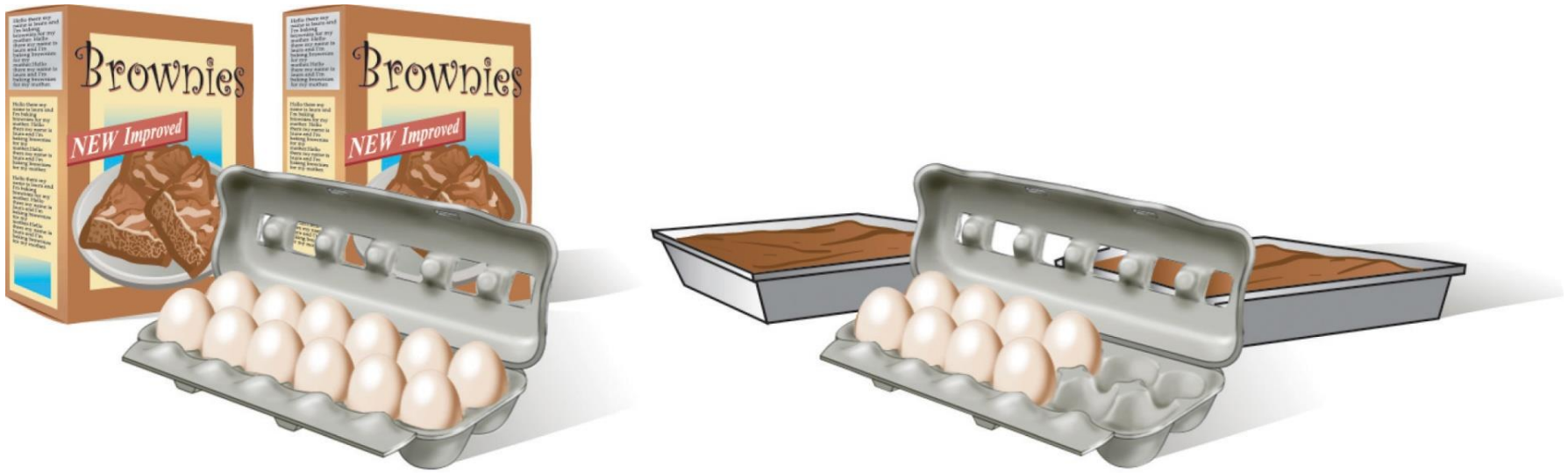
Limiting Reagents



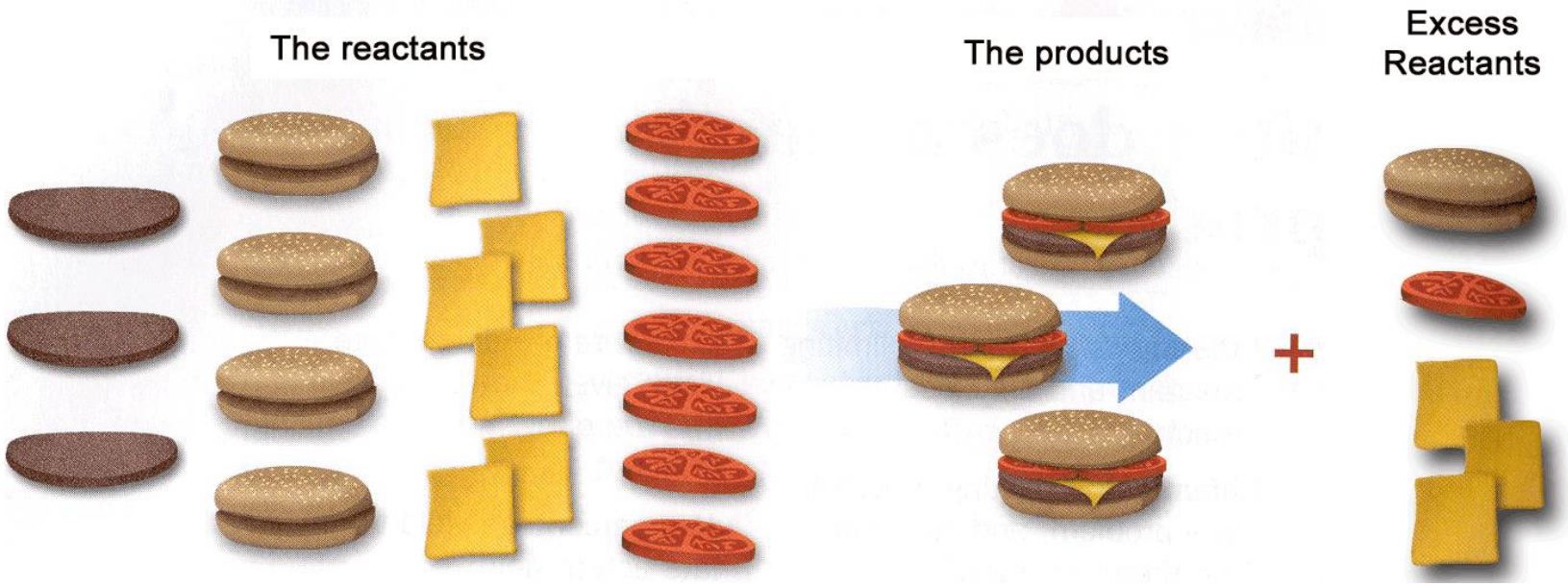
Outcome:

