

UNIVERSITY OF MANITOBA
DEPARTMENT OF CHEMISTRY
Chemistry 2290, Winter 2012, G. Schreckenbach

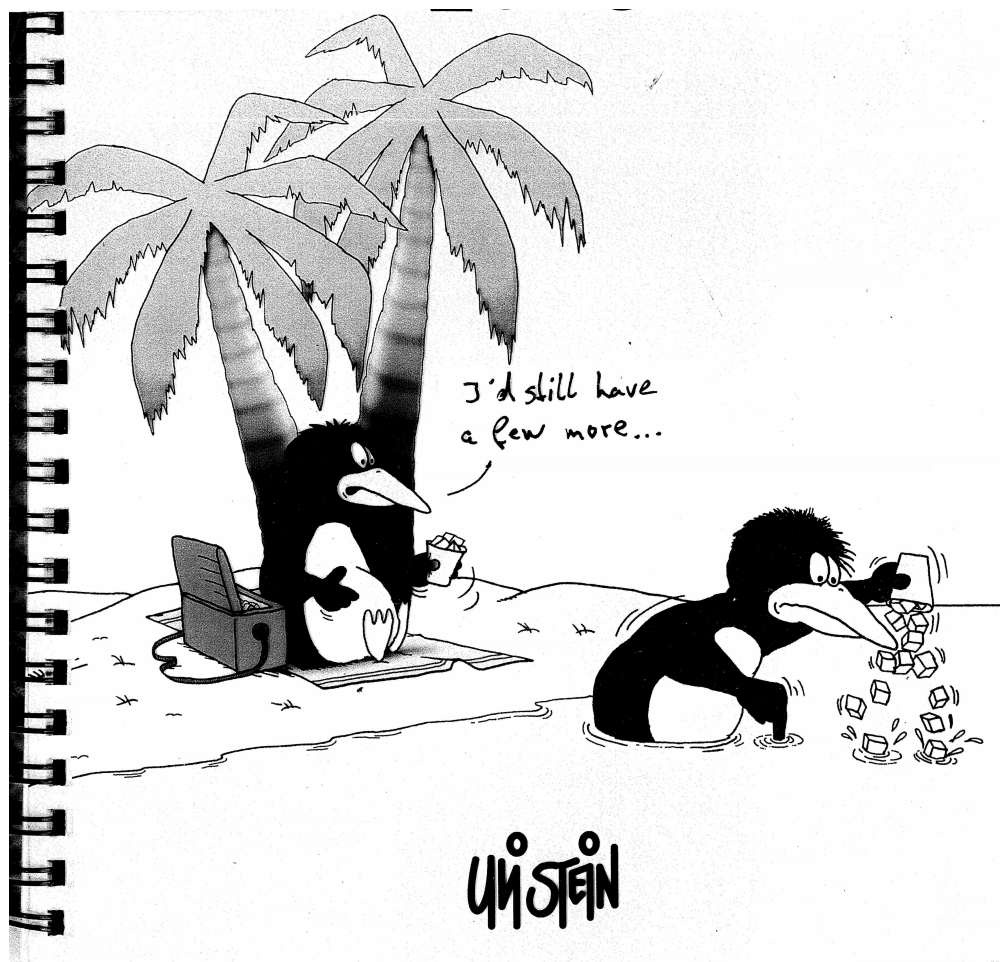
PROBLEM SET 3, Jan. 27, 2012

Due date: The solved problem set is due on Monday, March 5, 2012, at the time of the lecture.
Questions to be marked: A *pre-selected (by me)* set of **four (4)** out of the six questions will be marked.

1. Calculate the final temperature T_f of the mixture and the change in entropy ΔS when
(a) 145g of water at 0.00°C and
(b) 145g of ice at 0.00°C

is added to 165g of water at 100.00°C in an *insulated* container. Take the molar heat capacity of water as $75.3 \text{ J K}^{-1} \text{ mol}^{-1}$ and independent of the temperature. Use the molar mass of water and a latent heat of fusion of ice at 0.00°C of 6.02 kJ mol^{-1} .

Hints: Use the first law to obtain the final temperature in each case. Recall the procedure for calculating entropy changes that required constructing reversible model processes that connect the initial and final states.



2. Consider 1.50 mol of a *monoatomic* ideal gas ($C_{v,m} = \frac{3}{2}R$) that is initially at 390.K (taken as 3 significant figures) and 2.20 atm pressure. For this system, calculate the change in entropy (ΔS), the change in internal energy (ΔU), and the change in enthalpy (ΔH) for a reversible adiabatic expansion of this gas to a final pressure of 1.10 atm. Also calculate the final temperature (T) and volume (V).

3. The values of ΔH and ΔS for a chemical reaction are $-85.2 \text{ kJ mol}^{-1}$ and $-170.2 \text{ J K}^{-1} \text{ mol}^{-1}$, respectively, and the values can be taken to be independent of temperature.

(a) Calculate ΔG for the reaction at 300. K, 600. K, and 1000. K.

(b) At which temperature would ΔG be zero?

Comment: This is problem LM31 from the Laidler questions that I have posted.

4. Consider 0.250 moles of an ideal gas. The gas is compressed at a temperature of 21.0 °C from an initial volume of 6.00 L to a final volume of 3.00 L. This process is carried out

(a) isothermally and reversibly

(b) isothermally and irreversibly against an external pressure of 3.00 atm.

For each case, determine w , q , ΔU , ΔS_{system} , ΔS_{surr} and ΔG .

5. Derive an expression for $\left(\frac{\partial U}{\partial V}\right)_T$ for a gas that obeys the van der Waals equation of state.

6. (a) Calculate ΔG for 1.00 mole of liquid water as the external pressure is increased from 1.00 bar to 2.00 bar at a constant temperature of 298.0K. *You may need some or all of the following information: molar mass of water: $18.015 \text{ g mol}^{-1}$; density at 25.0°C: 997.05 kg m^{-3} .*

(b) Calculate ΔG for 1.00 mole of an ideal gas as the external pressure is increased from 1.00 bar to 2.00 bar at a constant temperature of 298.0K.