Balancing Chemical Equations- Notes

Unit 04, Chemistry Themed

Balancing equations - Overview

- Goal: Find the simplest possible equation coefficients that give the same number of each kind of atom for the left and right side of equation

<u>Preview of where we're headed</u>

- Not Balanced: $H_2 + O_2 \rightarrow H_2O$
  - Reason: two oxygen atoms on left side and only one on right side

- Not correctly balanced: $H_2 + ½O_2 \rightarrow H_2O$
  - Reason: Only integers are allowed as coefficients

- Not correctly balanced: $4H_2 + 2O_2 \rightarrow 4H_2O$
  - Reason: Not "simplest" equation (all coefficients are divisible by 2 and can be reduced)

- Correctly balanced: $2H_2 + O_2 \rightarrow 2H_2O$
  - Reason: Simplest possible coefficients without any fractions balancing all atoms

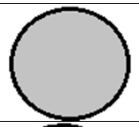
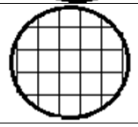
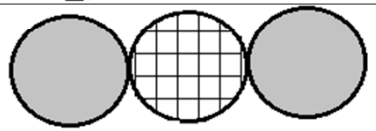
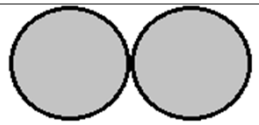
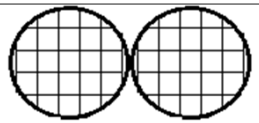
What is a chemical equation?

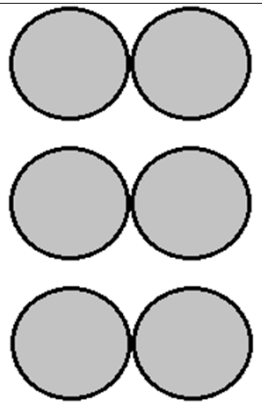
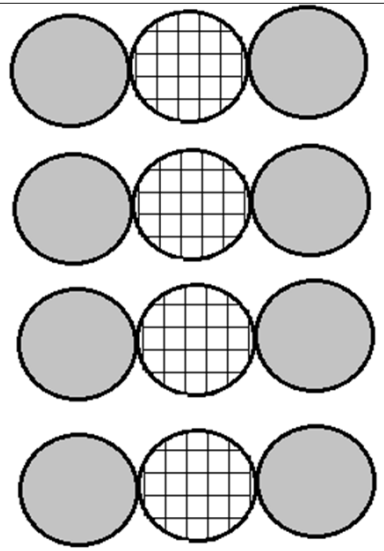
- A chemical equation is a reaction recipe
  - $2H_2 + O_2 \rightarrow 2H_2O$
  - It's like: "mix 2 parts hydrogen with one part oxygen and you get 2 servings of water"
  - But, in chemistry we would say: two hydrogen molecules react with one oxygen molecule to produce 2 water molecules
- Each molecule is like each ingredient in the recipe:
  - Molecules are lists of symbols with a subscript (number) to the right of the symbol
    - No subscript shown? It means subscript value is 1

Examples

- H_2O is a molecule where two hydrogen atoms are bonded to a single oxygen atom
- $FeCl_3$ is a molecule where a single iron ion is bonded to three chloride ions (metals bond with non-metals as ions)
- H_2 is a molecule where two hydrogen atoms are bonded to each other
- You can change how much of each ingredient to use, but NOT what each ingredient is – you can't change subscripts
- Coefficients: These just change how much of each ingredient is used. You change these however you want until equation is balanced

Illustration explaining subscripts and coefficients

Symbol in chemistry	Picture illustration	Descriptive explanation
H		1 atom of hydrogen
O		1 atom of oxygen
H_2O		1 molecule of water (two hydrogen atoms bonded to one oxygen atom)
H_2		1 molecule of hydrogen gas (two hydrogen atoms bonded to each other)
O_2		1 molecule of oxygen gas (two oxygen atoms bonded to each other)

Symbol in chemistry	Picture illustration	Descriptive explanation
3 H_2		3 molecules of hydrogen (6 total hydrogen atoms)
4 H_2O		4 H_2O is four molecules of water (8 total hydrogen atoms and 4 total oxygen atoms)

