CHM 151 Cheat Sheet for CHM 152

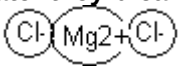
These are things that are vital to your understanding of CHM 152. You should know the following. For additional help see the Help Page at http://web.gccaz.edu/~ksmith8/help.htm

Oxidation states (just a fancy name for charge)

1. **Elements are all charge zero** in their natural states which are:
   i. Gas: H_2, N_2, O_2, F_2, Cl_2 and noble gases
   ii. Liquid: Hg and Br_2 are the only liquids
   iii. Solid: everything else
   iv. Diatomic: H_2, N_2, O_2, F_2, Cl_2, Br_2 and I_2 are the diatomic elements
2. Alkali metals are **always** charged +1 when in a compound. Their goal is to lose one electron, thus becoming +1 cations.
3. Alkaline Earth metals are **always** charged +2 when in a compound. Their goal is to lose two electrons, thus becoming +2 cations.
4. B column is usually charged +3 or -5 depending on what they are bonded to. They can lose 3 electrons becoming +3 OR gain 5 electrons becoming -5. Actually Al, Ga and In are **always** +3.
5. C column is usually charged +4 or -4 depending on what it is bonded to. They can lose 4 electrons becoming +4 OR gain 4 electrons becoming -4. (They can also be +2 or -2.) Example CH_4 : C is -4 and H is +1. Example CO_2 : C is +4 and O is -2.
6. N column is usually charged -3 in compounds but sometimes +5. They can lose 5 electrons becoming +5 OR gain 3 electrons becoming -3. Example NH_3 N is -3 and H is +1.
7. Chalcogens are usually charged -2 in compounds (Oxygen is **always** charged -2 when in a compound except for peroxides like H_2O_2 where it is -1) unless they are bonded to something more electronegative than they are, in this case they can be +6 +4 or +2. Example sulfate ion. SO_4^{2-} Here the total charge is -2 so S is +6, each O is -2 (there are 4 of them so that adds up to -8 for all four O's) so that adds up to -2 overall, which is why sulfate is an ion and not a molecule - it has an overall charge.
8. Halogens are usually charged -1 in compounds (F **always** is -1) unless they are bonded to something more electronegative than they are, in this case they can be +7 +5 or +3. Example IF_7. Here F is -1 since it always is -1. That makes I +7. Note that IF_5 and IF_3 also exist.
9. Noble gases are stable and unreactive, they don't often have a charge - they are neutral atoms.
10. Transition metals have many charges, too many to predict. Exceptions are Zn and Cd which are **always** +2 and silver which is **always** +1. Re can be charged from +1 all the way up to +9!!!
11. H is usually +1. When H is bonded to a metal however, it can be -1. Example NaH where Na is +1 since it is always +1 so H must be -1.
12. Remember the atoms in a pure element have a charge of ZERO!!! Atoms don't have charges unless they are bonded to something else.

Ions and Ionic Formulas – note an ionic formula must add up to zero total charge

1. Metals or cations are always first (NaCl not ClNa)
2. A few examples:
   a. magnesium phosphate = $Mg_3(PO_4)_2$ (Mg is +2 so we need 3 of them, phosphate is -3 so 2 are needed)
   b. sodium sulfate = Na_2SO_4 (Na is +1 so we need 2 of them since sulfate is -2)
   c. calcium hydroxide = $Ca(OH)_2$ (Ca is +2 and OH is -1 so we need 2 of them)
3. **Polyatomic ions** you should know: sulfate SO_4^{2-} , phosphate PO_4^{3-} , carbonate CO_3^{2-} , hydroxide OH^- , ammonium NH_4^+ , acetate CH_3COO^{-1} , nitrate NO_3^- , bicarbonate HCO_3^- , monohydrogen phosphate HPO_4^{2-} , dihydrogen phosphate $H_2PO_4^{-1}$
4. **Don't show the charges in a compound** (NaCl not Na^+Cl^-). Write the charges on scratch paper, but not in your chemical reactions or answers. We should not see charges above your compounds on your final answers.
5. Fluorine is F not Fl by the way.
6. If we say aluminum, we mean the element Al(s). If we say aluminum chloride, then we have Al^{3+} ions because it is an ionic compound or $AlCl_3$(aq). Note that $AlCl_3$(aq) really means one Al^{3+}(aq) ion and 3 Cl^-(aq) ions in water. There is no such thing as Al^{3+}(s). Al is either a solid element with no charge, OR it is an ion with a +3 charge.
7. **Dissolving in water.** Soluble ionic compounds dissolve in water, which is NOT reacting with water. NaCl (s) → Na^+(aq) + Cl^-(aq) is the correct way to show dissolving. NaCl (s) + H_2O(l) → some products is NOT correct since the salt is not reacting WITH water, it is just dissolving IN water.

