**Ch 16 Chemical Equilibrium Name:**

*16.1 Fetal Hemoglobin and Equilibrium*  Read the intro paragraph.

Why does the hemoglobin equilibrium for blood cells shift to the right in our lungs and then left in our muscles?

How are babies able to get oxygen from their mother’s blood across the placenta?

*16.2 The Concept of Dynamic Equilibrium*

Even though nearly all chemical reactions are theoretically reversible why do you think many do NOT reverse?

What is dynamic equilibrium? Why is it called “dynamic”?

What can you say about reactant and product concentrations at equilibrium? What cannot be said?

How can you tell when the reaction has reached equilibrium in *Figure 16.2*? *CC16.1 \_\_\_\_*

*16.3 The Equilibrium Constant (K)*

The equilibrium constant is a way to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the reactants and products at

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. It is defined as the \_\_\_\_\_\_\_\_\_\_\_ *-at equilibrium-*of the concentration of \_\_\_\_\_\_\_\_\_\_\_s raised

to their stoichiometric \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ divided by the concentration of the \_\_\_\_\_\_\_\_\_\_\_\_\_s raised to their

stoichiometric coefficients.

Write the expression for the general equation (the law of mass action). *K =*

*Practice 16.1*

*CC16.2 \_\_\_\_*

When *K*>>1 there are more \_\_\_\_\_\_\_\_\_\_\_\_\_s than \_\_\_\_\_\_\_\_\_\_\_\_\_\_s so the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ reaction is favored.

Remember that *K* says nothing about how \_\_\_\_\_\_ a reaction reaches \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ only how \_\_\_\_ the

reaction has proceeded. What does it mean when *K*<<1?

*CC16.3 \_\_\_\_ 16.4 \_\_\_\_*

*Note the 3 ways in which K changes when a chemical equation is modified.*

1) Reverse the equation \_\_\_\_\_\_\_\_\_ *K*  2) Multiple the coefficients raise *K* to the same \_\_\_\_\_\_\_\_\_\_\_\_.

3) Add 2 or more equations to obtain an overall equation then \_\_\_\_\_\_\_\_\_\_ the *K*s to obtain overall *K.*

*CC 16.5 (Show the calculation.)*

*Practice 16.2 More Practice 16.2*

*16.4 Expressing the Equilibrium Constant in Terms of Pressure*

What is the difference between *Kc* and *Kp*?

*The use of [ ] implies concentrations and ( ) implies pressures* ***(must be in atm)****. Since you can also determine the moles per liter for a gas they can be measured in molarity to use Kc.*

*Note on pg693 the mathematical relationship between Kc* and *Kp* is derived: *Kp* = What is Δ*n*?

*This calculation is not required by AP but it is very useful in understanding equilibrium.*

*Practice 16.3 CC16.6 \_\_\_\_*

*Note the use of units in the equilibrium expression is beyond the level of this class. Kc* and *Kp* are unitless.

*16.5 Heterogeneous Equilibria: Reactions Involving Solids and Liquids*

Why are solids and liquid left out of equilibrium expressions?

*Practice 16.4 CC16.7 \_\_\_\_*

*16.6 Calculating the Equilibrium Constant from Measured Equilibrium Concentrations*

What does *Table 16.1* show? *(Note temperature is constant.)*

Review how an ICE table can be used to determine the equilibrium concentrations in order to determine *K* on pg697.

*Practice 16.5 Practice 16.6*

CO(g) + 2 H2(g) ⇋ CH3OH(g) 2 CH4(g) ⇋ C2H2(g) + 3 H2(g)

I I

C C

E E

*K = K =*

*16.7 The Reaction Quotient: Predicting the Direction of the Change*

How is the reaction quotient *(Q*c*)* defined? How is it different from *K*c?

The value of *Q*c when a reaction contains: only reactants = \_\_\_ only products = \_\_\_

products & reactants each at 1M = \_\_\_ How is the reaction quotient useful?

*Figure 16.7* and the information on pg700 nicely summarize the relationship between *Q* and *K.*

When *Q* < *K* there are too many \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_s and the rxn will shift \_\_\_\_\_\_\_\_\_ to make \_\_\_\_\_\_\_\_\_\_\_\_\_\_s.

When *Q* > *K* there are too many \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_s and the rxn will shift \_\_\_\_\_\_\_\_\_ to make \_\_\_\_\_\_\_\_\_\_\_\_\_\_s.

When *Q* = *K* the reaction is at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. *(remember rxns will adjust to achieve equilibrium)*

*Practice 16.7 CC 16.8 (standard state for gases is 25oC and 1atm)* Explain Q vs K

*16.8 Finding Equilibrium Concentrations*

*Review Example 16.8 and complete Practice 16.8 (an ICE chart is not necessary since equilibrium concentrations are given)*

In problems where only the initial concentrations are given the variable “\_\_\_” is used to represent the change in conc.

Review *Examples 16.9-11(Note how the quadratic formula is not needed in #11 since you can take the square root of both sides)* and complete *Practices 16.9 & 16.11. (Note AP does not test problems that require use of the quadratic formula but it is a useful to see an application of the principle.)*

On pgs707-8 examples are shown with approximations in order to avoid using the quadratic formula. In AP chemistry the idea that the value of “x” is *small* when compared to initial concentrations is often used especially when we study the next few chapters. The method works when “x” has value of less than 5% of the original concentration. We will not use the method of successive approximations.

*Practice 16.12 (Set up the problem using an ICE chart and place the calculated eq concentrations at the bottom of the chart.)*

*16.9 LeChâtelier’s Principle: How a System at Equilibrium Responds to Disturbances (STRESS)*

What is this principle? How does it relate to the discussion of *Q* vs *K*?

*Practice 16.14*

Pressure and \_\_\_\_\_\_\_\_\_\_\_\_\_ are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ related. Decreasing volume means increasing \_\_\_\_\_\_\_\_\_\_\_\_\_

and increasing volume means decreasing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. In *Figure 16.11* why does the reaction shift left or right

in response to changes in volume (on the particle level)?

*Practice 16.15*

In an ***exothermic*** reaction heat can be treated as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and in endothermic reactions as a

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Adding heat causes a reaction to use up the heat. Removing heat causes the reaction to make

more heat. *Note changing the temperature changes the value of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

*(as long as the new temperature is maintained).* Lowering the temperature (\_\_\_\_\_\_\_\_ing heat) causes *K* to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

while increasing the temperature (\_\_\_\_\_ing heat) causes *K* to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. See *Figure 16.12*

*Practice 16.16*

*CC16.11 \_\_\_\_*

*Exercises* (pgs 722-726) #21(c,d), 23-27, 29, 31(b,c), 32b, 33(a,b), 35, 39, 41, 43, 45, 47, 49, 53, 55-57, 63, 65, 67, 69, 71, 79