- oxidation and reduction always occur together. In other words, we can't just make free electrons using oxidation without giving them somewhere to go.

- Many of the types of reactions that you might have heard of before are actually redox reactions!

- SINGLE REPLACEMENT reactions

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

$$Cu \rightarrow Cu^{2+} + 2e^-$$ oxidation

$$2Ag^+ + 2e^- \rightarrow 2Ag(s)$$ reduction

net ionic $\rightarrow$ $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

- COMBUSTION reactions (burning)

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

$$2Mg(s) \rightarrow 2Mg^{2+} + 4e^-$$ oxidation

$$O_2(g) + 4e^- \rightarrow 2O^{2-}$$ reduction

REDOX LANGUAGE

"oxidizer"

- "Oxidation" is loss of electrons, but an OXIDIZING AGENT is something that causes ANOTHER substance to lose electrons. An oxidizing agent is itself reduced during a redox reaction.

- "Reduction" is gain of electrons, but a REDUCING AGENT is something that causes ANOTHER substace to gain electrons. Reducing agents are themselves oxidized during a redox reaction.

$$2\overset{0}{Al}(s) + 3\overset{0}{Br_2}(l) \longrightarrow 2\overset{+3}{Al}\overset{-1}{Br_3}(s)$$

Aluminum is OXIDIZED during this process. We say that metallic aluminum is a REDUCING AGENT!

Bromine is REDUCED during this process. We say that bromine is an OXIDIZING AGENT!

* Strong oxidizers (oxidizing agents) can cause spontaneous fires if placed into contact with combustibles (safety issue!).

* Reactive metals tend to be REDUCING AGENTS, while oxygen-rich ions like NITRATES tend to be OXIDIZING AGENTS. HALOGENS (Group VIIA) also tend to be OXIDIZING AGENTS

CHEMICAL CALCULATIONS - RELATING MASS AND ATOMS

$$\_\_ Na_2CO_3 + \underline{2} HCl \rightarrow \_\_ H_2O + \_\_ CO_2 + \underline{2} NaCl$$

Chemical equations are written and balanced in terms of ATOMS and MOLECULES

- While chemical equations are written in terms of ATOMS and MOLECULES, that's NOT how we often measure substances in lab!

- measurements are usually MASS (and sometimes VOLUME), NOT number of atoms or molecules!

CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- Chemical reactions proceed on an ATOMIC basis, NOT a mass basis!

- To calculate with chemical reactions (i.e. use chemical equations), we need everything in terms of ATOMS ... which means MOLES of atoms

$$2\,Al(s) + 3\,Br_2(l) \rightarrow 2\,AlBr_3(s)$$

coefficients are in terms of atoms and molecules!

2 atoms Al = 3 molecules Br_2 = 2 formula units $AlBr_3$

2 mol Al = 3 mol Br_2 = 2 mol $AlBr_3$

- To do chemical calculations, we need to:
  - Relate the amount of substance we know (mass or volume) to a number of moles
  - Relate the moles of one substance to the moles of another using the equation
  - Convert the moles of the new substance to mass or volume as desired

$$2Al(s) + 3Br_2(l) \longrightarrow 2AlBr_3(s)$$

* Given that we have 25.0 g of liquid bromine, how many grams of aluminum would we need to react away all of the bromine?

(1) Convert grams of bromine to moles: Need formula weight Br_2: $2 \times 79.90 = 159.80$

$159.80\ g\ Br_2 = mol\ Br_2$

$$25.0\ g\ Br_2 \times \frac{mol\ Br_2}{159.80\ g\ Br_2} = 0.15645\ mol\ Br_2$$

(2) Use the chemical equation to relate moles of bromine to moles of aluminum

$2\ mol\ Al = 3\ mol\ Br_2$

$$0.15645\ mol\ Br_2 \times \frac{2\ mol\ Al}{3\ mol\ Br_2} = 0.10430\ mol\ Al$$

(3) Convert moles aluminum to mass: Need formula weight Al: 26.98

$26.98\ g\ Al = mol\ Al$

$$0.10430\ mol\ Al \times \frac{26.98\ g\ Al}{mol\ Al} = \boxed{2.81\ g\ Al}$$

You can combine all three steps on one line if you like!

