Unit 4A Ionic, Covalent, and Acid Naming Test SG

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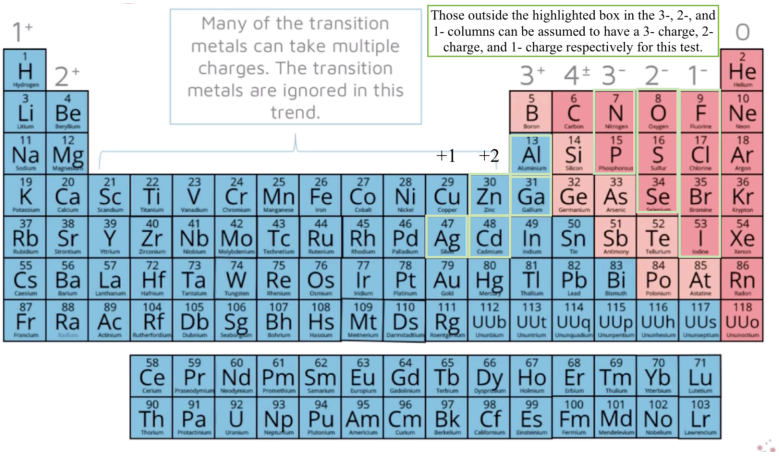
- Test structure - ⅓ multiple choice, ⅓ name -> formula, ⅓ formula -> name
- Category A and B (Ionic Compound Naming) = majority of test, covalent compound naming (category C) = small portion of test, acid naming = very small portion of test

Ion Formation, Polyatomic Ions, & Ionic Formulas

- Valence electrons
  - **Definition:** electrons at the outermost shell of an atom (highest energy), participate in bonding and reactions
  - For a main group, there is the same # of valence electrons as the group/column number
  - Valence electrons are the **s & p electrons** in the highest principal energy level (n)
    - They cannot be d or f since d sublevels are always one behind, f sublevels are always 2 behind the principal energy level
    - All d & f sublevels will have **2 valence electrons** unless you are an exception
    - e.g. [Se] 6s^2 4f^1 has 2 valence electrons, only in the 6s subshell
  - Losing valence electrons helps an element be more like a noble gas
    - Helium (a noble gas) is an exception, it only has 2 valence electrons but does not form bonds (a normal noble gas has 8 valence electrons, but helium = exception)
  - 

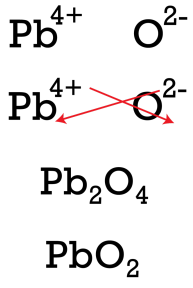
- Naming Monatomic Ions (**Cations**)
  - When naming a cation **individually and by itself**: name the element as is and add the word "ion" after it to indicate that the atom is charged.
    - E.g. Sodium -> Sodium ion
  - Some metals can form **cations** with different charges depending on the situation. Thus, **roman numerals** are needed to specify the charge of the **cation**.
    - E.g.: copper (Cu) can form multiple ions.
    - Cu^1+ would be copper (I) ion, Cu^2+ = copper (II) ion
    - The roman numeral indicates the (+) charge
      - It can never be negative from the definition of a cation

        - Roman numerals are only needed for **CATIONS**
- Naming Monatomic Ions (**Anions**)
    - When naming anions, change the ending of an atom to "-ide" to indicate a **negatively** charged ion. Technically, it is more accurate to say nitride **ion**, but nitride by itself is also **sufficient** to describe that it is negatively charged.
        - C^4-: carb**on** -> carb~~**on**~~ -> carb**ide**
        - N^3-: nitride, H^-: hydride
- Polyatomic Ions
    - An ion composed of multiple (2 or more) atoms
    - **-ide/ate** on the name of the compound indicates that the compound contains a polyatomic anion
    - A group of atoms that are covalently bonded to each other and collectively form a **net charge**, either positive or negative
    - You cannot just distribute polyatomic ions. For example, (CO_3)_2 would NOT be C_2 O_6.
    - Just a (-) in the exponent symbolizes a charge of 1- for the whole polyatomic ion, NOT JUST one element.
    - You should NEVER modify or change a polyatomic ion's name, e.g. from nitrate to nitride. **Keep the name as is** since the name for the polyatomic ion has the polyatomic ion **already charged**.
    - Polyelemental (polyatomic) ions

1+	1–	2–
Ammonium, NH_4^+	Hydroxide, OH^- Bicarbonate (hydrogen carbonate), HCO_3^- Cyanide, CN^- Chlorate, ClO_3^- Bromate, BrO_3^- Nitrate, NO_3^- Nitrite, NO_2^- Permanganate, MnO_4^- Acetate, $C_2H_3O_2^-$, CH_3COO^-	Carbonate, CO_3^{2-} Sulfate, SO_4^{2-} Sulfite, SO_3^{2-} Chromate, CrO_4^{2-} Dichromate, $Cr_2O_7^{2-}$ Oxalate, $C_2O_4^{2-}$
3–		
Phosphate, PO_4^{3-}		

