Equilibrium (#11-1)
Models of equilibrium

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$A(s) + 2B(g) + C(g) \leftrightarrow + D(l) + F(g)$

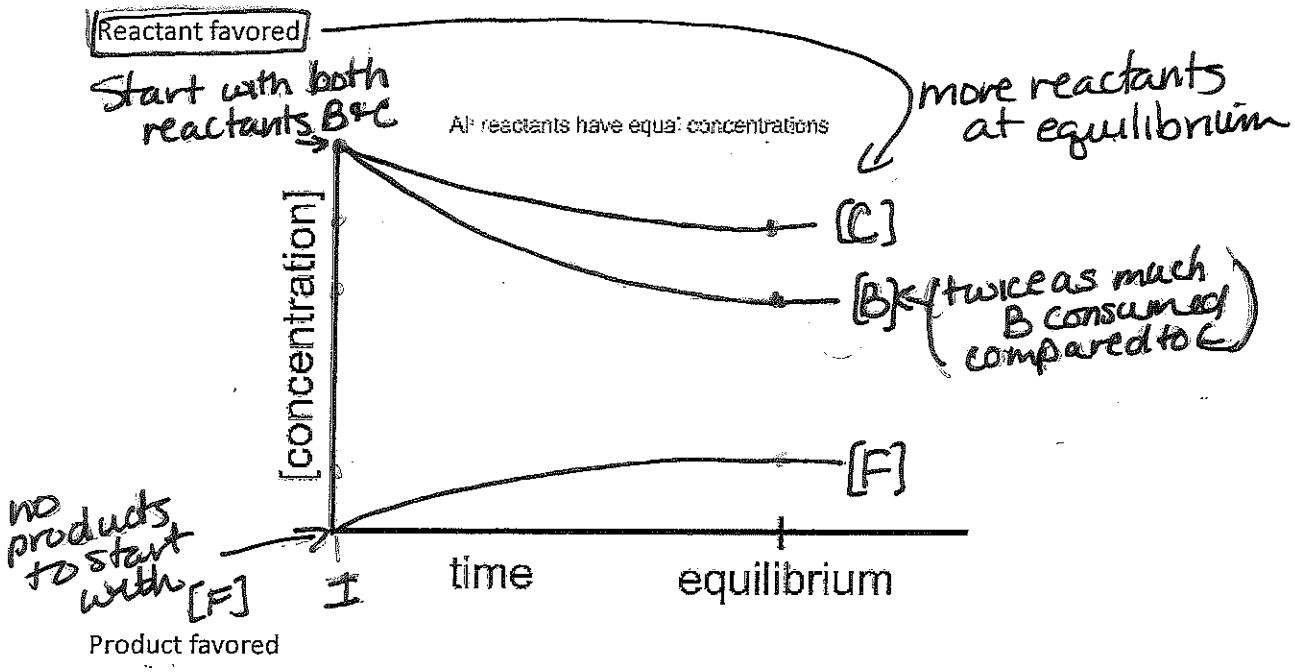
1. Write a Kc expression for this reaction above.

