Lab 2: Ideal Gas Law

Due Date: February 12

Background

You are on an interstellar voyage to Kepler-186f, an Earth-size planet 500 light years away in the Cygnus constellation. Your crew consists of an atmospheric scientist, a chemical engineer, a mechanical engineer, and an astronomer. Kepler-186f is in the "habitable zone" where water would be in the liquid phase. Your first task is to **characterize the atmosphere** (find its molar mass). Your second task is to **calibrate the volume of your gardyloo** (a glass flask plus rubber tubing connected to the pressure sensor), a critical piece of equipment for further analyzing the atmosphere.

Available materials:

gardyloo	GPS unit	thermometer	pressure sensor
Logger Pro software	the atmosphere	stairs	

Technical details

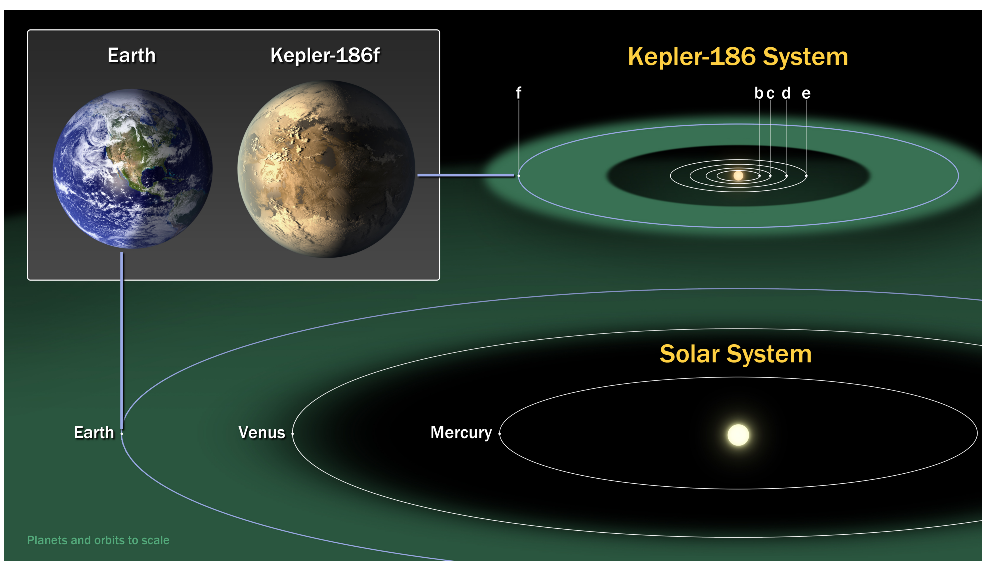
You must find a non-liquid-based calibration technique.
Note: a gardyloo will melt if exposed to liquid!
Be patient and allow the GPS unit to pick up enough satellites for a relatively stable measurement.
Avoid strong winds affecting your pressure measurements.

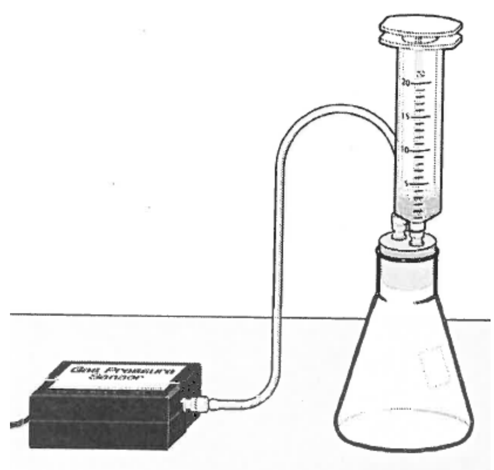
Lab report considerations

A first-order approximation is to assume an *isothermal* temperature profile of the planet's atmosphere.
An improved (second-order) approach assumes the temperature decreases with increasing altitude.
Use the dataset to report both an average *error* and its *uncertainty*.
A photo of the lab setup must also be included.

Teacher signatures

Please get either Prof. Dale or a TA to sign your experimental plan and the completion of the lab.
These signatures will be worth 4% of the lab grade and will help to promote a successful experience.





Theoretical considerations

Assuming that the atmosphere has the same temperature *T* and chemical composition (and hence the same molar mass *M*) at all altitudes *y*, the pressure *p* as a function of altitude is

$$p = p_0 e^{-Mgy/RT}$$

where subscripting with "0" implies at *y*=0.

If the temperature decreases with altitude, then a more appropriate expression is

$$\ln\left(\frac{p}{p_0}\right) = \frac{Mg}{R\alpha}\ln\left(\frac{T_0 - \alpha y}{T_0}\right)$$

where α = 0.6 degrees Celsius per 100 meters.