CHE 1302

Basic Principles of Modern Chemistry II

Week 6

Hello and welcome to the weekly resources for Chemistry 1302! This resource covers topics typically taught by professors during the 6th week of classes.

On our website, https://baylor.edu/tutoring, you'll find the following links:

"Online Study Guide Resources" – If you don't see the topics you're learning right now, click here to find the weekly resources for the rest of the semester!

"How to Participate in Group Tutoring" - See if there is a Chemistry 1302 group tutoring session being hosted this semester – these are weekly question/answer sessions taught by our master tutors!

You can also view tutoring times for your course or schedule a private 30-minute appointment! Check out the website to learn more. You can also give us a call at (254)710-4135, or drop in. Our hours are Monday-Thursday 9 am – 8 pm on class days.

KEY WORDS: ICE Tables, Equilibrium Calculations, X is Small

TOPIC OF THE WEEK:

ICE Tables

How to solve problems involving a disturbed equilibrium state:

The following device is called a RICE table (you may also hear it called an ICE table). It is a helpful way to keep track of the changes for each reactant/product!

Reaction	Write the equation here. You will not do any of the calculations below on solids/liquids!
Initial concentrations	Beneath each reactant and product, write its concentration at the start of the experiment. If the problem doesn't say that any was added/present, assume initial concentration = 0.
Change *here, "change" refers to the change in concentration between the	1. Write ONE change in concentration. a. If you know that some reagent gets used up completely: the change in concentration in that reagent will be equal to its initial concentration. b. If you don't know how much the reagents changed, write "x" under any one of them. 2. Fill in the rest of the changes in concentrations based on that one.

start of a reaction and when it reaches equilibrium	**a.** These changes are related stoichiometrically. Multiply each reagent's change by this ratio: **(its coefficient)/(coefficient of the reagent from step 1)** b. To figure out the signs of each "change," calculate Q and compare it to K. i. If Q<K, the ratio of products/reactants will want to increase to get to equilibrium. So, the "changes" on the product side will be positive, and the "changes" on the reactant side will be negative. ii. If Q>K, the ratio of products/reactants will want to decrease to get to equilibrium. So, the "changes" on the product side will be negative, and the "changes" on the reactant side will be positive.
Equilibrium	Add the I and C rows together.

Highlight 1: Problem-Solving: ICE Tables

Different problems will start you with different pieces of information, but you can consistently follow these steps:

1. Write the balanced chemical equation.
2. Write K's expression.
3. Create an ICE table.
4. Fill in K's expression using the E row of the ICE table.
5. Solve for unknowns

I've written out the example from a YouTube video by Engineer4Free (How to find equilibrium concentrations using an ICE table - YouTube)

Start with 1 M BrCl, which will undergo the reaction given.

$2BrCl(g) \rightleftharpoons Br_{2(g)} + Cl_{2(g)}$ K=5.81

Calculate the concentrations of all reaction components at equilibrium.

We already have the balanced equation. Let's start by writing an expression for K. Remember the equation for K:

$$K_c = \frac{[C]^m * [D]^n}{[A]^j * [B]^k}$$

$$K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2}$$

Next, set up an ICE table.

Put the initial concentration of BrCl (given) in the I row. Assume that the other two concentrations are* ***0 M*.*

Put the x under one of the two products – since their* ***coefficients are 1*, we won't have to deal with fractions. The change in concentration for BrCl is x*(2/1), and it is negative because BrCl is a reactant. The change in the other product concentration is calculated similarly.*

$2BrCl_{(g)} \rightleftharpoons Br_{2(g)} + Cl_{2(g)}$

	$2BrCl_{(g)}$	$Br_{2(g)}$	$Cl_{2(g)}$
I(M)	1.0	0	0
C(M)	$-2x$	$+x$	$+x$
E(M)	$(1-2x)^2$	x	x

The next step is to plug the equilibrium concentrations (E row) into the K_c expression.

