mathrm{f}'(x)=) \frac{10(x^2-2)+10x(4x+9)}{(4x+9)^{\frac{1}{2}}}=\frac{50x^2+90x-20}{(4x+9)^{\frac{1}{2}}}$ $(\mathrm{f}'(x)=) \frac{10(5x^2+9x-2)}{(4x+9)^{\frac{1}{2}}}$	M1A1 dM1 A1
		(4)
(b)	Sets $\mathrm{f}'(x)=0$ to give $x=-2, \frac{1}{5}$	B1
		(1)
(c)	$y=5\left(("-2")^2-2\right)\left(4\times("-2")+9\right)^{\frac{1}{2}}=10$ $(-2, 10)$	M1 A1cao
		(2)
(d)	$\mathrm{f}(0)=-30$ $\text{Upper bound}=2\times"10"+4=...$ or $\text{Lower bound}=2\times"-30"+4=...$ $-56\leqslant \mathrm{g}(x)\leqslant 24$	B1 M1 A1
		(3)
		(10 marks)

A1 $k>3.6$ or eg $k>\frac{18}{5}$ but not $k\geqslant\frac{18}{5}$ If $k<-2$ is found then it must be rejected

(a)

M1 Attempts the product rule. Award for $\pm A(5x^2-10)(4x+9)^{-\frac{1}{2}}\pm Bx(4x+9)^{\frac{1}{2}}$ or equivalent where $A, B \neq 0$ The indices do not need to be processed for this mark.

If they quote the product rule eg $uv'+u'v$ and state the expressions for u, u', v and v' then allow a miscopy when substituted. They must have

eg $u = 5x^2 - 10 \rightarrow u' = Ax$ and $v = (4x+9)^{\frac{1}{2}} \rightarrow v' = B(4x+9)^{-\frac{1}{2}}$

May also attempt the product rule on $5x^2(4x+9)^{\frac{1}{2}} - 10(4x+9)^{\frac{1}{2}}$ so award for

$\pm Ax(4x+9)^{\frac{1}{2}} \pm Bx^2(4x+9)^{-\frac{1}{2}} \pm C(4x+9)^{-\frac{1}{2}}$ $A, B, C \neq 0$

A1 Correct unsimplified expression for $f'(x)$ eg $2(5x^2-10)(4x+9)^{-\frac{1}{2}} + 10x(4x+9)^{\frac{1}{2}}$ oe

dM1 Proceeds to a single fraction, multiplies out the brackets on the numerator and proceeds to the form $\frac{3TQ}{(4x+9)^{\frac{1}{2}}}$ or $3TQ(4x+9)^{-\frac{1}{2}}$. They cannot proceed straight to the given 3TQ or a multiple of it without some working seen to score this mark.

Alternatively, you may only see manipulation of the numerator and then $\frac{3TQ}{(4x+9)^{\frac{1}{2}}}$ which is acceptable: $10(x^2-2)+10x(4x+9) = 10(x^2-2+4x^2+9x) = 10(5x^2+9x-2) \Rightarrow \frac{10(5x^2+9x-2)}{(4x+9)^{\frac{1}{2}}}$

Condone arithmetical slips in their working but their method to proceeding to a single fraction must be correct.

It is dependent on the previous method mark.

A1 $\left(f'(x) =\right) \frac{10(5x^2+9x-2)}{(4x+9)^{\frac{1}{2}}}$ with no errors seen in the main body of their solution.

Accept $\frac{10(5x^2+9x-2)}{\sqrt{4x+9}}$

Condone invisible brackets as long as they are recovered, or their subsequent working makes their intention clear. They do not need to explicitly state $k = 10$ but if there is a contradiction between their expression and their stated value then the expression takes precedence. Do not be concerned with what they have before the =

(b) Mark (b) and (c) together

B1 Sets $f'(x) = 0$ to give $-2, \frac{1}{5}$ Withhold if one is rejected. Condone $(-2, 0)$ $\left(\frac{1}{5}, 0\right)$. May be seen in (c)

(c)

M1 Substitutes their smaller root from solving $5x^2 + 9x - 2 = 0$ into $y = 5(x^2-2)(4x+9)^{\frac{1}{2}}$ and proceeds to find a value for *y*. Condone bracket omissions, miscopying or arithmetical slips as long as it is clear that they are attempting to substitute their smaller root into f(*x*)

A1cao $(-2, 10)$ only (Allow $x = -2,\ y = 10$)

(d)

B1 $\left(\text{f}(0)=\right)-30$ seen (which may be implied by sight of -56)

M1 A correct attempt at the lower or upper bound.

