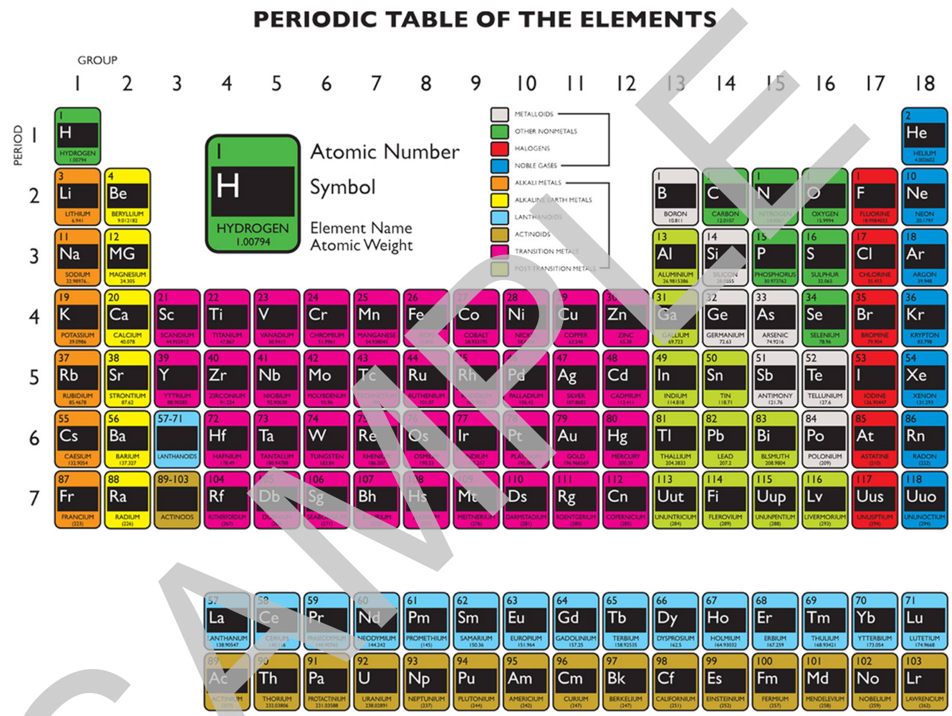
UIL CHEMISTRY CONCEPTS



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For High School

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CHEMISTRY BASICS

The material covered in this section contains the basic calculations, formulas and equations you need to be comfortable with. Sometimes you might be asked to perform these skills directly or they may be the first step in solving the question. For example, on an Invitational test, you might be asked to choose a correct formula/name combination or balance an equation. On a District test you might have a limiting reactant problem but you must first write and balance the equation. A Regional test could require predicting the products and putting the reaction in net ionic form. In other words, the stuff in this section gets you to a lot of places. Learn it well.

You will find discussion of these topics:

- Calculations using dimensional analysis
- Formulas and nomenclature
- Equations
- Mole conversions
- Stoichiometry
- Empirical and molecular formulas
- Limiting reactants
- Electron configurations and Lewis structures
- Molecular Geometry
- Gas laws
- Solutions

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Calculations

I suggest **dimensional analysis** methods for use on all calculations. As scary as the name sounds, it just means that when you manipulate numbers in chemistry you also manipulate the units attached to them. Your goal is to arrange the terms (number/unit combination) so that you cancel out the units you don't want and end up with the unit asked for. Clear as mud? We'll look at a few examples, but first we need some other bits of information—conversion factors. These are number/unit combinations that get us from one measurement to another. Like 60 min = 1 hour or 1 mole = 22.4 L. You will find the conversion factors in your FlipCards.

<u>Example 1</u>

How far can light travel in one year?

- Gather all the conversion factors you'll need that include distance (how far) and time (year) and that pertain to light.
  Speed of light, c = 3.00×10^8 m/s
  1 year = 365 days
  1 day = 24 hours
  1 hour = 3600 sec

- Place your starting number (1 year) on the **magic grid** (see below) and place the other conversion factors on the grid, canceling as you go. Your required units (in

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Type of Reaction	Description	Form	Example
Double replacement	Cations from both compounds trade places	AB + CD → AD + CB	$AgNO_3$ + LiBr → AgBr + $LiNO_3$
Single replacement	Cation trades places with the free element	A + BC → B + AC	Mg + $FeCl_3$ → Fe + $MgCl_2$
Anhydrides	Element or a compound reacts with water	Nonmet. oxide + H_2O → Acid Met. oxide + H_2O → Base	CO_2 + H_2O → H_2CO_3 Na_2O + H_2O →NaOH
Addition	2 elements combine to make a compound OR 2 compounds combine to make a new compound	A + B → AB AB + CB → CAB	Li + N_2 → Li_3N SO_2 + CaO → $CaSO_3$
Decomposition	1 compound breaks down into its elements or an element and a simpler compound	AB → A + B AB → AB + B ABC → AC + AB	2NaCl → 2Na + Cl_2 H_2O_2 → H_2O + O_2 $MgCO_3$ → MgO + CO_2
Acid-Base	Strong acid and base neutralize each other to form a salt and water	HA + BOH → BA + H_2O	HCl + NaOH → NaCl + H_2O

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Moles

The mole (Avogadro's number) is arguably THE most important number in Chemistry. Students should know: "When in doubt, change it to moles." If you consider the mole as the hub of a wheel, the spokes represent all the different chemical quantities you can get to. For basic mole conversions, you need these conversion factors (which are in your FlipCards):

Moles to particles

A particle could be an atom, an ion, a molecule, or a formula unit. It could even be dogs, pencils or roses. In that respect, a mole is no different than a dozen.

$$1 \text{ mol} = 6.02 \times 10^{23} \text{ particles}$$

**mol is the abbreviation for mole. (Leave it to chemists to shorten a four letter word to a three letter symbol!)

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You know the drill—time to try it.

