Question	Answer	Marks	Guidance
1	$\pm\frac{1}{3}(x+2)(2x+1)(x-3)$ isw	3	**B1** for $\pm$ with 3 factors or expanded out cubic **B1** for $\frac{1}{3}$ in a product with 3 factors **B1** for $(x+2)(2x+1)(x-3)$ and no extra terms or $2(x+2)(x+0.5)(x-3)$ and no extra terms
2	$x^{\frac{2}{3}}+x^{\frac{1}{3}}-6\ (=0)$ oe soi	B1	For multiplying through by $x^{\frac{1}{3}}$ Allow if substitution is used
	$\left(x^{\frac{1}{3}}+3\right)\left(x^{\frac{1}{3}}-2\right)\ (=0)$ oe	M1	Allow if substitution is used
	$x=-27$	A1	**A0** if rejects $x=-27$
	$x=8$	A1	
3(a)	$5x^2-30x+45\ (=0)$ or equivalent 3 term quadratic	2	**M1** for attempt to eliminate one variable
	Use of discriminant or solution to show one repeated root or a single solution	A1	Must have conclusion e.g. Discriminant = 0 (so tangent) oe One solution only (so tangent)
	Alternative 1		
	Centre of the circle (5, 2) Equation of radius perpendicular to given line $y-2=-\frac{1}{2}(x-5)$ Intersection at $(3,3)$	(2)	**M1** for a complete method to obtain the point of intersection
	Show that P lies on the circle or that $CP=\sqrt{5}$	(A1)	
	Alternative 2		
	The line $y=kx+n$ touches the circle $(x-p)^2+(y-q)^2=r^2$ if $(-kp+q-n)^2=r^2(1+k^2)$ so $(-(2\times5)+2-3)^2=5(1+2^2)$	(2)	**M1** for a complete method showing substitution, allow one slip
	25 = 25, so a tangent	(A1)	

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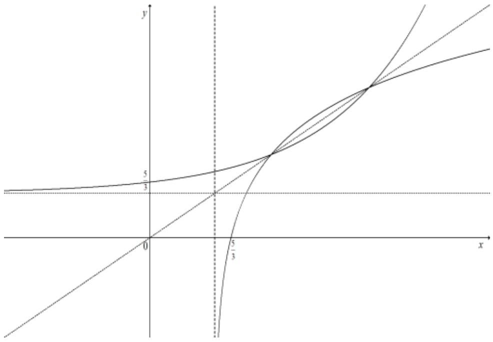
3(b)	(3, 3)	**2**	**B1** for each
3(c)	Radius = $3\sqrt{2}$ oe soi	**B1**	
	$(x-3)^2+(y-3)^2$ soi	**B1**	**FT** on *their* answer to **(b)** only
	$(x-3)^2+(y-3)^2=18$ oe	**B1**	ISW any expansion
4(a)	$[-\cos\theta]_0^{\pi}$	**B1**	May be implied by $(-\cos\pi)-(-\cos 0)$
	2	**B1**	
4(b)	$\dfrac{\frac{1}{\cos\alpha}}{\frac{\cos\alpha}{\sin\alpha}+\frac{\sin\alpha}{\cos\alpha}}$	**B1**	For ratios in terms of sine and cosine
	$\dfrac{\frac{1}{\cos\alpha}}{\frac{\cos^2\alpha+\sin^2\alpha}{\sin\alpha\cos\alpha}}$	**B1**	For simplifying the denominator to one term
	$\dfrac{\frac{1}{\cos\alpha}}{\frac{1}{\cos\alpha\sin\alpha}}$ $=\sin\alpha$	**B1**	Must show sufficient correct detail
	Alternative		
	$\dfrac{\frac{1}{\cos\alpha}}{\frac{1}{\tan\alpha}+\tan\alpha}$ or $\dfrac{\sec\alpha}{\frac{1}{\tan\alpha}+\tan\alpha}$	**(B1)**	For ratios in terms of tangent and cosine or secant and tangent
	$\dfrac{\frac{1}{\cos\alpha}}{\frac{\sec^2\alpha}{\tan\alpha}}$ or $\dfrac{\sec\alpha}{\frac{\sec^2\alpha}{\tan\alpha}}$ oe	**(B1)**	For dealing with the denominator
	$\frac{\tan\alpha}{\sec\alpha}=\frac{\sin\alpha}{\cos\alpha}\times\cos\alpha$ oe $=\sin\alpha$	**(B1)**	Must show correct sufficient detail

