Question Number	Scheme	Marks
5	$4y^2 \to 8y\frac{dy}{dx}$	M1
	$e^{xy} \to \left(y + x\frac{dy}{dx}\right)e^{xy}$ or e.g. $e^{xy} \to ye^{xy} + x\frac{dy}{dx}e^{xy}$	M1
	$2 + 8y\frac{dy}{dx} = 3\left(y + x\frac{dy}{dx}\right)e^{xy}$	A1
	$2 = 3\times\frac{9}{2}\times\frac{dy}{dx} \Rightarrow \frac{dy}{dx} = \frac{4}{27}$	M1
	$y = \frac{4}{27}\left(x - \frac{9}{2}\right) \Rightarrow 4x - 27y - 18 = 0$	**d**M1A1
		(6)
		(6 marks)

Question	**Scheme**	**Marks**
7(a)	$\frac{dx}{dt} = \cos t + 6\cos t\sin t \qquad \frac{dy}{dt} = 3\cos t - 2\sin t$	B1B1
	$\frac{dy}{dx} = \frac{dy}{dt}\times\frac{dt}{dx} = \frac{3\cos t - 2\sin t}{\cos t + 6\cos t\sin t} = \frac{3\cos\pi - 2\sin\pi}{\cos\pi + 6\cos\pi\sin\pi} = 3$ *	M1A1*
		(4)
(b)	When $t = \pi,\ x = -3,\ y = -2$	B1
	$y - "-2" = 3(x - "-3")$	M1
	$y = 3x + 7$	A1
		(3)
(c)	$y = 3x + 7 \Rightarrow 3\sin t + 2\cos t = 3\left(\sin t - 3\cos^2 t\right) + 7$ or $y = 3\left(x + 3\cos^2 t\right) + 2\cos t \Rightarrow 3x + 7 = 3x + 9\cos^2 t + 2\cos t$	M1
	$\Rightarrow 9\cos^2 t + 2\cos t - 7 = 0$ *	A1*
		(2)
(d)	$\cos t = \frac{7}{9}$	B1
	$y = 3\times\frac{\sqrt{32}}{9} + 2\times\frac{7}{9} = \frac{4\sqrt{2}}{3} + \frac{14}{9}$	M1A1
		(3)
		(12 marks)

Question Number	Scheme	Marks
8(a)	$x = 2$	B1
		(1)
(b)	$(2.5, 1.5)$	B1
		(1)
(c)	$\frac{dy}{dx} = \frac{1 + \frac{1}{t^2}}{1 - \frac{1}{t^2}}$	M1
	$t = 2 \Rightarrow \frac{dy}{dx} = \frac{5}{3} \Rightarrow y - 1.5 = -\frac{3}{5}(x - 2.5)$	dM1
	$3x + 5y = 15*$	A1*
		(3)

(d)	l crosses x-axis at $x=5$	B1
	$\frac{1}{3}\pi\times1.5^2(5-2.5)\left(=\frac{15}{8}\pi\right)$	M1
	$V=\pi\int y^2\mathrm{d}x=\pi\int y^2\frac{\mathrm{d}x}{\mathrm{d}t}\,\mathrm{d}t=\pi\int\left(t-\frac{1}{t}\right)^2\left(1-\frac{1}{t^2}\right)\mathrm{d}t$	M1
	$\pi\int\left(t^2-2+\frac{1}{t^2}\right)\left(1-\frac{1}{t^2}\right)\mathrm{d}t=\pi\int\left(t^2+\frac{3}{t^2}-\frac{1}{t^4}-3\right)\mathrm{d}t=...$	M1
	$\pi\left[\frac{t^3}{3}-\frac{3}{t}+\frac{1}{3t^3}-3t\right]$	A1
	$\pi\left[\frac{t^3}{3}-\frac{3}{t}+\frac{1}{3t^3}-3t\right]_1^2=\pi\left(\left(\frac{8}{3}-\frac{3}{2}+\frac{1}{24}-6\right)-\left(\frac{1}{3}-3+\frac{1}{3}-3\right)\right)$	M1
	$V=\frac{13}{24}\pi+\frac{15}{8}\pi=\frac{29}{12}\pi$ Cao	A1
		(7)
		Total 12

Question Number	Scheme	Marks
4(a)	A and B are where $t^3-4t=0\Rightarrow t(t^2-4)=0\Rightarrow t=2$ or -2	M1
	Substitutes $t=2, x=2\times4-6\times2=-4$ Hence $A=(-4,0)$	A1
	When $t=-2, x=2\times4-6\times-2=20, (y=0)$ Hence $B=(20,0)$ *	B1*
		(3)
(b)	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{d}y/\mathrm{d}t}{\mathrm{d}x/\mathrm{d}t}=\frac{3t^2-4}{4t-6}$	M1A1
	Sub $t=-2$ into $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{3t^2-4}{4t-6}\Rightarrow$ gradient $=\left(-\frac{4}{7}\right)$	M1
	Uses their $\left(-\frac{4}{7}\right)$ and $(20,0)$ to produce eqn of tangent $\Rightarrow 7y+4x-80=0$ *	M1 A1*
		(5)
(c)	Substitutes $x=2t^2-6t,\ y=t^3-4t$, into $7y+4x-80=0$	
	$\Rightarrow 7\left(t^3-4t\right)+4\left(2t^2-6t\right)-80=0$	M1
	$\Rightarrow 7t^3+8t^2-52t-80=0$	A1
	$\Rightarrow (t+2)^2(7t-20)=0$	
	$t="\frac{20}{7}"\Rightarrow x=....$	dM1
	$x=-\frac{40}{49}$	A1
		(4)
		(12 marks)

Question Number	Scheme	Marks
1	Attempts to get t in terms of x or y. E.g. $x=\frac{t}{t-3}\Rightarrow t=\frac{3x}{x-1}$	M1
	Forms a Cartesian equation and makes progress to making y the subject E.g. $y=\frac{1}{t}+2\Rightarrow y=\frac{x-1}{3x}+2$	dM1
	$\Rightarrow y=\frac{7x-1}{3x}$	A1
		(3)
		(3 marks)

Question	Scheme	Marks
9(a)	$\frac{\mathrm{d}x}{\mathrm{d}t}=\sec t\tan t$ and $\frac{\mathrm{d}y}{\mathrm{d}t}=\sqrt{3}\sec^2\left(t+\frac{\pi}{3}\right)$	**B1**
	$\left(\frac{\mathrm{d}y}{\mathrm{d}x}=\right)\frac{\mathrm{d}y}{\mathrm{d}t}\div\frac{\mathrm{d}x}{\mathrm{d}t}=\frac{\sqrt{3}\sec^2\left(t+\frac{\pi}{3}\right)}{\sec t\tan t}$ oe	**M1** **A1**
		(3)
(b)	$t=\frac{\pi}{3}\Rightarrow x=2,\ y=-3$	**B1**
	$t=\frac{\pi}{3}\Rightarrow\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\sqrt{3}\sec^2\frac{2\pi}{3}}{\sec\frac{\pi}{3}\tan\frac{\pi}{3}}=\ldots(=2)$	**M1**
	Tangent is $y+3=2(x-2)\Rightarrow y=2x-7$ cso	**M1A1**
		(4)
(c)	$y=\sqrt{3}\frac{\tan t\pm\tan\frac{\pi}{3}}{1\pm\tan t\tan\frac{\pi}{3}}$	**M1**
	$x^2=\sec^2 t=1+\tan^2 t\Rightarrow\tan t=\sqrt{x^2-1}\Rightarrow y=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}}{1-\sqrt{3}\sqrt{x^2-1}}$	**M1** **A1**
	$=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}}{1-\sqrt{3}\sqrt{x^2-1}}\times\frac{1+\sqrt{3}\sqrt{x^2-1}}{1+\sqrt{3}\sqrt{x^2-1}}=..$	
	$=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}\left(x^2-1\right)+\sqrt{3}+3\sqrt{x^2-1}}{1-\left(3x^2-3\right)}=\frac{..\sqrt{x^2-1}+..x^2}{4-3x^2}$	**M1**
	$=\frac{3x^2+4\sqrt{3x^2-3}}{4-3x^2}$	**A1**
		(5)

