Stoichiometry Examples

Moles to Moles

Calculate the number of moles of carbon dioxide formed when 40.0 mol of oxygen is consumed in the burning of propane.

Step 1: Write out complete chemical equation. Be sure to balance.

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

Step 2: Identify your molar ratio

$3\ CO_2 / 5\ O_2$

Step 3: Convert moles using molar ratio.

$$40.0 \text{ mol } O_2 \times \frac{3 \text{ mol } CO_2}{5 \text{ mol } O_2} = 24.0 \text{ mol } CO_2$$

Step 4: Summary

Therefore 24.0 mol of carbon dioxide are required to react with 40.0 mol of oxygen.

Mass to Moles

Iron reacts with superheated steam to form hydrogen gas and the oxide Fe_3O_4.
Calculate the number moles of hydrogen produced by 10.0 g of iron and enough steam.

$3\ Fe(s) + 4\ H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

10.0 g ?

Convert mass of iron to moles of iron:

$$10.0 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g}} = 0.179 \text{ mol Fe}$$

Convert moles iron to moles hydrogen gas:

$$0.179 \text{ mol Fe} \times \frac{4 \text{ mol } H_2}{3 \text{ mol Fe}} = 0.239 \text{ mol } H_2$$

Therefore 0.239 mol of H_2 is produced from 10.0 g of iron and steam.

Mass to Mass

Iron(III) oxide, also known as rust, can be removed from iron by reacting it with hydrochloric acid to produce iron(III) chloride and water.

$Fe_2O_3(s)$ 6HCl(aq) . $2FeCl_3(aq)$ $3H_2O(l)$

What mass of hydrogen chloride is required to react with 100 g of rust?

Convert from mass to moles:

$$100 \text{ g Fe2O3} \times \frac{1 \text{ mol } Fe_2O_3}{159.7 \text{ g } Fe_2O_3} = 0.0626 \text{ mol } Fe_2O_3$$

Convert moles of Fe_2O_3 to moles of hydrogen chloride:

$$0.0626 \text{ mol } Fe_2O_3 \times \frac{6 \text{ mol HCl}}{1 \text{ mol } Fe_2O_3} = 3.756 \text{ mol HCl}$$

Convert moles of HCl to mass of HCl:

$$3.756 \text{ mol HCl} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 137 \text{ g HCl}$$

OR

$$100 \text{ g } Fe_2O_3 \times \frac{1 \text{ mol } Fe_2O_3}{159.7 \text{ g } Fe_2O_3} \times \frac{6 \text{ mol HCl}}{1 \text{ mol } Fe_2O_3} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 137 \text{ g HCl}$$

Limiting Reagent

Calculate the number of grams of solid aluminum chloride that will form when a mixture containing 0.150 g of aluminum powder and 1.00 g of chlorine gas is allowed to react.

$2\ Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$

0.150g 1.00g ?

Convert known masses to moles:

$$0.150\ g\ Al \times \frac{1\ mol\ Al}{26.98g\ Al} = 0.00556\ mol\ Al$$

How much Cl_2 would be required?

$$0.00556\ mol\ Al \times \frac{3\ mol\ Cl_2}{2\ mol\ Al} = 0.00834\ mol\ Cl_2$$

How much do I actually have?

$$1.00\ g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.90g\ Cl_2} = 0.0141\ mol\ Cl_2$$

I have a lot more chlorine available than I need, thus Cl_2 is the limiting reactant. I must use the mass of Al to finish my calculation.

Convert moles of Al to moles of $AlCl_3$ to mass of $AlCl_3$:

$$0.00556\ mol\ Al \times \frac{2\ mol\ AlCl_3}{2\ mol\ Al} \times \frac{133.3\ g\ AlCl_3}{1\ mol\ AlCl_3} = 0.741\ g\ AlCl_3$$

Therefore 0.150 g of Al and 1.00 g of Cl_2 will form 0.741 g of $AlCl_3$.