Question	Answer	Marks	Guidance
5(a)	$p'(x) = 9x^2 - 14x + a$ soi	**B1**	
	$p'(-1) = 9 + 14 + a = 21$ $a = -2$	**B1**	
	$p(2) = 24 - 28 + 2a + b = 0$ soi	**B1**	Each term must be simplified, allow using *their a*
	$b = 8$	**B1**	
5(b)	$[x-2](3x^2 - x - 4)$ soi	**2**	**M1** for quadratic factor with two terms correct **A1** must be from correct *a* and *b*
	$(x-2)(x+1)(3x-4)$	**A1**	**A1** must be from correct *a* and *b*
5(c)	$(e^{2y} - 2) = 0$ soi	**B1**	
	$y = \frac{1}{2}\ln\frac{4}{3}$ oe, $y = \frac{1}{2}\ln 2$ oe	**2**	**B1** for one correct solution **B2** for both solutions and no extra solution.
6(a)	$\ln y = mx^3 + c$ soi	**B1**	*c* may be shown as a log term
	$25 = -8m + c$ $5 = 2m + c$	**M1**	For at least one correct equation, may be used with gradient of –2
	$m = -2,\ c = 9$	**A1**	$y = -2x + 9$ seen implies **M1A1**
	$y = e^{9-2x^3}$ oe	**A1**	
6(b)	$25 = 9 - 2x^3$	**M1**	For equating exponential indices and obtaining $x = \ldots$ or use of $x = \sqrt[3]{\frac{25 - their\ 9}{their\ -2}}$
	$x = -2$ only	**A1**	

Question	Answer	Marks	Guidance
7(a)	$ar^3 = \frac{8k^6}{27}$, $ar^5 = \frac{32k^{10}}{243}$ soi	**B1**	May be implied by a correct 5th term $\frac{16k^8}{81}$
	$r = \frac{2k^2}{3}$	2	**M1** for solution of *their* equations to obtain either $r = mk^2$ or $a = c$, where m is an unsimplified numeric constant and c is a non-zero constant e.g. Use of $r^2 = \frac{\text{6th term}}{\text{4th term}}$
	$a = 1$	**A1**	
7(b)	$\frac{1}{1 - \frac{2k^2}{3}} = 3$ soi	**B1**	For use of sum to infinity formula with *their* values of a where a is numeric and r which is in terms of k^2
	$k = \pm 1$	2	**B1** for each must be from correct work
8(a)	$\left(\frac{dy}{dx} =\right) \frac{(x+2)\frac{6x}{3x^2+16} - \ln(3x^2+16)}{(x+2)^2}$	3	**B1** for $\frac{6x}{3x^2+16}$ **M1** for differentiation of a quotient or equivalent product **A1** for all other terms apart from $\frac{6x}{3x^2+16}$ correct
	When $x = 0$, $\frac{dy}{dx} = -\frac{\ln 16}{4}$ $= \ln\frac{1}{2}$ from correct work	2	**M1 dep** for attempt to substitute in $x = 0$ and obtain a single log term For **A1**, **all** previous marks must have been awarded.
8(b)	Change = $h \ln\frac{1}{2}$ oe	**B1**	**FT** on *their* single log answer to part **(a)** **B0** for $\ln\frac{1}{2}h$ or *their* $\ln\frac{1}{2}h$
9(a)	$\frac{4}{3}$ or $a = \frac{4}{3}$	**B1**	Award **B1** when a correct answer is seen
9(b)	$\mathbb{R}$ oe	**B1**	May be in terms of f or y but not x
9(c)	$\left[f^{-1}(x)\right] = \frac{4 + e^{\frac{x}{2}}}{3}$ oe	2	**M1** for a complete valid method, allow a sign error **A1** must be using the correct notation

Question	Answer	Marks	Guidance
9(d)		4	**B1** for $y = \mathrm{f}(x)$ in the 1st and 4th quadrants and appropriate asymptotic behaviour **B1 dep** on previous B mark for $y = \mathrm{f}^{-1}(x)$ intersecting twice with $y = \mathrm{f}(x)$, in the 1st and 2nd quadrants and appropriate asymptotic behaviour **B1 dep** on first **B1** for $\frac{5}{3}$ marked correctly on each axis or stated, and no other intercepts **B1** for $y = \frac{4}{3}$ and $x = \frac{4}{3}$ (independent) either on the graph or at the side.
10(a)	$\frac{1}{2}\left(\frac{4r}{3}\right)^2 \theta - \frac{1}{2}r^2 \sin\theta$ oe	3	**B1** for $\frac{1}{2}\left(\frac{4r}{3}\right)^2 \theta$ **B1** for $\frac{1}{2}r^2 \sin\theta$ or $r^2 \sin\frac{\theta}{2}\cos\frac{\theta}{2}$ or $\dfrac{r^2 \sin^2 \frac{\theta}{2}}{\tan\frac{\theta}{2}}$ oe Allow final answer unsimplified
10(b)	Arc length = $r\dfrac{(\pi - \theta)}{2}$	B1	
	$BE = \sqrt{2r^2(1-\cos\theta)}$ or $2r\sin\frac{\theta}{2}$ or $\dfrac{r\sin\theta}{\sin\left(\frac{\pi-\theta}{2}\right)}$ oe	2	**M1** for complete method to find BE or BE^2, using either cosine rule, sine rule or basic trig using r and a correct angle. **A0** if an error in rearranging to obtain BE is made. Allow unsimplified
	Perimeter = $r(\pi - \theta) + 2r + \sqrt{2r^2(1-\cos\theta)}$ oe	2	**M1** for a correct plan using *their* lengths 2 arc lengths + 2r + *their BE* Allow **A1** for an unsimplified answer

