Balancing Chemical Equations

$$Fe(NO_3)_3 + NaOH \longrightarrow Fe(OH)_3 + NaNO_3$$

1. Make a list of each element in products and reactants → in same order
2. Count up each element
3. Start from left to right & balance any element that appears in the equation no more than 3 times. More than 3x leave it alone → skip. Leave diatomics & monatomics for last (O_2, Cl_2, S_8, Fe, Na)
4. "Chase the charge" → When balancing one element, and a different element is thrown off → balance the element that was thrown off next
5. For odd numbers of diatomics (O_2, Cl_2, F_2, H_2...) use a factional coefficient.

   example 3O $\quad \frac{3}{2} O_2 = 3O$

6. Clear fractional coeficients

$$Fe(NO_3)_3 + 3\,NaOH \longrightarrow Fe(OH)_3 + 3\,NaNO_3$$

Fe	1		Fe	1
N	3		N	~~1~~ 3 ✓
O	~~10~~ 12		O	~~6~~ 12
Na	~~1~~ 3		Na	~~1~~ 3
H	~~1~~ 3		H	3

* You may only change Coefficients
Never Subscripts

Combustion Problem

Diatomic → save for last

$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$

$1 + x2 = 13$

$x2 = 12$

$x = 6$

C	4	
H	10	
O	~~3~~	13

C	✓	4 ✓
H	✗	10 ✓
O	~~3~~	~~9~~ 13

$2[C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O]$

fractional coefficient not allowed

C	4	
H	10	
O	✗	13

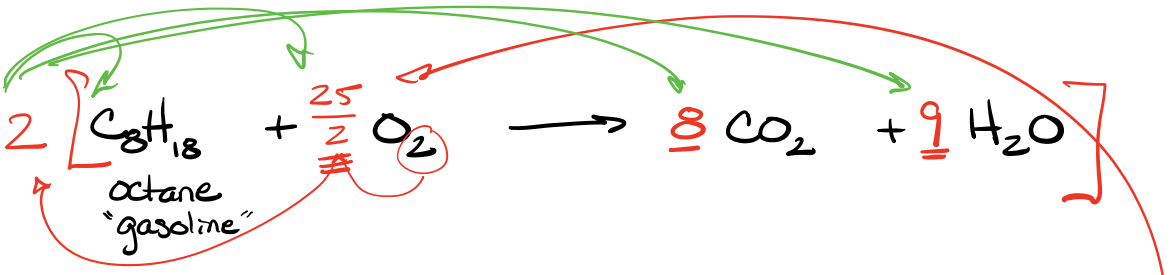
C	✓	4
H	✗	10
O	~~3~~	~~9~~ 13

Cleared fraction

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

$A = B$

$2A = 2B$

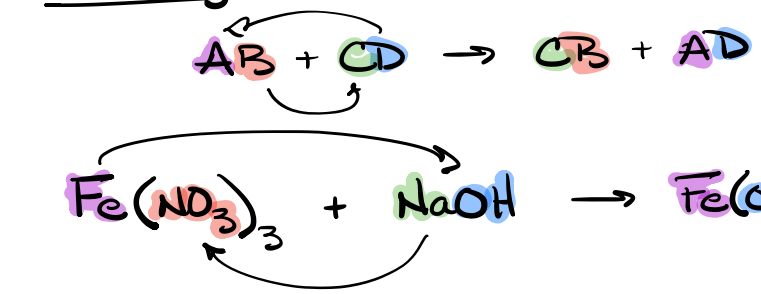


C	8	C	~~1~~ 8
H	18	H	~~2~~ 18
O	~~2~~ = 25	O	~~3~~ ~~17~~ 25 (odd #)

~~2~~ × $\frac{25}{2}$

$$2\,C_8H_{18} + 25\,O_2 \rightarrow 16\,CO_2 + 18\,H_2O$$

Balancing Double Displacement Equations



Polyatomics stay together

$$Fe(NO_3)_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaNO_3$$

Fe^{3+}	1
NO_3^-	3
Na^+	~~1~~ 3
OH^-	~~1~~ 3

Fe^{3+}	1
NO_3^-	~~1~~ 3
Na^+	~~1~~ 3
OH^-	3

$$IrBr_{3(aq)} + 3AgC_2H_3O_{2(aq)} \rightarrow 3AgBr_{(s)} + Ir(C_2H_3O_2)_3$$

~~Ir~~	Ir^{3+}	1	Ir^{3+}	1 ✓
~~Br~~	Br^-	3	Br^-	✗ 3 ✓
~~Ag~~	Ag^+	✗ 3	Ag^+	✗ 3 ✓
~~C~~	$C_2H_3O_2^-$	✗ 3	$C_2H_3O_2^-$	3 ✓
~~H~~				
~~O~~				

$$3Sn(NO_3)_{2(aq)} + 2Na_3PO_{4(aq)} \rightarrow Sn_3(PO_4)_{2(s)} + 6NaNO_{3(aq)}$$

2 (from $Sn(NO_3)_2$) × 3 (from Na_3PO_4) = 6 $NaNO_3$

1:1 Ratio

$2 \times 3 = 6$

Sn^{2+}	✗ 3		Sn^{2+}	3
NO_3^-	✗ 6		NO_3^-	1
Na^+	✗ 6		Na^+	1
PO_4^{3-}	✗ 2		PO_4^{3-}	2

If you find a problem is taking more than 4 steps do this:

$CO_2 + H_2O$

1. Recount all atoms (watch those in mult. places)
2. Recheck subscripts with problem source
3. Start over & follow balancing steps

Balancing Chemical Equations

- Stoichiometry (mass to mole conversions)
- % yield
- Limiting reagent problems

If 3.67 g of propane (C_3H_8) is combusted with excess oxygen gas, how many grams of Carbon dioxide gas will be produced?

