MAPPING
COLLEGE CHEMISTRY

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USING GRAPHIC ORGANIZERS TO SOLVE AND UNDERSTAND THE TOUGHEST UNIT PROBLEMS IN GENERAL CHEMISTRY

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Using Graphic Organizers to Solve and Understand the Toughest Unit Problems in General Chemistry

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This book would not have been possible if it wasn't for
Dan Gimenez, Mark Hesse, and my many students who were asked to
struggle, to persevere, and to ultimately make
meaning by solving science word problems.
It is my hope that they have become better problem solvers,
not just in chemistry, but in other academic subject areas.

For their trust and effort,
I dedicate this book to them.

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CHAPTER 1

The Problem Solving Strategy

"It is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."
- Abraham Maslow

I will begin by saying what we all know, many General Chemistry courses on the high school AP and college levels "weed" out the strong students from the weak. While this might not be the main purpose of these courses, it is in effect what these courses do. Knowing that many students struggle just to get by, and many more hope to get very good grades in order to apply to medical, veterinary, and dentistry school, physical therapy and pharmacy programs, as well as chemistry and biochemistry graduate schools, I decided to write a book to help you, the student, succeed and not become a casualty of a "killer" curriculum.

My three-fold strategy is simple: First focus on specific content taught in the first year of general chemistry. It would be redundant to cover all of the topics in an introductory course; there are ample textbooks out there if one wants to get a survey or overview of chemistry. Instead, it would be much wiser to address in depth only the most challenging topics and problems, the ones that can make or break a student's grade.

The second part of my strategy involves reverse engineering. Instead of starting with descriptive content, I have focused my attention on the end-of-the-chapter problems and determined what must be known and what process must be used to solve those problems. This is just the opposite direction to how textbooks present knowledge. Working in reverse allows me to clearly identify the most critical information that must be understood to solve a problem.

The third and last strategic item is to transform the pre-requisite knowledge into a graphic organizer or visual tool. Shaping knowledge into a tool has a lot of benefits: first a good tool provides structure – there is a beginning, middle and end, and the transitions between the parts are logical and explicit. Secondly, a good tool can be more readily memorized than expository or descriptive writing found in many textbooks. Lastly and most importantly, a good tool can do more than one job well. In terms of learning, this means that a useful tool is one that is generalizable to a group of related problems, not just one specific problem type.

The purpose of drawing upon this three-fold strategy is straight forward: it is to help you structure and make sense of challenging material that is covered regularly in introductory science courses, and by so doing, improve their grades.

Visual tools are not something new; many of us have used a flow or Venn diagram, or perhaps even a concept map. What is novel about the type of graphic organizer found in this book is how it connects procedural knowledge (problem solving steps) with conceptual knowledge (concepts and facts). This connection is very important. Research is very clear about how students become good problem solvers: they must know how to solve a problem as well as understand the concepts behind the problem. Many students can go step by step through a problem and generate a correct answer without understanding what these steps and their answer mean. In other words, they only know how to “plug and chug” to get an answer. Students who have used my graphic organizers, I call them “decision maps”, have reported that they helped them solve problems, understand concepts and organize their knowledge. Research on graphic organizers in general have shown that graphic organizers can help promote student achievement.

Using decision maps to tackle challenging chemistry problems doesn’t mean that suddenly doing problems will be easy. Difficult material demands attention, perseverance, and practice. Like any tool found in a toolbox, only through good old hard work will the tool become useful. I have found that many science and especially pre-med majors do indeed possess the work ethic that is necessary to use these visual tools correctly. I believe strongly in the value of these tools. I am enthusiastic about presenting them to you so that you can achieve high grades and realize your professional goals.

How each Chapter is Organized

Each chapter begins with a rationale explaining why the chapter is important to know and why it is challenging to understand. This is followed by a discussion of “must know” or prerequisite knowledge that is critical to understand when solving problems in a specific subject area. The prerequisite knowledge can be found in most chemistry textbooks and I strongly recommend that you still use your textbook and read the appropriate chapters before using any of the visual tools. My book will make a lot more sense if you have a familiarity with the subject matter.

The prerequisite knowledge at the beginning of each chapter will be used to build the decision maps. Because we don’t want the maps to be too cumbersome, only key parts of the prerequisite knowledge will be embedded; their placement being associated to specific procedural steps.

It might be tempting to go directly to the decision map and start solving problems. I don’t recommend doing this. Jumping over the prerequisite knowledge that makes up the map and starting with a very dense seemingly complex arrangement of knowledge can be intimidating. If you can understand the following prerequisite knowledge, one piece at a time, you will be in a much better position to successfully use the tool. Just remember: if you can understand the pieces that make up these decision maps, then you can successfully use any map being presented.

After a presentation of the prerequisite information, the decision map is introduced. Each map represents essential features of the problem solving process in a highly structured and concise manner. For instance, the first tool is two pages in length. These two pages represent eleven pages in one popular chemistry textbook. By condensing and summarizing the voluminous information found in textbooks and presented in lectures, you will have a better chance of discerning what is crucial to know from what is less important to know.