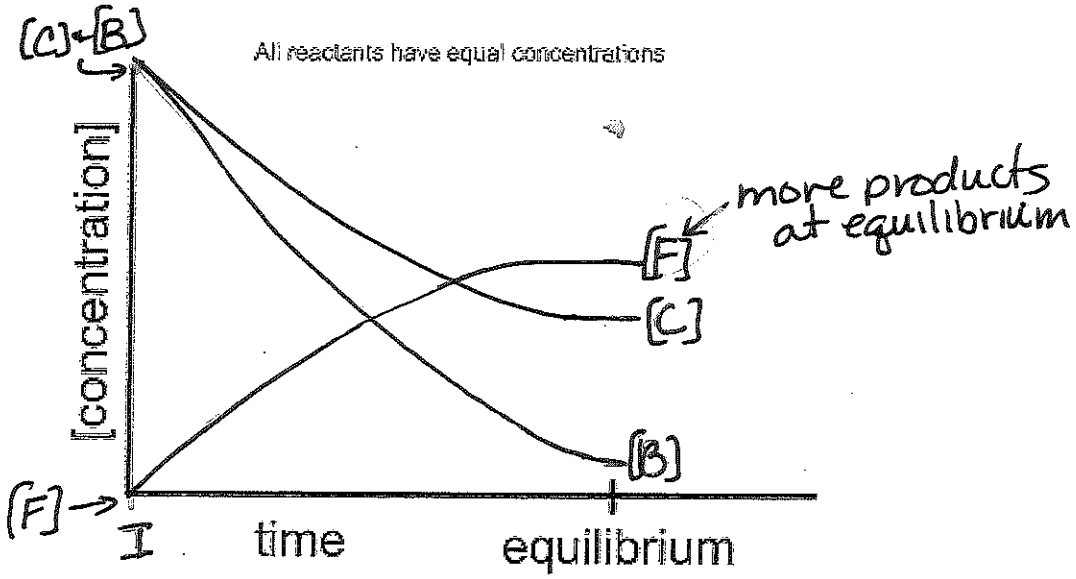
(gas or aqueous only) $K_c = \frac{[F]}{[B]^2[C]}$ ← use straight sided brackets for concentration

2. Write a Kp expression for the reaction above.

(gas only) $K_p = \frac{(P_F)}{(P_B)^2(P_C)}$ ← use partial pressures

3. Fill out the chart below for the reaction above.



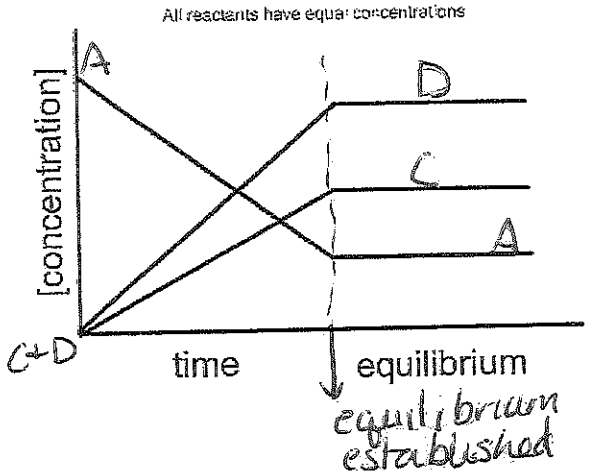
4. $A(g) \leftrightarrow C(g) + 2D(g)$

A sample of "A" is placed in a vessel and the reaction occurs until equilibrium.

a. Label line for each chemical it represents.
b. Label when equilibrium is established.
c. Write the Kc and Kp expressions for this reaction.

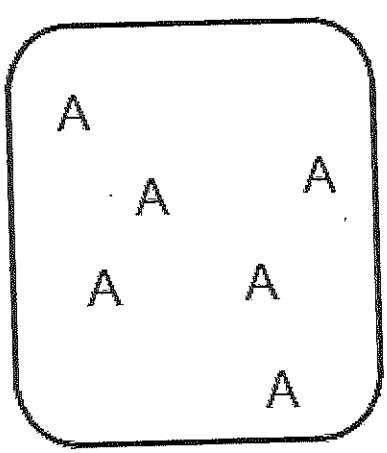
$$K_c = \frac{[D]^2[C]}{[A]}$$

$$K_p = \frac{(P_D)^2(P_C)}{(P_A)}$$

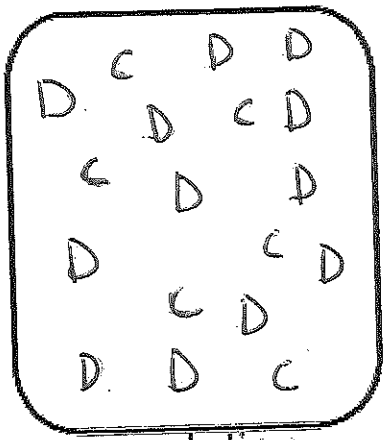



d. Complete the following particulate drawings.