Question Number	Scheme	Marks
6(a)	$\frac{dy}{dx} = 6\cos t \times \frac{1}{-8\sin t} = k\frac{\cos t}{\sin t}$	M1
	$\frac{dy}{dx} = -\frac{3}{4}\cot\left(\frac{\pi}{3}\right) = -\frac{\sqrt{3}}{4}$	dM1A1
		(3)
	Mark (a) and (b) together.	

(b)	$\left(6, 3\sqrt{3}-3\right)$	B1B1
	$-\frac{\sqrt{3}}{4} \to \frac{4}{\sqrt{3}}$	B1ft
	$y - 3\sqrt{3} + 3 = \frac{4}{\sqrt{3}}(x-6)$ or $y = \frac{4}{\sqrt{3}}x + c \Rightarrow -3\sqrt{3}+3 = \frac{4}{\sqrt{3}} \times 6 + c \Rightarrow c = \left(-3-5\sqrt{3}\right)$	M1
	When $y=0$ $-3\sqrt{3}+3 = \frac{4}{\sqrt{3}}(x-6) \Rightarrow x = \ldots$	dM1
	$\left(\frac{15+3\sqrt{3}}{4}, 0\right)$	A1
		(6)

(c)	$x = 8\cos t + 2 \Rightarrow \cos t = \frac{x-2}{8}$ $\quad y = 6\sin t - 3 \Rightarrow \sin t = \frac{y+3}{6}$	M1
	$\frac{(x-2)^2}{64} + \frac{(y+3)^2}{36} = 1$	A1
		(2)
		(11 marks)

Question Number	Scheme	Marks
6(a)	$\frac{dy}{dx} = 6\cos t \times \frac{1}{-8\sin t} = k\frac{\cos t}{\sin t}$	M1
	$\frac{dy}{dx} = -\frac{3}{4}\cot\left(\frac{\pi}{3}\right) = -\frac{\sqrt{3}}{4}$	dM1A1
		(3)
	Mark (a) and (b) together.	

(b)	$\left(6, 3\sqrt{3}-3\right)$	B1B1
	$-\frac{\sqrt{3}}{4} \to \frac{4}{\sqrt{3}}$	B1ft
	$y-3\sqrt{3}+3=\frac{4}{\sqrt{3}}(x-6)$ or $y=\frac{4}{\sqrt{3}}x+c \Rightarrow -3\sqrt{3}+3=\frac{4}{\sqrt{3}}\times 6+c \Rightarrow c=\left(-3-5\sqrt{3}\right)$	M1
	When $y=0$ $\;-3\sqrt{3}+3=\frac{4}{\sqrt{3}}(x-6) \Rightarrow x=...$	**d**M1
	$\left(\frac{15+3\sqrt{3}}{4}, 0\right)$	A1
		(6)
(b)		

(c)	$x=8\cos t+2 \Rightarrow \cos t=\frac{x-2}{8}$ $\quad y=6\sin t-3 \Rightarrow \sin t=\frac{y+3}{6}$	M1
	$\frac{(x-2)^2}{64}+\frac{(y+3)^2}{36}=1$	A1
		(2)
		(11 marks)

Question Number	Scheme	Marks
5(a)	$\frac{\mathrm{d}x}{\mathrm{d}t}=\frac{2(1-t)-(-1)(3+2t)}{(1-t)^2}=\frac{5}{(1-t)^2}$ and $\frac{\mathrm{d}y}{\mathrm{d}t}=-2t$ At $t=2 \Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=\frac{(-1)^2}{5}\times(-2(2))=-\frac{4}{5}$	M1A1
	$(-7, -3)$	B1
	$y+3=\frac{5}{4}(x+7)$	M1
	$5x-4y+23=0$	A1
		(5)
(b)	$x=\frac{3+2t}{1-t} \to t=\frac{x-3}{x+2}$	M1
	$y=1-\left(\frac{x-3}{x+2}\right)^2=\frac{(x+2)^2-(x-3)^2}{(x+2)^2}=\frac{10x-5}{(x+2)^2}$	dM1A1
	$x \neq -2$	B1
		(4)
		(9 marks)

Question Number	Scheme	Marks
6 (a)(i)	Area $R=\int y\dfrac{\mathrm{d}x}{\mathrm{d}t}\,\mathrm{d}t=\int 4\sin t\times -4\sin 2t\,\mathrm{d}t$	M1 A1
	$=-\int 32\sin^2 t\cos t\,\mathrm{d}t$	dM1
	$x=0\Rightarrow t=\frac{\pi}{4}$ and $y=0\Rightarrow t=0\Rightarrow$ Area $=-\int_{\frac{\pi}{4}}^{0}32\sin^2 t\cos t\,\mathrm{d}t=\int_{0}^{\frac{\pi}{4}}32\sin^2 t\cos t\,\mathrm{d}t$ *	A1*
		(4)
(ii)	Area $=\left[\frac{32}{3}\sin^3 t\right]_0^{\frac{\pi}{4}}=\frac{32}{3}\times\frac{2\sqrt{2}}{8}=\frac{8\sqrt{2}}{3}$	M1 A1
		(2)
(b)	Attempts to use $\cos 2t=1-2\sin^2 t\Rightarrow\frac{x}{2}=1-2\left(\frac{y}{4}\right)^2$	M1A1
	$y=\sqrt{8-4x}$	A1
		(3)
(c)	Range is $0\leqslant f\leqslant 4$	B1
		(1)
		(10 marks)

Question Number	Scheme	Marks
3 (a)	$x=\dfrac{t+15}{t+4}\Rightarrow t=\dfrac{15-4x}{x-1}$	M1
	$y=\dfrac{5}{t+2}\Rightarrow y=\dfrac{5}{\frac{15-4x}{x-1}+2}$	M1
	$y=\dfrac{5(x-1)}{15-4x+2(x-1)}$	dM1
	$\mathrm{g}(x)=\dfrac{5x-5}{13-2x}\qquad 1<x\leqslant\dfrac{15}{4}$	A1B1
		(5)
(b)	$0<\mathrm{g}(x)\leqslant\dfrac{5}{2}$	M1A1
		(2)
		(7 marks)

