Question Number	Scheme	Marks
8	Solves one of $(3x-y)=25$ and $(x+y)=1$ or $(3x-y)=5$ and $(x+y)=5$	M1
	Correct solution of one. Either $\left.\begin{aligned}3x-y&=25\\x+y&=1\end{aligned}\right\}\Rightarrow 4x=26\Rightarrow x=6.5,(y=-5.5)$ Or $\left.\begin{aligned}3x-y&=5\\x+y&=5\end{aligned}\right\}\Rightarrow 4x=10\Rightarrow x=2.5,(y=2.5)$	A1
	Solves both equations	dM1
	Both solved correctly with a minimal reason given for the contradiction e.g "not integers" with conclusion "hence there are no integers x and y such that $3x^2+2xy-y^2=25$"	A1
		(4)

Question Number	Scheme	Marks
1(a)	$(8-3x)^{-\frac{1}{3}}=\frac{1}{2}\left(1-\frac{3}{8}x\right)^{-\frac{1}{3}}$	B1
	$\left(1-\frac{3}{8}x\right)^{-\frac{1}{3}}=1+\left(-\tfrac{1}{3}\right)\left(-\frac{3}{8}x\right)+\frac{-\frac{1}{3}\left(-\frac{1}{3}-1\right)}{2!}\left(-\frac{3}{8}x\right)^2+\frac{-\frac{1}{3}\left(-\frac{1}{3}-1\right)\left(-\frac{1}{3}-2\right)}{3!}\left(-\frac{3}{8}x\right)^3+\ldots$	M1
	$(8-3x)^{-\frac{1}{3}}=\frac{1}{2}+\frac{1}{16}x+\frac{1}{64}x^2+\frac{7}{1536}x^3+\ldots$	A1 A1
		(4)
(b)	$\frac{1}{2}+\frac{1}{16}\left(\frac{2}{3}\right)+\frac{1}{64}\left(\frac{2}{3}\right)^2+\frac{7}{1536}\left(\frac{2}{3}\right)^3+\ldots=\frac{2851}{5184}\Rightarrow\sqrt[3]{6}=\left(\frac{2851}{5184}\right)^{-1}=\ldots$	M1
	$=\frac{5184}{2851}$ or $1\frac{2333}{2851}$	A1
		(2)
		Total 6

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

Question Number	Scheme	Notes	Marks
7(a)	$\frac{dV}{dt}=300-kV \Rightarrow \int \frac{dV}{300-kV}=\int dt$	Correct separation of variables	B1
	$\int \frac{dV}{300-kV}=-\frac{1}{k}\ln(300-kV)$	$\int \frac{dV}{300-kV}=\alpha\ln(300-kV)$	M1
	$-\frac{1}{k}\ln(300-kV)=t+c$	Correct equation including a constant of integration	A1
	$-\frac{1}{k}\ln(300-kV)=t+c \Rightarrow \ln(300-kV)=-kt+d$ $\Rightarrow 300-kV=e^{-kt+d}$ Correct processing to remove the "ln"		M1
	$kV=300-e^{-kt+d} \Rightarrow V=\frac{300}{k}-Be^{-kt}$ $V=\frac{300}{k}+Ae^{-kt}$ *	Correct proof	A1*
			(5)
(b)	$V=0, t=0 \Rightarrow 0=\frac{300}{k}+A \Rightarrow A=-\frac{300}{k}$	Uses $V=0$ when $t=0$ to find A in terms of k	M1
	$V=\frac{300}{k}-\frac{300}{k}e^{-kt} \Rightarrow \frac{dV}{dt}=300e^{-kt}$	$\frac{dV}{dt}=\alpha e^{-kt}$	M1
	$300e^{-10k}=200 \Rightarrow e^{-10k}=\frac{2}{3} \Rightarrow k=...$	Uses $\frac{dV}{dt}=200$ when $t=10$ and correct processing to find k	M1
	$k=-\frac{1}{10}\ln\frac{2}{3}$	Oe e.g. $\frac{1}{10}\ln\frac{3}{2}$	A1
			(4)
(b) Way 2	$V=0, t=0 \Rightarrow 0=\frac{300}{k}+A \Rightarrow A=-\frac{300}{k}$	Uses $V=0$ when $t=0$ to find A in terms of k	M1
	$\frac{dV}{dt}=200, t=10 \Rightarrow 200=300-kV$ $\Rightarrow kV=100$	Uses $\frac{dV}{dt}=200$ when $t=10$ to find a value for kV	M1
	$V=\frac{300}{k}+Ae^{-kt} \Rightarrow kV=300-300e^{-10k}$ $\Rightarrow 100=300-300e^{-kt} \Rightarrow e^{-10k}=\frac{2}{3} \Rightarrow k=...$	Substitutes for kV, kA and $t=10$ and uses correct processing to find k	M1
	$k=-\frac{1}{10}\ln\frac{2}{3}$	Oe e.g. $\frac{1}{10}\ln\frac{3}{2}$	A1
(c)	$6000=\frac{3000}{\ln 1.5}-\frac{3000}{\ln 1.5}e^{-\frac{t}{10}\ln 1.5}$ $\Rightarrow e^{-\frac{t}{10}\ln 1.5}=1-2\ln 1.5$ $\Rightarrow -\frac{t}{10}\ln 1.5=\ln(1-2\ln 1.5)$	Correct strategy using V = 6000 to reach $\alpha t=\ldots$	M1
	$t=41$	Correct value	A1
			(2)
			Total 11

