**1** **(a)** Phobos is one of the two moons orbiting Mars. Fig. 1.1 shows Phobos and Mars.

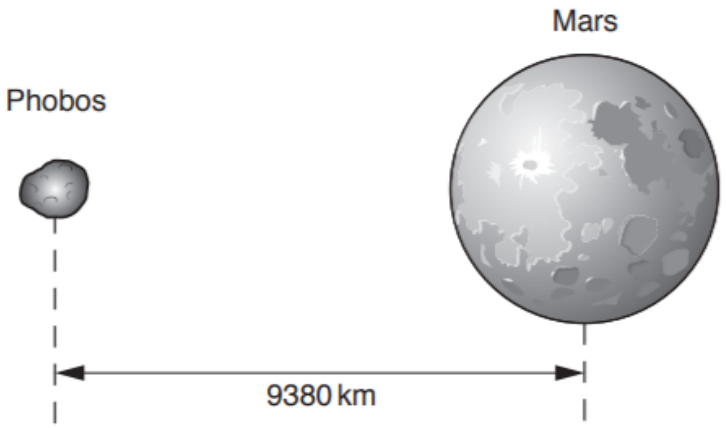


**Fig. 1.1**

The orbit of Phobos may be assumed to be a circle. The centre of Phobos is at a distance 9380 km from the centre of Mars and it has an orbital speed $2.14 \times 10^3$ m $s^{-1}$.

**(i)** On Fig. 1.1, draw a cross to show the point where the net force acting on a third mass placed at that point is zero. [1]

**(ii)** Calculate the mass $M$ of Mars.

$M$ = …….. kg [4]

**(b)** The Earth and Mars move in elliptical orbits around the Sun. In July 2018, the closest distance between the centre of Mars and the centre of Earth will be $5.8 \times 10^{10}$ m.

Fig. 1.2 shows the variation of the resultant gravitational field strength $g$ between the two planets with distance $r$ from the centre of the Earth.

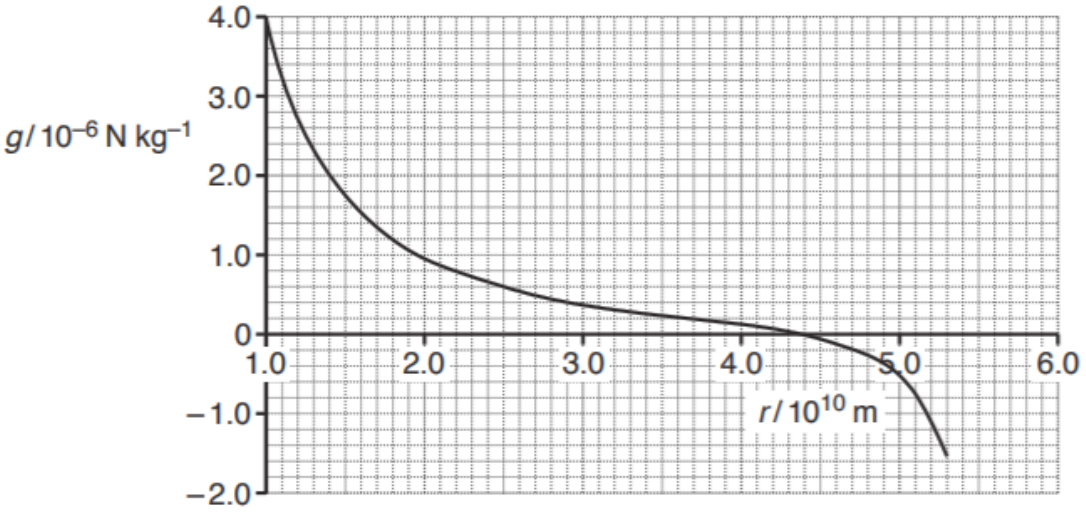


**Fig. 1.2**

**(i)** Explain briefly the overall shape of the graph in Fig. 1.2.

.....

.....

.....

..... [2]

**(ii)** Determine the ratio $\frac{\text{mass of Earth}}{\text{mass of Mars}}$.

$\frac{\text{mass of Earth}}{\text{mass of Mars}}$ = ..... [2]

**(iii)** After successfully collected some geological samples on the surface of Mars, a space rover with a total mass of 200 kg, wants to return to Earth.

Estimate the minimum energy required to return to Earth, assuming that it starts from the distance of $5.3 \times 10^{10}$m from the centre of the Earth.

minimum energy = …….. J [3]