PHY411 Homework Set 11

1. [10 pts] Kittel-Kroemer, problem 9-2. Assume that the proton and hydrogen masses are about the same. In (a) consider only the ground state for the hydrogen atom.

2. [10 pts] The following pertain to chemical reactions.

   (a) Write down the quotients Q for the following reactions:

   $$\begin{aligned} \mathrm{N_2} + 3\,\mathrm{H_2} &\rightarrow 2\,\mathrm{NH_3}\,, \\ \mathrm{CO} + 2\,\mathrm{H_2} &\rightarrow \mathrm{CH_3OH}\,, \\ 2\,\mathrm{NO} + \mathrm{O_2} &\rightarrow 2\,\mathrm{NO_2}\,. \end{aligned}$$

   (b) Consider the reactions

   $$\mathrm{CO} + \mathrm{H_2O} \rightarrow \mathrm{CO_2} + \mathrm{H_2}\,,$$

   and

   $$\mathrm{CH_4} + \mathrm{H_2O} \rightarrow \mathrm{CO} + 3\,\mathrm{H_2}\,.$$

   The equilibrium constant for the first reaction is $K_1 = 1.4$ and for the second $K_2 = 5.3 \times 10^{-3}\,\mathrm{M}^2$. Here M is the common unit of concentration in chemistry $\mathrm{M} = \mathrm{mol/l} = \mathrm{kmol/m^3}$. What is the equilibrium constant for the reaction

   $$\mathrm{CH_4} + 2\,\mathrm{H_2O} \rightarrow \mathrm{CO_2} + 4\,\mathrm{H_2}\,?$$

   (c) Assume that the following reaction,

   $$2\,\mathrm{H_2S} + \mathrm{CH_4} \rightarrow 4\,\mathrm{H_2} + \mathrm{CS_2}\,,$$

   has an equilibrium constant $K = 4.56$, where the unit is an appropriate power of M Given the following equilibrium concentrations: $n_{\mathrm{H_2S}} = 0.15\,\mathrm{M}$, $n_{\mathrm{CH_4}} = 0.56\,\mathrm{M}$, and $n_{\mathrm{CS_2}} = 0.37\,\mathrm{M}$, what is the equilibrium concentration of $\mathrm{H_2}$?

3. [10 pts] Kittel-Kroemer, problem 9-4. Note that quotients and equilibrium constants could be defined either in terms of the forward or reverse reactions. The textbook alternates between the definition reverse to the standard in the literature and one consistent with the standard. In the particular problem, the book adopts the reverse definition. You are free to adopt either, just be consistent within the problem.

4. [5 pts] Kittel-Kroemer, problem 9-5.