Question	Answer	Marks	Guidance
11(a)	$\overrightarrow{OQ} = \mathbf{a} + \frac{1}{3}(\mathbf{b} - \mathbf{a})$ or $\overrightarrow{OQ} = \mathbf{b} + \frac{2}{3}(\mathbf{a} - \mathbf{b})$ $\left(\overrightarrow{OQ} = \frac{2}{3}\mathbf{a} + \frac{1}{3}\mathbf{b}\right)$	2	**M1** for attempt to use $\overrightarrow{OQ} = \mathbf{a} + k(\mathbf{b} - \mathbf{a})$ or $\overrightarrow{OQ} = \mathbf{b} + k(\mathbf{a} - \mathbf{b})$, where k can be positive or negative Allow unsimplified
	$\overrightarrow{PQ} = -\frac{3}{4}\mathbf{a} + \textit{their}\ \overrightarrow{OQ}$	M1	
	$\overrightarrow{PQ} = -\frac{3}{4}\mathbf{a} + \frac{2}{3}\mathbf{a} + \frac{1}{3}\mathbf{b}$ $\left(\overrightarrow{PQ} = \frac{1}{3}\mathbf{b} - \frac{1}{12}\mathbf{a}\right)$	A1	Allow unsimplified
	$\overrightarrow{OP} = \frac{3}{4}\mathbf{a}$	B1	Allow anywhere
	$\overrightarrow{OR} = \frac{3}{4}\mathbf{a} + \mu\left(\frac{1}{3}\mathbf{b} - \frac{1}{12}\mathbf{a}\right)$ oe	B1	Must be simplified
	Alternative		
	$\overrightarrow{PQ} = \frac{1}{4}\mathbf{a} + \frac{1}{3}(\mathbf{b} - \mathbf{a})$ $\left(\overrightarrow{PQ} = \frac{1}{3}\mathbf{b} - \frac{1}{12}\mathbf{a}\right)$	(4)	**B1** for $\overrightarrow{PA} = \frac{1}{4}\mathbf{a}$ **M1** for $\overrightarrow{AQ} = \frac{1}{3}(\mathbf{b} - \mathbf{a})$, allow a sign error i.e. use of $(\mathbf{a} - \mathbf{b})$ **M1** for attempt to use $\overrightarrow{PQ} = \textit{their}\frac{1}{4}\mathbf{a} + \textit{their}\overrightarrow{AQ}$ Allow unsimplified
	$\overrightarrow{OP} = \frac{3}{4}\mathbf{a}$	(B1)	
	$\overrightarrow{OR} = \frac{3}{4}\mathbf{a} + \mu\left(\frac{1}{3}\mathbf{b} - \frac{1}{12}\mathbf{a}\right)$ or $\overrightarrow{OR} = \frac{3}{4}\mathbf{a} - \frac{\mu}{12}\mathbf{a} + \mu\left(\frac{1}{3}\mathbf{b}\right)$ or $\overrightarrow{OR} = \left(\frac{3}{4} - \frac{\mu}{12}\right)\mathbf{a} + \frac{\mu}{3}\mathbf{b}$	(B1)	Must be simplified

Question	Answer	Marks	Guidance
11(b)	$\lambda = \frac{1}{3}\mu$	B1	For equating **b** vectors
	$\frac{3}{4} - \frac{1}{12}\mu = 0$ oe	B1	For equating **a** vectors to zero
	$\mu = 9,\ \lambda = 3$	B1	
12	When $\frac{dy}{dx} = 0,\ x = \frac{2}{5}$	B1	Must come from first derivative and not the second derivative
	$(y =)\ \frac{3}{20}(5x-2)^{\frac{4}{3}}\ (+c)$	2	**M1** for $k(5x-2)^{\frac{4}{3}}$
	$\frac{32}{5} = \frac{3}{20}((5 \times 2) - 2)^{\frac{4}{3}} + c$ oe	M1	**Dep** for attempt to find c using *their* $k(5x-2)^{\frac{4}{3}}$
	$c = 4$	A1	Allow an unsimplified fraction
	Stationary point $\left(\frac{2}{5},\ 4\right)$	B1	**Dep** on first **B** mark