(1) From a spacecraft orbiting 200 km above the Earth where the atmospheric density and scale height are, respectively, 4×10^{-10} kg/m^3 and 50 km, a baseball is tossed out. How long will it last?

The ball won't last much longer than the time for its altitude to decrease by an atmospheric scale height. After that, with the drag exponentially increasing, it will soon end its life as a fireball. Orbital radius and orbital speed are related by $v^2 = Rg$. For low Earth orbit, R is approximately Earth radius 6×10^6 m and g is about 10 m s^{-2}, from which we find $v \approx 8000$ m/s. The scale height given, 50 km, is about 1% of R. A decrease in R by 1% is accompanied by an increase in g by 2%, hence an increase in v^2 by 1%. That is a 1% increase in kinetic energy of the ball, and a 2% decrease in total energy. In what time t is the work done against the drag force equal to 1% of the kinetic energy of the ball? The baseball is moving much more rapidly than the air molecules it runs into. To a first approximation it simply endows with its own speed every molecule it encounters. When it has encountered 1% of its own mass as air, that air will have acquired kinetic energy equal to 1% of that of the baseball. (Note that the baseball will have *gained* an equal amount of *kinetic* energy.) So we need only ask, how soon will the baseball have swept up air equal to 1% of its mass? For the mass and geometrical cross section of the ball, we shall assume 0.1 kg and 0.003 m^2, respectively. Traveling at 8000 m/s through air of density 4×10^{-10} kg m^{-3}, it takes about 10^5 s to sweep up 0.001 kg of air. We predict that the ball will last one day, but probably not more than three.