Particle model and Balancing Equations

Used to show chemical reactions have occured.

Matter is made up of atoms and molecules and is subject to change.

Counting atoms in a molecule

NaCl	3 NaCl	Na_2SO_4	2 Na_2SO_4
3 $CuSO_4$	$C_5H_{11}OH$	3 $C_5H_{11}OH$	$Ca_3(PO_4)_2$
3 $Ca_3(PO_4)_2$	$Cu(NO_3)_2$	2 $Cu(NO_3)_2$	3 NH_4Cl

Brackets

coefficients

Various symbols can be used to represent the molecules.

Na	2 Na	2 H_2	H_2SO_4
$Cu(NO_3)_2$	2 $Cu(NO_3)_2$	$Ca_3(PO_4)_2$	3 $Ca_3(PO_4)_2$

Chemical reactions can be represented by a balanced chemical equation:

$HCl + NaOH \text{ -----> } NaCl + H_2O$

$4\ Al + 3\ O_2 \Rightarrow 2\ Al_2O_3$

$Fe_2O_3 + 3\ CO \Rightarrow 2\ Fe + 3\ CO_2$

$HNO_3 + 4\ H_2 \Rightarrow NH_3 + 3\ H_2O$

Conservation of Matter (Mass)

Matter is never created or destroyed, it is just changed.

Balancing Chemical Equations: placing a coefficient before each reactant and product so that the # of atoms is equal on both sides!

Reactants: Left of equation (react together)

Product: Right of equation (result of reaction)

Rules for balancing:

1- Count the number of atoms on both sides to see what is missing!!! The **number** of each atom stays the same before and after the reaction.

2- The **type** of atoms must stay the same before and after the reaction (you cannot add new atoms or remove any)

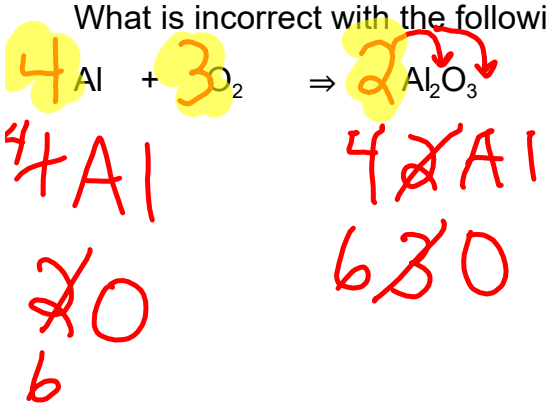
3- The **mass** of the atoms stays the same before and after the reaction.

4- Only change the **coefficients** when balancing (must be whole numbers, must be as small as possible!! SIMPLIFY)

5- **DO NOT TOUCH THE SUBSCRIPTS OF ANY ATOMS!!!**

CHECK by counting atoms on both sides to make sure they are equal!!!

What is incorrect with the following equation?