- Either attempts $2\times\text{"10"}+4$ and identifies this as the upper bound. Follow through on their part (c) y coordinate. $<\text{"24"}$ or $\leqslant\text{"24"}$ is acceptable
- Or attempts $2\times\text{"}-30\text{"}+4$ and identifies this as their lower bound. $>\text{"}-56\text{"}$ or $\geqslant\text{"}-56\text{"}$ is acceptable for this mark. It cannot be scored for using $2\times\text{f}\left(\frac{1}{5}\right)+4$ as their lower bound.

Note that $g>-56$ or $g\geqslant-56$ will score B1M1.

Allow use of max or min for upper and lower bound for this mark.

A1 $-56\leqslant\text{g}(x)\leqslant 24$ oe eg "$\left\{g(x)\in\mathbb{R}:-56\leqslant\text{g}(x)\cap\text{g}(x)\leqslant 24\right\}$" or "$-56\leqslant\text{g}(x)$ AND $\text{g}(x)\leqslant 24$" or $\text{g}\in\left[-56,\ 24\right]$ or other variations similar to these. Condone g for g(x) and $-56\leqslant y\leqslant 24$ or $-56\leqslant 2\text{f}(x)+4\leqslant 24$ but not $-56\leqslant\text{f}\leqslant 24$

DO NOT ACCEPT "$-56\leqslant\text{g}(x)\cup\text{g}(x)\leqslant 24$" or "$-56\leqslant\text{g}(x)$ OR $\text{g}(x)\leqslant 24$"

Question Number	Scheme	Marks
7(a)	$3\cot^2 2\theta - 7 = \dfrac{13}{2\sin\theta\cos\theta}$ **or** $2\sin\theta\left(3(\text{cosec}^2 2\theta - 1) - 7\right) = 13\sec\theta$ **oe**	M1
	$3(\text{cosec}^2 2\theta - 1) - 7 = \dfrac{13}{2\sin\theta\cos\theta}$	dM1
	$\Rightarrow 3\text{cosec}^2 2\theta - 10 = 13\text{cosec}\,2\theta \Rightarrow 3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$*	ddM1A1*
		(4)
(b)	$3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$	
	$(3\text{cosec}\,2\theta + 2)(\text{cosec}\,2\theta - 5) = 0 \Rightarrow (\text{cosec}\,2\theta) = 5 \Rightarrow (\sin 2\theta) = \dfrac{1}{5}$	M1A1
	$\theta = \dfrac{\sin^{-1}\left("\frac{1}{5}"\right)}{2} = \ldots$	dM1
	$(\theta =)$ awrt 0.101, 1.47	A1
		(4)
		(8 marks)
Alt(a)	$2\sin\theta\left(\dfrac{3(1-\sin^2 2\theta)}{\sin^2 2\theta} - 7\right) = 13\sec\theta$	M1
	$\dfrac{3(1-\sin^2 2\theta)}{\sin^2 2\theta} - 7 = \dfrac{13}{2\sin\theta\cos\theta}$	dM1
	$\dfrac{3}{\sin^2 2\theta} - 10 = \dfrac{13}{\sin 2\theta}$	ddM1
	$3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$ *	A1*

(a)

M1 Attempts **EITHER**

- to divide both sides by $(2)\sin\theta$ and use $\sec\theta = \dfrac{1}{\cos\theta}$ (or $\text{cosec}\,\theta = \dfrac{1}{\sin\theta}$) to achieve a term of the form $\dfrac{A}{B\sin\theta\cos\theta}$ oe (implied by $\dfrac{\ldots}{\ldots\sin 2\theta}$ or $\ldots\text{cosec}\,\theta\sec\theta$).
  Note $\sin 2\theta(3\cot^2 2\theta - 7) = 13$ does not score this mark. They have not divided by (2)$\sin\theta$

- to use $\pm 1 \pm \cot^2 2\theta = \pm\text{cosec}^2 2\theta$ to replace the $\cot^2 2\theta$ term in the equation or in the alternative method it is for using $\cot^2 2\theta = \dfrac{\cos^2 2\theta}{\sin^2 2\theta}$ and using $\pm 1 \pm \sin^2 2\theta = \pm\cos^2 2\theta$ to replace the $\cos^2 2\theta$

  Condone arithmetical slips and invisible brackets.