Question	Scheme	Marks
4(a)	$(l=)\sqrt{25+r^2}$	B1
		(1)
(b)	$(S=\pi r^2+)\pi r\sqrt{25+r^2} \Rightarrow \left(\frac{dS}{dr}=2\pi r+\right)\pi\sqrt{25+r^2}+\pi r.\frac{1}{2}(25+r^2)^{-\frac{1}{2}}.2r$ Or $(S=\pi r^2+)\pi\sqrt{25r^2+r^4} \to \left(\frac{dS}{dr}=2\pi r+\right)\pi.\frac{1}{2}(25r^2+r^4)^{-\frac{1}{2}}\times(50r+4r^3)$	M1 A1
	$\left(S=\pi(l^2-25)\right)+\pi l\sqrt{l^2-25} \Rightarrow \left(\frac{dS}{dl}=2\pi l+\right)\pi\sqrt{l^2-25}+\pi l.\frac{1}{2}(l^2-25)^{-\frac{1}{2}}.2l$	(M1 A1)
	$\frac{dS}{dt}=\frac{dS}{dr}\times\frac{dr}{dt}=..\times 3$	M1
	$=81.5\ (\text{cm}^2/\text{min})$	A1
		(4)
		(5 marks)

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	Marks
4(a)	Assume that there exists a positive number k such that $k+\frac{9}{k}<6$	B1
	$k+\frac{9}{k}<6 \Rightarrow k^2+9<6k \Rightarrow k^2-6k+9<0$ **or** $k+\frac{9}{k}<6 \Rightarrow k+\frac{9}{k}-6<0 \Rightarrow (\sqrt{k}...)(\sqrt{k}...)<0$ **or** $k+\frac{9}{k}<6 \Rightarrow \left(k+\frac{9}{k}\right)^2<36 \Rightarrow k^2+18+\frac{81}{k^2}-36<0$	M1
	$\Rightarrow (k-3)^2<0$ **or** $\Rightarrow \left(\sqrt{k}-\frac{3}{\sqrt{k}}\right)^2<0$ **or** $\Rightarrow \left(k-\frac{9}{k}\right)^2<0$	A1
	But numbers squared are $\geqslant 0$, hence $k+\frac{9}{k}\geqslant 6$	A1*
		(4)
(b)	E.g. When $k=-3$, $-3+\frac{9}{-3}(=-6)$ which is not $\geqslant 6$	B1
		(1)

