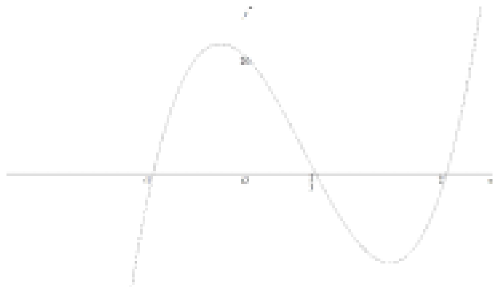
Question	Answer	Marks	Guidance
1(a)		3	**B1** for a well-drawn cubic graph in the correct orientation with both arms extending beyond x-axis **B1** for $x=-1$, $x=2$ and $x=\frac{2}{3}$ either on the graph or stated with a cubic graph **B1** for $y=20$ either on the graph or stated with a cubic graph
1(b)	$-1<x<\frac{2}{3}$	**B1**	Must be found from a cubic graph
	$x>2$	**B1**	
2	$\left[\ln(x-1)+\frac{1}{x-1}\right]_3^5$	2	**B1** for $\ln(x-1)$ **B1** for $+\frac{1}{x-1}$
	$\left(\ln 4+\frac{1}{4}\right)-\left(\ln 2+\frac{1}{2}\right)$	**M1**	**Dep** on at least one B mark, for correct use of limits
	$\ln 2-\frac{1}{4}$	2	**A1** for $\ln 2$ **A1** for $-\frac{1}{4}$ oe
3(a)	$\text{p}(2):\ 8a-36+2b-6=0$	**B1**	
	$\text{p}(3):\ 27a-81+3b-6=66$	**B1**	
		M1	**Dep** on at least one of the previous B marks, for attempt to solve *their* equations and obtain a solution for both a and b
	$a=6,\ \ b=-3$	**A1**	For both
3(b)	$(x-2)(6x^2+3x+3)$	2	**M1** for attempt at quadratic factor either by observation to obtain $6x^2+px+3$ or by algebraic long division to obtain at least $6x^2+3x...$ **A1** all correct

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3(c)	Discriminant of $\mathrm{q}(x) = 3^2 - 4\times6\times3$ $= -63$ which is < 0	**M1**	For calculation of discriminant and confirmation that it is < 0
	$\mathrm{q}(x)=0$ has no real solutions hence $\mathrm{p}(x)=0$ has only one real solution	**A1**	For a correct conclusion from correct work.
4	$(a+x)^3 = a^3+3a^2x+3ax^2\left[+x^3\right]$	**B1**	
	$\left(1-\frac{x}{3}\right)^5 = 1-\frac{5}{3}x+\frac{10}{9}x^2...$	**2**	**M1** allow one sign error or one arithmetic slip
	$a^3=27,\quad a=3$	**B1**	
	Term in x: $3a^2-\frac{5}{3}a^3=b$	**M1**	For multiplying *their* terms, must have sum of 2 relevant products = b
	$b=-18$	**A1**	
	Term in x^2 : $3a-\frac{5}{3}\left(3a^2\right)+\frac{10}{9}a^3=c$	**M1**	For multiplying *their* terms, must have sum of 3 relevant products = c
	$c=-6$	**A1**	
5(a)	$\mathrm{f}\geqslant -4$	**2**	**M1**for a valid method to find the least value of x^2+4x **A1** for $\mathrm{f}\geqslant -4$, $y\geqslant -4$ or $\mathrm{f}(x)\geqslant -4$
5(b)	$\mathrm{g}>1$	**B1**	Allow $y>1$ or $\mathrm{g}(x)>1$
5(c)	$\left(1+\mathrm{e}^{2x}\right)^2+4\left(1+\mathrm{e}^{2x}\right)[=21]$	**M1**	
	$\mathrm{e}^{4x}+6\mathrm{e}^{2x}-16=0$ $\left(\mathrm{e}^{2x}+8\right)\left(\mathrm{e}^{2x}-2\right)=0$	**M1**	**Dep** for quadratic in terms of e^{2x} and attempt to solve to obtain $\mathrm{e}^{2x}=k$
	$\mathrm{e}^{2x}=2$ $x=\frac{1}{2}\ln k$	**M1**	**Dep** on both previous M marks, for attempt to solve $\mathrm{e}^{2x}=k$
	$x=\ln\sqrt{2}$ or $\ln 2^{\frac{1}{2}}$	**A1**	
6(a)(i)	720	**B1**	
6(a)(ii)	480	**B1**	

Question	Answer	Marks	Guidance
6(a)(iii)	[Starts with 6 or 8]: 192	**B1**	
	[Starts with 9]: 72	**B1**	
	Total = 264	**B1**	
	Alternative [Ends with 9]:48	**(B1)**	
	[Ends with 1,3 or 5]:216	**(B1)**	
	Total = 264	**(B1)**	
6(b)	$\frac{45n!}{(n-4)!4!} = \frac{(n+1)(n+1)!}{((n+1)-5)!5!}$	**B1**	
	$45 = \frac{(n+1)^2}{5}$ leading to $15 = n+1$ or $n^2+2n-224=0$	**M2**	**M1** for 15 **M1** for $n + 1$ OR **M1** for $n^2+2n-224=0$ oe **M1** for $(n-14)(n+16)=0$
	$n=14$ only	**A1**	
7(a)(i)	110 (m)	**B1**	
7(a)(ii)		**B2**	**B1** for a line joining $(0,5)$ and $(10,5)$ **B1** for a line joining $(10,-2)$ and $(40,-2)$
7(b)(i)	$v=(2t+4)^{\frac{1}{2}}(+c)$	**M1**	For $k(2t+4)^{\frac{1}{2}}$
	$9=4+c$	**M1**	**Dep** for attempt to find c using $v=9$ and $t=6$ in *their* v
	$(2t+4)^{\frac{1}{2}}+5$	**A1**	

