Question Number	Scheme	Marks
2(a)	States or uses $S = 6x^2$ **or** $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$	B1
	States or uses $S = 6x^2$ **and** $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$	B1
	Attempts to use $\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow 4 = 12x \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = ...$	M1
	$\Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{3x}$ oe	A1
		(4)
(a) Alt	States or uses $S = 6x^2$ **or** $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$	B1
	States or uses $S = 6x^2$ **and** $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$	B1
	$\frac{\mathrm{d}S}{\mathrm{d}t} = 4 \Rightarrow S = 4t + c \Rightarrow S = 6x^2 \Rightarrow 6x^2 = 4t + c \Rightarrow 12x\frac{\mathrm{d}x}{\mathrm{d}t} = 4 \Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = ...$ or $S = 6x^2 \Rightarrow 6x^2 = 4t + c \Rightarrow 12x = 4\frac{\mathrm{d}t}{\mathrm{d}x} \Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = ...$	M1
	$\Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{3x}$ oe	A1
(b)	States or uses $\frac{\mathrm{d}V}{\mathrm{d}x} = 3x^2$	B1
	Attempts to use $\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow \frac{\mathrm{d}V}{\mathrm{d}t} = 3x^2 \times \frac{1}{3x} = x$	M1
	$\Rightarrow \frac{\mathrm{d}V}{\mathrm{d}t} = V^{\frac{1}{3}}$	A1
		(3)
(b) Alt	$V = x^3,\ S = 6x^2 \Rightarrow S = 6V^{\frac{2}{3}} \Rightarrow \frac{\mathrm{d}S}{\mathrm{d}V} = 4V^{-\frac{1}{3}}$	B1
	Attempts to use $\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}S} \times \frac{\mathrm{d}S}{\mathrm{d}t} = \frac{1}{4V^{-\frac{1}{3}}} \times 4$	M1
	$\Rightarrow \frac{\mathrm{d}V}{\mathrm{d}t} = V^{\frac{1}{3}}$	A1
		(7 marks)

(a) **Condone the use of different variables provided the intention is clear.**
This will most likely be the use of *A* rather than *S* for surface area.

B1: States or uses $S = 6x^2$ or $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$ (ignore any units associated with either)

Note that $S = 6x^2$ may be implied by $\frac{\mathrm{d}S}{\mathrm{d}x} = 12x$

B1: States or uses $S = 6x^2$ and $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$ (ignore any units associated with either)

Note that $S = 6x^2$ may be implied by $\frac{\mathrm{d}S}{\mathrm{d}x} = 12x$

M1: Attempts to use $\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t}$ or equivalent with their $\frac{\mathrm{d}S}{\mathrm{d}x}$ and $\frac{\mathrm{d}S}{\mathrm{d}t}$ where $\frac{\mathrm{d}S}{\mathrm{d}x} = kx$ and $\frac{\mathrm{d}S}{\mathrm{d}t}$ is a constant, in an attempt to find $\frac{\mathrm{d}x}{\mathrm{d}t}$. May be implied by their working.

A1: $\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{3x}$ oe e.g. $\frac{1/3}{x}$, $\frac{4}{12x}$ from correct work and apply isw once a correct answer is seen.

Allow correct work leading to e.g. $k = \frac{1}{3}$.

The "$\frac{\mathrm{d}x}{\mathrm{d}t} =$" must appear at some point in their working for this mark.

(a) **Alt.**

B1: States or uses $S = 6x^2$ or $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$ (ignore any units associated with either)

Note that $S = 6x^2$ may be implied by $\frac{\mathrm{d}S}{\mathrm{d}x} = 12x$

B1: States or uses $S = 6x^2$ and $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$ (ignore any units associated with either)

Note that $S = 6x^2$ may be implied by $\frac{\mathrm{d}S}{\mathrm{d}x} = 12x$

M1: Integrates $\frac{\mathrm{d}S}{\mathrm{d}t} = 4$ to obtain $S = 4t + c$ or $S = 4t$ and replaces S in terms of x and differentiates wrt t or wrt x to obtain $\alpha x \frac{\mathrm{d}x}{\mathrm{d}t} = \beta$ or $\alpha x = \beta \frac{\mathrm{d}t}{\mathrm{d}x}$

A1: $\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{3x}$ oe e.g. $\frac{1/3}{x}$, $\frac{4}{12x}$ from correct work and apply isw once a correct answer is seen.

Note that $\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{3x}$ sometimes comes from incorrect work so check their method.