Balancing equations

1. $4\,P + 5\,O_2 \rightarrow P_2O_5$

4P

2. $H_2 + O_2 \rightarrow H_2O$

3. $P + Cl_2 \rightarrow PCl_3$

4. $P + O_2 \rightarrow P_2O_5$

5. $N_2 + O_2 \rightarrow N_2O_5$

6. $Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + CO_2$

7. $2\,KOH + H_2SO_4 \rightarrow K_2SO_4 + H_2O$

8. $NH_3 + Cl_2 \rightarrow HCl + N_2$

9. $NaOH \rightarrow Na + O_2 + H_2O$

10. $FeS + O_2 \rightarrow Fe_2O_3 + SO_2$

11. $HCl + Fe \rightarrow FeCl_2 + H_2$

12. $Na + H_2O \rightarrow NaOH + H_2$

13. $H_2SO_4 + S \rightarrow SO_2 + H_2O$

14. $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$

15. $HNO_3 + H_2 \rightarrow NH_3 + H_2O$

16. $FeCl_3 + NH_4OH \rightarrow Fe(OH)_3 + NH_4Cl$

17. $H_2SO_4 + C \rightarrow CO_2 + H_2O + SO_2$

1. $4P + 5O_2 \rightarrow 2P_2O_5$

4 1P 4 2P

10 2O 10 5O

2. $2H_2 + O_2 \rightarrow 2H_2O$

4 2H 4 2H

2 O 2 1O

3. $2P + 3Cl_2 \rightarrow 2PCl_3$

2 1P 2 1P

6 2Cl 6 3Cl

4. $2N_2 + 5O_2 \rightarrow 2N_2O_5$

4 2N 4 2N

10 2O 10 5O

5. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

2 Fe
6 O
3 C

2 Fe
6 O
3 C

6. $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

2 K
6 O
4 H
1 S

2 K
6 O
4 H
1 S

7. $2NH_3 + 3Cl_2 \rightarrow 6HCl + N_2$

2 N
6 H
6 Cl

2 N
6 H
6 Cl

8. $4NaOH \rightarrow 4Na + O_2 + 2H_2O$

4 Na
4 O
4 H

4 Na
4 O
4 H

9. $4FeS + 7O_2 \rightarrow 2Fe_2O_3 + 4SO_2$

4 2 1 Fe
4 2 1 S
14 10 2 O

4 2 Fe
4 2 1 S
14 10 3 O

10. $2HCl + Fe \rightarrow FeCl_2 + H_2$

2 1 H
2 1 Cl
1 Fe

2 H
2 Cl
1 Fe

11. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

2 Na
4 H
2 O

2 Na
4 H
2 O

12. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

16 C
36 H
50 O

16 C
36 H
50 O

13. $HNO_3 + 4H_2 \rightarrow NH_3 + 3H_2O$

9 H
1 N
3 O

9 H
1 N
3 O

14. $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl$

1 Fe
3 Cl
3 N
3 O
15 H

1 Fe
3 Cl
3 N
3 O
15 H

15. $H_2SO_4 + C \rightarrow CO_2 + H_2O + SO_2$

Mass of Equations

1. You combined 80 g of 2 KOH with 100 g of H_2SO_4 to produce 120 g of K_2SO_4 and 2 H_2O. How much water was produced?

$2\,KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

$80g + 100g \quad 120g + x$

$180 \quad x = 60g$

2. You combined 160 g of 2 H_2 with O_2 and produced 197 g of 2 H_2O. How much O_2 was produced?

$2H_2 + O_2 \rightarrow 2H_2O$

$160g + x = 197g$

$x = 37g$

3. You combined 25 g of C_3H_8 with 5 O_2 to produce 37 g of 3 CO_2 and 30 g of 4 H_2O. How much O_2 was produced?

$C_3H_8 + 5O_2 = 3CO_2 + 4H_2O$

$25g \quad x \quad 37g \quad 30g$

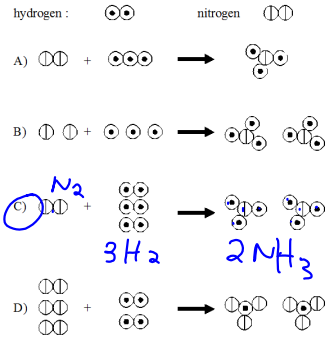
$x = 42g \quad 67g$

Past Exam Questions

1. One litre of nitrogen (N_2) reacts with three litres of hydrogen (H_2) to produce two litres of ammonia, according to the following equation :

$$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$$

Which of the following models best describes the chemical change that occurs?

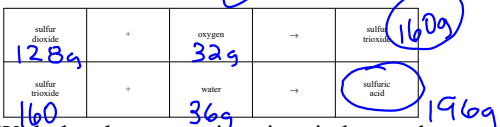


2. Which of the following chemical equations are correctly balanced?

1. $4\ Bi_{(s)} + 3\ O_{2(g)} \rightarrow 2\ Bi_2O_{3(s)}$
2. $2\ Bi_{(s)} + 3\ Cl_{2(g)} \rightarrow 2\ BiCl_{3(s)}$
3. $2\ Bi_2S_{3(s)} + 9\ O_{2(g)} \rightarrow 2\ BiO_{3(s)} + 6\ SO_{2(g)}$
4. $Bi_2O_{3(s)} + 3\ C_{(s)} \rightarrow 2\ Bi_{(s)} + 3\ CO_{(g)}$
5. $As_2O_{3(s)} + 6\ H_{2(g)} \rightarrow 2\ AsH_{3(s)} + 3\ H_2O_{(g)}$

A) 1, 3 and 4 C) 3, 4 and 5
B) 1, 4 and 5 D) 2 and 3

3. One of the causes of acid rain is the sulfur released when fossil fuels such as coal and oil are burned. The following two reactions take place when these fuels are burned:



With the above reactions in mind, a student combined 128 g of sulfur dioxide with 32 g of oxygen to produce sulfur trioxide. He then combined all the resulting sulfur trioxide with 36 g of water to produce sulfuric acid. What mass of sulfuric acid did he produce?

4. The Iron and Steel Company uses a chemical reaction to transform ferric oxide (rust) into iron. The balanced equation for this reaction is as follows:

$$2\ Fe_2O_{3(s)} + 3\ C_{(s)} + \text{energy} \rightarrow 4\ Fe_{(s)} + 3\ CO_{2(g)}$$

To determine how much CO_2 it emits, the company took a sample and obtained the data presented in the table below

Masses of the four Substances before and after the reaction

Substance	Initial Mass (g)	Final Mass (g)
Fe_2O_3	80	0
C	9	0
Fe	0	55
CO_2	0	?

Using the law of conservation of matter, calculate the mass of CO_2 emitted during this reaction.