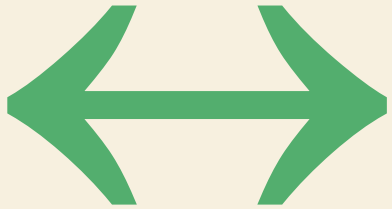
N45
ICE Tables



TARGET:

I CAN FIND THE CONCENTRATION OF REACTANTS AND PRODUCTS AT EQUILIBRIUM USING AN ICE TABLE

DETERMINING CONCENTRATIONS AT EQUILIBRIUM

What if you wanted to determine the concentrations of your reactants and products at equilibrium, but only know the initial concentrations?

USE AN ICE TABLE!

WHAT IS AN ICE TABLE?

- A strategy for organizing information about a reaction in order to solve for [ ]'s at equilibrium

$$A + B \leftrightarrow C$$

- **<u>ICE stands for</u>:**
  - –Initial
  - –Change
  - –Equilibrium

Rxn	A	+	B	↔	C
I					
C					
E					
5%					
Answer					

STEPS FOR SETTING UP AN ICE TABLE

Glue in your steps
for setting up an ICE table.
We will walk through them together
as we do some practice problems!
Highlight, annotate, process them as
we go through them!

PRACTICE PROBLEM #1

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous and Keq = 78.3.

$$PCl_5 \rightarrow PCl_3 + Cl_2$$

PRACTICE PROBLEM #1 STEPS 1, 2, 3

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I			
C			
E			
5%			
Answer			

PRACTICE PROBLEM #1 STEP 4

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C			
E			
5%			
Answer			

PRACTICE PROBLEM #1 STEP 5

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Be careful here! Include coefficients! Easy this time because all ones ☺

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C	- x	+ x	+ x
E			
5%			
Answer			

PRACTICE PROBLEM #1 STEP 6

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C	- x	+ x	+ x
E	1.3 - x	x	x
5%			
Answer			

Be careful with the +/-signs, pay attention!

PRACTICE PROBLEM #1 STEP 7

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C	- x	+ x	+ x
E	1.3 - x	x	x
5%	NA	NA	NA
Answer			

K > 1, so cant use the 5% rule ☹

PRACTICE PROBLEM #1 STEP 8

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Forward Reaction is happening

zero products means Q = 0 so shifting right

$$PCl_5 \rightarrow PCl_3 + Cl_2$$ ✓

Equilibrium Expression

$$K_{eq} = \frac{[PCl_3]\,[Cl_2]}{[PCl_5]}$$

PRACTICE PROBLEM #1

STEP 8 cont…

Plug what you know about the [ ]'s at equilibrium into your equilibrium expression

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C	- x	+ x	+ x
E	1.3 - x	x	x
5%	NA	NA	NA
Answer			

$$K_{eq} = \frac{[PCl_3]\,[Cl_2]}{[PCl_5]}$$

$$78.3 = \frac{[x]\,[x]}{[1.3 - x]}$$

PRACTICE PROBLEM #1 STEP 8 cont…

$$78.3 = \frac{(x)(x)}{(1.3 - x)}$$

$$(1.3 - x)\,78.3 = x^2$$

$$101.79 - 78.3x = x^2$$

$$0 = x^2 + 78.3x - 101.79$$

Solve using quadratic equation!

$ax^2 + bx + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{-78.3 \pm \sqrt{78.3^2 - 4(1)(-101.79)}}{2(1)}$$

x = 1.28 or -79.58

-79.58 makes no sense!

PRACTICE PROBLEM #1 STEP 9

If you have an initial concentration of [PCl_5] at 1.3M, what are the concentrations of the products at equilibrium? Assume all reactants and products are aqueous.

Plug your x value into your E row to find your final answers! →

Rxn	$PCl_5 \leftrightarrow$	PCl_3 +	Cl_2
I	1.3	0	0
C	- x	+ x	+ x
E	1.3 - x	x	x
5%	NA	NA	NA
Answer	1.3-1.28 = **0.02 M**	**1.28 M**	**1.28 M**

ISN'T THE QUADRATIC FORMULA FUN?????

What if we didn't have to use it ?!

WHAT IF THERE WAS A BETTER WAY????

USE THE 5% RULE!

5% RULE

What is it?

- A way for us to simplify the math involved when solving ICE table problems.

When can I use it?

- When X is small enough to be considered negligible
- The change ends up being so small that it isn't even considered valid when you take significant figures into account so you might as well ignore it!

5% RULE

What counts as "negligible?"

- Required: K < 1
- When x ends up being 5% or less of the initial concentrations
  - *Can't know that until the end when you solve for x! Ugh!*
  - *Good guestimate… if K is at least 1000x smaller that initial concentrations, you have a good chance of the 5% rule working*
- *You MUST check at the end to show that* $\frac{x}{[initial]} x\ 100\ \leq 5\%$

5% RULE EXAMPLE – PROBLEM #2

In the following reaction, $K_{eq} = 9.3 \times 10^{-7}$ at room temperature. Calculate the equilibrium concentration of N_2O_4 in a flask initially containing only 3.00 M of NO_2

$$2\ NO_{2(g)} \leftrightarrow N_2O_{4(g)}$$

5% RULE EXAMPLE

Set up your ICE table as normal through the equilibrium row. $2\ NO_{2(g)} \rightarrow N_2O_{4(g)}$

Rxn	$2\ NO_2$	$\leftrightarrow$ N_2O_4
I	3	0
C	- 2x	+ x
E	3 – 2x	x
5%		
Answer		

Careful to use the coefficients! It's stoich right?!

5% RULE EXAMPLE

Now check to see that K is at least 1000x smaller than initial [ ]'s *(K_{eq} = 9.3x10^{-7} vs. 3)*

Rxn	$2\ NO_2 \leftrightarrow N_2O_4$	
I	3	0
C	- 2x	+ x
E	3 – 2x	x
5%	3	x
Answer		

Yes it is! Probably can use the 5% rule! Ignore any subtraction or addition of x values.

Leave any x values that are by themselves alone!

5% RULE EXAMPLE

Now plug your 5% equilibrium values into the Equilibrium Expression and solve for x! Math is easier! Woohoo!

Rxn	$2\ NO_2 \leftrightarrow N_2O_4$	
I	3	0
C	- 2x	+ x
E	3 – 2x	x
5%	3	x
Answer	**3 M**	**8.37 x 10^{-6}M**

$$K_{eq} = \frac{[N_2O_4]}{[NO_2]^2}$$

$$9.3 \times 10^{-7} = \frac{X}{3^2}$$

$$X = 8.37 \times 10^{-6}$$

Plug your x value into your 5% row to find your final answers!

5% RULE EXAMPLE

DON'T FORGET! PROVE YOUR 5% RULE WAS VALID!

Rxn	$2\ NO_2 \leftrightarrow N_2O_4$	
I	3	0
C	- 2x	+ x
E	3 – 2x	x
5%	3	x
Answer	3 M	8.37 x 10^{-6}M

$$\frac{x}{[initial]} x\ 100\ \leq 5\%$$

$$\frac{8.37\ x\ 10^{-6}}{3} x\ 100$$

$$= 2.79\ x\ 10^{-4}$$

Yes, 5% rule was valid!