Balancing Equations

Chemical Equations

Reactants ➔ Products

Color change
Solid forms (Cloudiness … precipitation)
Bubbles (gas) form
Heat and/or flame is produced
Heat is absorbed (cooling)

Reactants
Substances present at the beginning
Starting materials
Initial materials that enter into the reaction; things consumed

Products
Substances present at the end of the reaction
New materials formed
Ending materials; things produced

Chemical Equations

For: Reactants (A + B) ➔ Products (C + D)

+ is read as
"plus"
"and"

➔ is read as
"yields"
"produces"
"forms"

May use "state symbols" (often as subscript):

(aq)	=	aqueous, dissolved in water
(s)	=	solid, precipitate; also
(l)	=	liquid
(g)	=	gas

Chemical Equations Must

be "balanced"
follow the Law of Conservation of Mass
Total mass reactants = Total mass products
No mass is lost during chemical reaction
No atoms destroyed during ordinary reactions
Atoms recombined into new materials (products)

Total # atoms reactants = Total # atoms products

Total # atoms reactants = Total # atoms products

To balance: need same # atoms on both sides of the ➔

Start with correct chemical formulas

WORK WITH COEFICIENTS
(Trial and error until atoms on both sides are equal)

For Hydrogen + Oxygen yields water

Write Starting Materials and Products

$H_2(g) + O_2(g) \rightarrow H_2O(l)$

Count atoms ➔ must be same on both sides
2 H 2 O ➔ 2 H 1 O

There is a tendency (wrong) to balance with subscripts:

$H_2(g) + O_2(g) \rightarrow H_2O_2(l)$

2 H 2 O ➔ 2 H 2 O

But, H_2O is not the same as H_2O_2

Chemical Equations

Balance With Coefficients, not subscripts

'cause balancing with subscripts changes the reaction

Remember, H_2O is chemically not the same as H_2O_2

For Hydrogen + Oxygen yields water

Write Starting Materials and Products

$H_2(g) + O_2(g) \rightarrow H_2O(l)$

Count atoms ➔ must be same on both sides

2 H 2 O ➔ 2 H 1 O

Oxygen unbalanced; Try

$H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

Count atoms ➔ must be same on both sides

2 H 2 O ➔ 4 H 2 O

Oxygen now balanced, try

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

Count atoms ➔ must be same on both sides

4 H 2 O ➔ 4 H 2 O

Success!

Chemical Equations

Which is correct?

$H_2(g) + O_2(g) \rightarrow H_2O(l) + O(g)$

$H_2(g) + O(g) \rightarrow H_2O(l)$

$H_2(g) + O_2(g) \rightarrow H_2O_2(l)$

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

Which is correct?

Oxygen should be diatomic, so these are wrong

$H_2(g) + O_2(g) \rightarrow H_2O(l) + O(g)$

$H_2(g) + O(g) \rightarrow H_2O(l)$

Equation balanced, but not for water:

$H_2(g) + O_2(g) \rightarrow H_2O_2(l)$

Equation balanced for water formation:

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

Hints for Balancing

I tend to work with whole numbers …
fractional coefficients tend to confuse

Bottom line:
No fixed rule … every reaction is different
Requires practice to develop balancing skills

My two guidelines:
Start with a metal or most complex reaction material
Save water (or diatomic gasses) last step

Genius is 10% inspiration and 90 % perspiration.
Thomas Alva Edison

Balance This Chemical Equation

$$\mathbf{TiCl_4 + H_2O \rightarrow TiO_2 + HCl}$$

Safety Tip: HCl is a corrosive acid; lab precautions needed

Start with Chlorine:

$$TiCl_4 + H_2O \rightarrow TiO_2 + 4\,HCl$$

Atom Count: 1 Ti; 4 Cl; 2 H; 1 O ➔ 1 Ti; 4 Cl; 4 H; 2 O

Ti & Cl balanced; H & O are not

Hint: Leave H & O for last, especially if water is involved

4 H suggests 2 waters, so try 2 H_2O

$$TiCl_4 + 2\,H_2O \rightarrow TiO_2 + 4\,HCl$$

Atom Count: 1 Ti; 4 Cl; 4 H; 2 O ➔ 1 Ti; 4 Cl; 4 H; 2 O

Success!

Balance This Chemical Equation

Fe_3O_4 + H_2 ➔ Fe + H_2O

Start with Iron

Fe_3O_4 + H_2 ➔ 3 Fe + H_2O

Atom Count: 3 Fe; 2 H; 4 O ➔ 3 Fe; 2 H; 1 O

Fe & H balanced; O is not … suggests water is key

Four O on the start side suggests 4 waters on product side; try 4 H_2O

Fe_3O_4 + H_2 ➔ 3 Fe + 4 H_2O

Atom Count: 3 Fe; 2 H; 4 O ➔ 3 Fe; 8 H; 4 O

Fe & O balanced; H is not … finish by balancing H

Fe_3O_4 + 4 H_2 ➔ 3 Fe + 4 H_2O

Success!

