Question	Answer	Marks	Partial Marks
1(a)	$3x^2-15x+12\,[*\,0]$ oe where * is any inequality sign or =	**B1**	
	Factorises or solves *their* 3-term quadratic	**M1**	**FT** *their* 3-term quadratic
	$x<1$ or $x>4$ mark final answer	**A1**	
1(b)(i)	$3(x-2)^2+4$	**3**	**B2** for $3(x-2)^2$ or **B1** for $(x-2)^2$ or $a=3$, $b=-2$ and **B1** for $a(x+b)^2+4$ with numerical values of a and b or $c=4$
1(b)(ii)	$y=$ *their* 4	**B1**	**STRICT FT** *their* 4 from part **(i)**
2(a)	$\frac{dy}{dx}=64x-\frac{2x^{-3}}{8}$ oe, isw	**B2**	**B1** for $\frac{dy}{dx}=64x+kx^{-3}$ or $\frac{dy}{dx}=kx-\frac{2x^{-3}}{8}$ where k is a non-zero constant or **SC1** for $\frac{dy}{dx}=64x-\frac{2}{8}x^{-3}+c$
	their $\frac{dy}{dx}=0$ and attempt to solve	**M1**	**FT** *their* derivative providing it has two terms and at least one term is a correct power of x
	(0.25, 4), (–0.25, 4) nfww, isw	**A2**	**A1** for either stationary point correct or for $x=\pm 0.25$ nfww or, if $\frac{dy}{dx}=64x-16x^{-3}$, then award **SC2** for $\left(\pm\frac{1}{\sqrt{2}},\frac{65}{4}\right)$ oe or **SC1** for either of these stationary points or $x=\pm\frac{1}{\sqrt{2}}$ oe

Question	Answer	Marks	Partial Marks
2(b)	Correct second derivative: $\frac{d^2y}{dx^2} = 64 + \frac{3}{4}x^{-4}$ oe, isw	**M1**	**FT** *their* $\frac{dy}{dx} = mx + nx^{-3}$ where $m \neq 0$ and $n \neq 0$ seen in part (a)
	$64 + \frac{3}{4}\left(\frac{1}{4}\right)^{-4} = 256$ or $64 + \frac{3}{4}\left(\frac{1}{4}\right)^{-4} > 0$ or when $x = 0.25$ $\frac{d^2y}{dx^2} = 256$ or $\frac{d^2y}{dx^2} > 0$ oe **and** minimum [points] oe OR $64 + \frac{3}{4}\left(-\frac{1}{4}\right)^{-4} = 256$ or $64 + \frac{3}{4}\left(-\frac{1}{4}\right)^{-4} > 0$ or when $x = -0.25$ $\frac{d^2y}{dx^2} = 256$ or $\frac{d^2y}{dx^2} > 0$ oe **and** minimum [points] oe OR $\frac{d^2y}{dx^2} = 64 + \frac{3}{4x^4}$ and this is positive for any value of x **and** minimum [points]	**A2**	**dep** on $x = \pm 0.25$ nfww in part **(a)** **A1 dep** on $x = 0.25$ or $x = -0.25$ nfww in part (a) for correctly showing or stating $\frac{d^2y}{dx^2}\left[= 64 + \frac{3}{4x^4}\right]$ is positive
3(a)	$-12 - 69 + 27 + 54 = 0$	**B1**	