- Identify the limiting reactant and calculate the mass of a product, given the ratio of products to reactants.
- Perform a lab involving stoichiometry, identifying the limiting reactant, and calculating the mole ratio.

Limiting Reagents (reactants)

A **LIMITING REACTANT *(*REAGENT*)*** is a reactant that **LIMITS** the **FINAL YIELD** of **PRODUCTS** because it is **USED UP** before the other reactant(s).

→ It is the reactant that is **USED UP FIRST**.



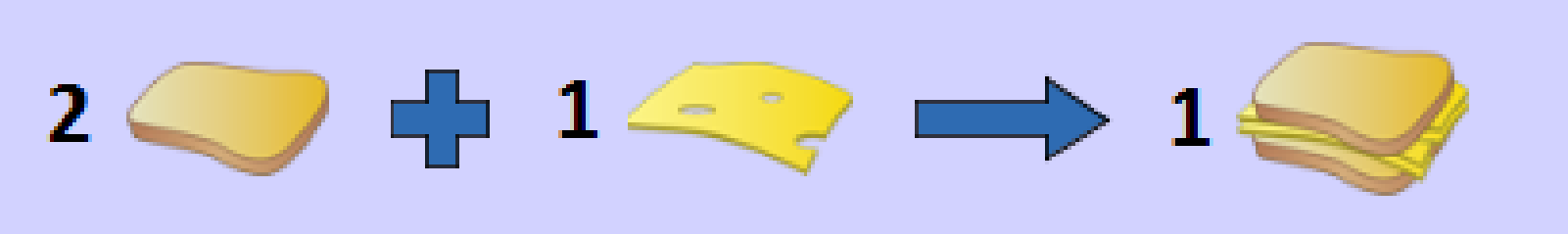
https://phet.colorado.edu/en/simulation/reactants-products-and-leftovers

Most chemical reactions proceed **UNTIL** the **LIMITING REACTANT** is **CONSUMED**. Once consumed, the reaction will **STOP**. All other reactants are said to be in **EXCESS*.***

Limiting Reagents (reactants)

Example:

It takes 2 **SLICES** of **BREAD** and 1 **KRAFT SINGLE** to make a **GRILLED CHEESE** sandwich.