Question Number	Scheme	Marks
8(a)	*A* and *B* are where *y* = 0 so $t^3 - 9t = 0 \Rightarrow t(t^2 - 9) = 0 \Rightarrow t = 3 \quad (0 \text{ and } -3)$ Substitutes $t = 3$ in $x = 3^2 + 2\times 3 = 15$ *B* (15, 0) $A = (3,0)$	M1 A1* B1 **(3)**
8(a) ALT	Uses answer *x* = 15: $t^2 + 2t = 15 \Rightarrow t = 3$ (-5) Substitutes $t = 3$ in $y = t^3 - 9t = 27 - 27 = 0$ ✓ *B* (15, 0) $A = (3,0)$	M1 A1* B1 **(3)**
(b)	$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{3t^2 - 9}{2t + 2}$ Substitutes $t = 3$ into $\frac{dy}{dx} = \frac{3t^2 - 9}{2t + 2} \Rightarrow \frac{dy}{dx} = \frac{9}{4}$ Uses their $\frac{9}{4}$ with $(15, 0)$ to produce tangent equation $9x - 4y - 135 = 0$	M1 A1 dM1 A1 **(4)**
(c)	Substitutes $x = t^2 + 2t,\ y = t^3 - 9t,$ into their $9x - 4y - 135 = 0$ $\Rightarrow 9(t^2 + 2t) - 4(t^3 - 9t) - 135 = 0$ $\Rightarrow 4t^3 - 9t^2 - 54t + 135 = 0$ $\Rightarrow (t^2 - 6t + 9)(4t + 15) = 0$ $t = -\frac{15}{4}$ Coordinates of *X* are $\left(\frac{105}{16}, -\frac{1215}{64}\right)$	M1 dM1 A1 dM1A1 **(5)** **(12 marks)**

Question Number	Scheme	Marks
10(a)	$\frac{\mathrm{d}x}{\mathrm{d}t}=6t$ o.e.	B1
	$\text{Area}=\left(\int \sin t \sin 2t \times 6t\,\mathrm{d}t=\right)\int \sin t \times 2\sin t \cos t \times 6t\,\mathrm{d}t$	M1
	$=12\int_0^{\frac{\pi}{2}} t\sin^2 t\cos t\,\mathrm{d}t$	A1
		(3)
(b)	$=(12)\left[\frac{t}{3}\sin^3 t\right]_0^{\frac{\pi}{2}}-(12)\int_0^{\frac{\pi}{2}}\frac{1}{3}\sin^3 t\,\mathrm{d}t$	M1
	$=(12)\left[\frac{t}{3}\sin^3 t\right]_0^{\frac{\pi}{2}}-\left(\frac{12}{3}\right)\int_0^{\frac{\pi}{2}}\sin t\left(1-\cos^2 t\right)\mathrm{d}t$	M1
	$=\left[4t\sin^3 t+4\cos t-\frac{4}{3}\cos^3 t\right]_0^{\frac{\pi}{2}}$	A1
	$=2\pi-\left(4-\frac{4}{3}\right)$	M1
	$=2\pi-\frac{8}{3}$	A1
		(5)
		Total 8

(a) On EPEN this is M1M1A1 but we are marking this as B1M1A1

Question Number	Scheme	Marks
6(a)	$4y^2+3x=6ye^{-2x}$	
	$4y^2+3x\to 8y\frac{\mathrm{d}y}{\mathrm{d}x}+3$	B1
	$6ye^{-2x}\to -12ye^{-2x}+6e^{-2x}\frac{\mathrm{d}y}{\mathrm{d}x}$	M1 A1
	$8y\frac{\mathrm{d}y}{\mathrm{d}x}+3=-12ye^{-2x}+6e^{-2x}\frac{\mathrm{d}y}{\mathrm{d}x}\Rightarrow\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{12ye^{-2x}+3}{6e^{-2x}-8y}$ oe	M1 A1
		(5)
(b)	Sets $x=0$ in $4y^2+3x=6ye^{-2x}\Rightarrow y=\frac{3}{2}$ oe	B1
	Substitutes $\left(0,\frac{3}{2}\right)$ in their $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{12ye^{-2x}+3}{6e^{-2x}-8y}=\left(\frac{7}{-2}\right)$	M1
	$m_N=-1\div"\frac{7}{-2}"\Rightarrow y="\frac{2}{7}"x+"\frac{3}{2}"$	dM1
	$y=\frac{2}{7}x+\frac{3}{2}$ oe e.g. $y=\frac{6}{21}x+\frac{3}{2}$	A1
		(4)
		(9 marks)

Question Number	Scheme	Marks
5	$4y^2 \to 8y\dfrac{dy}{dx}$	M1
	$e^{xy} \to \left(y + x\dfrac{dy}{dx}\right)e^{xy}$ or e.g. $e^{xy} \to ye^{xy} + x\dfrac{dy}{dx}e^{xy}$	M1
	$2 + 8y\dfrac{dy}{dx} = 3\left(y + x\dfrac{dy}{dx}\right)e^{xy}$	A1
	$2 = 3 \times \dfrac{9}{2} \times \dfrac{dy}{dx} \Rightarrow \dfrac{dy}{dx} = \dfrac{4}{27}$	M1
	$y = \dfrac{4}{27}\left(x - \dfrac{9}{2}\right) \Rightarrow 4x - 27y - 18 = 0$	**d**M1A1
		(6)
		(6 marks)

Question Number	Scheme	Marks
5(a)	$\dfrac{dx}{dt} = \dfrac{2(1-t)-(-1)(3+2t)}{(1-t)^2} = \dfrac{5}{(1-t)^2}$ and $\dfrac{dy}{dt} = -2t$ At $t = 2 \Rightarrow \dfrac{dy}{dx} = \dfrac{(-1)^2}{5} \times (-2(2)) = -\dfrac{4}{5}$	M1A1
	$(-7, -3)$	B1
	$y + 3 = \dfrac{5}{4}(x + 7)$	M1
	$5x - 4y + 23 = 0$	A1
		(5)
(b)	$x = \dfrac{3+2t}{1-t} \to t = \dfrac{x-3}{x+2}$	M1
	$y = 1 - \left(\dfrac{x-3}{x+2}\right)^2 = \dfrac{(x+2)^2 - (x-3)^2}{(x+2)^2} = \dfrac{10x-5}{(x+2)^2}$	dM1A1
	$x \neq -2$	B1
		(4)
		(9 marks)

