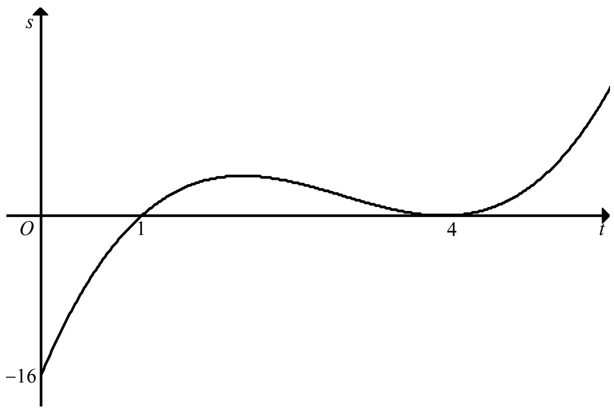
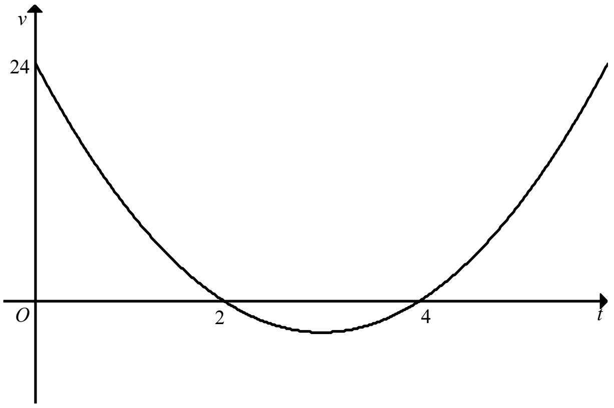
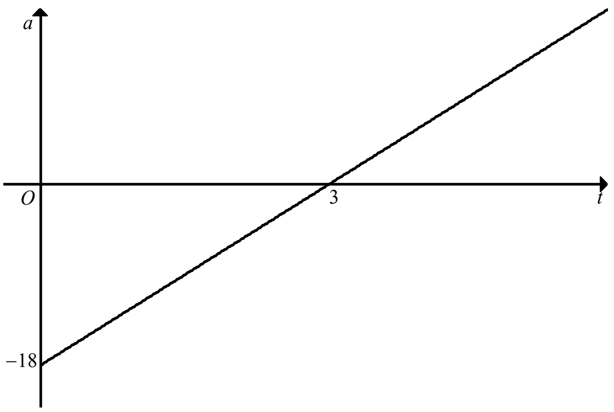
Question	Answer	Marks	Partial marks
1	$5x+2*3$ and $5x+2*-3$ oe	**M1**	where * could be = or any inequality sign
	Critical values: $\frac{1}{5}$, –1 soi	**A2**	**A1** for one correct value
	$x \leqslant -1 \quad x \geqslant \frac{1}{5}$ oe mark final answer	**A1**	
	Alternative method		
	$(5x+2)^2 * 3^2$	**(M1)**	where * could be = or any inequality sign
	Critical values: $\frac{1}{5}$, –1 soi	**(A2)**	**A1** for $25x^2+20x-5[*0]$
	$x \leqslant -1 \quad x \geqslant \frac{1}{5}$ oe mark final answer	**(A1)**	
2 (a)	Fully correct graph with all intercepts stated  	**2**	**B1** for correct cubic shape with maximum in the first quadrant, a point of tangency to the t-axis at the minimum point; must meet the s-axis **B1** for correct intercepts; must have attempted the correct shape
2(b)	v: $2(t-4)(t-1)+(t-4)^2(1)$ or s: $t^3-9t^2+24t-16$ **and** v: $3t^2-18t+24$	**M1**	
	v: $3(t-4)(t-2)$	**A1**	

