CH302 Worksheet 3—Introduction to Chemical Equilbria Answer Key

1. Write a mass action quotient (aka mass action expression) for the general equation below:
$aA + bB \rightarrow cC + dD$

$Q = [C]^c \cdot [D]^d / [A]^a \cdot [B]^b$

2. What sort of mathematical relationship exists between ΔG and K? Which of these terms should have a wider range of possible values?

There is a log-linear (aka exponential) relationship between ΔG and K - when ΔG increases, K increases exponentially. K should have a wider range of values, since it is proportional to the base *e* exponent of ΔG, i.e. if ΔG is doubled, K will increase by a factor equal to e^2.

3. What is the difference between Q and K?

Q can have any value depending on the concentrations of reactants and products, and it can describe any and all non-equilibrium states for a system. K, on the other hand, can have only one value at a given temperature and pressure and that value is always equal to the mass action quotient when the system is at equilibrium.

4. What can you for certain about ΔG when K is less than 1, equal to 1 or greater than 1?

You know that ΔG is positive, zero or negative, respectively.

5. Based on your answer to question 4, what does the value of K tell you about the spontaneity of a reaction?

The value of K tells you whether a given reaction is spontaneous (K>1), non-spontaneous (K<1) or at equilibrium (K=1)

6. If a given reaction has K = 10, and presently has a Q = 5, what must happen in order for the reaction to reach equilibrium?

The reaction must proceed in the forward direction, producing more products (the numerator in our mass action quotient) until the value of Q is also 10.

7. Based on your understanding of reaction stoichiometry, complete the RICE diagram below by filling in the blank regions.

Reaction	$CH_4(g)$ +	$2\ O_2(g) \rightarrow$	$CO_2(g)$ +	$2\ H_2O(g)$
Initial	10 moles	19 moles	**1 moles**	**7 moles**
Change	**-9 moles**	**-18 moles**	**+ 9 moles**	**+18 moles**
Equilibrium	1 mol	**1 mol**	10 moles	25 moles

8. Write a mass action quotient and determine K for the reaction in question 7.

$K = [CO2] \cdot [H2O]^2 / [CH4] \cdot [O2]^2 = 10 \cdot 25^2 / 1 \cdot 1^2 = 6{,}250$

9. If the equilibrium established in question 17 were disturbed by the addition of 90 moles of CO_2, what would the value of Q then be? Fill in a new RICE diagram, using X for unknown values.

Reaction	$CH_4(g)$ +	$2\ O_2(g) \rightarrow$	$CO_2(g)$ +	$2\ H_2O(g)$
Initial	**1 mol**	**1 mol**	**100 moles**	**25moles**
Change	**+X moles**	**+2X moles**	**-X moles**	**-2X moles**
Equilibrium	**1 + X moles**	**1 + 2X moles**	**100 - X moles**	**25 - 2X moles**

$Q = [CO2] \cdot [H2O]^2 / [CH4] \cdot [O2]^2 = 100 \cdot 25^2 / 1 \cdot 1^2 = 62{,}500$

0. How will the system respond to the stress in question 9 in order to re-establish equilibrium?

The reaction will have to shift back toward the product side in order to increase the denominator in the mass action expression and make Q once again equal to K.