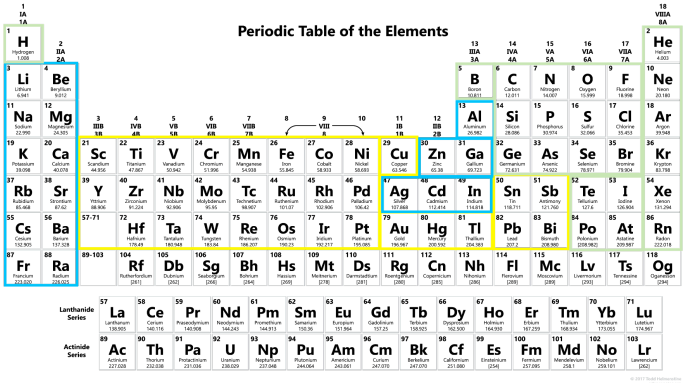
    - Highlighted polyatomic ions and their names should be **memorized** for the test.
        - https://knowt.com/study/flashcards/b3709ff6-a623-4624-b800-af2dbb0eef93/review
        - Test will NOT include a table of polyatomic ions
    - Check Polyatomic if the subscript is on the bottom, not on the top
        - NO^3- is NOT nitrate ion (NO_3^-)
- Oxyanions
    - A series of anions containing an element with different numbers of oxygen atoms
    - When there are two possible combinations with oxygen…
        - The one with **more oxygen atoms** ends in "-ate"
        - The one with **less oxygen atoms** ends in "-ite"
    - If there's even more or even less, you would use…
        - Hypo- prefix for even less oxygen atoms
        - Per- prefix for even more oxygen atoms
- Ionic compounds (also called salt)

    - Built by electrons transferred, and made of (+) cations and (-) anions, such that the **TOTAL CHARGE** is neutral (0 charge)
        - E.g.: NaCl is an ionic compound, since Na has 1+ charge and Cl has 1- charge, and the total charge balances to 0
    - Ionic compounds form a **crystal lattice** structure, a repeating three-dimensional arrangement of ions. The lattice consists of cations and anions held together by electrostatic forces of attraction (ionic bonds).
    - Ionic compounds do **NOT** consist of discrete molecules like covalent compounds do. Instead, the entire structure is a **continuous** network of ions.
    - The formula for an ionic compound is the lowest/simplest ratio of ions needed to make a neutral compound
        - E.g. 3 Cl and 3 Na would be reduced to 1 Na and 1 Cl, even though we know that there's infinite of each (crystal lattice, repeating structure)
        - This ratio is called a **formula unit** - the smallest ratio of ions in a formula
    - Names and formulas in an ionic compound list the cation first, and the anion second (e.g. NaCl -> sodium chloride)
    - Properties of Ionic Crystals / salts
        - Hard, brittle, high melting points, poor/bad conductors of heat/electricity, unless dissolved aqueously
- Writing Ionic Formulas - Criss Cross method
    - Determine charge on the cation and the charge on the anion
    - Write the chemical symbols of each ion - cation first, anion second
    - Cross over charge numbers as subscripts (Such that the ionic compound is overall neutral)
        - Essentially: how many cations (e.g. Pb) and anions (e.g. O) do I need to balance out the ionic compound?
    - Simplify as necessary
        - Simplest **whole number** ratio (e.g. Pb_2 O_4 -> Pb O_2)

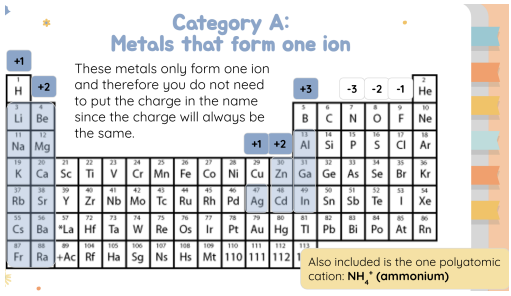


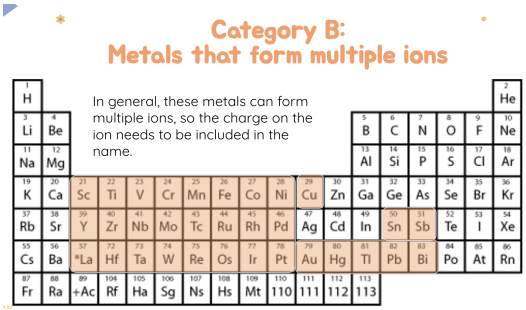
    - If you have multiple of a polyatomic ion like 2 of OH^-: use **parentheses**: e.g. Mn^2+ and OH^- -> Mn(OH)_2
    - If you have just one polyatomic ion, it is NOT NECESSARY.
- The **first** element is **ALWAYS** the cation **UNLESS** it is NH_4 (ammonium, the only (+) polyatomic ion). Everything AFTER is the anion.

