

## Home work week 2

1. I said I'd write this one down for you, but perhaps it is better to try yourself: Show that for one mole of ideal gas (equation of state:  $PV = RT$ ) in isolation (*i.e.*, adiabatic  $dQ = 0$ ) we have that  $PV^\gamma = \text{constant}$  during *reversible* expansion, where  $\gamma = \frac{c_P}{c_V}$ . Use that with  $dQ = 0$  the change in the energy ( $U$ ) of the ideal gas (which is not constant if  $V$  or  $P$  are varied; why?) is  $dU = dW = -PdV$  and that  $U$  depends on  $T$  only. Further hints are that the heat capacity of the ideal gas at constant volume is  $c_V = (\frac{dQ}{dT})_V = (\frac{dU}{dT})_V$  and heat capacity at constant pressure is  $c_P = (\frac{dQ}{dT})_P = (\frac{dU}{dT})_P + P\frac{dV}{dT}$ .

2. Calculate the change in entropy when 1 kg of liquid water is heated by 20 K at constant pressure. From wikipedia I found that the heat capacities of water at constant pressure is:  $c_P = 4.1813 \text{ Jg}^{-1}\text{K}^{-1}$ . You can assume  $c_P$  to remain constant over the temperature range of interest.

As a side note, the heat capacity of water is quite a bit higher than of most other materials. Can you speculate why that is?

3. Calculate the change in entropy of an ideal gas when the gas is expanded isothermally from  $V_1$  to  $V_2$ .
  - Does it matter whether the expansion is done reversibly or irreversibly?
  - What is the change in entropy for the bath (environment) if the expansion is done reversibly? And how large is the change in the entropy of the gas plus environment ( $\Delta S^{\text{tot}}$ )?
  - What is the entropy change for the bath if the expansion done irreversibly by simply letting the piston go? What is then the change in the entropy of the gas plus environment ( $\Delta S^{\text{tot}}$ )?

4. Calculate the change in entropy of an ideal gas isolated from the environment (adiabatic) when the gas is expanded reversibly from  $V_1$  to  $V_2$ . What if we would do the expansion irreversibly, but still in isomation (*i.e.*,  $dQ = 0$ )?