This can be scored from obtaining $S = 4t + c$ or $S = 4t$ earlier.

The "$\frac{\mathrm{d}x}{\mathrm{d}t} =$" must appear at some point in their working for this mark.

(b)

B1: States or uses $\frac{\mathrm{d}V}{\mathrm{d}x} = 3x^2$ Allow this mark to score anywhere in the question.

M1: Attempts to use $\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t}$ or equivalent with their $\frac{\mathrm{d}V}{\mathrm{d}x}$ and $\frac{\mathrm{d}x}{\mathrm{d}t}$ which may be implied.

A1: $\frac{\mathrm{d}V}{\mathrm{d}t} = V^{\frac{1}{3}}$ which may be implied by e.g. $\frac{\mathrm{d}V}{\mathrm{d}t} = x,\ x = V^p \Rightarrow p = \frac{1}{3}$.

The "$\frac{\mathrm{d}V}{\mathrm{d}t} =$" must appear at some point in their working for this mark.

(b) **Alt:**

B1: States or uses $\frac{\mathrm{d}S}{\mathrm{d}V} = 4V^{-\frac{1}{3}}$ (from $S = 6x^2,\ V = x^3 \Rightarrow S = 6V^{\frac{2}{3}}$)

M1: Attempts to use $\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}S} \times \frac{\mathrm{d}S}{\mathrm{d}t}$ or equivalent with their $\frac{\mathrm{d}V}{\mathrm{d}S}$ and $\frac{\mathrm{d}S}{\mathrm{d}t}$ which may be implied.

A1: $\frac{\mathrm{d}V}{\mathrm{d}t} = V^{\frac{1}{3}}$ which may be implied by e.g. $\frac{\mathrm{d}V}{\mathrm{d}t} = x,\ x = V^{p} \Rightarrow p = \frac{1}{3}$

The "$\frac{\mathrm{d}V}{\mathrm{d}t} =$" must appear at some point in their working for this mark.

Note that a common incorrect response involves using $S = x^2$ rather than $S = 6x^2$, giving:

(a) $S = x^2,\ \frac{\mathrm{d}S}{\mathrm{d}t} = 4,\ \frac{\mathrm{d}S}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow 4 = 2x \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow \frac{\mathrm{d}x}{\mathrm{d}t} = \frac{2}{x}$ scoring B1B0M1A0

(b) $\frac{\mathrm{d}V}{\mathrm{d}x} = 3x^2,\ \frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}x} \times \frac{\mathrm{d}x}{\mathrm{d}t} \Rightarrow \frac{\mathrm{d}V}{\mathrm{d}t} = 3x^2 \times \frac{2}{x} = 6x = 6V^{\frac{1}{3}}$ scoring B1M1A0

Question Number	Scheme	Marks
3(i)	$\int x^2 e^{2x}\,dx = \frac{1}{2}x^2 e^{2x} - \int x\,e^{2x}\,dx$	M1
	$= \frac{1}{2}x^2 e^{2x} - \left\{\frac{1}{2}xe^{2x} - \int \frac{e^{2x}}{2}\,dx\right\}$	M1
	$= \frac{1}{2}x^2 e^{2x} - \frac{1}{2}xe^{2x} + \frac{e^{2x}}{4}$	A1
	$\int_0^4 x^2 e^{2x}\,dx = \left[\frac{1}{2}x^2 e^{2x} - \frac{1}{2}xe^{2x} + \frac{e^{2x}}{4}\right]_0^4 = 8e^8 - 2e^8 + \frac{e^8}{4} - \frac{1}{4}$	M1
	$= \frac{25e^8}{4} - \frac{1}{4}$	A1
		(5)

(i) Condone the omission of "dx" throughout

M1: Attempts to integrate by parts once to achieve $Px^2e^{2x} - Q\int x\,e^{2x}dx, \quad P,Q>0$

M1: Attempts to integrate xe^{2x} to achieve $\lambda xe^{2x} \pm \mu\int e^{2x}\,dx, \ \lambda>0$

A1: $\int x^2e^{2x}\,dx = \frac{1}{2}x^2e^{2x} - \frac{1}{2}xe^{2x} + \frac{e^{2x}}{4}$ which may be unsimplified and isw once a correct answer is seen.

Watch for $\int x^2e^{2x}\,dx = \frac{1}{2}x^2e^{2x} - \left(\frac{1}{2}xe^{2x} - \frac{e^{2x}}{4}\right)(+c)$ which scores all 3 marks. ISW after sight of this.

