**1** **(a)** **(i)** Define gravitational potential at a point.

.....

.....

..... [2]

**(ii)** Starting from the equation for the gravitational potential due to a point mass, show that the gravitational potential energy $E_P$ of a point mass $m$ at a distance $r$ from another point mass $M$ is given by

$$E_P = -\frac{GMm}{r}$$

where $G$ is the gravitational constant.

[1]

**(b)** Fig. 1.1 shows the path of a comet of mass $2.20 \times 10^{14}$ kg as it passes around a star of mass $1.99 \times 10^{30}$ kg.

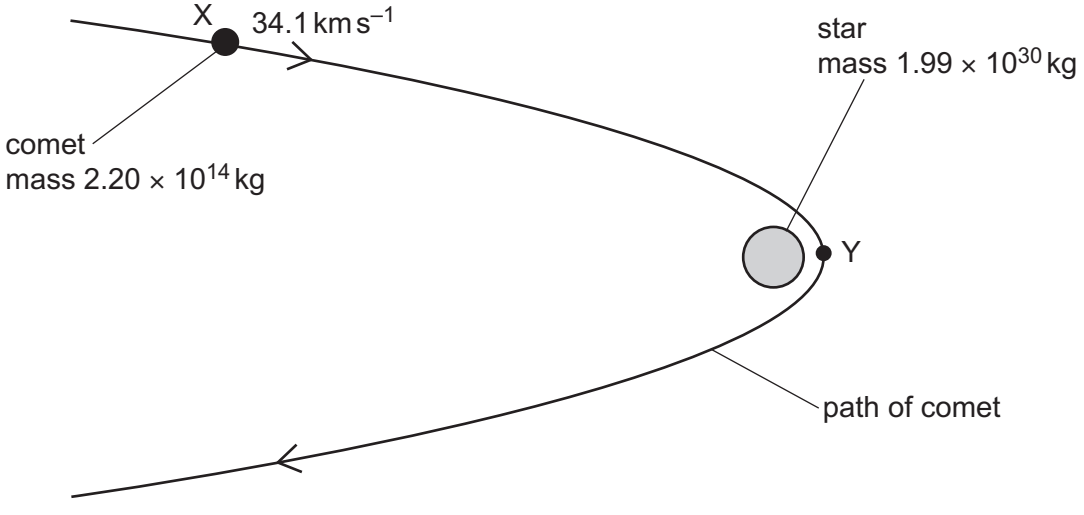


**Fig. 1.1** (not to scale)

At point X, the comet is $8.44 \times 10^{11}$ m from the centre of the star and is moving at a speed of 34.1 km s$^{-1}$.

At point Y, the comet passes its point of closest approach to the star. At this point, the comet is a distance of $6.38 \times 10^{10}$ m from the centre of the star.

Both the comet and the star can be considered as point masses at their centres.

**(i)** Calculate the magnitude of the change in the gravitational potential energy $\Delta E_P$ of the comet as it moves from position X to position Y.

$\Delta E_P$ = ..... J [2]

**(ii)** State, with a reason, whether the change in gravitational potential energy in **(b)(i)** is an increase or a decrease.

.....

..... [1]

**(iii)** Use your answer in **(b)(i)** to determine the speed, in $km\,s^{-1}$, of the comet at point Y.

speed = ..... $km\,s^{-1}$ [3]

**(c)** A second comet passes point X with the same speed as the comet in **(b)** and travelling in the same direction. This comet is gradually losing mass. The mass of this comet when it passes point X is the same as the mass of the comet in **(b)**.

Suggest, with a reason, how the path of the second comet compares with the path shown in Fig. 1.1.

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..... [1]

[Total: 10]