Introductory Tutorials Thermodynamics Project 2019

Exercise 1

In thermodynamics the concept of a thermal reservoir (or bath) in thermal contact with the system is often used in thought experiments. Such a bath has two essential properties.
-The thermal contact of the bath and the system is perfect and so is the transfer of heat.
-The temperature of the bath is constant.
We will examine the achievability of the second property of a thermal reservoir. We will calculate the change in temperature of a system that consists of a closed glass tube (V = 100 ml) completely filled with water, which we will immerse in a bath of 100 L water. The initial temperature of the water in the tube is 50 °C. The bath has a temperature of 300 K.
We assume that the density of water under these circumstances is constant and equal to $\rho = 1.0 \cdot 10^6$ gm^{-3}. The heat capacity of water is $c = 4.2$ Jg^{-1}K^{-1} and the heat capacity of the glass of the tube is considered negligible.

a) Calculate how much energy the bath has absorbed after the tube has reached the temperature of the bath. Assume that the change in temperature of the bath is negligible.

b) Calculate the final temperature of the tube and the bath without the assumption of the former part.

c) Repeat part b) for a bath of 10000 L and for a bath of 100 mL.

d) Which of these three baths do you think is realistic for the definition of a bath?

Exercise 2

We want to measure the electrical work, performed by an electrical current in a resistor, according to the first law of thermodynamics. For that we build a calorimeter. Our calorimeter is a sealed vial, completely filled with water (V=250 mL) and thermally isolated from its surroundings. In the middle of the vial is an electrical resistor of 10 Ω.
The current is supplied by two wires through the lid of the vial. We can measure the temperature of the water in the vial with a thermometer with a resolution of ± 0.1 °C. The heat capacity of water is $c_V = 4.2$ Jg^{-1}K^{-1}, and its density is $\rho = 1.0 \cdot 10^6$ gm^{-3}. We assume that these values are constant between T = 300 K and T = 350 K.

a) Which forms of work can be performed on the water and which on the resistor?

b) Which parameters can you adapt for the most optimal instrument if we use the calorimeter between T = 300 K and T = 350 K?

c) Determine the values of the parameters from b) for which the change in temperature is equal to the resolution of the thermometer.

d) Argue if this design is realistic. Can we test the first law of thermodynamics with this calorimeter?