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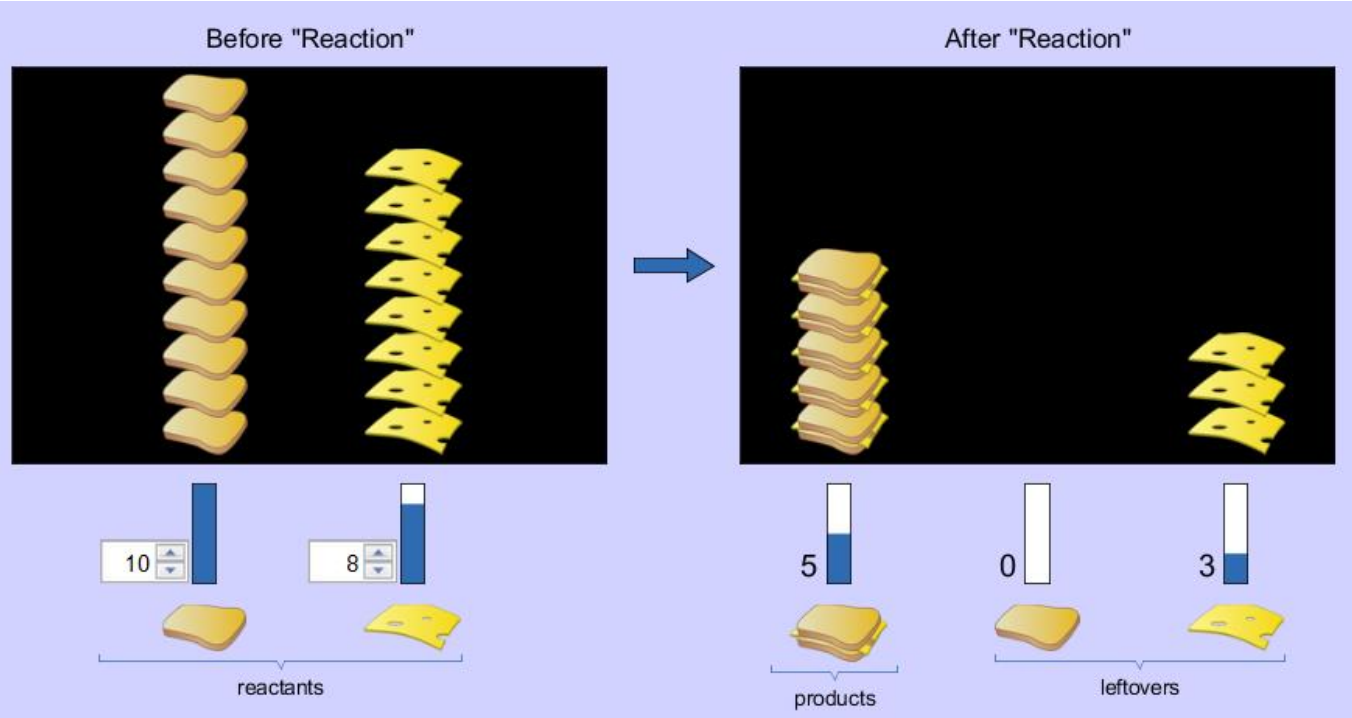
If you have 8 **SINGLES** and 10 **SLICES** of **BREAD**, how many **SANDWICHES** can be made?

Lets check it out...

Limiting Reagents (reactants)



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Which reactant is limiting?

→ The **BREAD!!!** (enough **CHEESE** for **8** sandwiches, but only **BREAD** for **5**)

How much excess reactant is there?

→ You will be left with **3** slices of **CHEESE**

Limiting Reagents (reactants)

Steps to solving limiting reactant problems:

1. Write the **BALANCED EQUATION**.
2. Change the **QUANTITIES** of **REACTANTS** to **MOLES**.
3. **DETERMINE** which reactant is **LIMITING**, using the **MOLAR RATIO** of the **REACTANTS**.
4. Use the **MOLES** of **LIMITING REAGENT** to **DETERMINE** the **MOLES** of **PRODUCT** required.
5. **CONVERT MOLES** of product to the **REQUIRED UNITS**.

Limiting Reagents (reactants)

Examples:

1. Ammonia gas combines with HCl to produce ammonium chloride. If 1.00g of ammonia is mixed with 1.00g HCl. Calculate the mass of NH_4Cl produced.