Question	Answer	Marks	Partial Marks
3(b)	$10x+7=-2x^3+3x^2+33x-5$ oe, soi	**M1**	
	Uses the correct factor $x + 3$ to find a quadratic factor of the polynomial from part (a) oe with at least 2 terms correct	**M1**	
	$-2x^2+9x-4$ or $2x^2-9x+4$	**A1**	
	Factorises or solves *their* 3-term quadratic factor = 0: $(2x-1)(-x+4)$ or $(-2x+1)(x-4)$ or $(2x-1)(x-4)$ oe	**DM1**	**dep** on previous **M1**
	$x = -3$, $x = 0.5$, $x = 4$ nfww	**A1**	**dep** on at least **M0 M1 A1 DM1** awarded
	$A(-3, -23)$, $B(0.5, 12)$, $C(4, 47)$ oe **and** correct method to show mid-point e.g.: $\left(\frac{-3+4}{2}, \frac{-23+47}{2}\right) = \left(\frac{1}{2}, 12\right)$ oe or $\left[\overrightarrow{AB} =\right]\begin{pmatrix}0.5\\12\end{pmatrix}-\begin{pmatrix}-3\\-23\end{pmatrix}=\begin{pmatrix}3.5\\35\end{pmatrix}$ and $\left[\overrightarrow{BC} =\right]\begin{pmatrix}4\\47\end{pmatrix}-\begin{pmatrix}0.5\\12\end{pmatrix}=\begin{pmatrix}3.5\\35\end{pmatrix}$ oe OR [x-coordinate mid-point] $\frac{-3+4}{2}=\frac{1}{2}$ oe **and** valid comment e.g. The points are collinear [so B is the mid-point of AC].	**B2**	**dep** on $x = -3$, $x = 0.5$, $x = 4$ nfww **B1 dep** on $x = -3$, $x = 0.5$, $x = 4$ nfww for $A(-3, -23)$, $B(0.5, 12)$, $C(4, 47)$ oe or [x-coordinate of the mid-point] $\frac{-3+4}{2}=\frac{1}{2}$ oe

Question	Answer	Marks	Partial Marks
4	$\frac{dy}{dx} = -\sec^2(1-x)$ oe	B2	**must be seen** **B1** for $\frac{dy}{dx} = k\sec^2(1-x)$ oe, $k \neq -1$ or **SC1** for $\frac{dy}{dx} = -\sec^2 1 - x$ or $\frac{dy}{dx} = -\sec^2(1-x) + c$
	Solves $3 = 2 + \tan(1-x)$ as far as $1 - x = \tan^{-1} 1$	M1	
	$1 - x = \frac{\pi}{4}$ isw or 0.7853[98…] $x = 1 - \frac{\pi}{4}$ isw or 0.2146[01…]	A1	
	Correct use of chain rule **and** correctly writes in terms of cosine or tangent: $\frac{their(-1)}{\cos^2\left(their\frac{\pi}{4}\right)} \times 0.04$ oe, soi or $their(-1)\left\{1 + \tan^2\left(their\frac{\pi}{4}\right)\right\} \times 0.04$ oe soi	M1	**dep** on at least **B1** and an attempt to solve $3 = 2 + \tan(1-x)$
	–0.08 oe, nfww	A1	**dep** on all previous marks awarded
5(a)	$\lg P = \lg A + T\lg b$ oe nfww **and** correct comparison with $y = mx + c$ soi	B2	Must be seen and not from wrong working **B1** for $\lg P = \lg A + T\lg b$ isw, nfww
5(b)	$A = 10^6$ oe isw and $b = 10^{\frac{3}{7}}$ oe isw	4	**B2** for $A = 10^6$ oe isw **or B1**correct method which could be used to find A e.g. $\lg A = 6$ or $12 = \frac{3}{7} \times 14 + \lg A$ **B2** for $b = 10^{\frac{3}{7}}$ oe isw or **B1**correct method which could be used to find b e.g. $\lg b = \frac{12-6}{14-0}$ oe or $12 = 14\lg b + 6$

Question	Answer	Marks	Partial Marks
5(c)	lg P_1 = 8 and lg P_2 = 9 soi leading to T_1 = 4.6 to 4.8 or T_2 = 6.8 to 7.2	**M1**	If graph not used then allow **M1** for substitution of *their A* and *their b* in the exponential equation as far as $\frac{10^8}{theirA} = (theirb)^T$ and $\frac{10^9}{theirA} = (theirb)^T$ OR substitution of *their A* and *their b* or *their* lg*A* and *their* lg *b* in the log equation $\lg 10^8 = their \lg A + T(their \lg b)$ or better and $\lg 10^9 = their \lg A + T(their \lg b)$ or better
	Difference of correct times: $T_2 - T_1$ where T_2 = 6.8 to 7.2 T_1 = 4.6 to 4.8	**M1**	
	Answer in range 2.2 to 2.4 nfww	**A1**	
	Alternative method		
	Change in $T = \frac{9-8}{\frac{3}{7}}$	**(M2)**	**M1** for $\lg 10^8 = 8$ and $\lg 10^9 = 9$ **and** $\frac{\text{Change in } \lg P}{\text{Change in } T} = \frac{3}{7}$
	Answer in range 2.2 to 2.4 nfww	**(A1)**	
6(a)(i)	$1 + \frac{5}{7}x + \frac{10}{49}x^2$	**B2**	**B1** for any two correct terms or for the three terms listed but not summed
6(a)(ii)	12	**B2**	**B1** for $7n + 5 = 89$ or $7\left(n + \frac{5}{7}\right) = 89$ oe or ${}^nC_1 = 12$
6(b)	${}^8C_4 \times k^4 \times (-2)^4$ [$\times x^4$] oe or $1120k^4$ [x^4] soi	**B1**	
	${}^8C_2 \times k^6 \times (-2)^2$ [$\times x^2$] oe or $112k^6$ [x^2] soi	**B1**	
	$\frac{1120k^4}{112k^6} = \frac{5}{8}$ or $\frac{70 \times 16 \times k^4}{28 \times 4 \times k^6} = \frac{5}{8}$ oe, soi	**M1**	**FT** providing at least **B1** awarded and correct terms attempted
	$k^2 = 16$ soi	**A1**	
	[For coefficient of x to be positive $k < 0$, therefore] $k = -4$	**A1**	