6 A



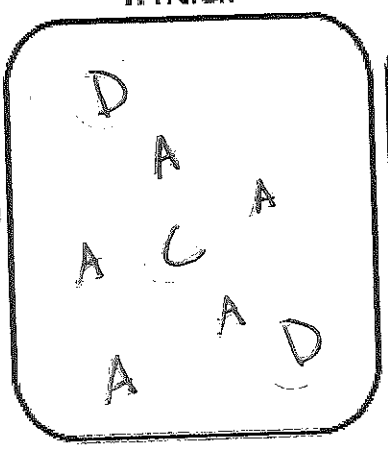

Initial

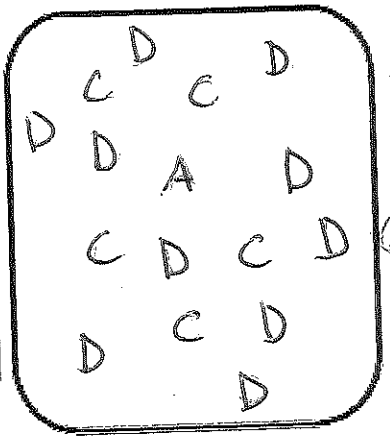



completion

| | $A_{(g)}$ | $\leftrightarrow C_{(g)}$ | $+ 2D_{(g)}$ |
|---|---|---|---|
| I | 6 | 0 | 0 |
| C | -6 | +6 | +12 |
| E | 0 | 6 | 12 |

| | $A_{(g)}$ | $\leftrightarrow C_{(g)}$ | $+ 2D_{(g)}$ |
|---|---|---|---|
| I | 6 | 0 | 0 |
| C | -1 | +1 | +2 |
| E | 5 | 1 | 2 |




| | $A_{(g)}$ | $\leftrightarrow C_{(g)}$ | $+ 2D$ |
|---|---|---|---|
| I | 6 | 0 | 0 |
| C | -5 | +5 | +10 |
| E | 1 | 5 | 10 |

reactant favored product favored

(#11-1)

Introduction to Completion vs. Equilibrium

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Completion:

.5 grams of methane burns in excess $O_2$ to produce $CO_2$ and $H_2O$. $0.5g\ CH_4 \frac{1\ mol}{16g} = 0.031\ mol\ CH_4$

Combustion goes to completion

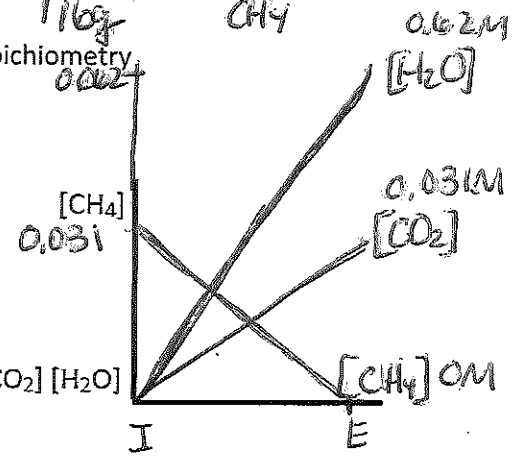
1. Write a balanced combustion reaction with an ISE table showing stoichiometry.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

| | $CH_4$ | $2O_2$ | $CO_2$ | $2H_2O$ |
|---|---|---|---|---|
| I | 0.031 | excess | 0 | 0 |
| S | -0.031 | -0.062 | +0.031 | +0.062 |
| E | 0 | – | 0.031 | 0.062 |

