Probability Distributions and Gasses Solutions

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1 Ideal Gas Law

1.1 Pressured balloons

The lake adds a pressure ρgh where h is the height beneath the surface. So letting D bet the depth of the lake,

$$\begin{aligned}
PV &= nRT \\
P' &= nRT'/V' \\
P_{balloon} + P_{depth} &= nRT'/V' \\
nRT/V + \rho gh &= nRT'/V' \\
\rho gh &= nR(T'/V' - T/V) \\
h &= \frac{nR}{\rho g}(T'/V' - T/V) \\
&= \frac{PV}{\rho gT}(T'/V' - T/V) \\
&= \frac{P}{\rho g}\left(\frac{VT'}{TV'} - 1\right)
\end{aligned}$$

1.2 Pressure gauges

Have fun!

1.3 Estimations with the ideal gas law

In a standard room, $P \approx 1atm$, $T \approx 300K$, $R \approx 8Jmol^{-1}K^{-1}$, $V \approx (5m)^2(4m) = 100m^3$, and $1atm \approx 10^5 Nm^{-2}$. So putting all this together,

$$n = \frac{PV}{RT} \approx \frac{(10^5 Nm^{-2})(100m^3)}{(8Nmmol^{-1}K^{-1})(300K)} \approx \frac{100}{25} \times 10^3 mol = 4000moles \tag{1}$$

Multiplying by Avogadro's number $\left(6.022 \times 10^{23}\right)$, we get

$$N \approx 2.5 \times 10^{26} \tag{2}$$

1.4 Partitioned boxes

(a) The gas expands into the remainder of the box that used to be a vacuum. So $V/2 \to V$ and by the Ideal Gas Law,

$$P_0 \frac{V}{2} = nRT_0$$
$$P_f V = nRT_f$$

The termpreature remains unaltered, however, because nothing has been doen to increase or decrease the kinetic energy of the molecules, so $T_f = T_0$ and therefore by the two equations above, $P_f = P_0/2$.

(b) This is trickier because along the way, something has to hold the wall in place, which does negative work on the gas (you can also think about the gas doing work on the wall to expand and push it outwards), so the temperature no longer remains constant. Hence, T decreases, V increases ($V/2 \to V$ as before) and P decreases (by more than half now).