Watch for D & I method which may be seen. You will just see the answer here.

D		**I**
x^2	+	e^{2x}
$2x$	−	$\frac{1}{2}e^{2x}$
2	+	$\frac{1}{4}e^{2x}$
0		$\frac{1}{8}e^{2x}$

$$= \frac{1}{2}x^2e^{2x} - \frac{1}{2}xe^{2x} + \frac{1}{4}e^{2x}$$

Score M2 for $Ax^2e^{2x} \pm Bxe^{2x} \pm Ce^{2x}, \ A>0$

and then A1 for $\frac{1}{2}x^2e^{2x} - \frac{1}{2}xe^{2x} + \frac{e^{2x}}{4}(+c)$

M1: Attempts to substitute **both** limits into an expression of the form $Ax^2e^{2x} \pm Bxe^{2x} \pm Ce^{2x}, \ A>0,$ subtracts either way round, and simplifies to the form $\alpha e^8 + \beta, \ \alpha,\beta \neq 0$ where α and β are numeric.

(Allow if the e^8 terms are not combined)

A1: $\frac{25e^8}{4} - \frac{1}{4}$ or exact simplified equivalent e.g. $\frac{1}{4}\left(25e^8 - 1\right), \ \frac{25}{4}\left(e^8 - \frac{1}{25}\right)$. Do **not** condone "+ c" here.

(ii)	**1.** $u = 2x-1 \Rightarrow \dfrac{\mathrm{d}u}{\mathrm{d}x} = 2$ or e.g. $\mathrm{d}u = 2\mathrm{d}x$ **OR** **2.** $u = \left(2x-1\right)^2 \Rightarrow \dfrac{\mathrm{d}u}{\mathrm{d}x} = 4\left(2x-1\right)$ or e.g. $\mathrm{d}u = 4\left(2x-1\right)\mathrm{d}x$ **OR** **3.** $u = 2x \Rightarrow \dfrac{\mathrm{d}u}{\mathrm{d}x} = 2$ or e.g. $\mathrm{d}u = 2\mathrm{d}x$	B1
	1. $u = 2x-1 \Rightarrow \displaystyle\int \frac{4x}{\left(2x-1\right)^2}\,\mathrm{d}x = \int \frac{2u+2}{u^2} \times \frac{1}{2}\,\mathrm{d}u$ **OR** **2.** $u = \left(2x-1\right)^2 \Rightarrow \displaystyle\int \frac{4x}{\left(2x-1\right)^2}\,\mathrm{d}x = \int \frac{2\sqrt{u}+2}{u} \times \frac{1}{4\sqrt{u}}\,\mathrm{d}u$ **OR** **3.** $u = 2x \Rightarrow \displaystyle\int \frac{4x}{\left(2x-1\right)^2}\,\mathrm{d}x = \int \frac{2u}{\left(u-1\right)^2} \times \frac{1}{2}\,\mathrm{d}u$	M1 A1
	1. $\displaystyle\int \left(\frac{1}{u} + \frac{1}{u^2}\right)\mathrm{d}u = \ln u - \frac{1}{u}$ **OR** **2.** $\displaystyle\frac{1}{2}\int \left(\frac{1}{u} + \frac{1}{u^{\frac{3}{2}}}\right)\mathrm{d}u = \frac{1}{2}\ln u - \frac{1}{\sqrt{u}}$ **OR 3.** $\displaystyle\int \frac{u}{\left(u-1\right)^2}\,\mathrm{d}u = -u\left(u-1\right)^{-1} + \int \frac{1}{u-1}\mathrm{d}u = -u\left(u-1\right)^{-1} + \ln\left(u-1\right)$	**d**M1 A1
	1. Uses limits $u = 5$ to $u = 20$: $\left(\ln 20 - \dfrac{1}{20}\right) - \left(\ln 5 - \dfrac{1}{5}\right)$ **OR** **2.** Uses limits $u = 25$ to $u = 400$: $\left(\dfrac{1}{2}\ln 400 - \dfrac{1}{20}\right) - \left(\dfrac{1}{2}\ln 25 - \dfrac{1}{5}\right)$ **OR** **3.** Uses limits $u = 6$ to $u = 21$: $\left(\ln 20 - \dfrac{21}{20}\right) - \left(\ln 5 - \dfrac{6}{5}\right)$	M1
	$= \dfrac{3}{20} + \ln 4$	A1
		(7)
		(12 marks)

Note that 'u' = $2x - 1$ is by far the most common approach.