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7(b)(ii)	$s=\frac{1}{3}(2t+4)^{\frac{3}{2}}\quad(+5t+d)$	M1	For $k(2t+4)^{\frac{3}{2}}$
	$\frac{1}{3}=\frac{64}{3}+30+d$	M1	**Dep** for attempt to find d using $s=\frac{1}{3}$ and $t=6$ in *their s*
	$\frac{1}{3}(2t+4)^{\frac{3}{2}}+5t-51$	A1	
8(a)	$x=\frac{\sqrt{3}+1}{2-\sqrt{3}}\times\frac{2+\sqrt{3}}{2+\sqrt{3}}$ leading to $x=\frac{5+3\sqrt{3}}{1}$	M1	For attempt to rationalise and simplify showing all working
	$x=5+3\sqrt{3}$	A1	
	Either: Using $x=5+3\sqrt{3}$ $y=(2-\sqrt{3})(52+30\sqrt{3})+5+3\sqrt{3}-1$ $=14+8\sqrt{3}+4+3\sqrt{3}$ Or: Using $x=\frac{\sqrt{3}+1}{2-\sqrt{3}}$ $y=(2-\sqrt{3})\frac{(\sqrt{3}+1)^2}{(2-\sqrt{3})^2}+\frac{\sqrt{3}+1}{2-\sqrt{3}}-1$ $=\frac{4+2\sqrt{3}+\sqrt{3}+1-2+\sqrt{3}}{2-\sqrt{3}}$ $=\frac{(4\sqrt{3}+3)}{2-\sqrt{3}}\times\frac{(2+\sqrt{3})}{(2+\sqrt{3})}$ $=\frac{8\sqrt{3}+6+12+3\sqrt{3}}{1}$	M1	For complete method, showing all steps. Allow one slip in arithmetic
	$11\sqrt{3}+18$	2	**A1** for 18 **A1** for $11\sqrt{3}$

Question	Answer	Marks	Guidance
8(b)	$\frac{dy}{dx} = 2x\left(2-\sqrt{3}\right)+1$	M1	For attempt at differentiation to obtain form of $\frac{dy}{dx} = kx+1$
	$0 = 2x\left(2-\sqrt{3}\right)+1$ $x = -\frac{1}{2\left(2-\sqrt{3}\right)} \times \frac{\left(2+\sqrt{3}\right)}{\left(2+\sqrt{3}\right)}$ leading to $x = -\frac{1}{2}\frac{\left(2+\sqrt{3}\right)}{1}$	M1	**Dep** on previous M for equating to zero, rationalisation and attempt to simplify
	$x = -1-\frac{\sqrt{3}}{2}$	A1	
9(a)(i)	$(3y+2)(2x+1)$	B1	
9(a)(ii)	$(3\cos\theta+2)(2\sin\theta+1)=0$ $\cos\theta = -\frac{2}{3}$, $\sin\theta = -\frac{1}{2}$	M1	For relating to part (i) and a correct attempt to obtain $\cos\theta = ...$ or $\sin\theta = ...$
	$\theta = 131.8°,\ 228.2°$ $\theta = 210°,\ 330°$	3	**M1** for solving one of the equations to obtain one correct solution **A1** for any two correct solutions **A1** for a further two correct solutions with no extra solutions within the range
9(b)	$\cos\left(2\phi+\frac{\pi}{4}\right) = \frac{\sqrt{3}}{2}$ oe	B1	
	$\phi = -\frac{5\pi}{24}, -\frac{\pi}{24}, \frac{19\pi}{24}, \frac{23\pi}{24}$	4	**M1** for solving to obtain one correct positive solution **M1** for solving to obtain one correct negative solution **A1** for any two correct solutions **A1** for a further two correct solutions with no extra solutions within the range
10(a)	$\sin\frac{AOB}{2} = \frac{7.5}{10}$	M1	For a valid method
	$AOB = 1.696$ = 1.70 to 2 dp	A1	Must see greater accuracy to justify given answer

Question	Answer	Marks	Guidance
10(b)	$AC^2 = 10^2 + 25^2 - \left(2 \times 10 \times 25 \cos\left(\frac{AOB}{2}\right)\right)$	**M1**	For a complete and valid method to find AC
	$AC =$ awrt 19.9	**A1**	
	Major arc AB = awrt 45.9 or awrt 45.8	**B1**	
	Perimeter = awrt 85.5 or awrt 85.6	**A1**	
10(c)	Area of major sector AOB = $\frac{1}{2} \times 10^2 (2\pi - AOB)$	**M1**	
	awrt 229	**A1**	
	Area of kite $OACB$ = $\frac{1}{2} \times 15 \times 25$	**B1**	Allow working with 2 separate triangles
	Area of *their* major sector plus area of *their* kite	**M1**	
	Total area = awrt 417	**A1**	