12. A star of mass M and radius R is moving with velocity v through a cloud of particles of density ρ. If all the particles that collide with the star are trapped by it, show that the mass of the star will increase at a rate

$$\frac{\mathrm{d}M}{\mathrm{d}t} = \pi\rho v \left(R^2 + \frac{2GMR}{v^2} \right).$$

Given that $M = 10^{31}\,\mathrm{kg}$ and $R = 10^8\,\mathrm{km}$, find how the effective cross-sectional area compares with the geometric cross-section πR^2 for velocities of $1000\,\mathrm{km\,s^{-1}}$, $100\,\mathrm{km\,s^{-1}}$ and $10\,\mathrm{km\,s^{-1}}$.