Question			Answer	Marks	Guidance	
1			Attempt use of product rule to find first derivative	M1	producing form … − … where one term involves $\ln x$ and the other does not	
			Obtain $8x\ln x + 4x$	A1	or unsimplified equiv	
			Attempt use of correct product rule to find second derivative	M1	with one term involving $\ln x$	
			Obtain $8\ln x + 12$	A1	or unsimplified equiv	
			Obtain 28	A1		
				[5]		
2			State or imply $\text{cosec}\,\theta = 1$, $\sin\theta$	B1	allow cosec = 1 , sin	
			Attempt to express equation in terms of $\sin\theta$ only	M1	using identity of form $-1-2\sin^2\theta$ for $\cos 2\theta$	
			Obtain $10\sin^2\theta + 2\sin\theta - 5 = 0$	A1	or unsimplified equiv involving $\sin\theta$ only but with no $\sin\theta$ remaining in denominator	
			Attempt use of formula to find $\sin\theta$ from 3-term quadratic equation involving $\sin\theta$ (using formula or completing square even if their equation can be solved by factorisation)	M1	use implied by at least one correct value of $\sin\theta$ or θ; if correct quadratic formula quoted, condone one sign error for M1; if formula not first quoted, any error leads to M0	if completion of square used to solve equation, this must be correct for M1 to be earned
			Obtain 37.9°	A1	or greater accuracy 37.8896…	
			Obtain 142°	A1	or greater accuracy 142.1103…; and no others between 0 and 180; ignore any answers, right or wrong, outside 0 - 180	no working and answers only (max 2/6): 37.9 (or greater accuracy) B1 142 (or greater accuracy) and no others … B1
				[6]		

Question			Answer	Marks	Guidance	
3	(i)		Attempt calculation $k(y + 4y + 2y + ...)$	M1	any constant k; using y values with coefficients 1, 2, 4 each occurring at least once; brackets may be implied by subsequent calculation	allow M1 for attempt using y values based on wrong x values such as 0, 1, 2, 3, 4; attempt based on $k(y_0 + y_4) + 4y_1 + 2y_2 + 4y_3$ is M0 unless subsequent calculation shows missing brackets are 'present'
			Obtain $k(e^0 + 4e^{\sqrt{0.5}} + 2e + 4e^{\sqrt{1.5}} + e^{\sqrt{2}})$	A1	or equiv perhaps involving decimal values 1, 2.02811..., 2.71828..., 3.40329..., 4.11325...	
			Use $k = \frac{1}{3} \cdot \frac{1}{2}$	A1		
			Obtain 5.38	A1	allow 5.379 but not, in final answer, greater 'accuracy'; answer $5.38 + c$ is final A0	answer only: 0/4
				[4]		
3	(ii)		Attempt calculation of form 10 · (answer to part i) + k	M1	implied by correct answer only or by answer following correctly from their incorrect part **(i)** ; any non-zero constant k	allow attempt involving second use of Simpson's rule: M1 for complete correct expression, A1 for answer
			Obtain 55.8 or greater accuracy based on their part **(i)** – more than 3 s.f. acceptable	A1ft	following their answer to part **(i)** but A0 for $55.8 + c$	answer only 54.8 with no working earns M1A0 (as does 10(their ans) + 1); otherwise incorrect answer with no working earns 0/2
				[2]		
4	(i)		Either: State $2x^3 + 4 = -50$	B1		
			State -3 and no other	B1		
			Or: Obtain $\sqrt[3]{\frac{1}{2}(x - 4)}$ for inverse of f	B1	or equiv; using any letter	
			State -3 and no other	B1		
				[2]		
4	(ii)		Show composition of functions the right way round	M1		
			Obtain $2x - 16$	A1	AG; necessary detail needed	first step $2(x - 10) + 4$ acceptable but then two more steps needed
				[2]		

