Question Number	Answer		Mark
16(a)	**Either** Use of $F = \frac{GMm}{r^2}$ with $F = m\omega^2 r$ Use of $\omega = \frac{2\pi}{T}$ $T = 5800$ s **Or** Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$ Use of $v = \frac{2\pi r}{T}$ $T = 5800$ s <u>Example of calculation</u> $\frac{GMm}{r^2} = m\omega^2 r$ $\therefore \omega = \sqrt{\frac{GM}{r^3}}$ $\therefore \omega = \sqrt{\frac{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 6.0 \times 10^{24}\ \text{kg}}{(6.4 \times 10^6\ \text{m} + 5.5 \times 10^5\ \text{m})^3}} = 1.09 \times 10^{-3}\ \text{rad s}^{-1}$ $T = \frac{2\pi\ \text{rad}}{1.09 \times 10^{-3}\ \text{rad s}^{-1}} = 5755\ \text{s}$	(1) (1) (1) (1) (1) (1)	3
16(b)	**Either** ($F = \frac{GMm}{r^2}$, so) the (gravitational) force is greater for a low Earth orbit $F = m\left(\frac{2\pi}{T}\right)^2 r$ So if F increases when r decreases, then T must decrease (MP3 dependent upon MP1 or MP2) **Or** ($\frac{2\pi}{T} = \sqrt{\frac{GM}{r^3}}$, so) $T^2 = \frac{4\pi^2 r^3}{GM}$ G and M are constant, so $T \propto \sqrt{r^3}$ So when r is smaller, T is smaller. (MP3 dependent upon MP1 or MP2) [Accept converse argument]	(1) (1) (1) (1) (1) (1)	3

16(c)	Use of $V_{grav} = (-)\frac{GM}{r}$ Use of $\Delta E_k = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\Delta E_k = 1.1 \times 10^9$ J (Do not credit use of $\Delta E_{grav} = mg\Delta h$, as g is not constant) <u>Example of calculation</u> $\Delta E_k = 6.67 \times 10^{-11}$ N m^2 kg^{-2} $\times$ 6.0 $\times$ 10^{24} kg $\times$ 227 kg $\left(\frac{1}{6.4 \times 10^6 \text{ m}} - \frac{1}{(6.4 \times 10^6 + 5.5 \times 10^5)\text{m}}\right)$ $\therefore \Delta E_k = 1.12 \times 10^9$ J	(1) (1) (1)	**3**
	Total for question 16		**9**