← more oxygen than need

Combustion problem

$$C_xH_yO_z + O_2 \longrightarrow CO_2 + H_2O$$

always the same

① write unbalanced equation

$$C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$$

② balance eq

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

C	3	C	~~1~~ 3
H	8	H	~~2~~ 8
O	~~2~~ 10	O	~~3~~ ≠ 10

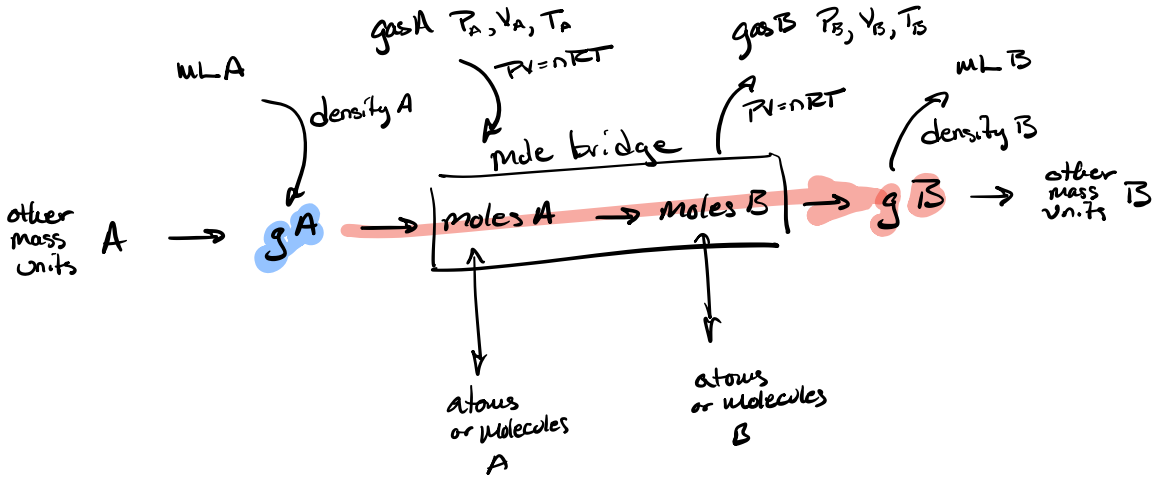
*③ use balanced equation to parce problem

$$1\,C_3H_8 + 5\,O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$$

3.67g | excess g | g ?

④ Road Map

$$g\,C_3H_8 \xrightarrow{\text{molar mass } C_3H_8} \text{moles } C_3H_8 \xrightarrow{\text{✓ coefficients in balanced eq}} \text{moles } CO_2 \xrightarrow{\text{molar mass } CO_2} g\,CO_2$$



⑤ Calculate any required equalities

C_3H_8

C $3 \times 12.01 = 36.03$

H $8 \times 1.008 = 8.064$

44.094

$44.09\ g/mol$

CO_2

C $1 \times 12.01 = 12.01$

O $2 \times 16.00 = 32.00$

$44.01\ g/mole$

⑥ write out problem

$$3.67\ g\ C_3H_8 \times \frac{1\ mole\ C_3H_8}{44.09\ g\ C_3H_8} \times \frac{3\ mole\ CO_2}{1\ mole\ C_3H_8} \times \frac{44.01\ g\ CO_2}{1\ mole\ CO_2} = 10.990022\ g\ CO_2$$

(3 sig figs; 4 sig figs; Exact; 4 sig figs)

⑦ Sig figs

11.0 g CO_2 produced

Sometimes a balancing problem can be presented in words.

Ex

Hydrogen gas is reacted with oxygen gas to produce water. Provide a balanced chemical equation for this reaction.

Hydrogen gas Oxygen gas

$H_2 + O_2 \longrightarrow H_2O$

H_2: diatomic O_2: diatomic

How do I know what is diatomic & what is not?

HOFBRINCl or BRINCLHOF

$H_2\ O_2\ F_2\ Br_2\ I_2\ N_2\ Cl_2$ $Br_2\ I_2\ N_2\ Cl_2\ H_2\ O_2\ F_2$

H_2

$N_2\ O_2\ F_2$
Cl_2
Br_2
I_2

Hydrogen gas H_2

Nitrogen gas N_2

Oxygen gas O_2

Fluorine gas F_2

Chlorine gas Cl_2

Bromine liquid Br_2

Iodine solid I_2

Hofbrincl

$2H_2 + O_2 \rightarrow 2H_2O$ ✓

H ≠ 4

O 2

H ≠ 4

O ✗ 2

Iron(III) oxide is reacted with carbon in blast furnace to produce Iron and Carbon dioxide. Write a balance chemical equation.

Fe^{3+}	O^{2-}
Fe^{3+}	O^{2-}
	O^{2-}
6+	6−

Carbon dioxide
CO_2

leave these for last

$$2\,Fe_2O_3 + 3\,C \longrightarrow 4\,Fe + 3\,CO_2$$

Fe	~~2~~ 4	Fe ~~4~~ 4 ✓
O	~~3~~ 6	O ~~2~~ 6 ✓
C	~~1~~ 3	C ~~1~~ 3 ✓