5 **(a)** The value of the gravitational potential ϕ at a point in the Earth's field is given by the equation

$$\phi = -\frac{GM}{r}$$

where M is the mass of the Earth and r is the distance of the point from the centre of the Earth such that r is greater than the radius of the Earth R_E.

Explain why the potential has a negative value.

....

....

....

.... [1]

(b) Fig. 5.1 shows the equipotential lines for Earth, where point A is at a potential of -4.0×10^7 J kg^{-1} and points B and C are at a potential of -5.0×10^7 J kg^{-1}.

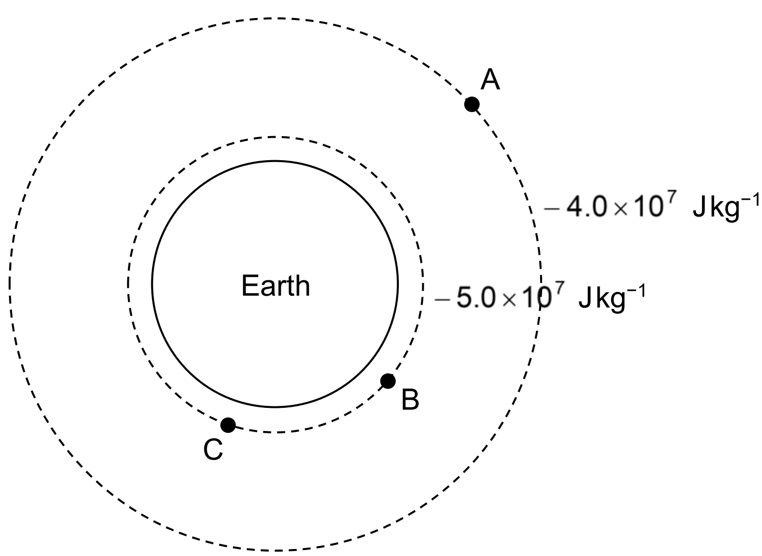

Fig. 5.1

(i) On Fig. 5.1, draw the equipotential line for the gravitational potential of -4.5×10^7 J kg^{-1}.

[1]

(ii) Calculate the work done by the gravitational force in bringing a body of mass 3000 kg from A to B.

work done = ... J [2]

(iii) The work done by the gravitational force in moving any mass along the equipotential line is zero. Explain why this is so.

....

....

.... [1]

(c) A satellite of mass 1500 kg is launched from the surface of the Earth into a circular orbit around the Earth at a height of 6800 km above the Earth's surface. At this height the satellite has an orbital period of 8.5×10^3 s. The radius of the Earth is 6400 km.

(i) A student uses the equation *gain in potential energy* = *mgh* to determine the increase in the potential energy of the satellite.

Suggest why this equation cannot be used and state whether the student's answer would be less than, equal to, or greater than the actual gain in potential energy.

....

....

.... [2]

(ii) Calculate the kinetic energy of the satellite.

kinetic energy = ... J [2]

(iii) State an advantage of having a satellite in a geostationary orbit round the Earth and explain whether the satellite orbiting at a height of 6800 km above the Earth's surface is in a geostationary orbit.

....

....

....

.... [2]