① $154.80\,g\ Br_2 = mol\ Br_2$ ② $2\ mol\ Al = 3\ mol\ Br_2$ ③ $26.98\,g\ Al = mol\ Al$

$$25.0\,g\ Br_2 \times \frac{mol\ Br_2}{154.80\,g\ Br_2} \times \frac{2\ mol\ Al}{3\ mol\ Br_2} \times \frac{26.98\,g\ Al}{mol\ Al} = 2.81\,g\ Al$$

(① ② ③)

Things we can do:

If we have ...	... and we need ...	Use ...
MASS	MOLES	FORMULA WEIGHT
SOLUTION VOLUME	MOLES	MOLAR CONCETRATION (MOLARITY)
MOLES OF A	MOLES OF B	BALANCED CHEMICAL EQUATION

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

---

1 - Convert 25.0 grams sodium carbonate to moles. Use FORMULA WEIGHT.
2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION.
3 - Convert moles HCl to volume HCl solution. Use MOLARITY (6.00 M)

---

(1) Na_2CO_3 - Na: 2 x 22.99
C: 1 x 12.01
O: 3 x 16.00

105.99 g Na_2CO_3 = mol Na_2CO_3

$$25.0\,g\,Na_2CO_3 \times \frac{mol\,Na_2CO_3}{105.99\,g\,Na_2CO_3} = 0.2358713086\,mol\,Na_2CO_3$$

---

(2) 2 mol HCl = mol Na_2CO_3

$$0.2358713086\,mol\,Na_2CO_3 \times \frac{2\,mol\,HCl}{mol\,Na_2CO_3} = 0.4717426172\,mol\,HCl$$

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

1 - Convert 25.0 grams sodium carbonate to moles. Use FORMULA WEIGHT.
2 - Convert moles sodium carbonate to moles HCl. Use CHEMICAL EQUATION.
3 - Convert moles HCl to volume HCl solution. Use MOLARITY (6.00 M)

(3) 6.00 mol HCl = L

$$0.4717426172 \text{ mol HCl} \times \frac{L}{6.00 \text{ mol HCl}} = 0.0786 \text{ L of } 6.00 \text{ M HCl}$$

We need to convert the answer's units to mL because we were asked for a specific unit!

$mL = 10^{-3} L$

$$0.0786 \text{ L} \times \frac{mL}{10^{-3} L} = \boxed{78.6 \text{ mL of } 6.00 \text{ M HCl}}$$

42.081 g/mol $\qquad\qquad$ 53.064 g/mol

$$4\,C_3H_6 + 6\,NO \longrightarrow 4\,C_3H_3N + 6\,H_2O + N_2$$

propylene $\qquad\qquad$ acrylonitrile

Calculate how many grams of acrylonitrile could be obtained from 651 g of propylene, assuming there is excess NO present.

---

1 - Convert 651 grams of propylene to moles. Use FORMULA WEIGHT.
2 - Covnert moles propylene to moles acrylonitrile. Use CHEMICAL EQUATION.
3 - Convert moles acrylonitrile to grams. Use FORMULA WEIGHT.

---

(1) $42.081\text{ g } C_3H_6 = \text{mol } C_3H_6$ (2) $4\text{ mol } C_3H_6 = 4\text{ mol } C_3H_3N$

(3) $53.064\text{ g } C_3H_3N = \text{mol } C_3H_3N$

$$651\text{ g } C_3H_6 \times \underbrace{\frac{\text{mol } C_3H_6}{42.081\text{ g } C_3H_6}}_{(1)} \times \underbrace{\frac{4\text{ mol } C_3H_3N}{4\text{ mol } C_3H_6}}_{(2)} \times \underbrace{\frac{53.064\text{ g } C_3H_3N}{\text{mol } C_3H_3N}}_{(3)} = \boxed{821\text{ g } C_3H_3N}$$