Question	Scheme	Marks
5(a)	$\dfrac{dx}{dt}=\dfrac{1}{2}(9-4t)^{-\frac{1}{2}}\times -4=\left(\dfrac{-2}{\sqrt{9-4t}}\right)$	M1
	$A=\displaystyle\int_{(x=0)}^{(x=3)} y\frac{dx}{dt}(dt)=\int_{\left(t=\frac{9}{4}\right)}^{(t=0)} \frac{t^3}{\sqrt{9+4t}}\times "\frac{-2}{\sqrt{9-4t}}"(dt)$	M1
	$=-2\displaystyle\int_{\left(\frac{9}{4}\right)}^{(0)} \frac{t^3}{\sqrt{81-16t^2}}(dt)$ or e.g. $-2\displaystyle\int_{\left(\frac{9}{4}\right)}^{(0)} \frac{t^3}{\sqrt{(9-4t)(9+4t)}}(dt)$ **Depends on both previous M marks.**	ddM1
	$=2\displaystyle\int_0^{\frac{9}{4}} \frac{t^3}{\sqrt{81-16t^2}}dt$	A1
		(4)
(b)	$\dfrac{du}{dt}=-32t$ or $du=-32t\,dt$ oe or $u=81-16t^2 \Rightarrow t^2=\dfrac{1}{16}(81-u)\Rightarrow t=\dfrac{1}{4}(81-u)^{\frac{1}{2}} \Rightarrow \dfrac{dt}{du}=-\dfrac{1}{8}(81-u)^{-\frac{1}{2}}$	B1
	$A=2\displaystyle\int_0^{\frac{9}{4}} \frac{t^2}{\sqrt{81-16t^2}}t\,dt=2\int_{(81)}^{(0)} \frac{(81-u)}{16\sqrt{u}}\frac{du}{-32}$ or $A=2\displaystyle\int_0^{\frac{9}{4}} \frac{t^2}{\sqrt{81-16t^2}}t\,dt=2\int_{(81)}^{(0)} \frac{\left(\frac{1}{4}(81-u)^{\frac{1}{2}}\right)^3}{\sqrt{u}}\times -\frac{1}{8}(81-u)^{-\frac{1}{2}}du$	M1
	$=k\displaystyle\int_{(81)}^{(0)} 81u^{-\frac{1}{2}}-u^{\frac{1}{2}}\,du$	A1ft
	$=K\left[\dfrac{81u^{\frac{1}{2}}}{\frac{1}{2}}-\dfrac{u^{\frac{3}{2}}}{\frac{3}{2}}\right]_{(81)}^{(0)}$	M1
	$=-\dfrac{1}{256}\left(0-\left(162\sqrt{81}-\dfrac{2}{3}\sqrt{81}^3\right)\right)=...$ **Depends on all previous M marks.**	ddM1
	$=\dfrac{243}{64}$	A1
		(6)
		(10 marks)

Question Number	Scheme	Notes	Marks
9(a)	$V=\pi\int y^2\,\mathrm{d}x=\pi\int y^2\frac{\mathrm{d}x}{\mathrm{d}\theta}\mathrm{d}\theta$ $=\pi\int(3\sin\theta-\sin2\theta)^2(-5\sin\theta)\,\mathrm{d}\theta$	Applies $V=\pi\int y^2\frac{\mathrm{d}x}{\mathrm{d}\theta}\mathrm{d}\theta$ with or without the π	M1
	$=\pi\int(3\sin\theta-2\sin\theta\cos\theta)^2(-5\sin\theta)\,\mathrm{d}\theta$	Applies $\sin2\theta=2\sin\theta\cos\theta$	M1
		Fully correct integral in terms of $\sin\theta$ and $\cos\theta$ only (π not needed)	A1
	$=\pi\int\sin^2\theta(3-2\cos\theta)^2(-5\sin\theta)\,\mathrm{d}\theta$ $V=-5\pi\int\sin^3\theta(3-2\cos\theta)^2\,\mathrm{d}\theta$ $V=-5\pi\int_\pi^0\sin^3\theta(3-2\cos\theta)^2\,\mathrm{d}\theta$ $V=5\pi\int_0^\pi\sin^3\theta(3-2\cos\theta)^2\,\mathrm{d}\theta$*	Completes correctly with correct limits and no incorrect statements previously. The factor of π must be present throughout.	A1*
			(4)
(b)	$u=\cos\theta\Rightarrow V=5\pi\int\sin^3\theta(3-2u)^2\frac{\mathrm{d}u}{-\sin\theta}$	Applies the substitution correctly	M1
	$\theta=0\Rightarrow u=1,\ \theta=\pi\Rightarrow u=-1$	Attempts to change θ limits to u limits	M1
	$V=-5\pi\int\sin^2\theta(3-2u)^2\,\mathrm{d}u=-5\pi\int(1-u^2)(3-2u)^2\mathrm{d}u$ Correct integral in terms of u only		A1
	$(1-u^2)(3-2u)^2=(1-u^2)(9-12u+4u^2)$	Attempt to expand	M1
	$=9-12u-5u^2+12u^3-4u^4$	Correct expansion	A1
	$V=5\pi\int_{-1}^{1}(9-12u-5u^2+12u^3-4u^4)\,\mathrm{d}u$ $=5\pi\left[9u-6u^2-\frac{5u^3}{3}+3u^4-\frac{4u^5}{5}\right]_{-1}^{1}=\ldots$ Integrates and applies their u limits		M1
	$=\frac{196}{3}\pi$	Cao	A1
			(7)
			Total 11

Question Number	Scheme	Marks
3 (a)	$x=\dfrac{t+15}{t+4}\Rightarrow t=\dfrac{15-4x}{x-1}$	M1
	$y=\dfrac{5}{t+2}\Rightarrow y=\dfrac{5}{\dfrac{15-4x}{x-1}+2}$	M1
	$y=\dfrac{5(x-1)}{15-4x+2(x-1)}$	dM1
	$\mathrm{g}(x)=\dfrac{5x-5}{13-2x} \qquad 1<x\leqslant\dfrac{15}{4}$	A1B1
		(5)
(b)	$0<\mathrm{g}(x)\leqslant\dfrac{5}{2}$	M1A1
		(2)
		(7 marks)

Question Number	Scheme	Marks
5 (a)	$\dfrac{\mathrm{d}y}{\mathrm{d}x}=\dfrac{\mathrm{d}y/\mathrm{d}t}{\mathrm{d}x/\mathrm{d}t}=\dfrac{16\sec^2 t\tan t}{2\sec^2 t}=8\tan t$	M1 A1
	At $x=3, \tan t=-1\Rightarrow$ Gradient $=-8$	dM1 A1
		(4)
(b)	Attempts to use $1+\tan^2 t=\sec^2 t\Rightarrow 1+\dfrac{(x-5)^2}{4}=\dfrac{y}{8}$	M1 A1
	$y=2(x-5)^2+8$	A1
		(3)
(c)	$8\leqslant \mathrm{f}\leqslant 32$	M1 A1
		(2)
		(9 marks)

Question Number	Scheme	Marks
4(a)	$k=2$ or $x>2$	B1
	$t=\dfrac{1}{x-2}\Rightarrow y=\dfrac{1-\frac{2}{x-2}}{3+\frac{1}{x-2}}$	M1 A1
	$\dfrac{1-\frac{2}{x-2}}{3+\frac{1}{x-2}}=\dfrac{x-2-2}{\dots}$ or $\dfrac{\dots}{3(x-2)+1}$	A1 (M1 on EPEN)
	$y=\dfrac{x-4}{3x-5}$	A1
		(5)
(b)	$-2<\mathrm{g}<\dfrac{1}{3}$	M1 A1
		(2)
		(7 marks)