Naming Ionic Compounds

- Note: The charge of an **anion** does **NOT** vary in most cases. When talking about Category A, B, C naming, we are talking about the cation, NOT the anion.
    - Anions' charge can still be expected by the regular 4-, 3-, 2-, 1- rule.
    - **Hydrogen** can be either 1+ **OR** 1-, so hydrogen CAN BE an **anion**.
- You can **identify** the cation's category based on its **placement** on the **periodic table.**
- Category C does not involve ions. You identify the category by the first element listed in the chemical formula.
    - 

Category A	Category B	Category C

    - Category A, B, C elements must be memorized (which elements are in what category). Periodic table will be provided on the test
    - Note: at times it is easy to mess up similar names. Sulfate and sulfite are polyatomics and not the same. Sulfide is just a regular sulfur ion with charge 2-, not a polyatomic ion.
- **Category A** cations
    - Metals (cations) that form **one kind** of ion (e.g. Na is a category A cation since it can only form a Na^+ ion).
    - Category A also includes **polyatomic ions** since they always have the same charge
        - Put even more simply, **NH_4^+** is the only polyatomic cation, so it is the only category A polyatomic ion.
    - Cation is listed first, then the anion
    - Monatomic cation = name of element as is
    - Monatomic **anion** = root + **ide**
        - If **anion** is **polyatomic**, do **NOT** change its name
    - 

- **Category B** cations
  - Cations that form **MULTIPLE** ions
    - All category B cations are metals, but not all metals are category B
  - Name the **cation** with **roman numerals**, and name the anion regularly (root + ide, unless it is a polyatomic anion, in which you keep the name as is)
    - The charge on the metal ion must be specified with a charge **per** cation
    - The roman numeral is **NOT** a measure of the number of cations or anions
    - Roman numerals = I, II, III, IV, V, VI, VII, VIII, IX, X, etc.
  - Identify the charge of each cation from the charge and # of atoms
  - Charge of each cation = charge of each anion * # of anions / # of cations
    - This is just a formula that helps you balance out the charges of the anions with the charges of the cations
  - Clarifications
    - For a **single atom** of copper (or any metal), you **don't need to specify the charge** (e.g., Copper(I) or Copper(II)) unless it's part of a compound.
    - If it's a copper ion, you do have to specify if you want it to be part of a compound
    - Given name: copper (II) hydroxide, you should be able to determine that there are 2 hydroxides
      - Copper (II) will be Cu^2+, while hydroxide will be OH^-, so you need 2 hydroxides to balance out each 1 copper (II) ion, hence the simplest whole number ratio/the formula unit will be Cu(OH)_2.
    - Given formula: Cu^2+ (Br^-)_2: copper **(II)** brom**ide**
    - If just given Cu Br_2: you should identify that Br has a charge 1- and there's only 1 Cu, so it would be 2(1)/1 = 2 -> II on the copper, hence Copper (II) bromide
  - Examples
    - CuCl -> cation charge of copper = charge of each chlorine * number of chlorine ions / # of copper ions = 1*1/1=1 -> I -> copper (**I**) chlor**ide**
    - Fe_2 O_3 -> oxygen forms 2- ions (always!) so 2*3/2=3 -> III -> each iron ion needs a 3+ charge, so iron (III) oxide
  - 

- Binary and Ternary Compounds
  - **Binary** compound - made of two elements (both monatomic ions)
    - E.g. NaCl - sodium chloride
    - Mg_3 P_2 - magnesium phosphide, Cr_2 O_3: chromium (III) oxide

- **Ternary** compound - made of three or more different elements (because the compound has one or more polyatomic ions)
  - E.g. NH_4 F - ammonium fluoride, Ca (NO_3)_2 - calcium nitrate, Fe SO_3 -> iron (II) sulfite
- Net charge **still has to be 0**, since they are still ionic compounds

Naming Covalent Compounds

- Recall: Ionic Bond = cations + anions **OR EQUIVALENTLY** metals + nonmetals
  - Most cations = metals, most anions = nonmetals
- Covalent Bond = metalloid + nonmetal **OR** nonmetal + nonmetal
  - No “ions” that are combined; rather, atoms share electrons to achieve stable electron configurations
  - DO NOT simplify formulas for category C because they represent actual **molecular** ratios (Category C cations form molecules), not just the ratio of atoms.
- Covalent Nomenclature/Naming (**Category C**)
  - Name the first element
    - Use the full name of the first element.
    - Add a **prefix** if there is **more than one atom** of the element (do **NOT** use "mono-" for the first element if there is only one atom).
  - Name the second element
    - Change the ending of the second element to **"-ide"**.
    - Always use a **prefix** to indicate the number of atoms, EVEN IF there is only one atom of the second element.
  - Mono prefix: only used on second element
  - Examples
    - NO - nitrogen monoxide
    - NO_2 - nitrogen dioxide
    - N_2O - dinitrogen monoxide
    - N_2O_3 - dinitrogen trioxide
    - SF_6 - sulfur hexafluoride (**NOT** **mono**sulfur hexafluoride)
  - Prefixes (memorize!):

