Studio PHY-2048C
Thermodynamics, Week 15

Fun with a helium balloon

A loosely filled balloon contains 4.5 liters of helium gas at atmospheric pressure (P_A = 101 kPa) and room temperature T = 20 °C. The gas in the balloon is then heated to body temperature, 37 °C, by a student.

(a) The pressure inside the balloon changes very little during the heating process. What is the change in the volume of the balloon?

(b) How much work does the expanding balloon do on its environment?

(c) How many moles n of helium are in the balloon?

(d) The average kinetic energy of an atom in a gas at absolute temperature T is $3kT/2$, where k is Boltzmann's constant, so the internal energy U of a monatomic gas of N particles is $3NkT/2$. If we rewrite $N = nN_A$, where n is the number of moles and N_A is Avagadro's number, then $U = 3nRT/2$, where $R = N_A k$ is gas constant. How much did the internal energy U (the total kinetic energy of all of the helium atoms) of the gas change during the heating process?

(d) How much heat (in Joules) did the student provide to the balloon?

Data: For ideal gases like helium, PV=nRT; R= 8.314 $J \cdot mol^{-1} \cdot K^{-1}$