17. If the angular velocity were any greater, loose objects on the surface would not go around with the planet but would travel out into space.

(a) The magnitude of the gravitational force exerted by the planet on an object of mass m at its surface is given by $F = GmM/R^2$, where M is the mass of the planet and R is its radius. According to Newton's second law this must equal mv^2/R, where v is the speed of the object. Thus,

$$\frac{GM}{R^2} = \frac{v^2}{R} \ .$$

Replacing M with $(4\pi/3)\rho R^3$ (where ρ is the density of the planet) and v with $2\pi R/T$ (where T is the period of revolution), we find

$$\frac{4\pi}{3} G\rho R = \frac{4\pi^2 R}{T^2} \ .$$

We solve for T and obtain

$$T = \sqrt{\frac{3\pi}{G\rho}} \ .$$

(b) The density is $3.0 \times 10^3\ \text{kg/m}^3$. We evaluate the equation for T:

$$T = \sqrt{\frac{3\pi}{(6.67 \times 10^{-11}\ \text{m}^3/\text{s}^2\cdot\text{kg})(3.0 \times 10^3\ \text{kg/m}^3)}} = 6.86 \times 10^3\ \text{s} = 1.9\ \text{h} \ .$$