Question Number	Scheme	Marks
7 (a) (i)	States that gradient normal is -2 or gradient tangent is $\frac{1}{2}$	B1
	Substitutes $x=4$ into $\frac{1}{2}=\frac{k-\sqrt{x}}{2x^2}\Rightarrow\frac{k-2}{32}=\frac{1}{2}\Rightarrow k=18$ *	M1, A1*
(ii)	(Substitutes $x=4$ in $y+2x-5=0$ $\Rightarrow$)$y=-3$	B1
	Method of tangent $y+3=\frac{1}{2}(x-4)\Rightarrow y=\frac{1}{2}x-5$	M1, A1
		(6)
(b)	$f'(x)=\frac{18-\sqrt{x}}{2x^2}=9x^{-2}-\frac{1}{2}x^{-\frac{3}{2}}\Rightarrow\quad f(x)=-\frac{9}{x}+x^{-\frac{1}{2}}(+c)$	M1, A1, A1
	Uses $P(4,'-3')\Rightarrow'-3'=-\frac{9}{4}+\frac{1}{2}+c\Rightarrow c=...$	dM1
	$(f(x)=)-\frac{9}{x}+x^{-\frac{1}{2}}-\frac{5}{4}$	A1
		(5)
		(11 marks)

(a)(i) Attempts to substitute $k=18$ and $x=4$ into $f'(x)$ send to review

B1: States that gradient normal is -2 or gradient tangent is $\frac{1}{2}$. Alternatively, may be seen in a **correct** equation provided it is explicitly seen e.g. $\frac{1}{2}=\frac{k-2}{2\times4^2}$ or $-2=\frac{32}{\sqrt{4}-k}$

It is insufficient to just state e.g. gradient / $\frac{dy}{dx}=-2$ or hence gradient = $\frac{1}{2}$ as these are too vague.

M1: Substitutes $x=4$ into $\frac{1}{2}=\frac{k-\sqrt{x}}{2x^2}$ oe and proceeds to find a value for *k*. Condone slips in the rearrangement or slips when substituting in/evaluating provided the overall method was correct. Accept $16=k-2\Rightarrow k=...$ to score this mark.

A1*: $k=18$ with both previous marks scored and no errors seen. **Must be seen in (a)(i)**

Minimum acceptable:

e.g. $\frac{1}{2}=\frac{k-2}{32}\Rightarrow k=18$ scores B1M1A1* ($\frac{1}{2}$ seen within a correct equation proceeding to $k=18$)

e.g. $m=\frac{1}{2}$ $k-2=16\Rightarrow k=18$ scores B1M1A1* (separately states $\frac{1}{2}$ and forms a valid equation proceeding to $k=18$)

But $16=k-2\Rightarrow k=18$ scores B0M1A0* (never states $\frac{1}{2}$ or -2)

(a)(ii)

B1: $y=-3$ (may be seen or used. Allow if seen in (a)(i)) May be implied if they equate the equation of the normal and the equation of the tangent and substitute in $x=4$ to find *c*.

M1: Attempts to find the equation of the tangent using a gradient of $\pm\frac{1}{2}$ and point $(4,...)$

E.g. $y+3=\frac{1}{2}(x-4)$. If the form $y=mx+c$ is used the method must proceed as far as *c* = …

Do not condone sign slips when substituting in the coordinates

A1: $y=\frac{1}{2}x-5$ oe in the form $y=mx+c$

(b) Note that if they only work in terms of *k* instead of 18 then max score M1A1A0dM0A0
If creditworthy work is seen in (a) it must be used in (b) to score.

M1: Attempts to split the fraction into two terms, and attempts to integrate at least one of the terms achieving a correct index. Indices do not need to be processed for this mark. Condone the omission of the + *c*

Look for $\left(f'(x)=\right)\frac{18-\sqrt{x}}{2x^2}=$ at least one of $...x^{-2}\pm...x^{-\frac{3}{2}}$ integrating to at least one of

$\Rightarrow \left(f(x)=\right)...x^{-2+1}\pm...x^{-\frac{1}{2}+1}\ (+c)$

Terms may be listed separately which is fine.