Sample un-balanced chemical equations

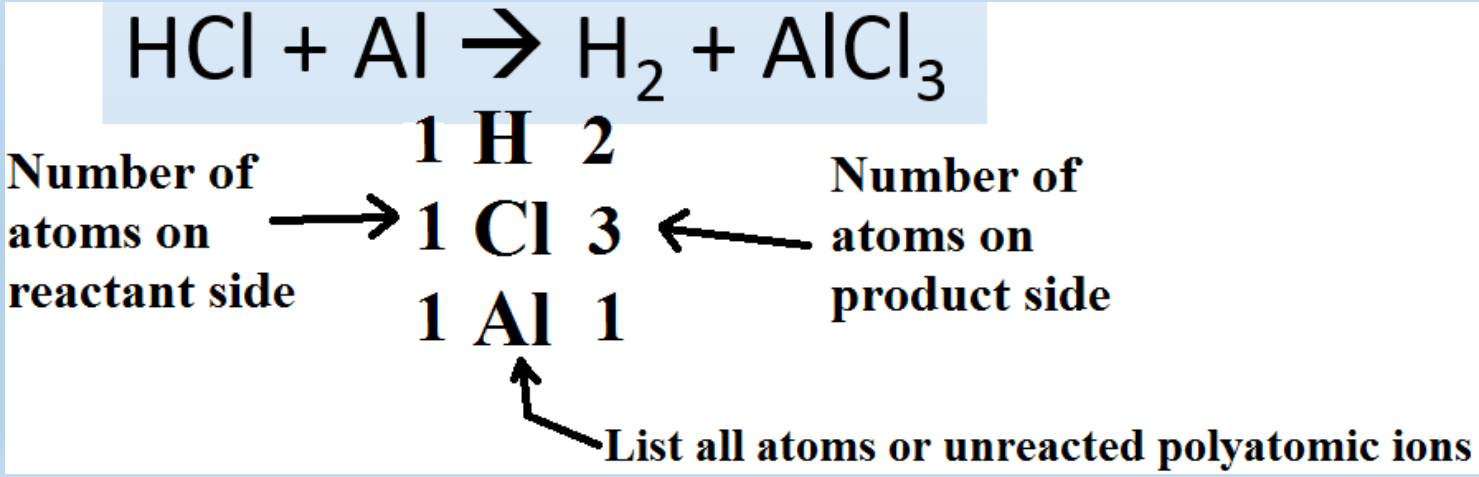
Let's look at these to learn balancing:

- $HCl + Al \rightarrow H_2 + AlCl_3$
- $H_3PO_4 + Ca(OH)_2 \rightarrow H_2O + Ca_3(PO_4)_2$
- $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

Atom inventory

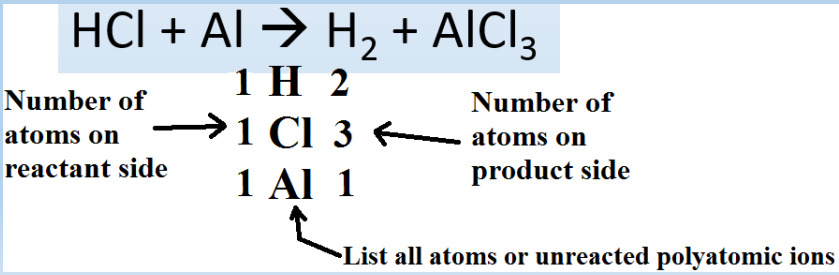
- $HCl + Al \rightarrow H_2 + AlCl_3$
- The left side of the chemical equation is the **reactant side**, the original chemicals present
- The right side of the chemical equation is the **product side**, what the reaction produces

Atom inventory used the rules of coefficients we learned about to fine how many of each atom side exists on both reactant and product sides:



Balancing tips

- Now it's kind of like an algebra problem…maybe a bit harder.
- You may change coefficients all you want, but you must accomplish the goal already mentioned: *Find the simplest possible equation coefficients that give the same number of each kind of atom for the left and right side of equation*
- Try these guidelines/tips:
  1. Treat polyatomic ions as "units" (unless reaction breaks them up), try balancing oxygen last and hydrogen second to last.
     - When OH (hydroxide) makes water, treat water (H_2O) like HOH
  2. If you can balance completely using 1/2 as coefficient, do it and then multiply everything by 2
  3. Use pencil and keep trying clever combinations if you're stuck
  4. Once balanced: reduce coefficients if possible (do all coefficients have a common factor?)