2. Draw a graphical representation tracking concentrations:

note: $O_2$ is in excess so we do not have an initial amount of $[O_2]$



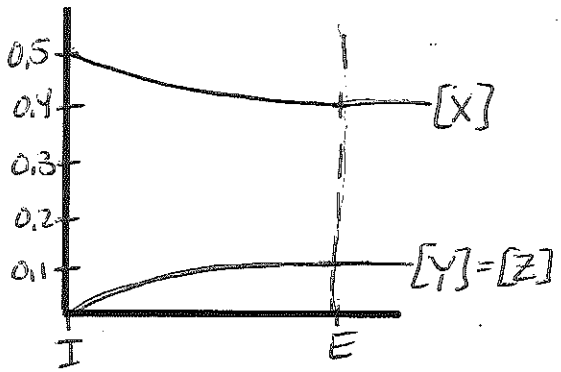

3. A Chemical process of .5M of X only goes 20% to product producing Y and Z. Write a balanced reaction with an ISC table showing ISE stoichiometry.

20% of 0.5M = 0.1M

moles (assume 1L)

$X \leftrightarrow Y + Z$

| | $X$ | $Y$ | $Z$ |
|---|---|---|---|
| I | 0.5 | 0 | 0 |
| S | -0.1 | +0.1 | +0.1 |
| E | 0.4 | 0.1 | 0.1 |




4. Draw a graphical representation of this process?
   a. Write out the equilibrium expression Kc.
   b. Determine the value of K.

$$K_c = \frac{[Y][Z]}{[X]} = \frac{(0.1M)(0.1M)}{(0.4M)} = 0.025$$

plug in numbers

no units (it is a ratio)

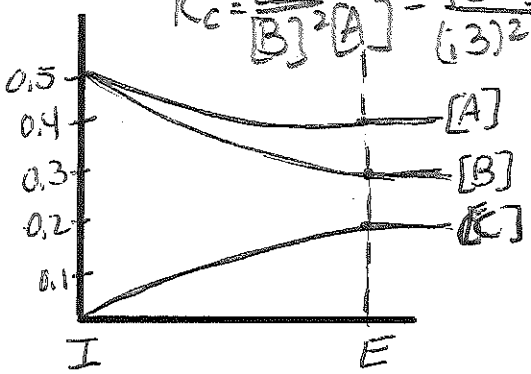
A chemical process of $A_{(aq)} + 2B_{(aq)} \leftrightarrow 2C_{(aq)}$ A and B both start at a concentration of .5M and when the process has come to equilibrium 20% of A is converted.

5. Write the equilibrium expression for this reaction.
6. Determine Kc for this process.
7. Draw a graphical representation of concentration.

$$K_c = \frac{[C]^2}{[B]^2[A]} = \frac{(0.2)^2}{(.3)^2(.4)} =$$

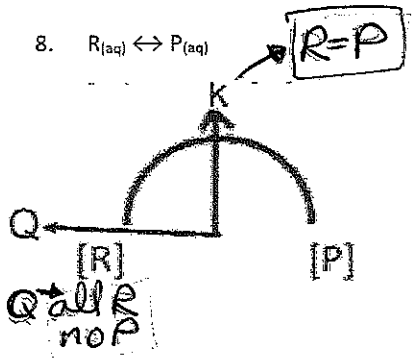
$A_{(aq)} + 2B_{(aq)} \leftrightarrow 2C_{(aq)}$

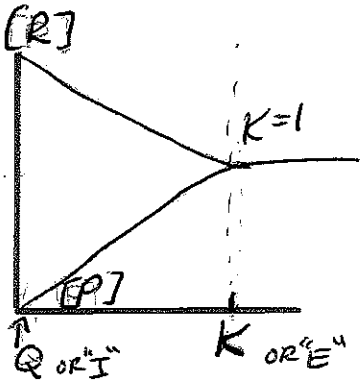
| | $A$ | $B$ | $C$ |
|---|---|---|---|
| I | 0.5 | 0.5 | 0 |
| S | -0.1 | -0.2 | +0.2 |
| E | 0.4 | 0.3 | 0.2 |



