

Question Number	Answer	Mark
16(a)	Dark matter has mass (1) Or Dark matter exerts a gravitational force	2
	Dark matter does not emit electromagnetic radiation (1)	
16(b)	Use of $\Delta E = c^2 \Delta m$ (1)	3
	Use of $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ (1)	
	$m = 8.5 \times 10^{-19} \text{ (kg)}$ (1)	
	<u>Example of calculation</u> $m = \frac{4.8 \times 10^8 \text{ GeV} \times 1.6 \times 10^{-19} \text{ J GeV}^{-1}}{(3.0 \times 10^8 \text{ m s}^{-1})^2} = 8.53 \times 10^{-19} \text{ kg}$	
16(c)	The ultimate fate of the universe depends upon the (average) density of the universe (1) Or the (average) density of the universe must be compared with the critical density of the universe	2
	The amount of dark matter is uncertain (so the average density is uncertain) (1)	
	Total for question 16	7