# of atoms	Prefix		# of atoms	Prefix
1	mono-		6	hexa-
2	di-		7	hepta-
3	tri-		8	octa-
4	tetra-		9	nona-
5	penta-		10	deca-

    - Double Vowels
        - When **ao** or **oo** occur together, drop the **first vowel**
        - Mg_10 O_10: dec**aox**ide -> dec**ox**ide
        - Only valid for **ao** and **oo**, if it is **io** or **ia**, you keep both
- Category C: covalent naming
    - Element listed first determines if it's in category C or not
    - Mostly nonmetals/semimetals
    - No polyatomic ions to worry about
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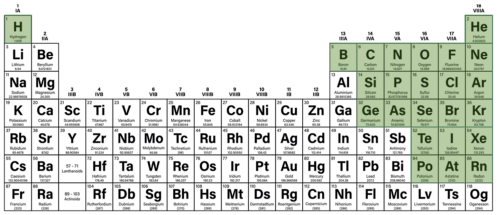
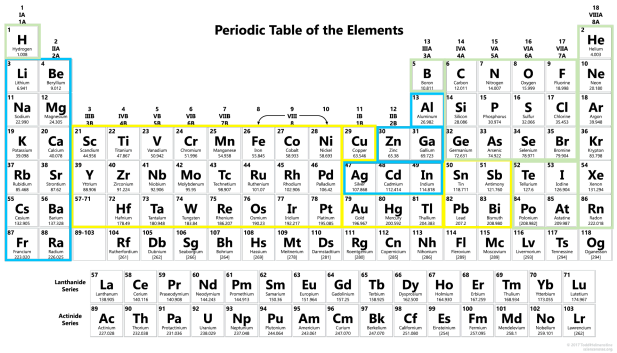


Naming Acids

- Acid formulas will start with a **Hydrogen atom** (HCl, HNO3, HNO2, H2SO4) as the cation
- Acids belong to Category C (covalent compounds) because their chemical bonds are primarily **covalent** but when they dissociate in water, they form ions.
- When the anion does **NOT** contain **Oxygen**: (usually just 2 elements)
    - Use the prefix **hydro** + root of the anion's name – ***ic*** + "acid"
    - Example: HCl = hydrochlor**ic** acid; HBr- hydrobrom**ic** acid
- When the anion **DOES** contain **Oxygen** (3 or more elements)
    - The name will depend on the name of the polyatomic anion.
    - Do **NOT** use the prefix hydro!!!
    - If the anion ends in ATE ⟶ change the name to end in **IC** + **acid**
    - If the anion ends in ITE ⟶ change the name to end in **OUS** + **acid**
    - ATE ⟶ IC
    - ITE ⟶ OUS
    - Examples
        - H_2 SO_4: SO_4 has an overall charge of 2-, so you need 2 hydrogen atoms (since hydrogen has a 1+ charge)
            - Anion is sulf**ate**, so the name of the acid ends in **ic** -> sulfur**ic** acid
        - H_2 SO_3: anion is sulf**ite**, so the name of the acid ends in **ous** -> sulfur**ous** acid
    - Acids must be **neutral** overall. The number of H^+ ions needed equals the absolute value of the anion's charge. Each Hydrogen ion contributes a 1+ charge. Add enough H^+ ions to balance the charge of the anion. Write the formula with the hydrogen atoms first, followed by the anion
        - H_2 SO_4: SO_4 has an overall charge of 2-, so you need 2 hydrogen atoms (since hydrogen has a 1+ charge)

Helpful References and Tables



Category A	Category B	Category C

Polyelemental (polyatomic) ions

1+	1–	2–
Ammonium, NH_4^+	Hydroxide, OH^-	Carbonate, CO_3^{2-}
3–	Bicarbonate (hydrogen carbonate), HCO_3^-	Sulfate, SO_4^{2-}
Phosphate, PO_4^{3-}	Cyanide, CN^-	Sulfite, SO_3^{2-}
	Chlorate, ClO_3^-	Chromate, CrO_4^{2-}
	Bromate, BrO_3^-	Dichromate, $Cr_2O_7^{2-}$
	Nitrate, NO_3^-	Oxalate, $C_2O_4^{2-}$
	Nitrite, NO_2^-	
	Permanganate, MnO_4^-	
	Acetate, $C_2H_3O_2^-$, CH_3COO^-