1	(i)	$u_2 = 12$ $u_3 = 9.6$, $u_4 = 7.68$ (or any exact equivs)	B1 B1√ 2	State $u_2 = 12$ Correct u_3 and u_4 from their u_2
	(ii)	$S_{20} = \frac{15(1-0.8^{20})}{1-0.8}$ $= 74.1$	M1 A1 A1 3	Attempt use of $S_n = \frac{a(1-r^n)}{1-r}$ with $n = 20$ or 19 Obtain correct unsimplified expression Obtain 74.1 or better
		OR		
			M1 A2 5	List all 20 terms of GP Obtain 74.1
2		$\left(x+\frac{2}{x}\right)^4 = x^4 + 4x^3\left(\frac{2}{x}\right) + 6x^2\left(\frac{2}{x}\right)^2 + 4x\left(\frac{2}{x}\right)^3 + \left(\frac{2}{x}\right)^4$	M1*	Attempt expansion, using powers of x and $\frac{2}{x}$, (or the two terms in their bracket), to get at least 4 terms
			M1* A1dep* A1	Use binomial coefficients of 1, 4, 6, 4, 1 Obtain two correct, simplified, terms Obtain a further one correct, simplified, term
		$= x^4 + 8x^2 + 24 + \frac{32}{x} + \frac{16}{x^2}$ (or equiv)	A1 5	Obtain a fully correct, simplified, expansion
		OR		
			M1* M1*	Attempt expansion using all four brackets Obtain expansion containing the correct 5 powers only (could be unsimplified powers eg $x^3 \cdot x^{-1}$)
			A1dep* A1 A1 5	Obtain two correct, simplified, terms Obtain a further one correct, simplified, term Obtain a fully correct, simplified, expansion
3		$\log 3^{(2x+1)} = \log 5^{200}$ $(2x+1)\log 3 = 200\log 5$	M1 M1 A1	Introduce logarithms throughout Drop power on at least one side Obtain correct linear equation (now containing no powers)
		$2x+1 = \frac{200\log 5}{\log 3}$ $x = 146$	M1 A1 5	Attempt solution of linear equation Obtain $x = 146$, or better
		OR		
		$(2x+1) = \log_3 5^{200}$ $2x+1 = 200\log_3 5$	M1 M1 A1 M1 A1 5	Introduce $\log_3$ on right-hand side Drop power of 200 Obtain correct equation Attempt solution of linear equation Obtain $x = 146$, or better
4	(i)	area $\approx \frac{1}{2}\times\frac{1}{2}\times\left\{\sqrt{5}+2\left(\sqrt{7}+\sqrt{9}+\sqrt{11}\right)+\sqrt{13}\right\}$ $\approx 0.25\times 23.766\ldots$ ≈ 5.94	M1 M1 A1 A1 4	Attempt y-values for at least 4 of the $x = 1, 1.5, 2, 2.5, 3$ only Attempt to use correct trapezium rule Obtain $\frac{1}{2}\times\frac{1}{2}\times\left\{\sqrt{5}+2\left(\sqrt{7}+\sqrt{9}+\sqrt{11}\right)+\sqrt{13}\right\}$, or decimal equiv Obtain 5.94 or better (answer only is 0/4)
	(ii)	This is an underestimate … …as the tops of the trapezia are below the curve	*B1 B1dep*B1 2 6	State underestimate Correct statement or sketch

5	(i)	$3(1-\sin^2\theta)=\sin\theta+1$	M1		Use $\cos^2\theta=1-\sin^2\theta$
		$3-3\sin^2\theta=\sin\theta+1$			
		$3\sin^2\theta+\sin\theta-2=0$	A1	2	Show given equation correctly
	(ii)	$(3\sin\theta-2)(\sin\theta+1)=0$	M1		Attempt to solve quadratic equation in $\sin\theta$
		$\sin\theta=\frac{2}{3}$ or -1	A1		Both values of $\sin\theta$ correct
		$\theta=42°, 138°, 270°$	A1		Correct answer of 270°
			A1		Correct answer of 42°
			A1√	5	For correct non-principal value answer, following their first value of θ in the required range (any extra values for θ in required range is max 4/5) (radians is max 4/5) SR: answer only (or no supporting method) is B1 for 42°, B1√ for 138°, B1 for 270°
				7	
6	(a)	(i) $\int x^3-4x=\frac{1}{4}x^4-2x^2+c$	M1		Expand and attempt integration
			A1		Obtain $\frac{1}{4}x^4-2x^2$ (A0 if $\int$ or dx still present)
			B1	3	$+c$ (mark can be given in (b) if not gained here)
		(ii) $\left[\frac{1}{4}x^4-2x^2\right]_4^6$	M1		Use limits correctly in integration attempt (ie F(6) − F(1))