Question	Answer	Marks	Partial Marks
7(a)	$\dfrac{10(4x-2)^4}{\sqrt{3+(4x-2)^5}}$ or $\dfrac{10(4x-2)^4}{\left(3+(4x-2)^5\right)^{\frac{1}{2}}}$ isw	3	**B2** for correct unsimplified form e.g. $\dfrac{1}{2}\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\times 5\left(4x-\ 2\right)^4\times 4$ or $10\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\left(4x-\ 2\right)^4$ or **B1** for $5(4x-2)^4\times 4$ soi or $\dfrac{1}{2}\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\times g(x)$
7(b)	$\dfrac{dy}{dx}=\dfrac{5(3x+2)-3(5x)}{(3x+2)^2}$ oe isw or $\dfrac{dy}{dx}=5x\left(-\left(3x+2\right)^{-2}\times 3\right)+5\left(3x+2\right)^{-1}$ oe isw	B1	
	[$y=10$] $x=-0.8$	B1	
	$\dfrac{0.01}{\delta x}=\left(their\ \dfrac{dy}{dx}\Big\|_{x=-0.8}\right)$ oe	M1	**FT** *their x* providing *their* $x\neq 10$ or 0.01and *their* genuine attempt at a derivative using product or quotient rule
	$\dfrac{1}{6250}$ or 0.00016 or 1.6×10^{-4} isw	A1	**dep** on all previous marks awarded
	Alternative method		
	$x=\dfrac{-2y}{3y-5}$ oe	(B1)	
	$\dfrac{dx}{dy}=\dfrac{-2(3y-5)-3(-2y)}{(3y-5)^2}$ oe isw or $\dfrac{dx}{dy}=-2y\left(-\left(3y-5\right)^{-2}\times 3\right)+(-2)\left(3y-5\right)^{-1}$	(B1)	
	$\dfrac{\delta x}{0.01}=\left(their\ \dfrac{dx}{dy}\Big\|_{y=10}\right)$ oe	(M1)	**FT** *their* genuine attempt at a derivative using product or quotient rule
	$\dfrac{1}{6250}$ or 0.00016 or 1.6×10^{-4} isw	(A1)	**dep** on all previous marks awarded
7(c)(i)	$3x^2\ln x+x^3\times\dfrac{1}{x}$ or better, isw	B2	**B1** for (*their* $3x^2$)$\ln x+x^3\times$ (*their* $\dfrac{1}{x}$)

