Tips for Learning General Chemistry Rules, Trends and Exceptions

It would be foolish to attempt to memorize every detail in the many charts of general chemistry information. After all, you are a college student with plenty of better things to do. Provided below are some smart tips on how to attack the large amounts of material in such tables by employing simple trends and rules for efficiently learning and recall of the material.

Know your Periodic table Groups:

- The columns are groups, the rows are rows.
- Assigning oxidation numbers to the groups, from the left. the common formal charge on an element
- increases, +1, +2, +3.... From the right, skipping the noble gases, the common formal charge on an element increases, -1, -2,-3. ..
- Group 1, Column 1, alkali metals (Na. K), +1 oxidation, soluble ions, explosive metals, cations of strong bases.
- Group 2, Column 2, alkali earths (Mg, Ca), +2 oxidation, react in hot water, cations of strong bases.
- Group 7, Column 7, halogens (Cl, Br), -1 oxidation, diatomic ($C1_2$), weak bases of strong acids.
- Group 8, Column 8, noble gases (He, Ar), non-reactive, monatomic.

Distinguishing metals and non-metals:

- Metallic character increases going down the periodic table and to the left. So Cs is metallic and F is not.
- Metalloids along a diagonal line from silicon, Si, separate metals/nonmetals; are semiconductor materials.

Solubility Rules.

If you can remember nothing else, the larger the charge, the less soluble the ion. So:

the singly charged ions are usually soluble

and

the multiply charged ions are usually insoluble.

The reason for this is something we will learn in CH 302. Now this doesn't work all the time, but it is a good rule of thumb if you forget the rules below:

Here is a more substantial, but still manageable, hierarchy of rules to minimize the memorization of solubility:

- Rule 1: Ions that are always soluble no matter what: alkali metal (Li^+, Na^+, K^+); ammonium, NH_4^+; also nitrate, NO_3^-, is the only common anion that is soluble with everything.
- Rule 2: Anions that are always insoluble except for rule 1: S^{2-}, O^{2-}, OH^-, CO_3^{2-}, PO_4^{2-}
- Rule 3: Anions that are soluble with famous exceptions: anions of strong acids (Cl^-, Br^-, I^-, SO_4^{2-}, NO_3^-, ClO_4^-, ClO_3^-) Note that by knowing the strong acids, you know this rule!!
- Famous exceptions to Rule 3: heavy metals like Ag^+, Pb^{2+}, Hg^+, and everyone's favorite exception, $BaSO_4$.

Sidebar: Understanding spectator ions. In Davis and some of the homework there is reference to spectator ions. Spectator ions are ions that do not react. In solubility reactions these are ions that remain soluble. This means then that Na^+, K^+,Li^+, NH_4^+ and NO_3^- are always spectator ions because they are alway. soluble.

Strong and Weak Acids:

- How to identify an acid. All acids have two parts:

  1) at least one H^+ at the front of the molecular formula combined with

  2) one or more elements from tbe far nght side of the periodic table (Group 6 and 7.) Example: H^+ with a Cl^- or H^+ with an NO_3^- or H^+ with a $COOH^-$ but not H^+ with a CH_3^-. There are a million weak acids that have these two components but only seven strong acids:

- There are seven strong acids. They are in two categories:

  1) H^+ with the halide ions except for F^- (HCl, HBr, HI) and

  2) H^+ with the oxidizing acids (these have several oxygens in them) HNO_3, H_2SO_4, $HClO_3$. $HClO_4$. Note not all acids with a lot of oxygen are strong: H_3PO_4 and H_2CO_3 are weak acids.

Strong and Weak Bases:

- Bases fall in two categones:

  1) the ones that contain hydroxide (OH^-) and

  2) the ones that contain amine (NH_2^-). Examples of bases with hydroxide are $Fe(OH)_3$, NaOH, $Ca(OH)_2$. Examples of bases with amines are ammonia (NH_3) and metbyl amine (CH_3NH_2).

- Strong bases consist of 1) a OH^- and 2) a cation from the first two groups of the periodic table. Example: NaOH. LiOH and $Ca(OH)_2$ are strong but $Al(OH)_3$ is not.

Assigning oxidation numbers (you don't need to balance redox equations till Chapter 11):

What do oxidation numbers tell us? Oxidation numbers tell us where the electron density is in a compound. So in

$$\overset{+6}{Cr_2}\overset{-2}{O_7}{}^{-2}$$

The electrons are more densely packed around the O though than Cr.

Rather than try to memonze all the possible combinations, learn the following hierarchy of rules:

- Rule 0: Free elements have an oxidation number of 0. Example: Oxygen in O_2 has 0 oxidation number

- Rule 1: Assigning oxidation numbers to the groups, from the left. the common formal charge on an element increases, +1, +2, +3.... From the right, skipping the noble gases, the common formal charge on an element increases, -1, -2,-3.

Complications involing hydrides, H, and oxides, O, with other elements in compounds:

- Rule 2: Alkali metals are always +1 except for rule 1. Example Na in NaO, is +1.

- Rule 3: Hydrogen is always +1 except for rules 1 and 2. Example, H is -1 in NaH but +1 in H_2O.

- Rule 4:. O is always -2 except for rules 1, 2, and 3. Example: O is -_ in NaO_2, but-2 in H_2O.

Using the formal changre of the ion or compounds to assign oxidation numbers in compounds:

- Rule 5: In every redox problem you do, assign tbe oxidation numbers in order using rules 0- 4. There will usually only be one element left to assign by difference. Example, what is the oxidation number of P in K_2HPO_4? Since K is +1 and H is +2 and O is -2, P = +5 for a net formal charge of 0.

Displacement Reactions.

One of the most famous oxidation reduction reactions occurs when you throw a metal, M, in water, H_2O. The following reaction happens:

$$M + H_2O \rightarrow M^{2+} + OH^{-} + H_2$$

The metal is oxidized (dissolves) and reduced bydrogen (H_2 that explodes) and a strong base (OH) are formed. When you watch me throw sodium (Na) in water and it caught on fire, the reaction above is what oappened.

Not all metals explode in water (thank goodness.) Some require more stringent conditiors and some don't react at all. There are four cases.

- Case 1: Metals that explode in cold water: The alkali metals Na, K, Li.
- Case 2: Metals that react in hot water alkali earths and Zn (a famous example).
- Case 3: Metals that rcact with acid like HCI: most of the transition metals that aren't coinage metals.
- Case 4: Metals that never react: coinage rnetals like Cu, Ag, Au, Pt.

Metals displace each other to form the more stable metal. Thus, metals in case 4 replace metals from case 1 through 3, etc.

For example,

- $Na + Au^{+} \rightarrow Na^{+} + Au$ (the more stable metal, Au, is formed.)
- $K^{+} + Zn \rightarrow$ does not happen. The more stable metal (Zn) already exists