Question Number	Answer	Marks
6 **(a)**	$V = (80-2x)(40-2x)x$	M1A1
	$V = 3200x - 240x^2 + 4x^3$ *	A1 (3)
(b)	$\frac{\mathrm{d}V}{\mathrm{d}x} = 3200 - 480x + 12x^2$	M1
	$\frac{\mathrm{d}V}{\mathrm{d}x} = 0 \quad 12x^2 - 480x + 3200 = 0$ $3x^2 - 120x + 800 = 0$	M1dep
	$x = \frac{120 \pm \sqrt{120^2 - 12 \times 800}}{6}$	M1dep
	$x = 31.54...(\text{not poss.})$ or $8.452... = 8.45$	A1
	$\frac{\mathrm{d}^2V}{\mathrm{d}x^2} = -480 + 24x$	M1
	$x = 8.45 \Rightarrow \frac{\mathrm{d}^2V}{\mathrm{d}x^2} < 0 \ \therefore \text{max.}$	A1 (6)
(c)	$V_{\max} = 3200 \times 8.452 - 240 \times 8.452^2 + 4 \times 8.452^3$ or $(80 - 2 \times 8.452)(\ )$ etc	M1
	$V_{\max} = 12300$	A1 (2) [11]

Notes

(a)

M1 for attempting the volume of the box, must be dimensionally correct

A1 for all three lengths correct

A1cso for $V = 3200x - 240x^2 + 4x^3$ *

(b)

M1 for differentiating the **given** expression for V

M1dep for equating their differential to 0

M1dep for solving the resulting 3 term quadratic. See general principles.

A1 for $x = 8.45$ **must be 3 sf** (31.54 need not be shown (unless calculator solution); if included, a choice must be made now or later)

M1 for attempting the second differential of V

A1cso for establishing a max. Award this mark only if the expression for the second differential is algebraically correct and a correct value of x has been obtained. No need to evaluate (ignore incorrect evaluations if that is the only error). A conclusion must be seen.

Alternatives for the last 2 marks:

(i)M1 for taking values of x near to and on either side of their x **and** calculating the numerical values of $\frac{dV}{dx}$ for both of these values.

A1 for all work correct and a correct conclusion.

(ii)M1 for taking values of x near to and on either side of their x **and** calculating the numerical values of V for both of these values and for their x.

A1 for all work correct and a correct conclusion.

If this method used, marks for (c) can be given also.

(iii) By considering the curve. Evidence that it is a cubic, through the origin, and V is negative when x is negative (M1). Hence max at lesser of the roots of quadratic ie at $x = 8.45$ (A1)

(c)

M1 for taking their value of x and substituting in the **given** expression for V

A1 for $V = 12300$ **must be 3 sf**, but deduction may have been made in (b).