Question Number	Scheme	Marks
4(a)	Attempts direction vector by subtracting $(5\mathbf{i}+6\mathbf{j}+3\mathbf{k})$ and $(4\mathbf{i}+8\mathbf{j}+\mathbf{k})$ either way around.	M1
	E.g. $\mathbf{r}=4\mathbf{i}+8\mathbf{j}+\mathbf{k}+\lambda(\mathbf{i}-2\mathbf{j}+2\mathbf{k})$, $\mathbf{r}=5\mathbf{i}+6\mathbf{j}+3\mathbf{k}+\mu(\mathbf{i}-2\mathbf{j}+2\mathbf{k})$	A1
		(2)
(b)	E.g $\overrightarrow{PC}=\begin{pmatrix}4+\lambda\\8-2\lambda\\1+2\lambda\end{pmatrix}-\begin{pmatrix}2\\-2\\1\end{pmatrix}=\begin{pmatrix}2+\lambda\\10-2\lambda\\2\lambda\end{pmatrix}$	M1
	Uses $\overrightarrow{PC}.(\mathbf{i}-2\mathbf{j}+2\mathbf{k})=0$ E.g. $\Rightarrow 1(2+\lambda)-2(10-2\lambda)+2\times 2\lambda=0 \Rightarrow \lambda=...$	dM1
	E.g I $\lambda=2 \Rightarrow \mathbf{c}=(4+2)\mathbf{i}+(8-4)\mathbf{j}+(1+4)\mathbf{k}$ E.g II $\mu=1 \Rightarrow \mathbf{c}=(5+1)\mathbf{i}+(6-2)\mathbf{j}+(3+2)\mathbf{k}$	ddM1
	$(6,\ 4,\ 5)$	A1
		(4)
(c)	$\overrightarrow{OP'}=\mathbf{p}+2\overrightarrow{PC}=2\mathbf{i}-2\mathbf{j}+\mathbf{k}+2(4\mathbf{i}+6\mathbf{j}+4\mathbf{k})$	M1
	$(10,\ 10,\ 9)$	A1
		(2)
(d)	$\lvert\overrightarrow{PP'}\rvert=2\lvert\overrightarrow{PC}\rvert=2\sqrt{4^2+6^2+4^2}=...$	M1
	$4\sqrt{17}$	A1
		(2)
		Total 10

Question Number	Scheme	Marks
3.	States or implies Volume = $\int_{\sqrt{5}}^{5} \pi \left(\sqrt{\frac{3x}{3x^2+5}}\right)^2 dx$	B1
	$\int \left(\sqrt{\frac{3x}{3x^2+5}}\right)^2 dx = \int \frac{3x}{(3x^2+5)} dx = \frac{1}{2}\ln(3x^2+5)$	M1A1
	Volume = $\{\pi\}\left(\frac{1}{2}\ln(3\times 25+5)-\frac{1}{2}\ln(3\times 5+5)\right)$	M1
	$=\pi \ln 2$	A1
		(5 marks)

Question Number	Scheme	Notes	Marks
4(a)	$\frac{4-4x}{x(x-2)^2} \equiv \frac{A}{x}+\frac{B}{x-2}+\frac{C}{(x-2)^2}$	Correct form for the partial fractions	B1
	$4-4x = A(x-2)^2 + Bx(x-2)+Cx$ $\Rightarrow A = ...$ or $B = ...$ or $C = ...$	Uses a correct strategy to find at least one of their constants	M1
	$\frac{4-4x}{x(x-2)^2} \equiv \frac{1}{x}-\frac{1}{x-2}-\frac{2}{(x-2)^2}$	2 correct constants	A1
		All correct	A1
			(4)
(b)	$\int\left(\frac{1}{x}-\frac{1}{x-2}-\frac{2}{(x-2)^2}\right)dx = \ln x - \ln(x-2)+\frac{2}{x-2}(+c)$		M1
	M1 for $\int \frac{\alpha}{x}dx = \beta \ln x$ or $\int \frac{\alpha}{x-2}dx = \beta\ln(x-2)$		M1
	M1 for $\int \frac{\alpha}{(x-2)^2}dx = \frac{\beta}{x-2}$ A1: All correct		A1
			(3)
(c)	$\left[\ln x - \ln(x-2)+\frac{2}{x-2}\right]_3^5 = \left(\ln 5 - \ln 3 + \frac{2}{3}\right) - (\ln 3 - \ln 1 + 2)$		M1
	$= \ln\frac{5}{9} - \frac{4}{3}$ M1: Correct use of limits and reaches the required form using log rules A1: Correct answer		A1
			(2)
			Total 9

Question Number	Scheme	Marks
1	Volume $= \int_0^8 \frac{16\pi}{(x+2)^2}(\mathrm{d}x)$ oe e.g. $\pi\int_0^8\left(\frac{4}{x+2}\right)^2(\mathrm{d}x)$	B1
	$\int \frac{16}{(x+2)^2}\mathrm{d}x = \frac{-16}{(x+2)}$ or e.g. $u = x+2 \Rightarrow \int \frac{16}{(x+2)^2}\mathrm{d}x = \int \frac{16}{u^2}\mathrm{d}u = \frac{-16}{u}$	M1 A1
	$\left[\frac{-16\pi}{(x+2)}\right]_0^8 = \frac{-16\pi}{10} - \left(\frac{-16\pi}{2}\right)$ or e.g. $\left[\frac{-16\pi}{u}\right]_2^{10} = \frac{-16\pi}{10} - \left(\frac{-16\pi}{2}\right)$	M1
	$= \frac{32}{5}\pi$	A1
		(5)
		(5 marks)