HOMEWORK 3, THERMAL PHYSICS (PHY306)

1.The measurement of the viscosity of argon Ar gas at normal pressure and $T = 500K$ give $\eta = 3.5 \cdot 10^{-6} Pa \cdot s$. Assuming atoms are rigid balls of radius R, what is the radius of argon atom?

2.An accelerator has vacuum chamber of radius $R = 5\,cm$ and the special pumps lower air pressure in it to some value p_{inside}. What fraction of normal atmospheric pressure p_{inside}/p_{atm} should they reach, in order that the air molecules would collide with walls rather than with each other? Assume that walls and air are at $T = 300K$ and use collision cross section $\sigma = 4 \times 10^{-19}\, m^2$.

3.Biblical stories tell us about paradise in which rivers carry milk and honey, instead of water. Suppose one takes a stream, which carries water with velocity (in its middle) $u = 1\, m/s$, and fill it with milk or honey, instead of water. What would be the stream's speed in these cases? Neglect the difference in weight per volume ($\rho_{water} \approx \rho_{milk} \approx \rho_{honey}$) but account for different viscosity

$$\eta_{water} = 10^{-3}\, Pa \cdot s;\;\; \eta_{milk} = 3 \times 10^{-3}\, Pa \cdot s;\;\; \eta_{honey} \approx 10 Pa \cdot s$$

4.A station on the Moon put both water and air reservoirs both on a nearby hill of hight $h = 10\, m$ above the station.
(a) Assuming they both are connected to station by exactly the same tubes, compare the velocity of outgoing air and water from the tube end. (Use $\rho_{air} = 1.3\, kg/m^3, \rho_{water} = 1000\, kg/m^3, \eta_{air} = 1.7 \cdot 10^{-5}\, Pa \cdot s, \eta_{water} = 10^{-3}\, Pa \cdot s$.
(b) Compare the water output on the Moon with that of its copy at NASA headquarters on Earth

5. A cup of tea cools from $T_1 = 100^o C$ to $T_2 = 20^o C$ in $\Delta t = 5\, min$ under normal conditions in the room. You put tea into a thermos bottle which has a layer of evacuated air of width $d = 1\, cm$ and $p = 10^4\, Pa$.
(a) Assuming that collisions are the only heat transfer mechanism, estimate for how long your tea will be hot.
(b) Estimate total pressure force on the outer thermos bottle walls, assuming it to be a cylinder of radius and hight $R = 5\, cm\, H = 10\, cm$.