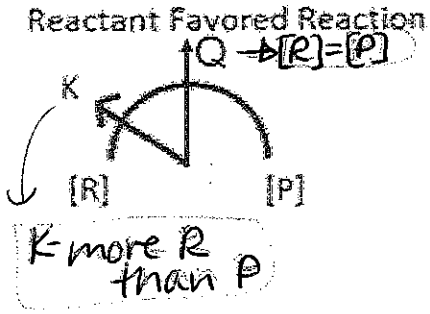
Q is the reaction not at equilibrium
- could be "I" from ISE table
- Q stands for Quotient

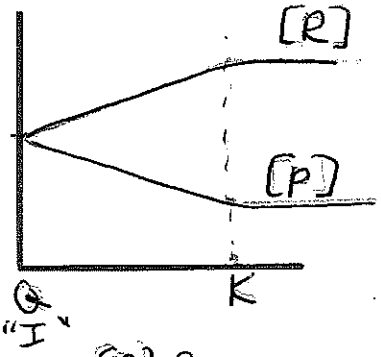
8. $R_{(aq)} \leftrightarrow P_{(aq)}$



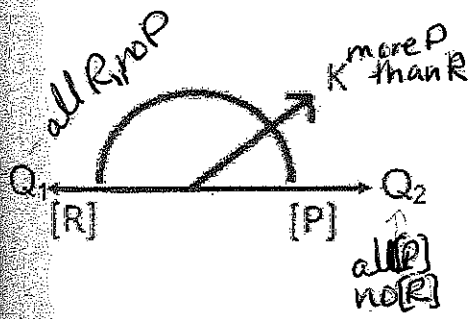



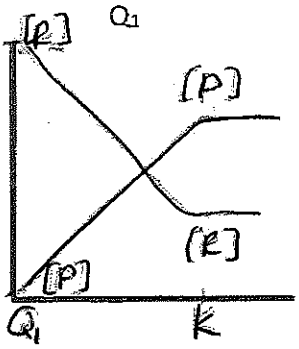

9. $R_{(aq)} \leftrightarrow P_{(aq)}$

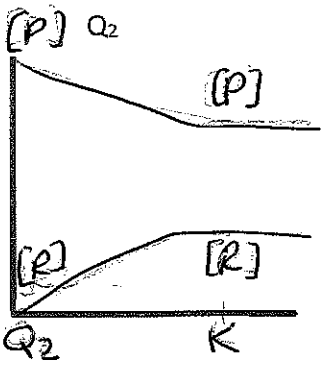


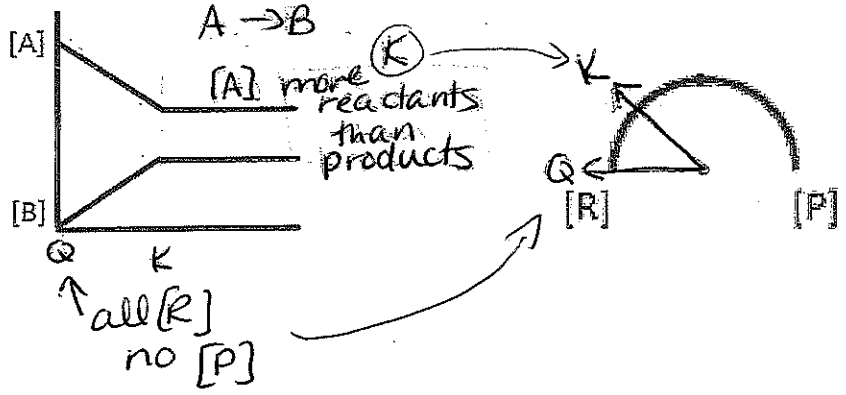

10. $R_{(aq)} \leftrightarrow P_{(aq)}$




11. Using the graph draw an arrow on the gauge indicating placement of equilibrium ratios. Draw an arrow on the graph to the right for both reaction Quotient and K. [A ↔ B]



(#11-1)

Can I determine the extent (favorability) of a chemical reaction?