A1: One correct term of $\left(f(x)=\right)-\frac{9}{x}+x^{-\frac{1}{2}}$ (which may be unsimplified). Terms may be listed separately which is fine as you just need to look for one correct term. The index must be processed.

A1: $\left(f(x)=\right)-\frac{9}{x}+x^{-\frac{1}{2}}\ (+c)$ (which may be unsimplified) but condone the omission of + *c* Must be an expression for this mark. Indices must be processed.

dM1: Uses $P(4,'-3')$ in their integrated function (it is dependent on the previous method mark) and proceeds to find a value for *c*. You do not need to check the mechanics of the rearrangement for this mark. Alternatively states e.g. $x=4,\ y='-3'$ and states a value for *c*. You may only have to check the value of *c* if neither the method is shown substituting in the values nor the values stated.

A1: $\left(f(x)=\right)-\frac{9}{x}+x^{-\frac{1}{2}}-\frac{5}{4}$ or exact equivalent in simplest form. (fractions must be cancelled down). Do not isw if they e.g. proceed to multiply all terms by 4

Question Number	Scheme	Marks
8 (a)	$x \geqslant 5,\ x = -4$	M1, A1 **(2)**
(b)	States or implies that $\mathrm{f}(x) = k(\pm x \pm 4)^2(\pm x \pm 5)$ oe	M1
	e.g. substitutes $(0, 20)$ into $\mathrm{f}(x) = k(x+4)^2(x-5) \Rightarrow k = ...$	dM1
	$(\mathrm{f}(x) =) -\frac{1}{4}(x+4)^2(x-5)$ or $(\mathrm{f}(x) =) \frac{1}{4}(x+4)^2(5-x)$	A1 **(3)**
(c)	$x = 5$	B1
	$-\frac{1}{4}(x+4)^2(x-5) = 3x(x-5) \Rightarrow (x-5)\left\{3x + \frac{1}{4}(x+4)^2\right\} = 0$	
	$\Rightarrow (x-5)(x^2+20x+16) = 0$	M1
	$\Rightarrow (x+10)^2 = 84 \Rightarrow x = ...$	dM1
	$x = -10 \pm 2\sqrt{21}$	A1 **(4)** **(9 marks)**

(a) Allow equivalent notation including set or interval notation

M1: For either $x \geqslant 5$ or $x = -4$. May be seen as e.g. $[5, \infty)$ or $\{x \in \mathbb{R} : x \geqslant 5\}$ or condone $x > 5$, or $(5, \infty)$ Allow variations on these as long as the intention is clear.

A1: $x \geqslant 5,\ x = -4$ oe Do not withhold this mark for use of 'and' oe and again allow variations on notation as long as the intention is clear and the inequality $x \geqslant 5$ is correct

(b)

M1: States or implies that $\mathrm{f}(x) = k(\pm x \pm 4)^2(\pm x \pm 5)$ even allowing $k = \pm 1$

dM1: Substitutes $(0, 20)$ into $\mathrm{f}(x) = k(x+4)^2(x-5) \Rightarrow k = ...$ or $\mathrm{f}(x) = k(x+4)^2(5-x) \Rightarrow k = ...$ It is dependent on the previous method mark. May use a different letter to k

A1: $(\mathrm{f}(x) =) -\frac{1}{4}(x+4)^2(x-5)$ oe such as $(\mathrm{f}(x) =) \frac{1}{4}(x+4)^2(5-x)$

Alt(b) Simultaneous equations $y = ax^3 + bx^2 + cx + d$

M1: Attempts to form 3 equations from

$(-4, 0) \Rightarrow 0 = -64a + 16b - 4c + d$

$(5, 0) \Rightarrow 0 = 125a + 25b + 5c + d$

$(0, 20) \Rightarrow d = 20$

$(-4, 0) \Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x} = 3ax^2 + 2bx + c \Rightarrow 48a - 8b + c = 0$

dM1: Forms all 4 equations and solves simultaneously to achieve values for a, b, c and d. It cannot be scored for just stating the values via a calculator.

A1: As above in main scheme and notes