Question	Answer	Marks	Partial marks
2(c)	Fully correct graph with all intercepts stated  	**B2**	**B1** for correct quadratic shape with minimum in the fourth quadrant; must meet the *v*-axis **B1** for correct intercepts; must have attempted the correct shape
2(d)	$6t - 18$ or $3(t - 4) + (3t - 6)$ oe	**B1**	**FT** *their* 3-term quadratic expression oe for *v* Correct linear expression for *a* from their *v* which must be either a 3-term quadratic or an expression that would simplify to a 3-term quadratic
2(e)	Fully correct ruled graph with all intercepts stated  	**3**	**B1** for a single ruled line with positive gradient in fourth and first quadrants; must meet the *a*-axis and cross the *t*-axis **B1 FT** for a line with *t*-intercept 3 **FT** –*their* (–18) ÷ *their* 6 providing *their a* is a linear expression of the form $mt + c$ **B1 FT** for a line with *a*-intercept –18 **FT** *their* (–18) providing *their a* is a linear expression of the form $mt + c$

Question	Answer	Marks	Partial marks
3	$\frac{3\sqrt{x+2}}{\sqrt{x+2}+4}=1$ soi OR $g(x)=f^{-1}(1)$ and $f^{-1}(x)=\frac{4x}{3-x}$ oe	2	**M1** for $f(\sqrt{x+2})\ [=1]$ soi or for $g(x)=f^{-1}(1)$ soi
	$x=2$ nfww	2	**M1 FT** for correct equation without an algebraic fraction e.g. $\sqrt{x+2}=2$ **FT** *their* $\frac{3\sqrt{x+2}}{\sqrt{x+2}+4}=1$ providing **M1** previously awarded and fg(x) is an algebraic fraction
	Alternative method		
	Solves $\frac{3x}{x+4}=1$ to find x = 2 and states $g(x)=2$	**(2)**	**M1** for solving $f(x)=1$ to find x = k and states $g(x)=k$, where k is a constant
	$x=2$ nfww	**(2)**	**M1 FT** for $\sqrt{x+2}=k$ **FT** $g(x)=k$ *their* providing **M1** previously awarded

Question	Answer	Marks	Partial marks
4(a)	$\left[\frac{dy}{dx}=\right]$ $4\left(\cos 2x(2\cos 2x)+\sin 2x(-2\sin 2x)\right)$ oe	**M1**	Use of the product rule with correct structure
	$\left[\frac{dy}{dx}=\right]$ $4\left(\cos 2x(2\cos 2x)+\sin 2x(-2\sin 2x)\right)$ oe, isw	**A1**	
	$\left[\left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{6}}=\right]4\left(2\cos^2\frac{2\pi}{6}-2\sin^2\frac{2\pi}{6}\right)$ oe	**M1**	**dep** on previous **M1** **FT** *their* $\frac{dy}{dx}$ providing it is of the form $a\cos^2 2x - b\sin^2 2x$ or equivalent where a, b are positive integers
	$\left[\left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{6}}=\right]-4$	**A1**	

Question	Answer	Marks	Partial marks
4(b)	$\left[\text{When } x = \frac{\pi}{6}\right] y = \sqrt{3}$	**B1**	
	Gradient of normal = $\frac{1}{4}$	**M1**	**FT** $\dfrac{-1}{\textit{their} \left.\frac{dy}{dx}\right\vert_{x=\frac{\pi}{6}}}$ from part **(a)**
	Equation of normal: $y = \frac{1}{4}x + \sqrt{3} - \frac{\pi}{24}$ or $y = \frac{1}{4}x + c$ and $\sqrt{3} = \frac{1}{4}\left(\frac{\pi}{6}\right) + c$ or $y - \sqrt{3} = \frac{1}{4}\left(x - \frac{\pi}{6}\right)$ oe	**M1**	**FT** $\dfrac{-1}{\textit{their} \left.\frac{dy}{dx}\right\vert_{x=\frac{\pi}{6}}}$ and *their y*, providing *their* $y \neq 0$
	$0 - \sqrt{3} = \frac{1}{4}\left(x - \frac{\pi}{6}\right)$	**M1**	**FT** *their* equation of normal providing gradient is $\dfrac{-1}{\textit{their} \left.\frac{dy}{dx}\right\vert_{x=\frac{\pi}{6}}}$
	$\left(\frac{\pi}{6} - 4\sqrt{3}, 0\right)$ or exact equivalent; mark final answer	**A1**	**dep** on all previous marks awarded and a fully correct solution to (a) or a correct derivative and gradient of tangent at $x = \frac{\pi}{6}$ stated in this part
5(a)(i)	300	**B1**	
5(a)(ii)	252	**2**	**M1** for 21 × 4 × 3 × 1 oe OR Starts with 5 OR ends with 0: 1 × 4 × 3 × 5 oe or 60 or Starts with 2, 4, 6 or 8 OR ends with 2, 4, 6 or 8: 4 × 4 × 3 × 4 oe or 192 OR [All possible –] ends with 5: 4 × 4 × 3 × 1 oe or 48