Question			Answer	Marks	Guidance	
4	(iii)		Obtain $\sqrt[3]{2x^3 - 6}$ or $(2x^3 - 6)^{\frac{1}{3}}$ for $gf(x)$	B1	or unsimplified equiv	
			Apply chain rule to function which is cube root of a non-linear expression	M1	condone incorrect constant; otherwise use of chain rule for their function must be correct	may use $u = 2x^3 - 6$; M1 earned for expression involving u
			Obtain $2x^2(2x^3 - 6)^{-\frac{2}{3}}$	A1	or similarly simplified equiv; do not accept final answer with $\frac{6}{3}$ unsimplified	... in terms of x
				[3]		
5	(a)		Differentiate to produce $ke^{-0.33t}$	M1	where constant k is different from 58	method must involve differentiation
			Obtain $-19.14e^{-0.33t}$ or $19.14e^{-0.33t}$	A1	or unsimplified equiv	
			Obtain -5.1 or 5.1	A1	whatever they claim value represents; accept 5.11 but not greater accuracy	
				[3]		
5	(b)		Either:			
			State or imply formula $42e^{kt}$ or $42a^t$	B1	$42e^{-kt}$, $42e^{-kx}$, etc. also acceptable	
			Attempt to find k from $42e^{6k} = 51.8$ or a from $42a^6 = 51.8$	M1	using sound process involving logarithms at least as far as $6k = \ldots$ or $a = \ldots$	
			Obtain $k = 0.035$ or $a = 1.0356$	A1	or greater accuracy 0.03495... or exact equiv $\frac{1}{6}\ln\frac{37}{30}$	
			Substitute 24 to obtain value between 97.1 and 97.3 inclusive	A1	allow greater accuracy than 3 s.f.	
			Or:			
			Use ratio $\frac{51.8}{42}$ in calculation	B1		
			Attempt calculation of form $42 \cdot r^n$	M1		
			Obtain $42 \cdot (\frac{51.8}{42})^4$ or $51.8 \cdot (\frac{51.8}{42})^3$	A1		
			Obtain value between 97.1 and 97.3 inclusive	A1	allow greater accuracy than 3 s.f.	
				[4]		

Question			Answer	Marks	Guidance	
6	(i)		Draw inverted parabola roughly symmetrical about the y-axis and with maximum point more or less on y-axis	M1	drawing enough of the parabola that two intersections occur, ignoring their locations at this stage	
			State $y = 9 - x^2$ and indicate two intersections by marks on diagram or written reference to two intersections	A1 [2]	now needs second curve drawn so that right-hand intersection occurs in first quadrant	
6	(ii)	(a)	Calculate values of quartic expression for 2.1 and 2.2	M1	if no explicit working seen, M1 is implied by at least one correct value; but if no explicit working seen and both values wrong, award M0	
			Obtain -1.9... and 1.6... and draw attention to sign change or clear equiv	A1 [2]		
6	(ii)	(b)	Obtain correct first iterate	B1	starting anywhere between –1 and 9 and showing at least 3 d.p.	
			Carry out process to produce at least three iterates in all	M1	implied by plausible sequence of values; allow recovery after error	2.1 fi 2.15056 fi 2.15531 fi 2.15575 fi 2.15579 2.15 fi 2.15526 fi 2.15574 fi 2.15579
			Obtain at least two more correct iterates	A1	showing at least 3 decimal places	
			Obtain 2.156	A1 [4]	final answer needed to exactly 3 d.p.; not given for 2.156 as final iterate in sequence, i.e. needs indication (perhaps just underlining) that value of a found	2.2 fi 2.15980 fi 2.15616 fi 2.15583 fi 2.15580 answer only: 0/4

Question			Answer	Marks	Guidance	
7	(i)		Integrate to obtain $k(4x+1)^{\frac{1}{2}}$ or $ku^{\frac{1}{2}}$	*M1	any constant k	
			Obtain correct $\frac{1}{2}\sqrt{3}(4x+1)^{\frac{1}{2}}$ or $\frac{1}{2}\sqrt{3}u^{\frac{1}{2}}$	A1	or exact equiv	
			Apply limits 0 and 20 and attempt subtraction of area of rectangle (or limits 1 and 81 if u involved)	M1	dep *M; or equiv such as including term $-\frac{1}{9}\sqrt{3}$ in the integration or finding $\frac{1}{9}\sqrt{3}\,dx$ separately; allow M1 if decimal values used here	Alternative: (region between curve and y-axis) Obtain equation $x = \frac{3}{4}y^{-2} - \frac{1}{4}$ B1 Integrate to obtain form $k_1y^{-1} + k_2y$ *M1 Apply limits $\frac{1}{9}\sqrt{3}$ and $\sqrt{3}$ the right way round M1 d*M
			Obtain $4\sqrt{3} - \frac{20}{9}\sqrt{3}$ and hence $\frac{16}{9}\sqrt{3}$	A1	answer must be exact and a single term; $\frac{16}{9}\sqrt{3} + c$ as answer is final A0	Obtain $\frac{6}{\sqrt{3}} - \frac{8}{36}\sqrt{3}$ or better A1
				[4]		
	(ii)		State volume is $p\,\dfrac{3}{4x+1}\,dx$	B1	no need for limits here; condone absence of dx; condone absence of p here if it appears later in solution	allow B1 for py^2 and $y^2 = \frac{3}{4x+1}$ stated
			Obtain integral of form $k\ln(4x+1)$	M1	any constant k with or without p	if brackets missing, and subsequent calculation does not show their 'presence', marks are max B1M1A0A0M1A0
			Obtain $\frac{3}{4}p\ln(4x+1)$ or $\frac{3}{4}\ln(4x+1)$	A1		
			Apply limits to obtain $\frac{3}{4}p\ln 81$ or $\frac{3}{4}\ln 81$	A1	or exact equiv perhaps with $\ln 1$ present	
			Attempt to subtract volume of cylinder, using correct radius and 'height'	M1	with exact volume of cylinder attempted	do not treat rotation around y-axis as mis-read: this is 0/6
			Obtain $3p\ln 3 - \frac{20}{27}p$ or $p(\frac{3}{4}\ln 81 - \frac{20}{27})$	A1	or exact equiv involving two terms	
				[6]		

