Equilibrium #11

Multiple choice: Equilibrium: 10.6% or about 5-6 questions.

As a multiple choice questions are concerned they do vary a lot but

- Le Chatelier's principle assessment is very common.
- Pictorial diagrams depicting various stages of equilibrium
- Ksp seems to be common as well.

Written: Shows up in some form most years.

- it can take many forms including, Ksp, acid base, or general Kc or Kp.

<u>(#11-1) I understand the value of K and can generate an equilibrium expression</u>

(#11-1a) I can write an equilibrium constant expression Kc or Keq

I can write an equilibrium constant expression Kp (partial pressures.)

I can write an equilibrium constant expression for solubility Ksp.

(#11-1b) I can explain how the value of the equilibrium constant (k) relates to the extent of the reaction.

(#11-1c) I can calculate a new K value from an old K value if the reaction is altered (Altered means reversed, or coefficients are a multiple of the original.)

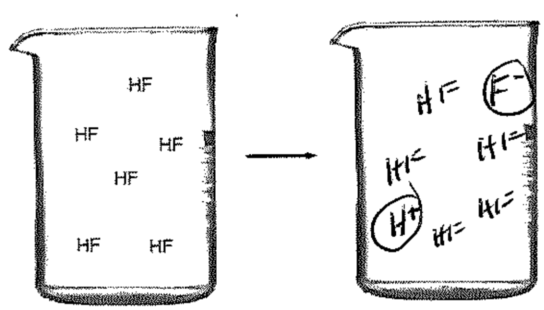
(#11-1d) I can add up the K values of individual elementary steps of a reaction to determine the K of an overall reaction. (K values are multiplied)

I can specifically model an equilibrium system using particulate diagrams.

I can determine if a reaction is at equilibrium.

1. In the following reactions write the corresponding equilibrium expressions. Both Kc and kp.
   a. $C(s) + O_2(g) \Leftrightarrow CO_2(g)$ $Kc = \frac{[CO_2]}{[O_2]}$ $Kp = \frac{p(CO_2)}{p(O_2)}$
   b. $HF_{(aq)} + H_2O(l) \Leftrightarrow H_3O^+_{(aq)} + F^{-1}_{(aq)}$ $Kc = \frac{[H_3O^+][F^-]}{[HF]}$ $Kp = X$ Not zero

2. The k value for letter "b" above is 7.2E-6. Use the beaker to draw a particulate model showing the equilibrium stalemate. Try to stay as proportional as possible.



3. Silver nitrate can dissolve at the rate of 122g/0.1L Determine the following. ($AgNO_3$ is pretty soluble)

$AgNO_3(s) \Leftrightarrow Ag^+(aq) + NO_3^{-1}$

$122g \cdot \frac{1\ mol}{169\ g} = 0.96 mol / .1L = 9.6M$

a. $[Ag^+]$
b. $[NO_3^{-1}]$
c. Ksp =

$Ksp = \frac{[Ag^+][NO_3^-]}{1} = (9.6)[9.6] = 92.9$ $[Ag^+] = [NO_3^-]$

Silver chloride can dissolve at a rate of 5.E-6g/0.1L Determine the following.

$AgCl \Leftrightarrow Ag^+ + Cl^{-1}$

$5.E\text{-}6g \cdot \frac{1\ mol}{142\ g} =$ AgCl (107, 35.4)

$\frac{3.5E\text{-}8\ mol}{.1L} = 3.5E\text{-}7\ M$

a. $[Ag^+]$ 3.5E-7 M
b. $[Cl^{-1}]$ 3.5E-7M
c. Ksp = $(3.5E\text{-}7)^2 = 1.23E\text{-}13$

d. $AgNO_3$ should have a larger Ksp value. What does this mean about this process and solubility?

Ksp ≈ Solubility ↑ Ksp means ↑ Solubility

4. A student chooses to write the solubility of $AgNO_3$ as follows: $Ag^+ + NO_3^{-1} \Leftrightarrow AgNO_3$

Not Ksp — called Kf, f = formation

a. What is the equilibrium expression for this process?

$Kf = \frac{1}{[Ag^+][NO_3^-]}$

b. Calculate the K value for this reaction.

flip Reaction, Reciprocal K value $\frac{1}{92.9} = 0.0107$

c. Is there anything wrong with this method, why would or wouldn't people use this version of solubility?

Solubility $\approx \frac{1}{Kf}$ Nothing wrong

5. (#11-1) Consider the following reaction:
$2A(g) + B(g) \Leftrightarrow 2C(g)$ Kp = 9.0 at a certain temperature. At the same temperature, what is Kp for the following reaction.