Question Number	Scheme	Marks
9(a)	$\tan\theta=\sqrt{3}\Rightarrow k=\dfrac{\pi}{3}(\text{or }60°)$ (Allow $x=\sqrt{3}\Rightarrow\theta=\dfrac{\pi}{3}(\text{or }60°)$)	B1
	$V=(\pi)\int y^2\mathrm{d}x=(\pi)\int(2\sin 2\theta)^2\sec^2\theta\,\mathrm{d}\theta$ oe	M1A1
	$4(\pi)\int\sin^2 2\theta\sec^2\theta\ \mathrm{d}\theta=4(\pi)\int 4\sin^2\theta\cancel{\cos^2\theta}\times\dfrac{1}{\cancel{\cos^2\theta}}\ \mathrm{d}\theta$	**dM1**
	$=16(\pi)\int\sin^2\theta\,\mathrm{d}\theta$ oe e.g. $16(\pi)\int(1-\cos^2\theta)\,\mathrm{d}\theta$	A1
	$\sin^2\theta=\dfrac{1-\cos 2\theta}{2}\Rightarrow 16(\pi)\int\sin^2\theta\ \mathrm{d}\theta=16(\pi)\int\dfrac{1-\cos 2\theta}{2}\ \mathrm{d}\theta$	**dM1**
	Volume $=\displaystyle\int_0^{\frac{\pi}{3}}8\pi(1-\cos 2\theta)\,\mathrm{d}\theta$	A1 **Cso**
		(7)
(b)	$\int(1-\cos 2\theta)\mathrm{d}\theta\to\theta-\dfrac{\sin 2\theta}{2}$	B1
	Volume $=\displaystyle\int_0^{\frac{\pi}{3}}8\pi(1-\cos 2\theta)\,\mathrm{d}\theta=[8\pi\theta-4\pi\sin 2\theta]_0^{\frac{\pi}{3}}=\dfrac{8}{3}\pi^2-2\sqrt{3}\pi$	M1 A1
		(3)
		(10 marks)

Question Number	Scheme	Marks
2 (a)	E.g. $x=\dfrac{t-1}{2t+1}\Rightarrow t=\dfrac{x+1}{1-2x}$ or $y=\dfrac{6}{2t+1}\Rightarrow t=\dfrac{6-y}{2y}$	**M1**
	E.g. $y=\dfrac{6}{2t+1}\Rightarrow y=\dfrac{6}{2\times\left(\dfrac{x+1}{1-2x}\right)+1}$ or $t=\dfrac{6-y}{2y}\Rightarrow x=\dfrac{\dfrac{6-y}{2y}-1}{2\times\dfrac{6-y}{2y}+1}$	**A1**
	E.g. $y=\dfrac{6}{2\times\left(\dfrac{x+1}{1-2x}\right)+1}\Rightarrow y=\dfrac{6(1-2x)}{2\times(x+1)+1(1-2x)}=ax+b$	**dM1**
	E.g. $y=\dfrac{6(1-2x)}{3}, y=2(1-2x)$ oe so linear *	**A1***
		(4)
(b)	$y=2(1-2x)$ and $y=x+12\Rightarrow\ 2(1-2x)=x+12\Rightarrow x=...$	**M1**
	$x=-2$	**A1cao**
		(2)

Question	Scheme	Marks
9(a)	$\dfrac{dx}{dt}=\sec t\tan t$ and $\dfrac{dy}{dt}=\sqrt{3}\sec^2\left(t+\dfrac{\pi}{3}\right)$	**B1**
	$\left(\dfrac{dy}{dx}=\right)\dfrac{dy}{dt}\div\dfrac{dx}{dt}=\dfrac{\sqrt{3}\sec^2\left(t+\dfrac{\pi}{3}\right)}{\sec t\tan t}$ oe	**M1** **A1**
		(3)

(b)	$t=\frac{\pi}{3}\Rightarrow x=2, y=-3$	B1
	$t=\frac{\pi}{3}\Rightarrow\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\sqrt{3}\sec^2\frac{2\pi}{3}}{\sec\frac{\pi}{3}\tan\frac{\pi}{3}}=...(=2)$	M1
	Tangent is $y+3=2(x-2)\Rightarrow y=2x-7$ cso	M1A1
		(4)
(c)	$y=\sqrt{3}\frac{\tan t\pm\tan\frac{\pi}{3}}{1\pm\tan t\tan\frac{\pi}{3}}$	M1
	$x^2=\sec^2 t=1+\tan^2 t\Rightarrow\tan t=\sqrt{x^2-1}\Rightarrow y=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}}{1-\sqrt{3}\sqrt{x^2-1}}$	M1 A1
	$=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}}{1-\sqrt{3}\sqrt{x^2-1}}\times\frac{1+\sqrt{3}\sqrt{x^2-1}}{1+\sqrt{3}\sqrt{x^2-1}}=..$	
	$=\sqrt{3}\frac{\sqrt{x^2-1}+\sqrt{3}\left(x^2-1\right)+\sqrt{3}+3\sqrt{x^2-1}}{1-\left(3x^2-3\right)}=\frac{..\sqrt{x^2-1}+..x^2}{4-3x^2}$	M1
	$=\frac{3x^2+4\sqrt{3x^2-3}}{4-3x^2}$	A1
		(5)

Question Number	Scheme	Marks
2 (a)	E.g. $x=\frac{t-1}{2t+1}\Rightarrow t=\frac{x+1}{1-2x}$ or $y=\frac{6}{2t+1}\Rightarrow t=\frac{6-y}{2y}$	M1
	E.g. $y=\frac{6}{2t+1}\Rightarrow y=\frac{6}{2\times\left(\frac{x+1}{1-2x}\right)+1}$ or $t=\frac{6-y}{2y}\Rightarrow x=\frac{\frac{6-y}{2y}-1}{2\times\frac{6-y}{2y}+1}$	A1
	E.g. $y=\frac{6}{2\times\left(\frac{x+1}{1-2x}\right)+1}\Rightarrow y=\frac{6(1-2x)}{2\times(x+1)+1(1-2x)}=ax+b$	dM1
	E.g. $y=\frac{6(1-2x)}{3}, y=2(1-2x)$ oe so linear *	A1*
		(4)
(b)	$y=2(1-2x)$ and $y=x+12\Rightarrow 2(1-2x)=x+12\Rightarrow x=...$	M1
	$x=-2$	A1cao
		(2)

Question Number	Scheme	Notes	Marks
2(a)	$\frac{x}{y}=t$	Cao	B1
			(1)
(b)	$y=\frac{\left(\frac{x}{y}\right)^3}{2\left(\frac{x}{y}\right)+1}$ or $x=\frac{\left(\frac{x}{y}\right)^4}{2\left(\frac{x}{y}\right)+1}$	Uses the y coordinate to obtain y in terms of x and y or uses the x coordinate to obtain x in terms of y and x	M1
	$y=\frac{x^3}{2xy^2+y^3}\Rightarrow y\left(2xy^2+y^3\right)=x^3$ or $x=\frac{x^4}{2xy^3+y^4}\Rightarrow x\left(2xy^3+y^4\right)=x^4$	Uses correct algebra to eliminate the fractions	M1
	$x^3-2xy^3-y^4=0$*	Cso	A1*
			(3)
			Total 4