Question	Answer	Marks	Partial Marks
7(c)(ii)	$\frac{x^3 \ln x}{6} + \frac{x^3}{18} + c$ oe, isw	**B3**	must have arbitrary constant **B2** for $\frac{x^3 \ln x}{6} + \frac{x^3}{18}$ or $\frac{x^3 \ln x}{6} + \frac{kx^3}{3} + c$, $k > 0$ nfww or **B1** for $\frac{1}{6}\int\left(3x^2 \ln x + x^2\right)\mathrm{d}x + \frac{1}{6}\int x^2\,\mathrm{d}x$ soi or $\frac{x^3 \ln x}{6} + \int \frac{x^2}{6}\mathrm{d}x$ soi or $\int\left(3x^2 \ln x\right)\mathrm{d}x = x^3 \ln x - \int x^2\,\mathrm{d}x$ soi or $\int\left(3x^2 \ln x\right)\mathrm{d}x = x^3 \ln x - \frac{x^3}{3}$ soi
8	$\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{4}\sin\frac{x}{4}$	**M2**	**M1** for $\frac{\mathrm{d}y}{\mathrm{d}x} = k\sin\frac{x}{4}$, $k < 0$ or $k = \frac{1}{4}$
	$y = 0.5$	**B1**	
	$\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=\frac{4\pi}{3}} = -\frac{1}{4}\times\frac{\sqrt{3}}{2}$ or $-\frac{\sqrt{3}}{8}$	**M1**	**FT** (*their k*) $\times\frac{\sqrt{3}}{2}$ providing at least **M1** awarded
	$[m_{\text{normal}} =]\frac{8}{\sqrt{3}}$ soi	**M1**	**FT** $\frac{-1}{\textit{their}\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=\frac{4\pi}{3}}}$
	$y - 0.5 = \frac{8}{\sqrt{3}}\left(x - \frac{4\pi}{3}\right)$ oe	**A1**	**dep** on previous **M1**; must have exact values **FT** *their* m_{normal} and *their* 0.5 providing both are non-zero, exact values
	$\left(\frac{4\pi}{3} - \frac{\sqrt{3}}{16}, 0\right)$ or exact equivalent; mark final answer	**A1**	

Question	Answer	Marks	Partial Marks
9	$\int e^{\frac{t}{4}}\,dt = 4e^{\frac{t}{4}}(+c)$ and $\int \frac{16e}{t^2}\,dt = \frac{-16e}{t}(+c)$	B3	**B2** for either correct or **B1** for $\int e^{\frac{t}{4}}\,dt = ae^{\frac{t}{4}}(+c)$ where a is a constant, $a > 0$ or $\int \frac{16e}{t^2}\,dt = \frac{-b}{t}(+c)$ where b is a constant $b > 0$
	Correct plan: $\int_0^4 e^{\frac{t}{4}}\,dt + \int_4^k \frac{16e}{t^2}\,dt = 13.4$ soi	M1	
	Correct equation: $4e^1 - 4e^0 + \left(-\frac{16e}{k} + \frac{16e}{4}\right) = 13.4$ OR [When $t = 4$ $s = 4e - 4$ When $t = k$ $s = \frac{-16e}{k} + 8e - 4$ and] $13.4 = \frac{-16e}{k} + 8e - 4$	A1	**dep** on **B3**; implies **M1**
	$k = 10$ or awrt 10.0	A1	dep on all previous marks awarded
10	$\lambda\left(\mathbf{c} + \frac{2}{5}\mathbf{b}\right)$ isw	B2	**B1** for $\lambda(\mathbf{c} + k\mathbf{b})$ where $k \neq \frac{2}{5}$ or 1, $k > 0$
	$2\mathbf{c} + \mu(\mathbf{b} - \mathbf{c})$ isw or $\mu\mathbf{b} + (2 - \mu)\mathbf{c}$ isw or $\mathbf{c} + \mathbf{b} + (1 - \mu)(\mathbf{c} - \mathbf{b})$ isw	B2	**B1** for any of the following with $n > 0$ $2\mathbf{c} + \mu(\mathbf{b} - n\,\mathbf{c})$ or $n\mathbf{c} + \mu(\mathbf{b} - \mathbf{c})$ or $\mathbf{c} + \mathbf{b} + (1 - \mu)(n\mathbf{c} - \mathbf{b})$ or $n(\mathbf{c} + \mathbf{b}) + (1 - \mu)(\mathbf{c} - \mathbf{b})$
	Equates components at least once $\lambda = 2 - \mu$ or $\frac{2}{5}\lambda = \mu$ soi	M1	**FT** providing of equivalent forms e.g.: $\lambda(s\mathbf{c} + t\mathbf{b})$ and $x\mathbf{c} + \mu(y\mathbf{b} + z\,\mathbf{c})$ where *s*, *t, x, y, z* are scalars
	$\lambda = 2 - \mu$ **and** $\frac{2}{5}\lambda = \mu$ soi, nfww	A1	
	$\mu = \frac{4}{7}$ $\left[\lambda = \frac{10}{7}\right]$	A1	
	[*AE* : *EB* =] 4 : 3 oe	A1	must have earned all previous marks