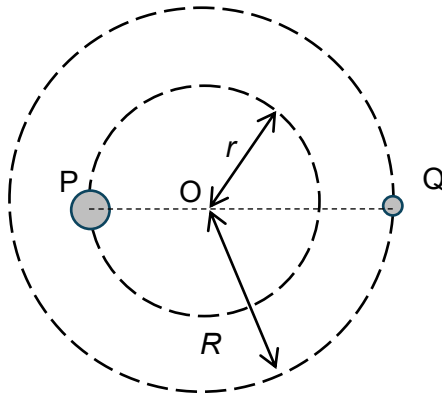**3**

(a)

Star P of mass M and star Q of mass m follow circular orbits of radii r and R respectively, centred on their common centre of mass O as shown in Fig. 3.1.

not drawn to scale

Fig. 3.1

(i)

Write down an expression for the gravitation force experienced by each star in terms of M, m, r and R.

[1]

(ii)

Using Fig. 3.1, explain why *M* is of a bigger mass compared to *m*.

…………………………………………………………………………………………..

………………………………………………………………………………………….…

....

[2]

(iii)

Write down the expressions for the centripetal acceleration experienced by star P and star Q in terms of M, m, r and R. Show your working clearly.

[2]

(iv)

The period of rotation of star P is equal to the period of rotation of star Q.

By considering the circular motion of each star about their common centre of mass, show that the period T of rotation of the stars is given by

$$T = \sqrt{\frac{4\pi^2(R+r)^3}{G(M+m)}}$$

(b)

A rocket is currently travelling at 830 km/h at O.

Calculate the minimum speed for the rocket to escape completely from star P and star Q's gravitational field.

Additional information given:

$m = 1.50 \times 10^{23}$ kg

$M = 4.50 \times 10^{23}$ kg

$R = 1.2 \times 10^{6}$ km

$r = 4.0 \times 10^{5}$ km

minimum speed = ... m s^{-1}

[2]