Question			Answer	Marks	Guidance	
8	(i)		Attempt use of quotient rule or equiv	M1	condone one slip only but must be subtraction in numerator; condone absence of necessary brackets; or equiv	
			Obtain $\frac{2(x^2+5)-2x(2x+4)}{(x^2+5)^2}$	A1	or correct equiv; now with brackets as necessary	correct numerator but error in denominator: max M1A0A1M1A1A1; numerator wrong way round: max M0A0A0M1A1A1
			Obtain $-2x^2-8x+10=0$	A1	or equiv involving three terms	
			Attempt solution of three-term quadratic equation based on numerator of derivative (even if their equation has no real roots)	M1	implied by no working but 2 correct values obtained	M1 for factorisation awarded if attempt is such that x^2 term and one other term correct upon expansion; if formula used, M1 awarded as per Qn 2
			Obtain -5 and 1	A1		
			Obtain $(-5, -\frac{1}{5})$ and $(1, 1)$	A1	Allow $-\frac{6}{30}$	
				[6]		
	(ii)	(a)	Sketch (more or less) correct curve	B1	showing negative part reflected in x-axis and positive part unchanged; ignore intercept values on axes, right or wrong	
			State values between 0 and their y-value of maximum point lying in first quadrant	M1	accept £ or < signs here	
			State correct $0 £ y £ 1$	A1ft	following their y-value of maximum point in first quadrant; now with £ signs; or equiv perhaps involving g or $g(x)$	for "$y ‡ 0$ and $y £ 1$", award M1A1; for separate statements $y ‡ 0$, $y £ 1$, award M1A0
				[3]		
	(ii)	(b)	Indicate, in some way, values between y-coordinates of maximum point and reflected minimum point (provided their y-coordinate of minimum point is negative)	M1	allow £ sign(s) here; could be clear indication on graph	for "$k > \frac{1}{5}$ and $k < 1$", award M1A1; for separate statements, award M1A0
			State $\frac{1}{5} < k < 1$	A1	or correct equiv; not £ now; correct answer only earns M1A1	
				[2]		

Question			Answer	Marks	Guidance	
9	(i)		Simplify to obtain $\frac{11}{2}\cos q + \frac{5\sqrt{3}}{2}\sin q$	B1	or equiv with two terms perhaps with $\sin 60$ retained	accept decimal values
			Attempt correct process to find R	M1	for expression of form $a\cos q + b\sin q$	obtained after initial simplification
			Attempt correct process to find a	M1	for expression of form $a\cos q + b\sin q$; condone $\sin a = \frac{11}{2}$, $\cos a = \frac{5}{2}\sqrt{3}$	obtained after initial simplification
			Obtain $7\sin(q + 51.8)$	A1	or greater accuracy 51.786…	
				[4]		
	(ii)	(a)	State stretch and translation in either order	M1	or equiv but using correct terminology, not move, squash, …	SC: if M0 but one transformation completely correct, award B1 for 1/3
			State stretch parallel to y-axis with factor $\frac{1}{7}$	A1ft	following their R and clearly indicating correct direction	
			State translation parallel to q-axis or x-axis by 51.8 in positive direction or state translation by vector $\begin{pmatrix} 51.8 \\ 0 \end{pmatrix}$	A1ft	following their a and clearly indicating correct direction; or equiv such as 308.2 parallel to x-axis in negative direction	
				[3]		
		(b)	State left-hand side (their R) $\sin(\frac{1}{3}b + g)$ where $g \neq -$(their a), $g \neq -40$, $g \neq -20$	M1	or equiv such as stating $q = \frac{1}{3}b + 20$	
			Obtain (their R) $\sin(\frac{1}{3}b +$ their $a + 20) = 3$	A1ft	(and, in this case, allowing A1ft provided value of $\frac{1}{3}b$ attempted later)	
			Attempt correct process to find any value of $\frac{1}{3}b$	M1	for equation of form $\sin(\frac{1}{3}b + g) = k$ where $\lvert k\rvert < 1$, $k \neq 0$	
			Attempt complete process to find positive value of b	M1	including choosing second quadrant value of their $\sin^{-1}\frac{3}{7}$	
			Obtain 248 or 249 or 248.5	A1	or greater accuracy 248.508…	
				[5]		