Balance This Chemical Equation

MnO_2 + HCl ➔ $MnCl_2$ + Cl_2 + H_2O

Safety Tip: Cl_2 is toxic; lab precautions needed

Mn Balanced: Start with 4 Chlorine on product side

MnO_2 + 4 HCl ➔ $MnCl_2$ + Cl_2 + H_2O

Atom Count: 1 Mn; 4 Cl; 4 H; 2 O ➔ 1 Mn; 4 Cl; 2 H; 1 O

O is odd on product side, try making it even

MnO_2 + 4 HCl ➔ $MnCl_2$ + Cl_2 + 2 H_2O

Atom Count: 1 Mn; 4 Cl; 4 H; 2 O ➔ 1 Mn; 4 Cl; 4 H; 2 O

Success!

Balance This Chemical Equation

NH_3 + O_2 ➔ N_2 + H_2O

Reaction has odd/even combination of diatomic molecules
Start with Nitrogen … try

$2\ NH_3 + O_2 \rightarrow N_2 + H_2O$

Atom Count: 2 N; 6 H; 2 O ➔ 2 N; 2 H: 1 O
Oxygen unbalanced … try

$2\ NH_3 + O_2 \rightarrow N_2 + 2\ H_2O$

Atom Count: 2 N; 6 H; 2 O ➔ 2 N; 4 H: 2 O
Hydrogen unbalanced … try changing N in product

$4\ NH_3 + O_2 \rightarrow 2\ N_2 + 2\ H_2O$

Atom Count: 4 N; 12 H; 2 O ➔ 4 N; 4 H: 2 O
H & O unbalanced … try balancing H with water

$4\ NH_3 + O_2 \rightarrow 2\ N_2 + 6\ H_2O$

Atom Count: 4 N; 12 H; 2 O ➔ 4 N; 12 H: 6 O
Only O unbalanced …finish with O on starting side

$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

Atom Count: 4 N; 12 H; 6 O ➔ 4 N; 12 H: 6 O

Success!

Balance This Chemical Equation

$FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$

Safety Tip: SO_2 is a corrosive acid; lab precautions needed

Atom Count: 1 Fe; 2 S; 2 O ➔ 2 Fe; 1 S; 5 O

Everything unbalanced … start with iron … try

$2\ FeS_2 + O_2 \rightarrow Fe_2O_3 + 4\ SO_2$

Atom Count: 2 Fe; 4 S; 2 O ➔ 2 Fe; 4 S; 11 O
Oxygen odd & unbalanced … try another Fe on product side

$4\ FeS_2 + O_2 \rightarrow 2\ Fe_2O_3 + 4\ SO_2$

Atom Count: 4 Fe; 8 S; 2 O ➔ 4 Fe; 4 S; 14 O

Sulfur unbalanced … try to balance Sulfur

$$4\ FeS_2 + O_2 \rightarrow 2\ Fe_2O_3 + 8\ SO_2$$

Atom Count: 4 Fe; 8 S; 2 O ➔ 4 Fe; 8 S; 22 O

Only Oxygen unbalanced … finish by balancing Oxygen

$$4\ FeS_2 + 11\ O_2 \rightarrow 2\ Fe_2O_3 + 8\ SO_2$$

Atom Count: 4 Fe; 8 S; 22 O ➔ 4 Fe; 8 S; 22 O

Success!

Balance This Chemical Equation

$$\mathbf{Sb_2S_3 + HCl \rightarrow H_3SbCl_6 + H_2S}$$

Safety Tip: H_2S is toxic; lab precautions needed

Atom Count: 2 Sb; 3 S; 1 H; 1 Cl ➔ 1 Sb; 1 S; 5 H; 6 Cl

Start with Antimony & Sulfur

$$Sb_2S_3 + HCl \rightarrow 2\ H_3SbCl_6 + 3\ H_2S$$

Atom Count: 2 Sb; 3 S; 1 H; 1 Cl ➔ 2 Sb; 3 S; 12 H; 12 Cl

Hydrogen & Chlorine Balanced Together

$$Sb_2S_3 + 12\ HCl \rightarrow 2\ H_3SbCl_6 + 3\ H_2S$$

Atom Count: 2 Sb; 3 S; 12 H; 12 Cl ➔ 2 Sb; 3 S; 12 H; 12 Cl

Success!

Practice Improves Performance

Assignment

Start Taking Unit 6 Practice Test
Blackboard only records highest score
Take until multiple 100's have been scored (questions are variable)
(Gives sense of test exam format and content)

The Practice Quiz is very similar to the Unit Exam
Success on Unit exam is directly related to practice exam experiences

At this point:

Elements & polyatomic ions should be memorized