3 (a) (i) Explain what is meant by the term *escape speed*.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………….. [2]

(ii) Mars has a radius of approximately 3.4×10^6 m and a mass of 6.4×10^{23} kg. Show that the escape speed from Mars is approximately 5 km s^{-1}.

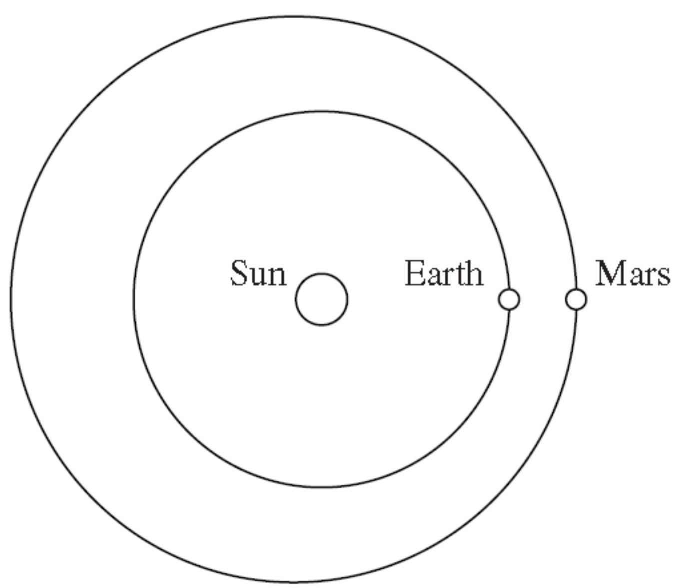
[3]

(iii) Suggest why a rocket would be able to escape from Mars with an initial speed much less than the escape speed given in part **(a)(ii)**.

……………………………………………………………………………………………..

…………………………………………………………………………………….. [1]

(b) Fig. 3.1 shows the Sun, Earth and Mars in alignment. Earth and Mars rotate around the Sun in the same directional sense.



Not to scale

Fig. 3.1

A rocket of mass 2.05×10^6 kg leaves the surface of Mars closest to Earth and heads for Earth.

Fig. 3.2 below gives data relevant to the rocket at the start of its journey.

astronomical object (AO)	mass of AO / kg	distance of rocket from the centre of AO / m	rocket's gravitational potential due to AO / J kg^{-1}	sign of gravitational potential
Mars	6.4×10^{23}	3.4×10^{6}	1.26×10^{7}	
Earth	6.0×10^{24}	5.6×10^{10}		negative
Sun	2.0×10^{30}	2.3×10^{11}	5.80×10^{6}	

Fig. 3.2

(i) Complete Fig. 3.2 by calculating the magnitude of gravitational potential of the rocket due to the presence of Earth and the signs of the gravitational potential energies due to Mars itself and the Sun.

[2]

(ii) Calculate the total gravitational potential energy of the rocket on the surface of Mars.

total gravitational potential energy = ………………………… J [2]

(c) **(i)** Derive an expression to show that for satellites in a circular orbit

$$T^2 \propto r^3$$

where T is the period of orbit and r is the radius of the orbit.

[2]

(ii) The orbits of the Earth and Mars can be approximated to be circular orbits around the Sun.

Hence, estimate the orbital period of Mars.

orbital period of Mars = ………………………….. days [3]