Principles of Physical Chemistry CHEM-C1230 exam 2 12.12.2022 (start at 9:00)

The exam where the exercises are counted. You will have 3.0 h exam time (and 0.5 h to return the exam)

This home exam starts at 9:00 and ends 12:30 (or at 13:30 if you have a special permit). Your answers have to be returned to MyCourses (there are two folders with different deadlines). The answers need to be in English.

The filename (or files) need to have your name in it. Your name and student number should be in the file too. Most common file types, like .doc .pdf are OK. The answers can be hand written and scanned but pay attention of the clarity of the output file. Try to send a single file.

You can use any material you find but do not copy it directly to the answers. The points will be reduced if I find direct copy form e.g. Correction Notes, Wikipedia or the textbook. Some of you have found earlier years **Corrections Notes**. These are NOT model answers. Replying according to these Notes directly will not give you very good points. One usually need more explanations.

The books appendix tables are needed in the exam. If you use other data quote the source.

1) Coal (graphite), gasoline and methane can be used as fuels in burning process. Which of them in standard condition produce most heat per CO_2 molecule. You can use n-hexane as a model for gasoline. Write first the reaction equations. What happen to the hydrogens of the hydrocarbons? Explain why. Explain your calculations and apply them to these reactions.

2) Explain how the constant pressure calorimeter works. A schematic picture would be useful. What thermodynamical quantity you can determine with it? What physical quantity you need to measure. You calibrate a calorimeter by measuring dissolution heat of 2.72 g Na_2SO_4(s). The calorimeter contains 150 g of water and it heats 0.05 K. The Na_2SO_4(s) dissolution reaction enthalpy is 2.4 kJ/mol and water molar heat capacity is 75.3 J/(K mol). Why you need the calibration?

3) Investigate the boiling of a liquid at constant pressure. What happen to systems volume, enthalpy and entropy when temperature changes from a bit below the boiling point to a bit above it. Use 1 mol of water or methanol at 1 atm and at the boiling point temperature as an example and give numerical values to these quantities. (The volume change does not need to be very accurate.)

4) Explain the fractional distillation process shown in figure 1. The components are benzene and toluene. You can assume that the solution mixture is ideal. What this means? Compute the vapor fractions at 25 C for system with 5.0 mol of benzene and 2.5 mol of toluene. (The vapor pressures are 96.4 Torr for pure benzene and 28.8 Tor for pure toluene). Explain why and how the fractional distillation procedure will lead to rather pure benzene.

5) What the reaction Gibbs energy will tell you of a reaction. Are the following reaction in equilibrium and if not, which directions the reactions will go (towards reactants or products). Explain your conclusions.
a) 2 NO_2(g) $\leftrightarrow$ N_2O_4(g) and the partial pressures are 0.25 bar (NO_2) and 0.75 bar (N_2O_4). T = 298 K

a) 2 NO_2(g) ⟷ N_2O_4(g) and the partial pressures are 0.5 bar (NO_2) and 0.5 bar (N_2O_4). T = 298 K

6) Explain what are the reaction rate and reaction constant of a model reaction A + B ⟷ C + D. What is the unit of the rate. How the rate constant depends on temperature. Below is data for hydrogen abstraction form hydrocarbons: C_2H_6(g) + Cl(g) -> C_2H_5(g) + HCl(g). Compute the parameters of Arrhenius equation. (You need Excel or similar here.)

Temp (K)	rate ($1/M^2s$)
270	$3.43*10^{10}$
370	$3.77*10^{10}$
470	$3.99*10^{10}$
570	$4.13*10^{10}$
670	$4.23*10^{10}$

Figure 1