$$K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2} = \frac{x^2}{(1-2x)^2} = 5.81$$

Now, we can solve for the unknown, x. Multiply both sides by the denominator, combine like terms, and simplify.

$$x = 0.41\ M$$

X can be used to solve for all of the concentrations at equilibrium:

$$[Br_2] = x = 0.41\ M$$

$$[Cl_2] = x = 0.41\ M$$

$$[BrCl] = (1-2x)^2 = 0.18\ M$$

Highlight 2: "X is Small"

For cases in which you are solving for x, as shown at the end of Highlight 1, and the expression requires the quadratic formula.

Here is an example from a YouTube video by Chantelle Anfuso (The "x is small" Approximation - YouTube):

- Consider the following reaction. If we start with 1.00 M of A, what are [A] and [B] at equilibrium?

$$A(g) \rightleftharpoons 2\,B(g) \qquad K_c = 2.2 \times 10^{-3}$$

$$K_c = \frac{[B]^2}{[A]} \qquad 2.2 \times 10^{-3} = \frac{[B]^2}{[A]}$$

	[A] (M)	[B] (M)
Initial	1.00	0.0
Change	- x	+ 2x
Equilibrium	1.00 - x	2x

$$2.2 \times 10^{-3} = \frac{[2x]^2}{[1.00 - x]}$$

You can see that an ICE table has been set up, and the equilibrium row has been calculated. In the bottom right corner, the K expression has been filled in with the expressions from the equilibrium row. Notice: in contrast to the example from Highlight 1, the numerator is not x^2.

*(UNLESS! If you think that x will be less than 0.05*initial concentration, so 0.05*1 M, then you can remove the x term when it is being subtracted. X is small enough that, if subtracted from the initial concentration 1 M, it will not have a huge impact. But keep it on the numerator! A very small number, multiplied by itself, is an even smaller number. Once you've solved for x, check and see if it is actually less than 0.05*1M. If it is, it was all right to use the "x is small" rule. If not, you need to go back and use the quadratic formula.)*

Highlight 3: Significance of the Equilibrium Constant

All throughout CHE 1302, we come across equilibrium constant K_c. It is important to conceptually understand what K_c is and what it tells us about an equilibrium reaction! Recall - K_c is an equilibrium constant without any units, and it always follows this form:

product concentrations/reactant concentrations

1. K>>1: (e.g. K=110), then the forward reaction essentially goes to completion – few reactants remain, much product formed
2. K>1: (e.g. K = 10-14), then the forward reaction occurs to a slight extent – some reactants remain, product formed
3. K<1: the reverse reaction is favored – higher concentration of reactants than products, little product formed
4. K<<1: the reverse reaction is very much favored – essentially no products, much reactant formed

NOTE: The size of K_c tells us what equilibrium will look like when we get there, but it says NOTHING about how quickly equilibrium is reached! How quickly equilibrium is reached is a different branch of chemistry – kinetics! Think back to rate laws.

Check Your Learning

1. Determine the value of Kc for the reaction $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ given the following information: At 525 K, a 20.82 g sample of PCl5 is placed in a 5.00 L container. At equilibrium there are 10.32 g of PCl3.
2. For the reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$, K=107, is the forward or reverse reaction favored? Are the products or reactants favored?
3. Consider the following equilibrium reaction: $4HCl(aq) + MnO_{2(s)} \rightleftharpoons MnCl_{2(aq)} + 2H_2O_l + Cl_{2(g)} \quad \Delta H = -272\frac{kJ}{mol}$. In which direction does the reaction occur if water is added?

Things You May Struggle With

1. Don't forget to balance the equation before using coefficients in a K expression!
2. Before doing ICE calculations: Compare Q and K so as to know which side of the equation has negative changes and which side of the equation has positive changes.

That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to Check Your Learning are below.

1. Kc=0.0450
2. Forward reaction; products
3. Left