Week 2 Worksheet

Chem 11200-2: Section 33

Jan. 18, 2022

***Problem* 1:** The exothermic reaction $NO_3\,(g) + NO\,(g) \rightleftharpoons NO_2\,(g)$ has a $K_c = 1.25 \times 10^{-3}$ at 250.°C.

a) Balance the above chemical equation.

b) A rigid, 3.00 liter flask is initially stocked with 0.600 mol of each reactant and product from this reaction at a temperature of 250.°C. Once the reaction has reached equilibrium, how many grams of nitrogen monoxide gas will be present in the flask?

c) To increase the $[NO_3]$ present in this flask at equilibrium, how should you adjust the reaction temperature? How will this action impact the value of K_c for the reaction, if at all? Explain.

d) At 250.°C, the reaction $CO\,(g) + NO_3\,(g) \rightleftharpoons CO_2\,(g) + NO_2\,(g)$ has a $K_c = 27.3$. Given this information, calculate K_p for the following reaction: $CO\,(g) + NO_2\,(g) \rightleftharpoons CO_2\,(g) + NO\,(g)$.

***Problem* 2:** A student sets up the reaction $4\,Fe_3O_4\,(s) + O_2\,(g) \rightleftharpoons 6\,Fe_2O_3\,(s)$ with a Q_c of 4.00 at a certain temperature in a sealed, 3.00 liter container. At equilibrium at that temperature, she finds the reaction to have a K_c of 100. Given that she isolates a mass of 10.0 grams of $Fe_3O_4\,(s)$ once the reaction reaches equilibrium, how many grams of $Fe_3O_4\,(s)$ did she initially put into the container?

***Problem* 3:** Calculate ΔS°_{surr} for the following reaction at 298 K, given that $\Delta S^\circ_{rxn} = 162.7$ J/mol·K and $K_{eq} = 1.2 \times 10^4$.

$$CH_4\,(g) + 2\,H_2S\,(g) \rightleftharpoons CS_2\,(g) + 4\,H_2\,(g)$$

***Problem* 4:** You are interested in the following enthalpy and entropy of reaction for the following reaction.

$$H_2O\,(l) \rightleftharpoons H_2\,(g) + \tfrac{1}{2}\,O_2\,(g)$$

Experimentally, you are only able to determine the K_{eq} at 2 temperatures, 1500 K and 2300 K, shown in the table below. Using what you know from lecture, determine ΔH° and ΔS° assuming both are temperature independent quantities.

T [K]	K_{eq}
1500.	1.94×10^{-6}
2300.	2.95×10^{-3}

The following problems relate to this weeks lab. Recall that Beer's law states that the absorbance is given by

$$A = \log \frac{I}{I_0} = \epsilon l c$$

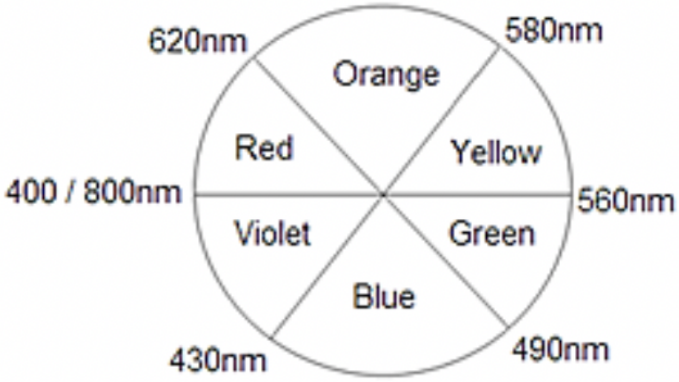
where ϵ is the molar absorptivity coefficient, l is the length of the cell, and c is the concentration of the species.

***Problem* 5:** Solution A has an absorbance value of 0.653 at 567nm. If you dilute solution A five-fold to obtain solution B, what is the absorbance for solution B at 567nm? Both solutions A and B contain the same chemical species.

***Problem* 6:** Use the color wheel shown below to answer the following question.

a) Explain why a blue solution has an optimum wavelength around 615 nm.

b) Explain why a red solution has an optimum wavelength around 525 nm.



***Problem* 7:** The molar absorptivity coefficient of an inorganic compound X in water is 5.00×10^3 cm^{-1} M^{-1} near its absorption maximum at 456 nm.

a) A student prepares a compound X solution that is 0.0300% (w/v) in concentration. The student labeled this solution as 'Solution 1.' Calculate the molarity of solution 1. Compound X has a molar mass of 300.00 g/mol.

b) The student makes a serial dilution of Solution 1 by using a 10-mL volumetric pipet to obtain an aliquot of Solution 1, then dispensing it in a 100-mL volumetric flask and diluting it to the mark, labeling it 'Solution 2.' Calculate the molarity of Solution 2.

c) Using the molar absorptivity coefficient for compound X and a 1.00 cm cuvette, calculate the absorbance for Solution 1 and Solution 2.

d) Calculate the following two ratios:

   (a) Molarites of Solution 2 to Solution 1

   (b) Absorbance values of Solution 2 to Solution 1

The following problems are written by Professor Mcleod, Head TA Miah Turke, or the textbook. They may mimic homework problems closely, but will be highly beneficial for the midterms and final.

***Problem* 8:** For the following reaction, calculate ΔG° and K_{eq} at 298 K. Write the equilibrium constant expression.

$$2\,\mathrm{NOCl\,(g)} \rightleftharpoons 2\,\mathrm{NO\,(g)} + \mathrm{Cl_2\,(g)}$$

	ΔG_f° [kJ/mol]
NOCl (g)	51.71
NO (g)	86.55

***Problem* 9:** *(From Oxtoby - Ch. 14 #51)* At $T = 1200$ °C the following reaction has an equilibrium constant $K = 0.612$.

$$\mathrm{P_4\,(g)} \rightleftharpoons 2\,\mathrm{P_2\,(g)}$$

a) Suppose the initial partial pressure of P_4 is 5.00 atm and that of P_2 is 2.00 atm. Calculate the reaction quotient (Q) and state whether the reaction proceeds to the right or to the left as equilibrium is approached.

b) Calculate the partial pressures at equilibrium.

c) If the volume of the system is then increased, will there be a net formation or net dissociation of P_4?

***Problem* 10:** Magnesium oxide is a compound that remains quite stable at high temperatures, thus is used as a fireproofing agent in construction materials. The enthalpy of formation of magnesium oxide is -1204 kJ/mol and is shown in the following reaction:

$$2\,\mathrm{Mg\,(s)} + \mathrm{O_2\,(g)} \rightleftharpoons 2\,\mathrm{MgO\,(s)}$$

Answer the following questions qualitatively and be sure to explain your answer.

a) In which direction, if any, will the equilibrium shift if the pressure of O_2 is increased?

b) In which direction, if any, will the equilibrium shift if the reaction is put on ice (cooled)?

c) In which direction, if any, will the equilibrium shift if the volume of the reaction vessel is increased?

d) In which direction, if any, will the equilibrium shift if the total pressure is doubled by the addition of Ar gas?

e) In which direction, if any, will the equilibrium shift if the volume of the reaction vessel is increased, but Ar gas is added to maintain the same total pressure?