Question	Answer	Marks	Partial marks
5(a)(iii)	108	**2**	**M1** for 9 × 4 × 3 × 1 oe OR Ends with 5: 4 × 4 × 3 × 1 oe or 48 or Ends with 0: 5 × 4 × 3 × 1 oe or 60 OR Starts 5, ends 0: 1 × 4 × 3 × 1 oe or 12 or Does not start 5: 4 × 4 × 3 × 2 oe or 96
5(b)	Correct simplified equation: $(n+1)^2 = 33 \times 12 \times 11$ oe, nfww	**B2**	**B1** for an equation with simplified algebraic component $(n+1)^2$ oe or simplified numerical component $33 \times 12 \times 11$ oe, nfww
	$n = 65$	**B1**	**dep** on **B2**; must be the only solution

Question	Answer	Marks	Partial marks
6	$r = 3$ nfww	**B1**	stated or very clearly implied
	$2\pi = 4\pi r^2 \times \frac{\mathrm{d}r}{\mathrm{d}t}$ soi or $\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{1}{2r^2}$ oe and $\frac{\mathrm{d}S}{\mathrm{d}r} = 8\pi r$	**M1**	Uses relevant chain rule e.g. $\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}r} \times \frac{\mathrm{d}r}{\mathrm{d}t}$ to find the derivatives and values of $\frac{\mathrm{d}r}{\mathrm{d}t}$ and $\frac{\mathrm{d}S}{\mathrm{d}r}$
	$\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{1}{18}$ and $\frac{\mathrm{d}S}{\mathrm{d}r} = 24\pi$ soi	**A1**	
	Correct chain rule including $\frac{\mathrm{d}S}{\mathrm{d}t}$	**B1**	e.g. $\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}r} \times \frac{\mathrm{d}r}{\mathrm{d}t}$ or $\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}t} \times \frac{\mathrm{d}r}{\mathrm{d}S}$ oe
	$\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{4\pi}{3}$ isw or 4.19 or 4.188 to 4.1888	**2**	**M1** for $\frac{\mathrm{d}S}{\mathrm{d}t} = 24\pi \times \frac{1}{18}$
	Alternative method 1		
	$r = 3$ nfww	**(B1)**	stated or very clearly implied
	$\frac{\mathrm{d}V}{\mathrm{d}r} = 4\pi r^2$ and $\frac{\mathrm{d}S}{\mathrm{d}r} = 8\pi r$	**(M1)**	Finds correct expressions for and values of $\frac{\mathrm{d}V}{\mathrm{d}r}$ and $\frac{\mathrm{d}S}{\mathrm{d}r}$
	$\frac{\mathrm{d}V}{\mathrm{d}r} = 36\pi$ and $\frac{\mathrm{d}S}{\mathrm{d}r} = 24\pi$ soi	**(A1)**	
	Correct chain rule including $\frac{\mathrm{d}S}{\mathrm{d}t}$	**(B1)**	e.g. $\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}r} \times \frac{\mathrm{d}r}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$ or $\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$
	$\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{4\pi}{3}$ isw or 4.19 or 4.188 to 4.1888	**(2)**	**M1** for $\frac{\mathrm{d}S}{\mathrm{d}t} = 24\pi \times \frac{1}{36\pi} \times 2\pi$ or $\frac{2}{3} \times 2\pi$

