Thermodynamics

Warm-Up questions

Basic vocabulary (Chapter 4.1-4.3,4.7,4.8)

i. Given 55 g of oxygen gas, find the total number of oxygen molecules as well as the moles of oxygen molecules. What is the advantage of using the unit of moles?

ii. A box contains a gas at 20 °C. The box is heated until the gas's internal energy doubles. What is the temperature of the gas now?

iii. Determine which of the following things can influence the internal energy of a gas:

a) kinetic translational energy of the gas molecules

b) heat energy of the gas molecules

c) potential energy due to the attractions between the gas molecules

d) rotational energy of the gas molecules

Which of the following contribute to the internal energy of an ideal gas?

Heat capacity and phase changes (Chapter 4.4,4.13)

iv. You have water at room temperature (20 °C) and want to make a block of ice that will have a temperature of -18 °C.

a) Sketch the change in temperature as time passes.

b) You are using liquid nitrogen to cool the water. How much liquid nitrogen do you need to cool 100 grams of water into ice? Helpful quantities: specific heat capacity of water $c_w = 4.18\,\mathrm{J \cdot g^{-1} \cdot K^{-1}}$, specific heat capacity of ice $c_i = 2.05\,\mathrm{J \cdot g^{-1} \cdot K^{-1}}$, enthalpy of fusion / heat of fusion of water $L_w = 333.5\,\mathrm{J \cdot g^{-1}}$, enthalpy of vaporization / heat of vaporization of nitrogen $L_n = 199\,\mathrm{J \cdot g^{-1}}$.

Ideal gas law (Chapter 4.5)

v. An air bubble is going up from the bottom of a water tank with height of 1 m. The initial volume is $5\,\mathrm{cm^3}$. Considering that the water temperature is constant. What is its volume at the surface?

vi. We have an ideal gas with molar mass M.

a) What is the relationship between the density and the temperature T? What is the relationship between the density and the pressure p?

b) As we know from experience, warm air rises. Does this also apply to ideal gases? If yes, why?

Processes and heat engines (Chapter 4.9-4.11)

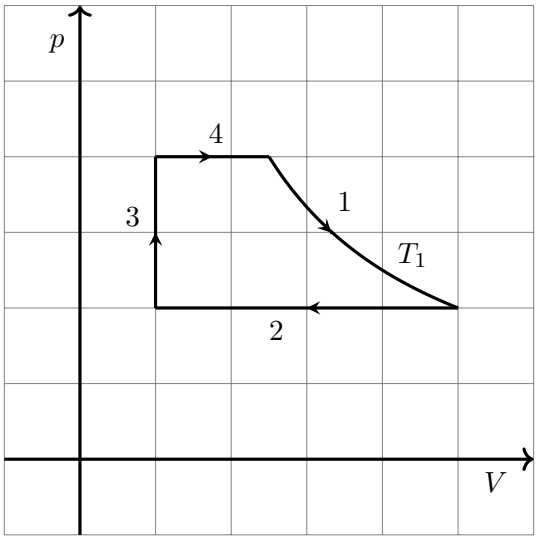
vii. Which thermodynamic processes (isobaric, isochoric, isothermal, adiabatic) best describes the following phenomena:

a) the heating of a hot air balloon

b) Internal combustion of a diesel engine

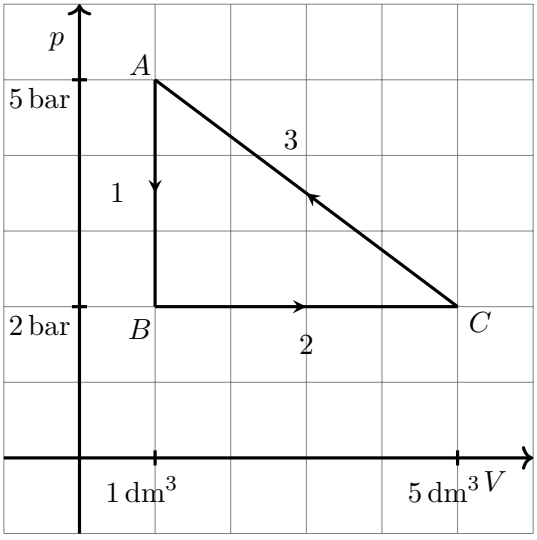
c) the inflation of a soccer ball

viii. The following thermodynamic cycle is described in a P-V diagram (Process 1 is isotherm bei Temperature T_1).



Qualitatively describe how the thermodynamic cycle would look in a T-V as well as a P-T diagram.

ix. A heat engine that is filled with one mole of an ideal gas goes through the following thermodynamic cycle.



a) What type of processes are described by paths 1 and 2?

b) In which paths of the cycle is work done by the heat engine and in which paths is work done on the heat engine (from outside)? Calculate the amount (with the correct sign) for each path.

c) What is the net work done by the heat engine after one full cycle?

d) Calculate the external heat that is supplied to paths 1 and 3. What is the net heat flow after one full cycle?