What mass of Cu_2S is produced when 80.0g of Cu reacts with 25.0 g of S according to the following balanced equation?

$$16\ Cu\ (s) + S_8\ (s) \rightarrow 8\ Cu_2S\ (s)$$

Step 1 – The equation is balanced.

Step 2 –

$$\left(\frac{80.0\ \cancel{g\ Cu}}{1}\right)\left(\frac{1\ \cancel{mol\ Cu}}{64\ \cancel{g\ Cu}}\right)\left(\frac{8\ mol\ Cu_2S}{16\ \cancel{mol\ Cu}}\right) = 0.625\ mol\ Cu_2S$$

$$\left(\frac{25.0\ \cancel{g\ S_8}}{1}\right)\left(\frac{1\ mol\ S_8}{256\ \cancel{g\ S_8}}\right)\left(\frac{8\ mol\ Cu_2S}{1\ \cancel{mol\ S_8}}\right) = 0.781\ mol\ Cu_2S$$

Step 3 – Since Cu makes the least number of moles of product, it is the limiting reactant and will be used to solve the problem. Start with the moles of product made from your limiting reactant and then change it to grams:

$$\left(\frac{.625\ \cancel{mol\ Cu_2S}}{1}\right)\left(\frac{160\ g\ Cu_2S}{1\ \cancel{mol\ Cu_2S}}\right) = 100\ Cu_2S$$

What if they want to know how much of the excess reactant is left over? Simple subtraction should take care of it, right? The amount you start with minus the amount used in the reaction should equal the amount left over. So, we have to find the amount used before we can subtract. Again, start with the limiting reactant:

$$\left(\frac{80\ \cancel{g\ Cu}}{1}\right)\left(\frac{1\ \cancel{mol\ Cu}}{64\ \cancel{g\ Cu}}\right)\left(\frac{1\ \cancel{mol\ S_8}}{16\ \cancel{mol\ Cu}}\right)\left(\frac{256\ g\ S_8}{1\ \cancel{mol\ S_8}}\right) = 20\ g\ S_8$$

Now, you can subtract.

25 g S_8 that you started with – 20 g S_8 used in the reaction = 5 g S_8 left

When you determined the amount of product that could be produced from the limiting reactant, you determined the theoretical yield. This is the amount that could be produced if conditions were perfect and the reaction was 100% efficient—not a likely scenario. What is actually produced in a reaction is called the actual yield (aren't chemists creative?). Comparing the actual to the theoretical yield is called percent yield.

You would be given the actual yield in the problem. In the problem we've been working with, the actual yield of Cu_2S was 195 g. Let's find the % yield:

$$\frac{195\ \cancel{g\ Cu_2S}\ (\text{actual yield})}{240\ \cancel{g\ Cu_2}\ (\text{theoretical yield})}\ x\ 100 = 81\%\ \text{yield}$$

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The electron configuration of chromium looks like this: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

Lewis structures are diagrams of molecules. They give us an idea of the three dimensional structure of the molecule. You need to be able to draw these and describe their geometry and hybridization based on that diagram. Lewis structures can also help you decide if a molecule is polar or not.

First, things first. How do you draw these things?

Step 1 – Arrange the atoms in a skeleton structure around a central atom.
The central atom is:

- the atom there is only one of (but never hydrogen),or
- the atom located the farthest from fluorine on the periodic table

Step 2 – Determine **N**, the number of electrons that will be needed to complete the octet of each atom. Usually all atoms need 8 electrons in their valence shell except hydrogen, which only needs 2.

Step 3 – Determine **V**, the number of valence electrons for each atom. Remember, the number of valence electrons are the same as the Roman numeral column heading on the periodic table.

- If the compound has a charge, you account for that in this step.
- If it has a positive charge, subtract that from V.
- If it has a negative charge, add that many.

Step 4 – Determine **S**, the number of electrons shared in the molecule. S = N – A

Step 5 – Determine **NS**, the number of electrons which are *not shared* in the molecule. NS = A – S

Step 6 – Place the shared electrons, in pairs, between the central atom and each peripheral atom. If all of the shared electrons have not been used, insert pairs to make double or triple bonds. Do not exceed the number of covalent bonds that the outer atom can form (H = only 1 shared pair).

Step 7 – Place the nonshared electrons, in pairs, to satisfy the octet for the remaining atoms.

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Let's try a couple of examples.

Example 1. Draw the Lewis structure for ammonia, NH_3.

Step 1 H N H
H

Step 2 **N** = (1 x 8) + (3 x 2) = 17 e- needed

Step 3 **V** = (1 x 5) + (3 x 1) = 8 valence e-

Step 4 **S** = 14 – 8 = 6 shared e-

Step 5 NS = 8 – 6 = 2 e- not shared

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