Question	Answer	Marks	Partial marks
6	**Alternative method 2**		
	$r=\sqrt[3]{\frac{3V}{4\pi}}$ nfww	**(B1)**	stated or very clearly implied
	$S=4\pi\left(\sqrt[3]{\frac{3V}{4\pi}}\right)^2 \rightarrow \frac{dS}{dV}=4\pi\times\left(\frac{3}{4\pi}\right)^{\frac{2}{3}}\times\frac{2}{3}V^{-\frac{1}{3}}$	**(M1)**	
	$\frac{dS}{dV}=\frac{2}{3}$ oe soi	**(A1)**	
	Correct chain rule including $\frac{dS}{dt}$	**(B1)**	e.g. $\frac{dS}{dt}=\frac{dS}{dV}\times\frac{dV}{dt}$
	$\frac{dS}{dt}=\frac{4\pi}{3}$ isw or 4.19 or 4.188 to 4.1888	**(2)**	**M1** for $\frac{dS}{dt}=\frac{2}{3}\times 2\pi$
	Alternative method 3		
	$r=3$ nfww	**(B1)**	stated or very clearly implied
	$r=\sqrt{\frac{S}{4\pi}}, V=\frac{4}{3}\pi\left(\sqrt{\frac{S}{4\pi}}\right)^3, \frac{dV}{dS}=\frac{4}{3}\pi\times\frac{1}{(4\pi)^{\frac{3}{2}}}\times\frac{3}{2}S^{\frac{1}{2}}$	**(M1)**	
	$S=36\pi$ **<u>and</u>** $\frac{dV}{dS}=\frac{3}{2}$ oe soi	**(A1)**	
	Correct chain rule including $\frac{dS}{dt}$	**(B1)**	e.g. $\frac{dS}{dt}=\frac{dS}{dV}\times\frac{dV}{dt}$
	$\frac{dS}{dt}=\frac{4\pi}{3}$ isw or 4.19 or 4.188 to 4.1888	**(2)**	**M1** for $\frac{dS}{dt}=\frac{1}{1.5}\times 2\pi$

Question	Answer	Marks	Partial marks
7(a)	Forms a correct equation from which the logarithms can be eliminated : has consistent powers of ln*x* in all terms $\frac{n}{2}\left(12\ln x+\left(n-1\right)\times 4\ln x\right)*43\times 24\ln x$ oe, soi OR uses log laws to combine terms $\ln\left(x^{6n}\times x^{2n(n-1)}\right)*\ln x^{24\times 43}$ or better	3	where * is = or any inequality sign **M2** for $a = 6$ **and** $d = 4$ or $a = 6\ln x$ soi **and** $d = 4\ln x$ soi or $a = \ln x^6$ soi **and** $d = \frac{2}{3}\ln x^6$ soi or $a = \frac{3}{2}\ln x^4$ soi **and** $d = \ln x^4$ soi or for $\ln x^{12\times\frac{n}{2}}+\ln x^{4(n-1)\times\frac{n}{2}}*\ln x^{24\times 43}$ oe or **M1** for any correct expression for *d* or for a correct expression for the sum to *n* terms using *their a* and *their d* providing *their d* is not one of the given terms
	$2n^2+4n-1032[*0]$ oe	A1	
	Solves *their* 3-term quadratic in *n*	M1	**dep** on attempt at the sum of an AP
	$n = 22$ cao, nfww	A1	**dep** on all previous marks awarded

Question	Answer	Marks	Partial marks
7(b)	Correct term e.g. [u_{25} =] $6\ln x + 24 \times 4\ln x$ or $\ln x^6 + 24 \times \frac{2}{3}\ln x^6$ or $\frac{3}{2}\ln x^4 + 24\ln x^4$ or $2\ln x^3 + 24 \times \left(2\ln x^7 - 5\ln x^2\right)$ oe or $2\ln x^3 + 24 \times \left(5\ln x^2 - 2\ln x^3\right)$ oe	**B1**	
	Forms and correctly simplifies an equation e.g. $102\ln x = 408$ or $17\ln x^6 = 408$ or $\frac{51}{2}\ln x^4 = 408$ or $\ln \frac{x^6 \times x^{336}}{x^{240}} = 408$ or $\ln \frac{x^6 \times x^{240}}{x^{144}} = 408$	**M1**	**FT** *their* u_{25} providing it is an expression for the term of an AP which requires the simplification/collection of two natural logarithms
	$x = e^4$	**A1**	