Question Number	Scheme	Marks
3 (a)	$x=\frac{t+15}{t+4}\Rightarrow t=\frac{15-4x}{x-1}$	M1
	$y=\frac{5}{t+2}\Rightarrow y=\frac{5}{\frac{15-4x}{x-1}+2}$	M1
	$y=\frac{5(x-1)}{15-4x+2(x-1)}$	dM1
	$\mathrm{g}(x)=\frac{5x-5}{13-2x}\qquad 1<x\leqslant\frac{15}{4}$	A1B1
		(5)
(b)	$0<\mathrm{g}(x)\leqslant\frac{5}{2}$	M1A1
		(2)
		(7 marks)

Question	Scheme	Marks
3(a)	$x=3+2\sin t \qquad y=\dfrac{6}{7+\cos 2t} \qquad -\dfrac{\pi}{2}\leqslant t\leqslant\dfrac{\pi}{2}$	
	$y=\dfrac{6}{7+1-2\sin^2 t}$	M1
	$\sin t=\dfrac{x-3}{2}\Rightarrow y=\dfrac{6}{8-2\left(\dfrac{x-3}{2}\right)^2}$	M1A1
	$\Rightarrow y=\dfrac{12}{16-(x-3)^2}=\dfrac{12}{(4-x+3)(4+x-3)}=\dfrac{12}{(7-x)(1+x)}*$	M1A1*
	$\left(t=-\dfrac{\pi}{2}\Rightarrow x=1, t=\dfrac{\pi}{2}\Rightarrow x=5 \text{ so}\right)$ $p=1$ and $q=5$	B1
		(6)
(a) Way 2	$y=\dfrac{6}{7+1-2\sin^2 t}$	M1
	$y=\dfrac{12}{16-4\sin^2 t}=\dfrac{12}{(4+2\sin t)(4-2\sin t)}$	M1A1
	$=\dfrac{12}{(4+x-3)(4-(x-3))}=\dfrac{12}{(7-x)(1+x)}*$	M1A1*
	$\left(t=-\dfrac{\pi}{2}\Rightarrow x=1, t=\dfrac{\pi}{2}\Rightarrow x=5 \text{ so}\right)$ $p=1$ and $q=5$	B1
(a) Way 3	$y=\dfrac{12}{(7-x)(1+x)}=\dfrac{12}{(4-2\sin t)(4+2\sin t)}$	M1
	$=\dfrac{12}{16-4\sin^2 t}$	M1A1
	$=\dfrac{12}{16-4\left(\dfrac{1-\cos 2t}{2}\right)}$	M1
	$=\dfrac{12}{16-2+2\cos 2t}=\dfrac{12}{14+2\cos 2t}=\dfrac{6}{7+\cos 2t}=y*$	A1*
	$\left(t=-\dfrac{\pi}{2}\Rightarrow x=1, t=\dfrac{\pi}{2}\Rightarrow x=5 \text{ so}\right)$ $p=1$ and $q=5$	B1

(a) Way 4	$y=\dfrac{6}{7+\cos 2t}\Rightarrow \cos 2t=\dfrac{6}{y}-7\Rightarrow 1-2\sin^2 t=\dfrac{6}{y}-7$	**M1**
	$\sin t=\dfrac{x-3}{2}\Rightarrow \dfrac{6}{y}-7=1-2\left(\dfrac{x-3}{2}\right)^2$	**M1A1**
	$\Rightarrow \dfrac{12}{y}=-x^2+6x+7\Rightarrow y=\dfrac{12}{-x^2+6x+7}=\dfrac{12}{(7-x)(1+x)}$ *	**M1A1***
	$\left(t=-\dfrac{\pi}{2}\Rightarrow x=1, t=\dfrac{\pi}{2}\Rightarrow x=5 \text{ so}\right)$ $p=1$ and $q=5$	**B1**
(b)	$\dfrac{12}{(7-x)(1+x)}=\dfrac{A}{7-x}+\dfrac{B}{1+x}\Rightarrow 12=A(x+1)+B(7-x)\Rightarrow A=\ldots, B=\ldots$	**M1**
	So $(y=)\dfrac{3}{2(x+1)}-\dfrac{3}{2(x-7)}$ oe	**A1A1**
		(3)
		(9 marks)

Question Number	Scheme	Marks
8 (a)	At $t=\dfrac{\pi}{4}$ $P=\left(\dfrac{1}{2},2\right)$	**B1**
	$\dfrac{dy}{dx}=\dfrac{dy/dt}{dx/dt}=\dfrac{2\sec^2 t}{2\sin t\cos t}=4$ when $t=\dfrac{\pi}{4}$	**M1 A1**
	Equation of l: $y-2=-\dfrac{1}{4}\left(x-\dfrac{1}{2}\right)\Rightarrow 8y-16=-2x+1\Rightarrow 8y+2x=17$*	**dM1 A1 *** cso
		(5)
(b)	$\int y\dfrac{dx}{dt}\,dt=\int 2\tan t\times 2\sin t\cos t\,dt$	**M1**
	$=\int 4\sin^2 t\,dt$	**A1**
	$=\int 2-2\cos 2t\,dt = 2t-\sin 2t$	**dM1 A1**
	Total area of $S=\left[2t-\sin 2t\right]_0^{\frac{\pi}{4}}+\dfrac{1}{2}\times 8\times 2=\dfrac{\pi}{2}-1+8=\dfrac{\pi}{2}+7$	**M1 A1**
		(6)
		(11 marks)

Question Number	Scheme	Marks
3 (a)	$x=\dfrac{t+15}{t+4} \Rightarrow t=\dfrac{15-4x}{x-1}$	M1
	$y=\dfrac{5}{t+2} \Rightarrow y=\dfrac{5}{\dfrac{15-4x}{x-1}+2}$	M1
	$y=\dfrac{5(x-1)}{15-4x+2(x-1)}$	dM1
	$\mathrm{g}(x)=\dfrac{5x-5}{13-2x} \qquad 1<x\leqslant\dfrac{15}{4}$	A1B1
		(5)
(b)	$0<\mathrm{g}(x)\leqslant\dfrac{5}{2}$	M1A1
		(2)
		(7 marks)

Question Number	Scheme	Marks
8(a)	A and B are where $y = 0$ so $t^3 - 9t = 0 \Rightarrow t(t^2 - 9) = 0 \Rightarrow t = 3 \quad (0 \text{ and } -3)$ Substitutes $t = 3$ in $x = 3^2 + 2 \times 3 = 15$ B(15, 0) $A = (3, 0)$	M1 A1* B1 **(3)**
8(a) ALT	Uses answer $x = 15$: $t^2 + 2t = 15 \Rightarrow t = 3$ (-5) Substitutes $t = 3$ in $y = t^3 - 9t = 27 - 27 = 0$ ✓ B(15, 0) $A = (3, 0)$	M1 A1* B1 **(3)**
(b)	$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{3t^2 - 9}{2t + 2}$ Substitutes $t = 3$ into $\frac{dy}{dx} = \frac{3t^2 - 9}{2t + 2} \Rightarrow \frac{dy}{dx} = \frac{9}{4}$ Uses their $\frac{9}{4}$ with $(15, 0)$ to produce tangent equation $9x - 4y - 135 = 0$	M1 A1 dM1 A1 **(4)**
(c)	Substitutes $x = t^2 + 2t,\ y = t^3 - 9t,$ into their $9x - 4y - 135 = 0$ $\Rightarrow 9(t^2 + 2t) - 4(t^3 - 9t) - 135 = 0$ $\Rightarrow 4t^3 - 9t^2 - 54t + 135 = 0$ $\Rightarrow (t^2 - 6t + 9)(4t + 15) = 0$ $t = -\frac{15}{4}$ Coordinates of X are $\left(\frac{105}{16}, -\frac{1215}{64}\right)$	M1 dM1 A1 dM1A1 **(5)** **(12 marks)**

