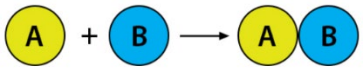
Combination reactions

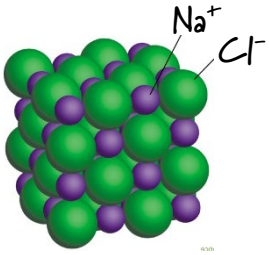
A combination reaction is a reaction in which two reactants combine to form one product. Oxygen and the halogens (fluorine, chlorine, bromine) are very reactive elements and are likely to undergo combination reactions with other elements.

A + B → AB



Examples

One combination reaction is two elements combining to form a compound.



Solid sodium metal reacts with chlorine gas to produce solid sodium chloride.

$$2Na(s)+Cl_2(g) \rightarrow 2NaCl(s)$$

Combination reactions can also take place when an element and a compound react to form a new compound composed of a larger number of atoms.

Oxygen reacts with carbon monoxide to form carbon dioxide.

$$O_2(g) + 2CO(g) \rightarrow 2CO_2(g)$$

Combination reactions can also take place when two compounds react to form a new compound composed of a larger number of atoms.

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$$

Combination reaction	element + element	element + compound	compound + compound
$2Fe(s) + O_2(g) \rightarrow 2FeO(s)$	✓		
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$			
$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$			
$4K(s) + 2O_2(g) \rightarrow 2K_2O(s)$			
$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$			
$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$			
$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$			
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$			

Combination reaction	element + element	element + compound	compound + compound
$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$			
$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$			
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$			
$Fe(s) + S(s) \rightarrow FeS(s)$			
$CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$			
$S(s) + O_2(g) \rightarrow SO_2(g)$			
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$			
$C(s) + O_2(g) \rightarrow CO_2(g)$			

Sometimes the same reaction can be classified in several ways. E.g. $C(s)+O_2(g) \rightarrow CO_2(g)$

This reaction could be called (1) combination (2) combustion (as the C is burning in oxygen) and (3) redox (not assessed in this Achievement Standard).

Some everyday examples of combination reactions

Sulfur trioxide gas reacts with water to form sulfuric acid. This is a reaction that occurs in the atmosphere in some places where oxides of sulfur are present as pollutants. The acid formed in the reaction falls to the ground as acid rain. $SO_3(g)+H_2O(l) \rightarrow H_2SO_4(aq)$

Ammonia gas has a variety of uses in our lives such manufacture of dye products, as a refrigerant gas, and also in the manufacture of explosives. Most farming also relies on ammonia for fertilisers. The following combination reaction of nitrogen gas and hydrogen gas can be used to produce ammonia gas. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Rusting of iron is actually quite complicated. A simple balanced equation for the rusting reaction is $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$.

Rusting occurs when iron is exposed to oxygen *and* water, which forms a reddish-brown substance on the surface of the metal. Technically, rust is a hydrated iron(III) oxide whose chemical formula is $Fe_2O_3.xH_2O$. There is an x here because there are a variety of different hydrated iron(III) oxides that can form.

iron + oxygen + water → hydrated iron(III) oxide.

$4Fe + 3O_2 + xH_2O \rightarrow 2Fe_2O_3.xH_2O$.

Test yourself.

1. What are combination reactions?

2. Write the product of the following reaction:
   $Ca(s) + Cl_2(g) \rightarrow$ ..... (The ions formed are Ca^{2+} and Cl^-).

3. A component of smog is nitrogen dioxide, a toxic gas with a sharp odour. Nitrogen dioxide can irritate the eyes and throat and trigger asthma attacks. It forms when nitrogen monoxide, from sources such as car exhausts, reacts with oxygen in the air.

   $$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

   Does this reaction demonstrate **conservation of mass**? Explain your answer.

4. The equation for the rusting of iron is complicated. One website has the following equation for the reaction:

   $$4Fe(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Fe(OH)_3(s).$$

   Is this a **combination** reaction? Explain your answer.

5. $CH_4(g) + 2O_2(g) \rightarrow 2H_2O(l) + CO_2(g)$

   Is this a **combination** reaction? Explain your answer.