Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 1 – IPSP

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Exercise Sheet 12 (WS 2011/12)

Date of Issue: Jan. 13^{th} 2012

Date of Submission: Jan. 20^{th} 2012

Submission Place: Marked mailbox next to room 302 (Linnestr. 5)
Submission Time: 11:00 a.m. at the submission day noted above

Please note: Write your name and matriculation number on EACH sheet of paper.
Only submit the calculations and results for exercise 1-3, exercise 4 will be discussed during the instruction classes.

Exercises:

1. A closed container with a volume of 6.00 l holds 10.0 g of liquid helium at 25.0 K and enough air to fill the rest of its volume at a pressure of 1.00 atm. The helium then evaporates and the container warms to room temperature (293 K). What is the final pressure inside the container? (5 Points)

2. State-of-the-art vacuum equipment can attain pressures as low as $7.0 \cdot 10^{-11}$ Pa. Suppose that a chamber contains helium at this pressure and at room temperature (300 K). Estimate the mean free path and the collision time for helium in the chamber. Assume the diameter of a helium atom is $1.0 \cdot 10^{-10}$ m. (5 Points)

3. A cylinder is filled with 0.10 mol of an ideal gas at standard temperature and pressure, and a 1.4-kg piston seals the gas in the cylinder (Figure 1) with a frictionless seal. The trapped column of gas is 2.4-m high. The piston and cylinder are surrounded by air, also at standard temperature and pressure. The piston is released from rest and starts to fall. The motion of the piston ceases after the oscillations stop with the piston and the trapped air in thermal equilibrium with the surrounding air. (a) Find the height of the gas column. (b) Suppose that the piston is pushed down below its equilibrium position by a small amount and then released. Assuming that the temperature of the gas remains constant, find the frequency of vibration of the piston. (10 Points)

4. A helium balloon is used to lift a load of 110 N. The weight of the envelope of the balloon is 50.0 N and the volume of the helium when the balloon is fully inflated is 32.0 m^3. The temperature of the air is 0°C and the atmospheric pressure is 1.00 atm. The balloon is inflated with a sufficient amount of helium gas that the net upward force on the balloon and its load is 30.0 N. Neglect any effects due to the changes of temperature as the altitude changes. (a) How many moles of helium gas are contained in the balloon? (b) At what altitude will the balloon be fully inflated? (c) Does the balloon ever reach the altitude at which it is fully inflated? (d) If the answer to (c) is "Yes", what is the maximum altitude attained by the balloon?

Figure 1: Exercise 3