Question	Answer	Marks	Partial marks
8	For A: $x=\frac{1}{3}$	**B1**	
	$\frac{dy}{dx}=-\frac{15}{x^2}+\frac{10}{x^3}$ oe. isw OR $\frac{dy}{dx}=\frac{-15x^2+10x}{x^4}$ oe, isw	**B2**	**B1** for each correct term OR for $\frac{dy}{dx}=\frac{-15x^2+...}{x^4}$ oe or $\frac{...+10x}{x^4}$
	Solves *their* $\frac{dy}{dx}=0$ as far as $x=$ …	**M1**	**FT** *their* $\frac{dy}{dx}$ providing at least one term is correct
	$B:\left(\frac{2}{3},\ \frac{45}{4}\right)$ oe, nfww	**A2**	**A1** for each correct coordinate
	Correct plan e.g. $\int_{their\frac{1}{3}}^{their\frac{2}{3}}\left(\frac{15}{x}-\frac{5}{x^2}\right)dx-\frac{1}{2}\times their\frac{45}{4}\times\left(their\frac{2}{3}-their\frac{1}{3}\right)$ or $\int_{their\frac{1}{3}}^{their\frac{2}{3}}\left(\frac{15}{x}-\frac{5}{x^2}-\left(their\frac{135}{4}x-their\frac{45}{4}\right)\right)dx$	**M1**	
	$\int\left(\frac{15}{x}-\frac{5}{x^2}\right)dx=15\ln x+\frac{5}{x}$ oe	**B2**	**B1** for $15\ln x$ or $k\ln x+\frac{5}{x}$ oe
	$\left(15\ln\frac{2}{3}+\frac{15}{2}\right)-\left(15\ln\frac{1}{3}+15\right)$ or exact equivalent	**M1**	**FT** *their* $\frac{1}{3}$ and *their* $\frac{2}{3}$ providing at least **B1** awarded for integration
	Area of shaded region: 15ln2 – 9.375 or $15\ln 2-\frac{75}{8}$ or exact equivalent	**A1**	**dep** on all previous marks awarded
9(a)	$\tan 3x=\frac{1}{\sqrt{3}}$ or $\frac{\sqrt{3}}{3}$ or 0.57735…	**B2**	**B1** for $\frac{3}{\cos 3x}=\frac{\sqrt{3}}{\sin 3x}$ oe
	$3x$ = 30 or 210 or –150 or –330	**M1**	Finds one correct and valid triple angle May be in radians for this mark implied by one correct value of x
	x: 10, 70, –50, –110 and no extras in range	**A2**	**A1** for any two correct angles ignoring extras

Question	Answer	Marks	Partial marks
9(b)	$\sin\left(y+\frac{\pi}{3}\right)=0$	**B1**	
	$\cos\left(y+\frac{\pi}{3}\right)=\frac{1}{2}$	**B1**	
	$y+\frac{\pi}{3}$ = 0 or π or 2π or $\frac{\pi}{3}$ or $\frac{5\pi}{3}$	**M1**	Finds one correct and valid compound angle May be in degrees for this mark
	y: $\frac{2\pi}{3}$, $\frac{5\pi}{3}$, 0, $\frac{4\pi}{3}$ oe, nfww	**A2**	**A1** for any two correct angles ignoring extras
10	$n = 6$ stated; nfww	**B2**	**B1** for first term: $(3x^2)^n$ or $(3x^2)^6$ soi
	$-6(3x^2)^5 a+2(729x^{10})=972x^{10}$ oe and $\frac{6\times5(3x^2)^4(-a)^2}{2}+6(3x^2)^5\times\frac{2}{x^2}(-a)+729x^8=bx^8$ oe	**B3**	**B2** for one correct equation **OR** **B1** for second term: $n(-a)(3x^2)^{n-1}$ or $6(-a)(3x^2)^5$ or $-1458ax^{10}$ soi **B1** for third term: $\frac{n(n-1)(-a)^2(3x^2)^{n-2}}{2}$ or $\frac{6(5)(-a)^2(3x^2)^4}{2}$ or $1215a^2x^8$ soi **B1** for $1\ [+]\ \frac{2}{x^2}\ [+]\ \frac{1}{x^4}$ soi
	$a=\frac{1}{3}$	**B2**	**B1** for $-1458a+1458=972$ soi
	$b = -108$	**B2**	**B1** for $1215a^2 - 2916a + 729$ soi