Finishing First Balancing example

$HCl + Al \rightarrow H_2 + AlCl_3$

(1)

1 H 2

1 Cl 3

1 Al 1

No oxygen, balance H, last and try Cl first (it's listed first)

$3HCl + Al \rightarrow H_2 + AlCl_3$

(2)

~~3~~ ~~1~~ H 2

~~3~~ ~~1~~ Cl 3

1 Al 1

Now need to balance H (last). A coefficient of 6 for HCl and 3 for H2 will do it

$6HCl + Al \rightarrow 3H_2 + AlCl_3$

(3)

~~6~~ ~~3~~ ~~1~~ H ~~2~~ 6

~~6~~ ~~3~~ ~~1~~ Cl 3

1 Al 1

Now a 2 in front of Al and AlCl3 will finish the balance

$6HCl + 2Al \rightarrow 3H_2 + 2AlCl_3$

(4)

~~6~~ ~~3~~ ~~1~~ H ~~2~~ 6

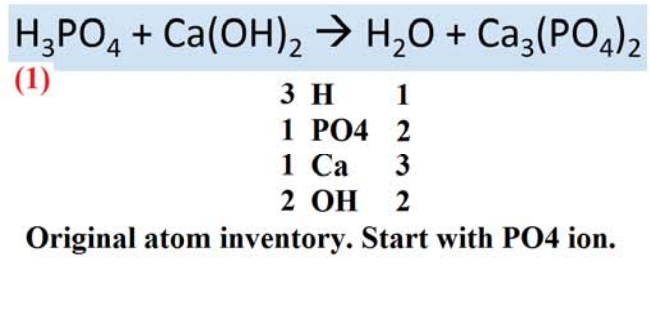
~~6~~ ~~3~~ ~~1~~ Cl ~~3~~ 6

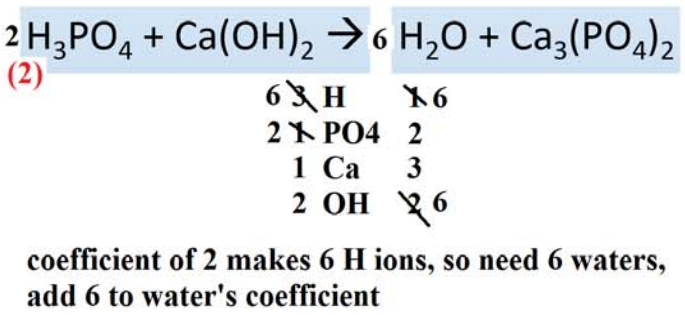
2 ~~1~~ Al ~~1~~ 2

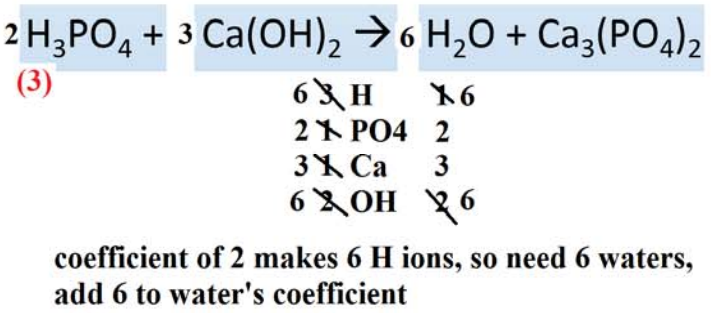
Double check atom inventory balances both sides and confirm the coefficients cannot be reduce..Done!

Polyatomic Example

- Remember this guideline when polyatomic ions are present (and don't react (break up) in the reaction)
  1. Treat polyatomic ions as "units" (unless reaction breaks them up), try balancing oxygen last and hydrogen second to last.
     - When OH (hydroxide) makes water, treat water (H_2O) like HOH
- Balance: $H_3PO_4 + Ca(OH)_2 \rightarrow H_2O + Ca_3(PO_4)_2$
- Trying to count individual atoms makes this a very hard problem
  - Note, 14 oxygens on both sides, you can count the individual atoms to verify this method works…treating water like HOH is a little tricky, but makes the number of steps much easier than counting each atom by itself







"½" as coefficient example (combustion)

- Remember this guideline when using ½ will balance the equation
  - If you can balance completely using 1/2 as coefficient, do it and then multiply everything by 2
- Balance: $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
- This is pretty straightforward, but "trick" makes it easier

(1) $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

4	C	1
10	H	2
2	O	3

Original atom inventory. Note: Start with C because do H and O last and, don't break up water into HOH (no OH ion present!)

(2) $C_4H_{10} + 6.5\,O_2 \rightarrow 4\,CO_2 + 5\,H_2O$

4	C	4
10	H	10
13	O	13

Everything balances perfectly. But you can't have half an oxygen molecule. It's okay, balance and then double everything!

(3) $2C_4H_{10} + 13\,O_2 \rightarrow 8\,CO_2 + 10H_2O$

8	C	8
20	H	20
26	O	26

All coefficients are doubled, everything balances and no illegal fractions. Done!