Write the equilibrium expression for the following chemical reactions.

1. For each of the following, provide a Kc and a Kp expression.

   a. $A(aq) + B(s) \leftrightarrow C(g)$

   $K_c = \frac{[C]}{[B]}$ $\quad K_p = (P_c)$

   b. $2A(s) + B(g) \leftrightarrow 2C(g)$

   $K_c = \frac{[C]^2}{[B]}$ $\quad K_p = \frac{(P_c)^2}{(P_B)}$

   c. $A(l) + B(aq) \leftrightarrow 3C(aq)$

   $K_c = \frac{[C]^3}{[B]}$ no $K_p$ (no gas)

   d. $Ag_2SO_4(s) \leftrightarrow 2Ag^+_{(aq)} + SO_4^{-2}{}_{(aq)}$ (Balance me please)

   Solid

   $K_c = K_{sp} = [Ag^+]^2[SO_4^{-2}]$ no $K_p$

   e. $PbSO_4(s) \leftrightarrow Pb^{+2} + SO_4^{-2}$ (provide balanced dissolving equation)

   $K_c = K_{sp} = [Pb^{+2}][SO_4^{-2}]$

Reaction Extent

2. A reaction that goes greatly to its extent produces a lot of (products / reactants)

3. A reaction that is product favored will have a (large K / small K)

   $K = \frac{[P]}{[R]}$ (P larger)

4. Question 1d above has a K value = 1.0E-5 and 1e has a K value = 6.3E-7.

   0.00001 $\quad$ 0.0000063

   a. Which reaction will produce more product at equilibrium?

   1d – larger K will have more product

   b. Is the answer from letter a considered product favored?

   K = 1.0E-5 is less than 1 and is reactant favored

5. Reaction $A(s) + B(aq) \leftrightarrow 2C(aq)$

   a. Top beaker has a K = 1.0 E-10 → reactant favored

   b. Bottom beaker has a k = 1.0

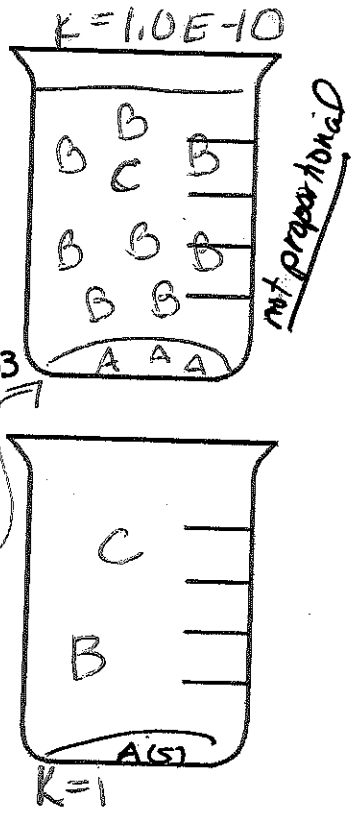
   K = 1

   Draw the beaker at equilibrium

   possibilities

   $K = \frac{[C]^2}{[B]} = \frac{1}{1} = 1$

   $K = \frac{(2)^2}{4} = 1$



Quiz 1 topic Reminder

I understand the value of K and can generate an equilibrium expression

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

(#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 specifically model an equilibrium system using particulate diagrams.
- I can determine if a reaction is at equilibrium.

$$A(aq) + B(s) \leftrightarrow 2C(g)$$

1. Write the equilibrium expression
   a. Kc = $\frac{[C]^2}{[A]}$
   b. Kp = $\longrightarrow K_p = (P_C)^2$
2. In a 2L ridged vessel, 0.2M A and solid B are added. Since the reaction is slightly product favored, draw a graph below and ridged container representing the reaction at equilibrium.
3.