		$=(324-72)-(\frac{1}{4}-2)$			
		$=253\frac{3}{4}$	A1	2	Obtain $253\frac{3}{4}$ (answer only is M0,A0)
	(b)	$\int 6x^{-3}dx=-3x^{-2}+c$	B1		Use of $\frac{1}{x^3}=x^{-3}$
			M1		Obtain integral of the form kx^{-2}
			A1	3	Obtain correct $-3x^{-2}$ $(+c)$ (A0 if $\int$ or dx still present, but only penalise once in question)
				8	
7	(a)	$S_{70}=\frac{70}{2}\{(2\times12)+(70-1)d\}$	M1		Attempt S_{70}
			A1		Obtain correct unsimplified expression
		$35(24+69d)=12915$	M1		Equate attempt at S_{70} to 12915, and attempt to find d
		$d=5$	A1	4	Obtain $d=5$
	OR				
		$\frac{70}{2}\{12+l\}=12915$	M1		Attempt to find d by first equating $\frac{n}{2}(a+l)$ to 12915
		$l=357$	A1		Obtain $l=357$
		$12+69d=357$	M1		Equate u_{70} to l
		$d=5$	A1		Obtain $d=5$
	(b)	$ar=-4$	B1		Correct statement for second term
		$\frac{a}{1-r}=9$	B1		Correct statement for sum to infinity
		$\frac{-4}{r}=9-9r$ or $a=9-\left(9\times\frac{-4}{a}\right)$	M1		Attempt to eliminate either a or r
		$9r^2-9r-4=0$ $a^2-9a-36=0$	A1		Obtain correct equation (no algebraic denominators/brackets)
		$(3r-4)(3r+1)=0$ $(a+3)(a-12)=0$	M1		Attempt solution of three term quadratic equation
		$r=\frac{4}{3}, r=-\frac{1}{3}$ $a=-3, a=12$	A1		Obtain at least $r=-\frac{1}{3}$ (from correct working only)
		Hence $r=-\frac{1}{3}$	A1	7	Obtain $r=-\frac{1}{3}$ only (from correct working only) SR: answer only "T&I" is B2 only
				11	

8	(i)	$\frac{1}{2}\times AB^2\times 0.9=16.2$	M1		Use $\left(\frac{1}{2}\right)r^2\theta=16.2$
		$AB^2=36\Rightarrow AB=6$	A1	2	Confirm $AB=6$ cm (or verify $\frac{1}{2}$ x 6^2 x 0.9 = 16.2)
	(ii)	$\frac{1}{2}\times 6\times AC\times\sin 0.9=32.4$	M1*		Use $\Delta=\frac{1}{2}bc\sin A$, or equiv
			M1dep*		Equate attempt at area to 32.4
		$AC=13.8$ cm	A1	3	Obtain $AC=13.8$ cm, or better
	(iii)	$BC^2=6^2+13.8^2-2\times 6\times 13.8\times\cos 0.9$	M1		Attempt use of correct cosine formula in ΔABC
			A1√		Correct unsimplified equation, from their AC
		Hence $BC=11.1$ cm	A1		Obtain $BC=11.1$ cm, or anything that rounds to this
		$BD=6\times 0.9=5.4$ cm	B1		State $BD=5.4$ cm (seen anywhere in question)
		Hence perimeter = 11.1 + 5.4 + (13.8 − 6)	M1		Attempt perimeter of region BCD
		= 24.3 cm	A1	6	Obtain 24.3 cm, or anything that rounds to this
				11	
9	(i)	(a) $f(-1)=-1-6-1-4=0$	B1	1	Confirm f(-1) = 0, through any method
		(b) $x=-1$	B1		State $x=-1$ at any point
		$f(x)=(x+1)(x^2+5x-4)$	M1		Attempt complete division by $(x+1)$, or equiv
			A1		Obtain x^2+5x+k
			A1		Obtain completely correct quotient
		$x=\frac{-5\pm\sqrt{25+16}}{2}$	M1		Attempt use of quadratic formula, or equiv, find roots
		$x=\frac{1}{2}\left(-5\pm\sqrt{41}\right)$	A1	6	Obtain $\frac{1}{2}\left(-5\pm\sqrt{41}\right)$
	(ii)	(a) $\log_2(x+3)^2+\log_2 x-\log_2(4x+2)=1$	B1		State or imply that $2\log(x+3)=\log(x+3)^2$
			M1		Add or subtract two, or more, of their algebraic logs correctly
		$\log_2\left(\frac{(x+3)^2x}{4x+2}\right)=1$	A1		Obtain correct equation (or any equivalent, with single term on each side)
		$\frac{(x+3)^2x}{4x+2}=2$	B1		Use $\log_2 a=1\Rightarrow a=2$ at any point
		$(x^2+6x+9)x=8x+4$			
		$x^3+6x^2+x-4=0$	A1	5	Confirm given equation correctly
		(b) $x>0$, otherwise $\log_2 x$ is undefined	B1*		State or imply that $\log x$ only defined for $x>0$
		$x=\frac{1}{2}\left(-5+\sqrt{41}\right)$	B1√dep*		State $x=\frac{1}{2}\left(-5+\sqrt{41}\right)$ (or x = 0.7) only, following their
				2	single positive root in (i)(b)
				14	