$A(g) + \frac{1}{2} B(g) \Leftrightarrow C(g)$

a.	9	d.	18
b.	4.5	e.	2.3
c.	3.0		

$(9)^{\frac{1}{2}} = 3$

Equilibrium

(#11-1b) How does the size a K affect the reaction at equilibrium? ↑K = more Product

6. Which of the following equilibrium constants (k) indicates that its corresponding reaction goes nearly to completion?

a. 1.0E-2 b. 1.0E-8 c. 1.0 d. 1.0E+2 e. 1.0E+8

Kc Kp Intro

(#11-2) ISE Table calculations

a. (#11-2a) I can solve for a K value given appropriate information.
b. (#11-2b) I can solve for an equilibrium concentration
c. (#11-2c) I can solve for equilibrium concentrations given common ion.
d. (#11-2d) I can qualitatively determine the relative concentrations as a reaction approaches equilibrium (this stoichiometry #4-4/#11-4)

(#11-2b) Typical example of solving for an equilibrium constant.

$$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$$

6. At a specific temperature 0.50 mol of SO_2 is mixed with 0.30 of O_2 in a 1L container. The process goes to equilibrium after an undisclosed period of time. The concentration of O_2 is 0.18M.

   a. Determine the concentration of each substance at equilibrium
   b. Determine the Kc for the reaction.

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

	$2SO_2$	O_2	$2SO_3$
I	.5	.3	0
S	-.24	-.12	+.24
E	.26	.18	.24

$$Ka = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

$$\frac{.24^2}{.18 \cdot .26^2} = 4.7$$

This is a common problem from previous tests that scored poorly. It involves both understanding of K and the stoichiometric ratio as the reaction approaches equilibrium.

$$A(aq) + 2B(aq) \Leftrightarrow 2C(aq) + D(l) \quad K = 500$$

7. (#11-2d) Equal moles of A and B are placed in a rigid 1 Liter container where the reaction is allowed to go to equilibrium. Which of the following is true:

I. [A] > [B] Yes
II. [A] does not change NO
III. [C] > [B] Yes ↑K

a. I and III only b. II and III only c. II only d. I, II and III

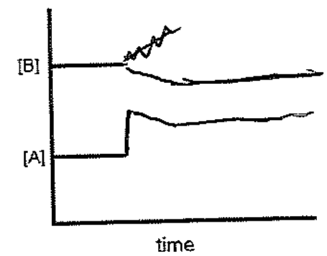
(#11-3) I know how a reaction will proceed when approaching equilibrium?

a. (#11-3a1) I can solve for a reaction quotient.
b. (#11-3a2) I can relate reaction quotient to equilibrium constant to judge how a reaction will proceed to get to equilibrium. (Q vs. K) (*note: will a precipitate form?*)
c. (#11-3b1) I can determine if a stress (change) actually alters the equilibrium position.
d. (#11-3b2) I can determine how the reaction will change if the reaction mixture was altered from equilibrium to get back to equilibrium (Le Chatelier's principle)

Note: The mathematical analysis or evaluation of Q Verses K is simply a matter of where is a reaction and where is it going? Which direction will a reaction proceed to go to or return to equilibrium. *This is a mathematical version of Le Chatelier's principle!*

change to A(aq)

1. The reaction is at equilibrium A(s) + B(aq) ⇔ 2C (s), A is added to the system increasing the concentration slightly after which it returns back to equilibrium quickly.
   a. In the chart add in a hypothetical graphical representation of the system leaving and returning to equilibrium.
   b. Where is C? ← No change in concentration



2. (#11-3b) ***This is an older style question but is a Le Chatelier's principle question.***

In which of the following systems would the number of moles of the substances present at equilibrium NOT be shifted by a change in the volume of the system at constant temperature?

a. $CO(g) + NO(g) \leftrightarrow CO_2(g) + 1/2\ N_2(g)$
b. $N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$
c. $N_2(g) + 2\ O_2(g) \leftrightarrow 2\ NO_2(g)$
d. $N_2O_4(g) \leftrightarrow 2\ NO_2(g)$
(e) $NO(g) + O_3(g) \leftrightarrow NO_2(g) + O_2(g)$ — same moles of gas

3. (#11-3b) ***Very common Le Chatelier's principle question.***

Consider a system at equilibrium according to the equation

$$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$$

4. If $H_{2(g)}$ is added to such an equilibrium system at constant volume and temperature, the total pressure
(a.) increases and the number of NH_3 molecules present increases
b. decreases and the number of NH_3 molecules present increases
c. remains the same and the number of NH_3 molecules present increases
d. remains the same and the number of NH_3 molecules present decreases
e. increases and the number of NH_3 molecules present remains the same

P↑ adding more stuff → shift; NH_3 ↑ N_2 ↓ H_2 ↑

Calculation of Reaction Quotient shows up in every exam.

$$2A(aq) + B(s) \Leftrightarrow C(aq)\ Kc = 10$$

5. The following reaction mixture was sampled and showed the following concentrations.
[A] = 0.1M [C] = 1.0M

(#11-3a) What is the current reaction quotient and is the reaction at equilibrium?
a. 100, No (c. 100, yes) c. 10, No d. 10, yes

$\frac{1}{(.1)^2} = 100$ yes K = Q

6. (#11-3a) As this reaction proceeds to equilibrium, what will happen to [A]?
a. (no change, reaction is at equilibrium)
b. Larger, reaction will shift toward reactants
c. Larger, reaction will shift to products
d. smaller, reaction shift to products