Homework 7.

During last class we discussed the gas laws. There are 3 simple laws which establish the connection between temperature, pressure and volume of ideal gas. Speaking about “ideal gas” we mean the gas consisting of the particles (atoms or molecules) which do not interact (repel or attract) with each other. This is not true for most of the real gases, but if the temperature is high enough the effect of the interaction is small and real gas behaves like the ideal one. So, the laws are:

1. Boyle -Mariotte law:

Pressure x Volume = does not change, or PV=const

This means that if the temperature of the gas remains unchanged decreasing the gas volume we will increase the gas pressure and vice versa.

2. Charle’s law:

$\frac{Volume}{Temperature}$ does not change, or $\frac{V}{T} = const$

If the pressure of the gas remains unchanged, as the temperature of the gas increases the volume of the gas increases as well. This law describes thermal expansion of gas at the constant pressure.

3. Gay-Lussac’s law

$\frac{Pressure}{Temperature}$ does not change, or $\frac{P}{T} = const$

If the volume of the gas remains unchanged, increasing the gas temperature we will increase the gas pressure and vice versa.

Important note: pay special attention to the units. **Kelvin scale should be used to express temperature**(!).

These three laws can be united into one “universal” ideal gas law:

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

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:

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

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

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

Problems:

1. A cylinder is filled with gas. The pressure inside is 10 000Pa, the temperature is 20C. We increase the temperature to 100C. What happens to the pressure inside the cylinder? Calculate the new pressure.

3. A cylinder with a piston is filled with gas and the pressure inside is 10 000Pa. The temperature of the cylinder is kept constant. The pressure inside the cylinder is equal to the pressure outside the cylinder, so the piston does not move. The volume of the gas inside the cylinder is 1000 cm3. We put a 1kg stone on the piston. The piston moves down and stops, compressing the gas in the cylinder. Find the new volume of the gas if the area of the piston is 10 cm^2.

4. 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 make experiment and explain the result based on the "universal" gas law.