8. **When ionic compounds dissolve in water they break into separate ions**. For example $MgCl_2$ (aq) breaks into 3 ions. The compound $MgCl_2$ looks like 

Notice the Cl^- ions are NOT next to each other. This is because negative ions repel, so the Cl^- ions try to get far away from each other on opposite sides of the Mg^{2+} ion to which they are attracted. When we write $MgCl_2$ we do not mean that chlorine, Cl_2 is in it. We mean there are two totally separate Cl^- ions in it. So when $MgCl_2$(s) is put in water we get three ions: Cl^- and Mg^{2+} and Cl^- which is Mg^{2+}(aq) and 2 Cl^-(aq). So now you know that the 2 in 2 Cl^-(aq) means two totally separated chloride ions floating around in water and not chlorine Cl_2 which is a gaseous element.
9. **There is no such thing as Cl_2^- ion.** Read above. Chlorine is either a gas element with no charge Cl_2(g) or it is Cl^- (aq) ions.
10. What about when we put calcium hydroxide, $Ca(OH)_2$ in water? It is soluble and makes 3 ions: One Ca^{2+} (aq) ion and two totally separate and distinct OH^- ions. Again this compound looks like the one above but Ca^{2+} is in the middle of the two OH^- ions. **So there is no $(OH)_2^-$ ion**. The OH^- ions were never touching, so they are not together making diatomic hydroxide ions. The formula $Ca(OH)_2$ merely indicates there are two OH^- ions in the chemical, but not how they are bonded.

Nomenclature Review

1. Binary Ionic Compounds (ionic compounds with two elements)
    a. use the metal's name + the nonmetal's name + the suffix "ide"
    b. NaCl is sodium chloride, Li_2O is lithium oxide, KBr is potassium bromide, MgI_2 is magnesium iodide
2. Ionic compounds with polyatomic ions
    a. treat polyatomic ions as groups
    b. never change the name of the polyatomic ion
    c. NaOH is sodium hydroxide, $Ca(NO_3)_2$ is calcium nitrate, $MgSO_4$ is magnesium sulfate
    d. ammonium sulfide is $(NH_4)_2$ S, calcium carbonate is $CaCO_3$, magnesium phosphate is $Mg_3(PO_4)_2$
3. Binary Covalent Compounds (covalent compounds with two elements)
    a. prefix + nonmetal + prefix + nonmetal + suffix "ide"
    b. prefixes are mono, di, tri, tetra, penta, hexa, hepta, octa
    c. if there is only one of the first nonmetal, don't use the mono prefix
    d. carbon tetraiodide is CI_4, sulfur dioxide is SO_2, N_2H_4 is dinitrogen tetrahydride
4. Transition metal compounds: name of transition metal, (charge in Roman numerals) + name of nonmetal + ide
    a. Fe_2O_3 - iron(III) oxide, CuS - copper(II) sulfide, $FeSO_4$ - iron(II) sulfate, iron(II) phosphate - $Fe_3(PO_4)_2$

Chemical Reactions

1. **You can not create charge during a reaction:** (this is wrong) A (aq) + B(aq) $\leftrightarrows$ C(aq) + D^{2+} (aq). The total charge of the reactants must be the same as the total charge of the products. Here the reactants are zero but the products are +2. So that means you created charge and solved the energy crisis! This reaction works: 2 A^+ (aq) + B(aq) $\leftrightarrows$ C(aq) + D^{2+} (aq). It works because both sides add up to +2. The charge is balanced.
2. Remember when writing reactions, you must have all the correct formulas for the reactant(s) and product(s) first. Formulas depend on the charges of the elements and polyatomic ions involved. Once you have determined the formulas, you can NOT change them later - don't change the subscripts in the formulas. For example sodium and chlorine make NaCl. You cannot later while balancing change this to $NaCl_2$. You can only add coefficients in front of the compounds to balance the reaction - like 2 NaCl.
3. Formation rxn: reactants are elements in their natural state forming a product compound. Example: N_2(g) + 3 H_2(g) $\leftrightarrows$ 2 NH_3(g)
4. Combustion rxn: hydrocarbon (molecule with only C and H) adding to oxygen producing water and CO_2
5. Precipitation rxn: (a type of double replacement) when the cations swap anions and one product is NOT soluble
6. Acid Base rxn: Typically where the H^+ from an acid comes off and the base (often hydroxide ion) gains the H+ to make water.
7. **Single Displacement:** typically when a solid metal element is put in solution and it trades places with the cation of a less active metal in solution. Note – two metals do NOT combine because positive ions repel. Example: 3 $CoCl_2$(aq) + 2 Al(s) $\leftrightarrows$ 2 $AlCl_3$(aq) + 3 Co(s) You need to be able to write similar rxns on your own. Note the product is not ZnAl – the metals don't combine because both want to get rid of electrons, not gain them. Also note that the cobalt product is a solid metal, not an ion, because we must balance charge!