NH_4^+ Cl^-

$NH_3 + HCl \longrightarrow NH_4Cl$

$1.00\,g\ NH_3 \times \frac{1\,mol}{17.03\,g} = 0.06\,mol\ NH_3 \times \frac{1\ mol\ HCl}{1\ mol\ NH_3} = 0.06\,mol\ HCl$ (NEED)

$1.00\,g\ HCl \times \frac{1\,mol}{36.5\,g} = 0.03\,mol\ HCl$ (HAVE)

$\therefore$ HCl is L.R.

$0.03\,mol\ HCl \times \frac{1\ mol\ NH_4Cl}{1\ mol\ HCl} = 0.03\,mol\ NH_4Cl \times \frac{53.54\,g}{1\,mol} = 1.6\,g\ NH_4Cl$

Limiting Reagents (reactants)

Examples:

2. Calcium metal burns in oxygen gas to give calcium oxide. Calculate the mass of calcium oxide that will be formed when 0.48g of calcium is burned in ~~0.32g oxygen~~.

Ca^{2+} O^{2-}

excess O_2

$$2Ca + O_2 \rightarrow 2CaO$$

$$0.48\,g\,Ca \times \frac{1\,mol}{40.1\,g} = 0.01\,mol\,Ca \times \frac{1\,mol\,O_2}{2\,mol\,Ca} = 0.005\,mol\,O_2$$

Need

$$0.32\,g\,O_2 \times \frac{1\,mol}{32\,g} = 0.01\,mol\,O_2$$

HAVE

$\therefore O_2$ is excess

Ca is L.R.

$$0.01\,mol\,Ca \times \frac{2\,mol\,CaO}{2\,mol\,Ca} = 0.01\,mol\,CaO \times \frac{56.1\,g}{1\,mol} = 0.561\,g\,CaO$$

Limiting Reagents (reactants)

Try these ones…

1. Sodium metal reacts violently with chlorine gas to produce sodium chloride. What mass of NaCl would result from the reaction of 0.460g of sodium with 0.426g of chlorine?

excess

0.702g

$2Na + 1Cl_2 \rightarrow 2NaCl$

Have

$0.46g\ Na \times \frac{1mol}{23g} = 0.02\ mol\ Na$

Need

$0.02\ mol\ Na \times \frac{1mol\ Cl_2}{2mol\ Na} = 0.01\ mol\ Cl_2$

$0.426g\ Cl_2 \times \frac{1mol}{71g} = 0.006\ mol\ Cl_2$

$\therefore Cl_2$ is limiting

$0.006\ mol\ Cl_2 \times \frac{2mol\ NaCl}{1mol\ Cl_2} = 0.012\ mol\ NaCl \times \frac{58.5g}{1mol} = 0.702g\ NaCl$

Limiting Reagents (reactants)

Try these ones…

2. If 40.0g of H_3PO_4 reacts with ~~60.0~~ excess g of $MgCO_3$ to produce $Mg_3(PO_4)_2$, carbon dioxide, and water. Calculate the volume of CO_2 produced. 13.8L CO_2

$2\,H_3PO_4 + 3\,MgCO_3 \rightarrow Mg_3(PO_4)_2 + 3CO_2 + 3H_2O$

$40.0\,g\,H_3PO_4 \times \frac{1\,mol}{98.03\,g} = 0.41\,mol\,H_3PO_4$ (Have)

$60.0\,g\,MgCO_3 \times \frac{1\,mol}{84.3\,g} = 0.71\,mol\,MgCO_3$

$0.41\,mol\,H_3PO_4 \times \frac{3\,mol\,MgCO_3}{2\,mol\,H_3PO_4} = 0.615\,mol\,MgCO_3$ (Need)

∴ $MgCO_3$ is excess, H_3PO_4 is L.R.

$0.41\,mol\,H_3PO_4 \times \frac{3\,mol\,CO_2}{2\,mol\,H_3PO_4} = 0.615\,mol\,CO_2 \times \frac{22.4\,L}{1\,mol} = 13.8\,L\,CO_2$