Question Number	Scheme	Marks
6 (a)(i)	$\overrightarrow{AB} = (\pm)\left[\left(8\mathbf{i}+3\mathbf{j}-7\mathbf{k}\right)-\left(2\mathbf{i}-3\mathbf{j}+5\mathbf{k}\right)\right] = ...$	**M1**
	$\overrightarrow{AB} = 6\mathbf{i}+6\mathbf{j}-12\mathbf{k}$	**A1**
(ii)	$\mathbf{r} = \begin{pmatrix}2\\-3\\5\end{pmatrix}+\lambda\begin{pmatrix}1\\1\\-2\end{pmatrix}$ o.e. such as $\mathbf{r} = \begin{pmatrix}8\\3\\-7\end{pmatrix}+\lambda\begin{pmatrix}6\\6\\-12\end{pmatrix}$	**B1ft**
		(3)
(b)	Attempts $\pm\overrightarrow{CP} = \pm\begin{pmatrix}2+\lambda-3\\-3+\lambda-5\\5-2\lambda-2\end{pmatrix}$	**M1**
	$\overrightarrow{CP}\bullet k\begin{pmatrix}1\\1\\-2\end{pmatrix} = 0 \Rightarrow \begin{pmatrix}\lambda-1\\\lambda-8\\-2\lambda+3\end{pmatrix}\bullet k\begin{pmatrix}1\\1\\-2\end{pmatrix} = 0 \Rightarrow 1\left(\lambda-1\right)+1\left(\lambda-8\right)-2\left(-2\lambda+3\right)=0$ Alt: $\left(\lambda-1\right)^2+\left(\lambda-8\right)^2+\left(-2\lambda+3\right)^2 = 6\lambda^2-30\lambda+74 = 6\left(\lambda-\frac{5}{2}\right)^2+\frac{73}{2}$	**dM1**
	$\Rightarrow \lambda = \frac{5}{2}$ $\left[\text{use of } \overrightarrow{AB} \text{ in } \overrightarrow{CP} \text{ gives } \lambda = \frac{5}{12}, \text{use of } \overrightarrow{OB}\ \lambda = \frac{-7}{2} \text{ or } \frac{-7}{12}\right]$	**A1**
	$\overrightarrow{OP} = \begin{pmatrix}2\\-3\\5\end{pmatrix}+\frac{5}{2}\begin{pmatrix}1\\1\\-2\end{pmatrix} = \frac{9}{2}\mathbf{i}-\frac{1}{2}\mathbf{j}$	**ddM1, A1** **(5)**
		(8 marks)

Notes:

Accept either form of vector notation throughout. Accept with **i**,**j** and **k** in their column vectors.

(a)(i)

M1: Attempts to subtract vectors $\overrightarrow{OA}$ and $\overrightarrow{OB}$ either way around. May be implied by two correct components.

A1: $\overrightarrow{AB} = 6\mathbf{i}+6\mathbf{j}-12\mathbf{k}$ o.e.

(a)(ii)

B1ft: Any correct equation for the line, may use a correct or follow through multiple of $\overrightarrow{AB}$ for direction and with any point on the line. Must start **r** = … or accept $x\mathbf{i}+y\mathbf{j}+z\mathbf{k} = ...$ (l = … is B0).

(b)

M1: Attempts $\pm\overrightarrow{CP}$ using point C and a general point on their l

dM1: Sets the scalar product of their $\overrightarrow{CP}$ (either direction) and their direction of l (or $\overrightarrow{AB}$) to 0 and proceeds to an equation in λ. Condone sign slips in components if the intention is clear.

Alternatively attempts to minimise the distance CP (by completing square as shown, or by differentiation) to obtain a linear equation in λ.

A1: Finds a correct value of λ for their *l*. Note if they use $\overrightarrow{AB}$ the correct value is $\frac{5}{12}$

ddM1: Substitutes their λ (from a correct method) into their *l*

A1: $\overrightarrow{OP} = \frac{9}{2}\mathbf{i} - \frac{1}{2}\mathbf{j}$ Accept as coordinates, and accept *P* = … instead of $\overrightarrow{OP}$.

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.)