

Problem 1.

One mole of an ideal gas is contained in a volume of 10^{-2} m^3 (10 liters). The temperature of the gas is 27°C and is held constant while the gas expands slowly against a moving piston to twice its original volume.

- a) What are the initial and final pressures of the gas?
- b) Is work done *on* the gas or *by* the gas?
- c) Calculate the amount of work done.
- d) How much heat flows in this process? Does it flow *into* the gas or *out of* the gas?

Problem 2.

A hot potato, mass = 100 grams, initially at 70°C , is dropped into Lake Matoaka, which is at 20°C ; the potato cools down to the lake's temperature (the lake is large enough that you can treat its temperature as unchanged). The specific heat of the potato is $3500 \text{ J/kg}\cdot\text{K}$.

- a) How much heat leaves the potato?
- b) What is the entropy change of the lake?
- c) What is the entropy change of the universe?

Problem 3.

Bob bought an old steam engine boiler on eBay. This boiler lacks a safety valve. He hires you to estimate the maximum operating temperature, beyond which the boiler will explode.

a) The boiler has a volume of 1 m^3 , and the maximum pressure that the boiler can stand before exploding is 5 atmospheres. The boiler is filled with 1 kg of water. The molecular mass of water is 18 grams per mole. What is the maximum operating temperature? (ignore the presence of air in the boiler).

b) How much heat is required to raise the water from $20 \text{ }^\circ\text{C}$ to this maximum temperature? Some possibly useful properties of water: latent heat of fusion = $3.33 \times 10^5 \text{ J/kg}$, latent heat of vaporization = $2.26 \times 10^6 \text{ J/kg}$, specific heat of liquid water = $4186 \text{ J/kg}\cdot\text{K}$, specific heat of steam = $2010 \text{ J/kg}\cdot\text{K}$.

c) If the heater operates at a power of 2000 W, how long will it take to provide this heat?

Problem 4.

Consider hydrogen gas (treat it as an ideal gas) at 10°C and a pressure of $2 \times 10^5 \text{ Pa}$.

- a) What is the root-mean-square velocity of the molecules? Note that hydrogen molecules are diatomic, and have a molecular mass of 2 grams per mole.
- b) How many molecules are in one cubic centimeter?
- c) If, instead of hydrogen, one had oxygen molecules at the same temperature, would the answer to part a) be less, more or the same?