Question Number	Scheme	Marks
8(a)	3π	B1
		(1)
(b)	$\dfrac{dy}{dx}=\dfrac{-2\sin t}{6-6\cos 2t}$	M1 A1
	$=\dfrac{-2\sin t}{6-6\left(1-2\sin^2 t\right)}=\dfrac{-2\sin t}{12\sin^2 t}=-\dfrac{1}{6}\operatorname{cosec} t$	M1 A1*
		(4)
(c)	$P=\left(\dfrac{3\pi}{2}-3,\sqrt{2}\right)$	B1
	E.g. $y-\sqrt{2}=-\dfrac{\sqrt{2}}{6}\left(0-\left(\dfrac{3\pi}{2}-3\right)\right)\Rightarrow y=...$ or $\sqrt{2}=-\dfrac{\sqrt{2}}{6}\left(\dfrac{3\pi}{2}-3\right)+c\Rightarrow c=...$	M1
	$\dfrac{\pi\sqrt{2}}{4}+\dfrac{\sqrt{2}}{2}$ o.e	A1
		(3)
(d)(i)	Attempts $y^2\dfrac{dx}{dt}=4\cos^2 t\left(6-6\cos 2t\right)$	M1 A1
	$=\left(2\cos 2t+2\right)\left(6-6\cos 2t\right)=6\left(2-2\cos^2 2t\right)=6\left(2-\left(1+\cos 4t\right)\right)$	**d**M1
	Volume $=\displaystyle\int_0^{\frac{\pi}{2}}\pi y^2\frac{dx}{dt}dt=\int_0^{\frac{\pi}{2}}6\pi\left(1-\cos 4t\right)dt$	A1
(ii)	$\left[6\pi t-\dfrac{6\pi\sin 4t}{4}\right]_0^{\frac{\pi}{2}}$, $=3\pi^2$	M1, A1
		(6)
		(14 marks)

Question Number	Scheme	Marks
8(a)	$x=2$	B1
		(1)
(b)	$(2.5, 1.5)$	B1
		(1)
(c)	$\dfrac{dy}{dx}=\dfrac{1+\frac{1}{t^2}}{1-\frac{1}{t^2}}$	M1
	$t=2\Rightarrow\dfrac{dy}{dx}=\dfrac{5}{3}\quad\Rightarrow y-1.5=-\dfrac{3}{5}(x-2.5)$	dM1
	$3x+5y=15*$	A1*
		(3)

(d)	l crosses x-axis at $x = 5$	B1
	$\frac{1}{3}\pi \times 1.5^2(5-2.5)\left(=\frac{15}{8}\pi\right)$	M1
	$V = \pi\int y^2 \mathrm{d}x = \pi\int y^2 \frac{\mathrm{d}x}{\mathrm{d}t}\,\mathrm{d}t = \pi\int\left(t-\frac{1}{t}\right)^2\left(1-\frac{1}{t^2}\right)\mathrm{d}t$	M1
	$\pi\int\left(t^2-2+\frac{1}{t^2}\right)\left(1-\frac{1}{t^2}\right)\mathrm{d}t = \pi\int\left(t^2+\frac{3}{t^2}-\frac{1}{t^4}-3\right)\mathrm{d}t = \ldots$	M1
	$\pi\left[\frac{t^3}{3}-\frac{3}{t}+\frac{1}{3t^3}-3t\right]$	A1
	$\pi\left[\frac{t^3}{3}-\frac{3}{t}+\frac{1}{3t^3}-3t\right]_1^2 = \pi\left(\left(\frac{8}{3}-\frac{3}{2}+\frac{1}{24}-6\right)-\left(\frac{1}{3}-3+\frac{1}{3}-3\right)\right)$	M1
	$V = \frac{13}{24}\pi + \frac{15}{8}\pi = \frac{29}{12}\pi$ Cao	A1
		(7)
		Total 12

Question Number	Scheme	Marks
8 (a)	At $t = \frac{\pi}{4}$ $P = \left(\frac{1}{2}, 2\right)$	**B1**
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y/\mathrm{d}t}{\mathrm{d}x/\mathrm{d}t} = \frac{2\sec^2 t}{2\sin t\cos t} = 4$ when $t = \frac{\pi}{4}$	**M1 A1**
	Equation of l: $y-2 = -\frac{1}{4}\left(x-\frac{1}{2}\right) \Rightarrow 8y-16 = -2x+1 \Rightarrow 8y+2x = 17*$	**dM1 A1 *** **cso**
		(5)
(b)	$\int y\frac{\mathrm{d}x}{\mathrm{d}t}\,\mathrm{d}t = \int 2\tan t \times 2\sin t\cos t\,\mathrm{d}t$	**M1**
	$= \int 4\sin^2 t\,\mathrm{d}t$	**A1**
	$= \int 2-2\cos 2t\,\mathrm{d}t = 2t-\sin 2t$	**dM1 A1**
	Total area of $S = \left[2t-\sin 2t\right]_0^{\frac{\pi}{4}} + \frac{1}{2}\times 8\times 2 = \frac{\pi}{2}-1+8 = \frac{\pi}{2}+7$	**M1 A1**
		(6)
		(11 marks)

Question	Scheme	Marks
5(a)	$y=\dfrac{2}{t(3-t)}=1 \Rightarrow 2=3t-t^2 \Rightarrow t=...$	M1
	$\left(t^2-3t+2=(t-1)(t-2)=0 \Rightarrow\right) a=1, b=2$	A1
		(2)
(b)	Area under curve $=\displaystyle\int_{t=\text{"1"}}^{t=\text{"2"}} y\,\mathrm{d}x=\int_1^2 y\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t=\int_1^2 \frac{2}{t(3-t)}\times(2t+2)\,\mathrm{d}t$	M1 A1
	$t=1 \Rightarrow x=3, \quad t=2 \Rightarrow x=8$	B1
	So area of $R=1\times(8-3)-\displaystyle\int_1^2 \frac{2}{t(3-t)}\times(2t+2)\,\mathrm{d}t$	M1
	$=5-4\displaystyle\int_1^2 \frac{t+1}{t(3-t)}\mathrm{d}t$	A1
		(5)
(c)(i)	$\dfrac{t+1}{t(3-t)}=\dfrac{A}{t}+\dfrac{B}{3-t}$	M1
	$\Rightarrow t+1=A(3-t)+Bt$ E.g. $t=0 \Rightarrow 1=3A \Rightarrow A=\dfrac{1}{3}$; $t=3 \Rightarrow 4=3B \Rightarrow B=\dfrac{4}{3}$	M1
	$\dfrac{t+1}{t(3-t)}=\dfrac{1}{3t}+\dfrac{4}{3(3-t)}$	A1
(ii)	$\displaystyle\int \frac{t+1}{t(3-t)}\mathrm{d}t=\int \frac{1}{3t}+\frac{4}{3(3-t)}\mathrm{d}t=\frac{1}{3}\ln t-\frac{4}{3}\ln(3-t)$	M1
	$\text{Area}=5-4\left[\dfrac{1}{3}\ln t-\dfrac{4}{3}\ln(3-t)\right]_1^2=5-4\left(\dfrac{1}{3}\ln 2-\dfrac{4}{3}\ln 1-\dfrac{1}{3}\ln 1+\dfrac{4}{3}\ln 2\right)$ $=5-4\left(\dfrac{1}{3}\ln 2+\dfrac{4}{3}\ln 2\right)$	dM1
	$=5-\dfrac{20}{3}\ln 2$	A1
		(6)
		(13 marks)

