Question Number	Scheme	Marks
7 (a)	$\frac{dV}{dr} = 4\pi r^2$	**B1** **(1)**
(b) (i)	$\frac{dV}{dt} = \frac{900}{(2t+3)^2} \Rightarrow V = -\frac{450}{2t+3} + c$ (oe)	**M1 A1**
	$t = 0, V = 0 \Rightarrow 0 = -\frac{450}{3} + c \Rightarrow c = ...$	**M1**
	$V = 150 - \frac{450}{2t+3} = \frac{300t + 450 - 450}{2t+3} = \frac{300t}{2t+3}$ *	**A1 ***
(ii)	150 cm^3	**B1**
		(5)
(c)	$t = 3 \Rightarrow V = \frac{300 \times 3}{2 \times 3 + 3} = \left(100\right)$	**M1**
	$100 = \frac{4}{3}\pi r^3 \Rightarrow r = 2.88$ cm	**dM1 A1cao** **(3)**
(d)	$\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt} \Rightarrow \frac{900}{(2t+3)^2} = 4\pi r^2 \times \frac{dr}{dt}$	**M1**
	$t = 3, r = "2.88" \Rightarrow \frac{900}{81} = 4\pi \times 2.88^2 \times \frac{dr}{dt} \Rightarrow \frac{dr}{dt} = ...$	**dM1**
	$\Rightarrow \frac{dr}{dt} =$ awrt 0.11 cm s^{-1}	**A1** **(3)**
		(12 marks)

Notes: Mark the question as a whole. Penalise only once for missing/incorrect units in the question.

(a)

B1: cao See scheme.

(b)(i)

M1: Integrates to a form $V = \frac{k}{2t+3}$ (oe) with or without + *c*. Condone a sign error in $2t - 3$.

A1: $V = -\frac{450}{2t+3}\left(+c\right)$ (oe). There is no need for + *c*

M1: Substitutes $V = 0, t = 0$ and proceeds to find a value for *c*. There must have been an attempt at integrating to achieve a function in *V* and *t* with a constant of integration.

A1*: Correct integration and value for *c* with at least one intermediate step with *c* substituted back in the equation before proceeding to the given answer.

(b)(ii)

B1: 150 cm^3. Must include units.

(c)

M1: Attempts to substitute t = 3 into the equation for *V*. Allow if there is a slip in substitution.

dM1: Uses their *V* in $V = \frac{4}{3}\pi r^3$ to find a value for *r*

A1: cao $r = 2.88$ cm. Must be to 3 s.f.. Must include units unless already penalised in (b)(ii).

(d)

M1: Attempts to use $\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$ (oe) with the given formula for $\frac{dV}{dt}$ and an attempt at substituting their $\frac{dV}{dr}$ (allow if this substitution is not in the correct place if a correct chain rule has been stated.)

dM1: Substitutes both $t = 3$ and their value for r and proceeds to find a value for $\frac{\mathrm{d}r}{\mathrm{d}t}$. If no substitution shown, the answer must be correct for their r to imply the method (may need to check).
A1: awrt 0.11 cm s^{-1}. Must include units unless already penalised in (b)(ii) or (c).

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)

Notes:

(a)

B1: Correct coordinates for P stated or implied by working.

M1: Attempts to find $\frac{\mathrm{d}y}{\mathrm{d}x}$ using $\frac{\mathrm{d}y/\mathrm{d}t}{\mathrm{d}x/\mathrm{d}t}$ at $t=\frac{\pi}{4}$. Condone poor differentiation. Substitution of the $\frac{\pi}{4}$ is sufficient for the method. Alternatively, may attempt $\frac{\mathrm{d}x}{\mathrm{d}y}$ or $-\frac{\mathrm{d}x}{\mathrm{d}y}$. Accept a value following finding $\frac{\mathrm{d}y}{\mathrm{d}x}$ (or its reciprocal etc) as an attempt to evaluate at $t=\frac{\pi}{4}$ if no contrary working is shown **but check carefully** as the correct answer may arise from incorrect working.

A1: Correct $\frac{\mathrm{d}y}{\mathrm{d}x}=4$ (oe equation) following correct differentiation. May be implied.

dM1: Attempts to find the equation of the normal at $t=\frac{\pi}{4}$. It is dependent upon the previous M and use of their P. The value of the gradient used must be correct for their differential.

A1*: **cso** Correct proof leading to $8y+2x=17$

(b)

M1: Attempts $\int y\frac{\mathrm{d}x}{\mathrm{d}t}\,\mathrm{d}t=\int 2\tan t\times"2\sin t\cos t"\,\mathrm{d}t$ with their $\frac{\mathrm{d}x}{\mathrm{d}t}$ condoning slips on coefficients.

A1: $\int 4\sin^2 t\,\mathrm{d}t$