1	i	$y' = 6x^2 - 18x + 12$	M1	condone one error		
		$= 12$	M1	subst of $x = 3$ in <u>their</u> y'		
		$y = 7$ when $x = 3$	B1			
		tgt is $y - 7 = 12 (x - 3)$	M1	f.t. their y and y'		
		verifying $(-1, -41)$ on tgt	A1	or B2 for showing line joining (3, 7) and		
				$(-1, -41)$ has gradient 12	5	
	ii	$y' = 0$ soi	M1	Their y'		
		quadratic with 3 terms	M1	Any valid attempt at solution		
		$x = 1$ or 2	A1	or A1 for (1, 3) and A1 for (2,2) marking		
		$y = 3$ or 2	A1	to benefit of candidate	4	
	iii	cubic curve correct orientation	G1			
		touching x- axis only at (0.2,0)				
		max and min correct	G1	f.t.		
		curve crossing y axis only at -2	G1		3	

2	i	$y' = 3x^2 - 6x$	B1	condone one error		
		use of $y' = 0$	M1			
		(0, 1) or (2, –3)	A2	A1 for one correct or $x = 0$, 2		
				SC B1 for (0,1) from their y'		
		sign of y' used to test or y' either side	T1	Dep't on M1 or y either side or clear cubic sketch	5	
	ii	$y'(-1) = 3 + 6 = 9$	B1			
		$3x^2 - 6x = 9$	M1	ft for their y'		
		$x = 3$	A1	implies the M1		
		At P $y = 1$	B1			
		grad normal $= -1/9$ cao	B1			
		$y - 1 = -1/9 (x - 3)$	M1	ft their (3, 1) and their grad, not 9		
		intercepts 12 and 4/3or use of	B1	ft their normal (linear)		
		$\int_0^{12} \frac{4}{3} - \frac{1}{9} x \ dx$ (their normal)				
		½ × 12 × 4/3 cao	A1		8	13

3		$x + x^{1}$ soi	B1			
		$y' = 1 - 1/x^2$	B1	$1 - x^{-2}$ is acceptable		
		subs $x = 1$ to get $y' = 0$	B1	Or solving $1 - x^{-2} = 0$ to obtain $x = 1$		
		$y''=2x^{-3}$ attempted	M1ft	or checking y' before and after $x = 1$		
		Stating $y'' > 0$ so min cao	A1	Valid conclusion		
				First quadrant sketch scores B2	5	

	Question		Answer	Marks	Guidance	
4	(i)		$x^2(9 - x^2) = 0$ soi	B1	$9 \times 0^2 - 0^4 = 0$	B0 in each case if correct answer appears from clearly incorrect working
			$x = 0$ and ± 3, [so $a = 3$ or $a = -3$]	B1	$9 \times 3^2 - 3^4 = 0$ *and* $9 \times (-3)^2 - (-3)^4 = 0$	$a = \pm 3$ without working does not score
				[2]		
4	(ii)		$y' = 18x - 4x^3$	B1		
			$y'' = 18 - 12x^2$ or ft	B1		
			their $y' = 0$ soi	M1		
			$2x(9 - 2x^2) = 0$ so $x = 0$ oe	A1	or $18 \times 0 - 4 \times 0^3 = 0$ oe	
			$x = 0$, $y'' = 18$ cao so minimum	B1	or evaluation of y' at $\pm h$ oe where $h < \sqrt{4.5}$	
			$x = \pm \sqrt{4.5}$ oe eg $\pm \dfrac{3\sqrt{2}}{2}$	A1	accept 2.12 or better for $\sqrt{4.5}$	
				[6]		
4	(iii)		$\int_0^3 \left(9x^2 - x^4\right)\mathrm{d}x$ soi or ft	M1	condone omission of, or wrong limits	
			$3x^3 - 0.2x^5$	A1	correct answer implies M1	ignore + c
			F[their positive a] $[- F[0]]$ **or** (not **and**) F[0] – F[their negative a]	M1	dependent on at least one term correct	M0 if neither of the limits is 0 M0 for F[0] – F[their positive a] M0 for use of Trapezium Rule
			32.4 oe cao	A1		
				[4]		

5	their $\dfrac{dy}{dx} = 0$ correct step $x = \frac{1}{2}$ c.a.o.	2 M1 DM1 A1	B1 each term s.o.i. s.o.i.	5

6	$y'' = 2x - 6$ $y'' = 0$ at $x = 3$ $y' = 0$ at $x = 3$ showing y' does not change sign	B1 B1 B1 E1	or that y'' changes sign	4