Question	Scheme	Marks
5(a)	$y=\dfrac{2}{t(3-t)}=1\Rightarrow 2=3t-t^2\Rightarrow t=...$	M1
	$\left(t^2-3t+2=(t-1)(t-2)=0\Rightarrow\right)a=1,b=2$	A1
		(2)
(b)	Area under curve $=\displaystyle\int_{t="1"}^{t="2"} y\,\mathrm{d}x=\int_1^2 y\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t=\int_1^2\frac{2}{t(3-t)}\times(2t+2)\,\mathrm{d}t$	M1 A1
	$t=1\Rightarrow x=3,\quad t=2\Rightarrow x=8$	B1
	So area of R = $1\times(8-3)-\displaystyle\int_1^2\frac{2}{t(3-t)}\times(2t+2)\,\mathrm{d}t$	M1
	$=5-4\displaystyle\int_1^2\frac{t+1}{t(3-t)}\mathrm{d}t$	A1
		(5)

(c)(i)	$\dfrac{t+1}{t(3-t)}=\dfrac{A}{t}+\dfrac{B}{3-t}$	M1
	$\Rightarrow t+1=A(3-t)+Bt$ E.g. $t=0\Rightarrow 1=3A\Rightarrow A=\dfrac{1}{3}$; $t=3\Rightarrow 4=3B\Rightarrow B=\dfrac{4}{3}$	M1
	$\dfrac{t+1}{t(3-t)}=\dfrac{1}{3t}+\dfrac{4}{3(3-t)}$	A1
(ii)	$\displaystyle\int\frac{t+1}{t(3-t)}\mathrm{d}t=\int\frac{1}{3t}+\frac{4}{3(3-t)}\mathrm{d}t=\frac{1}{3}\ln t-\frac{4}{3}\ln(3-t)$	M1
	Area $=5-4\left[\dfrac{1}{3}\ln t-\dfrac{4}{3}\ln(3-t)\right]_1^2=5-4\left(\dfrac{1}{3}\ln 2-\dfrac{4}{3}\ln 1-\dfrac{1}{3}\ln 1+\dfrac{4}{3}\ln 2\right)$ $=5-4\left(\dfrac{1}{3}\ln 2+\dfrac{4}{3}\ln 2\right)$	dM1
	$=5-\dfrac{20}{3}\ln 2$	A1
		(6)
		(13 marks)

Question Number	Scheme	Marks
6 (a)	For correct parameter $t=\frac{\pi}{4}$ or x coordinate at P $x=4$	B1
	$\frac{dy}{dx}=\frac{dy/dt}{dx/dt}=\frac{-4\sin 2t}{3\sec^2 t}$	M1 A1
	Equation of tangent $y-0=-\frac{2}{3}(x-4)\Rightarrow y=-\frac{2}{3}x+\frac{8}{3}$	dM1 A1
		(5)
(b)	$k=1-\sqrt{3}$	B1
		(1)
(c)	$-1,, \text{ f } ,, 2$	M1 A1
		(2) **(8 marks)**

Question Number	Scheme	Marks
8(a)	3π	B1
		(1)
(b)	$\frac{dy}{dx}=\frac{-2\sin t}{6-6\cos 2t}$	M1 A1
	$=\frac{-2\sin t}{6-6(1-2\sin^2 t)}=\frac{-2\sin t}{12\sin^2 t}=-\frac{1}{6}\operatorname{cosec} t$	M1 A1*
		(4)
(c)	$P=\left(\frac{3\pi}{2}-3, \sqrt{2}\right)$	B1
	E.g. $y-\sqrt{2}=-\frac{\sqrt{2}}{6}\left(0-\left(\frac{3\pi}{2}-3\right)\right)\Rightarrow y=\ldots$ or $\sqrt{2}=-\frac{\sqrt{2}}{6}\left(\frac{3\pi}{2}-3\right)+c\Rightarrow c=\ldots$	M1
	$\frac{\pi\sqrt{2}}{4}+\frac{\sqrt{2}}{2}$ o.e	A1
		(3)

(d)(i)	Attempts $y^2\dfrac{dx}{dt}=4\cos^2 t\left(6-6\cos 2t\right)$	M1 A1
	$=\left(2\cos 2t+2\right)\left(6-6\cos 2t\right)=6\left(2-2\cos^2 2t\right)=6\left(2-\left(1+\cos 4t\right)\right)$	**dM1**
	Volume $=\displaystyle\int_0^{\frac{\pi}{2}}\pi y^2\frac{dx}{dt}dt=\int_0^{\frac{\pi}{2}}6\pi\left(1-\cos 4t\right)dt$	A1
(ii)	$\left[6\pi t-\dfrac{6\pi\sin 4t}{4}\right]_0^{\frac{\pi}{2}}$, $=3\pi^2$	M1, A1
		(6)
		(14 marks)

Question Number	Scheme	Marks
10(a)	$\dfrac{dx}{dt}=6t$ o.e.	B1
	Area $=\left(\displaystyle\int\sin t\sin 2t\times 6t\,dt=\right)\int\sin t\times 2\sin t\cos t\times 6t\,dt$	M1
	$=12\displaystyle\int_0^{\frac{\pi}{2}}t\sin^2 t\cos t\,dt$	A1
		(3)
(b)	$=(12)\left[\dfrac{t}{3}\sin^3 t\right]_0^{\frac{\pi}{2}}-(12)\displaystyle\int_0^{\frac{\pi}{2}}\frac{1}{3}\sin^3 t\,dt$	M1
	$=(12)\left[\dfrac{t}{3}\sin^3 t\right]_0^{\frac{\pi}{2}}-\left(\dfrac{12}{3}\right)\displaystyle\int_0^{\frac{\pi}{2}}\sin t\left(1-\cos^2 t\right)dt$	M1
	$=\left[4t\sin^3 t+4\cos t-\dfrac{4}{3}\cos^3 t\right]_0^{\frac{\pi}{2}}$	A1
	$=2\pi-\left(4-\dfrac{4}{3}\right)$	M1
	$=2\pi-\dfrac{8}{3}$	A1
		(5)
		Total 8