7 **(a)** **(i)** Define *gravitational potential*.

.....

.....

.....[2]

(ii) Explain why gravitational potential is negative.

.....

.....

.....[2]

(b) **(i)** The gravitational potential due to the Sun of mass *M*, at a distance *r* from its centre is ϕ. Show that

$$r\phi = \text{constant}$$

[1]

In 2017, astronomers discovered an asteroid named Oumuamua, passing very close to the Sun. Oumuamua was of great scientific interest due to its unusually high speed. The following data are available for Oumuamua and the Sun.

Radius of the Sun	7.0×10^{8} m
Potential due to the Sun at its surface	-1.9×10^{11} J kg^{-1}
Minimum distance of Oumuamua to the centre of the Sun (point of closest approach to the Sun)	3.8×10^{7} km
Speed of Oumuamua at the point of closest approach to the Sun	88 km s^{-1}

(ii) Using the expression in **(b)(i)**, calculate the gravitational potential due to the Sun, at the point of closest approach of Oumuamua to the Sun.

gravitational potential = ...J kg^{-1} [2]

(iii) Hence, show that the total energy of Oumuamua is greater than zero.

[2]

(iv) Hence, explain whether Oumuamua orbits the Sun.

.....

.....

.....[1]

(c) Scientists are planning a mission to land an astronaut on an asteroid. To do this safely, the astronaut must land in an area that has a low electric field strength, so as to avoid the risk of damage to the spacecraft's electronics.

Fig. 7.1 shows a scale diagram of the equipotential lines around the asteroid Kleopatra, which is an irregular rocky asteroid that is electrically non-conductive.

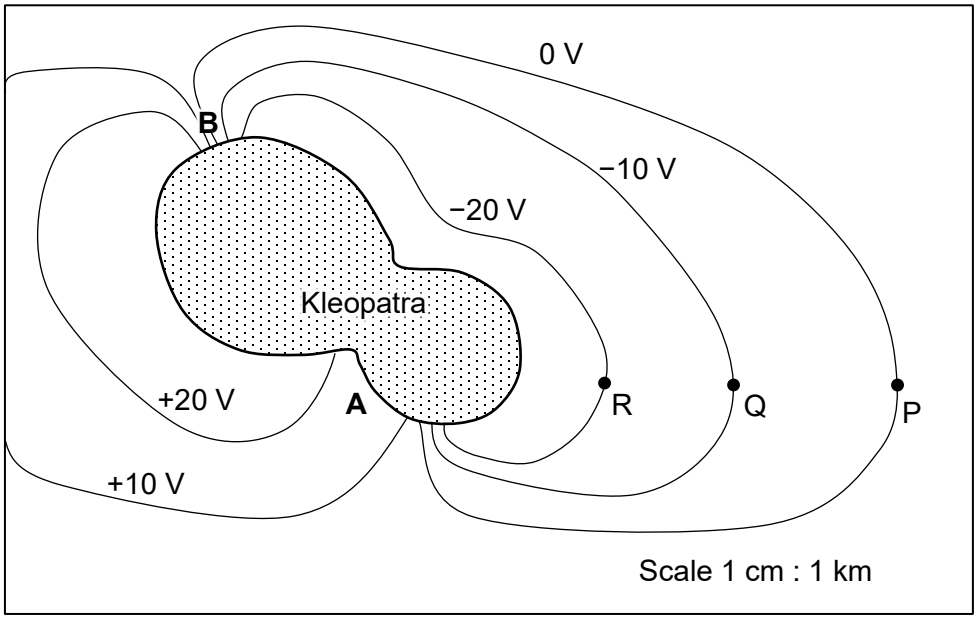

Fig. 7.1

(i) Explain what is meant by electric field strength.

.....

.....

.....[1]

(ii) State the relationship between electric field strength E and electric potential V.

.....

.....[1]

(iii) Two possible landing sites for the spacecraft are A and B. State and explain which landing site would be more suitable.

.....

.....

.....

.....[2]

(d) **(i)** The spacecraft approaches Kleopatra along the route P → Q → R.

Draw an arrow at point Q to indicate the direction of the electric field at Q. [1]

(ii) Estimate the magnitude of the electric field strength at point Q.

magnitude of electric field strength =..... N C^{-1} [2]

(iii) The spacecraft has a net charge of −2.0 mC. State the direction of the electric force on the spacecraft at point Q.

.....[1]

(iv) Calculate the work done by the electric field as the spacecraft moves from P to R.

work done by electric field = ... J [2]