Homework 21.

The combined gas law.

We have learned that all three ideal gas laws can be conveniently written in one expression:

$$\left(\frac{P \cdot V}{T}\right) = const$$

This expression is called "combined ideal gas law". Whatever we do to the ideal gas, its pressure multiplied by volume and divided by temperature stays the same if the do not change the mass (or the number of molecules) of the gas.

Example:

A closed $1m^3$ cylinder with a piston contains gas at the pressure of 10000Pa and temperature 300K. Find the pressure after we heat the gas to 400K and increase the volume of the gas to $1.5m^3$ by moving the piston.

Solution:

We use our "universal" ideal gas law:

$$\left(\frac{P \cdot V}{T}\right)_{before} = \left(\frac{P \cdot V}{T}\right)_{after}$$

$$\frac{10000Pa \cdot 1m^3}{300K} = \frac{P \cdot 1.5m^3}{400K}$$

$$P = \frac{10000Pa \cdot 1m^3 \cdot 400K}{300K \cdot 1.5m^3} \approx 8889Pa$$

Problem:

1. You slightly press two balloons of different diameters (but with the same pressure inside) against each other. Describe the shape of the balloon wall at the place of contact: will it be flat or bent toward one of the balloons? This is a little bit challenging but interesting problem. Try to explain your answer using the combined gas law.

2. We have vertical cylinder with a piston of area $\boldsymbol{A}$. The cylinder is filled with gas, which occupies volume $\boldsymbol{V}$ under the piston. The piston has mass $\boldsymbol{m}$ and can move without friction. What happens to the gas volume if we will move the cylinder vertically with acceleration $\boldsymbol{a}$? Assume that you know the atmospheric pressure P_0 and gas temperature is kept constant.