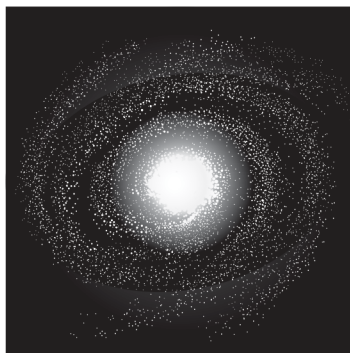16 The image shown is a representation of our galaxy, the Milky Way.

(a) Astronomers think that there is a very large concentration of stars in the central region of the galaxy. Outside this central region the concentration of stars is very much less. All stars in the galaxy are rotating about its centre.

It can be shown that the velocity v of a star a distance r from the centre of the galaxy is given by the expression

$$v = \sqrt{\frac{GM}{r}}$$

where M is the mass of the galaxy contained in a sphere of radius r.

(i) The graph shows how astronomers expect v to vary with r.
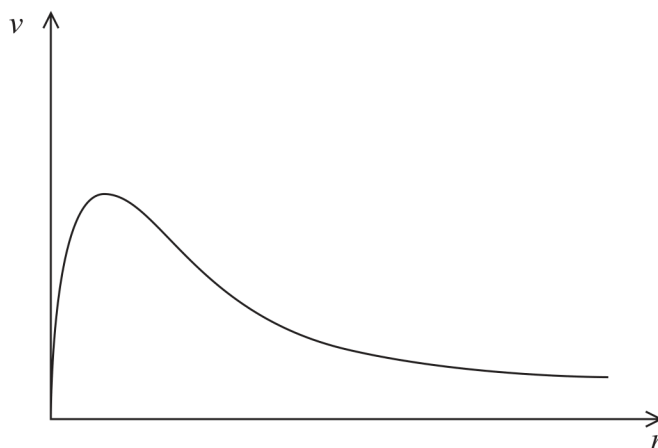
Explain how the expression gives the variation of v with r shown in the graph.

(3)

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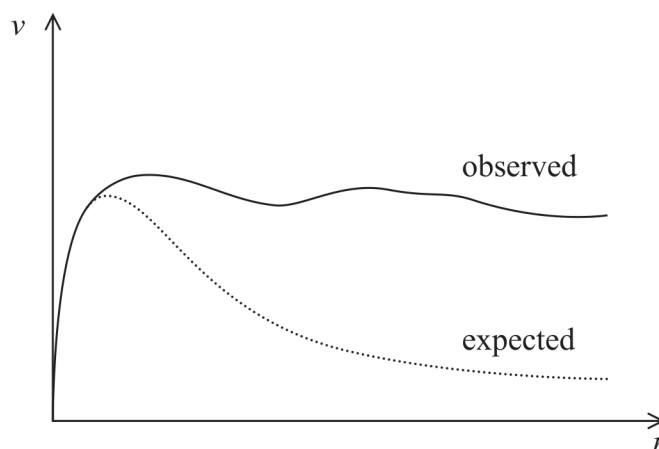
(ii) The observed variation of v with r has been added to produce the graph below.

Suggest why the 'observed' velocity varies as shown.

(2)

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(b) The ultimate fate of the universe may be a closed universe, but astronomers cannot be sure what their current models predict.

Explain why astronomers cannot be sure that the universe is closed.

(2)

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(Total for Question 16 = 7 marks)