Once the maps are introduced, a series of problems are solved using the maps. This is done so that you may know how to use a specific graphic organizer and follow its logic. This is followed by a series of questions that should be done on your own, or what I call "Do It Yourself" questions (DIY). Your answers can be checked with my detailed solutions contained in the chapter.

As you gain mastery, there will be less of a need for a long and densely packed map. In many cases, I have provided an abridged form of the original so that the map would be easier to use. For many of us, a smaller visual image could help with remembering the overall parts of the tool.

All of the decision maps presented in this book have been used with varying success with students enrolled in AP Chemistry and General Chemistry on the high school and college levels respectively. In some instances the effectiveness of the maps have been measured and the findings published in science education journals. One such article has been reproduced in the appendix of this book. I have done this in order to base this book on empirical data not just on my own personal view of how I thing students should solve problems.

There are many books on the market to help students better understand chemistry. But there is no book that uses graphical organizers to help science and pre-medical students with difficult content, content that can make or break a student's professional career path. The novelty and importance of this book rests on its ability to help chemistry students on a practical problem solving level as well as to help open up an underdeveloped area of educational research. To date, a book or article that focuses on an integrated use of graphic organizers to solve specific problems in chemistry has not been published.

The Journey

Every subject area does not lend itself to a graphic organizer such as a decision map. In order for a decision map to help elucidate a difficult topic, it must simplify a complex series of steps and solve a wide range of problems within a subject area. Deciding what maps to include rests on my own expertise and does not represent the only areas that could lend itself to map making.

As one begins to use these graphic organizers to solve problems, one will inevitably struggle – this is the journey that many experience when learning anything new. But through struggle and practice, greater confidence will come and the process will be less demanding. By the time one fully adopts and masters each decision map, surprisingly it will also be time to let them go. Students might feel that a detailed, multi-page map is too cumbersome and want something shorter like the mini maps I made near the end of each chapter. The search for an efficient process might encourage you to make your own maps, to transform these original tools into something that is personally meaningful and useful. For some, the journey might end with a collection of tools that look very different from the ones presented in this book. This is what I hope will happen, because it is the ability to re-represent knowledge into meaningful information that is necessary to become a strong problem solver.

While a main goal of this book is to help students get an "A" in their chemistry courses, another larger issue is becoming a better learner in general. It is hoped that you will add a new tool to their toolbox – decision maps – and perhaps continue where this book leaves off and create their own learning tools to master a subject area.

This brings me to my last bit of advice, how to achieve maximum success with this problem solving manual. I organized some expected outcomes with how different students might approach this book.

I will…	Outcome
not read my textbook, just rely on memorizing the maps, and will follow the problems (not do them).	Low success
read my textbook, strive for conceptual understanding, do all the problems myself using the maps.	Success
read my textbook, strive for conceptual understanding, do all the problems myself using the maps, redo some aspects of the maps, form a study group, do extra problems.	High Success

To have a chance of a successful or highly successful outcome, you have to make a commitment to learning General Chemistry that can be sustained over time. Very few challenges can be done quickly. More than intelligence, it will take perseverance to solve problems and achieve in competitive environments. I am sure that if you put the work in and use these maps to direct your thinking, you will be a better problem solver and achieve your academic goals.

Aim High & Work Hard,

Stephen DeMeo

For best resolution, the decision maps you encounter in each chapter should be printed out. The map should be placed side by side with a problem's solution in order to follow the reasoning process.

CHAPTER 2

Nomenclature

"You don't drown by falling in the water, you drown by staying there." - Edwin Louis Cole

What is nomenclature?
Nomenclature refers to the naming of chemical compounds. Because it is usually taught at the beginning of the first semester of General Chemistry, this topic usually refers to fairly simple ionic and covalent substances.

Why is nomenclature difficult?
When taking exams, students loose many points by incorrectly identifying chemical names and writing wrong formulas. This is done for a variety of reasons: 1) the topic seems trivial and therefore it is not studied very intensely, 2) textbooks rely on examples not an overall plan to name compounds, and 3) and there are exceptions to the rules that lead to confusion.

So be forewarned; nomenclature looks easy but can quickly and significantly lower a test grade.

The Nomenclature Decision Map
The nomenclature decision map consists of two pages. The first will help you name chemical formulas. For example, the name of NaCl is sodium chloride. The second will help you do the opposite, write formulas from names. I will give you problems to get you acquainted with the visual tool and then give you some to do on your own.

What do you have to know to solve nomenclature problems?
The prerequisite knowledge of nomenclature involves 11 parts. I will discuss each part briefly followed by an example. This prerequisite knowledge is presented because it is used in the tool or is essential to know. But because this knowledge is selective of the topic, I highly recommend that you initially read about nomenclature in your text to acquire a broader understanding.

1. Memorize the names of the most common elements in the Periodic Table and their corresponding symbol (especially those in the first 3 periods).

Example: F is Fluorine

Zn is Zinc

Know which of the gaseous elements are diatomic and which are monatomic.

Example: I_2 not I exists in nature as a diatomic gas.

Other diatomic gases are: hydrogen, oxygen, chlorine, nitrogen, bromine, fluorine.
Some monatomic gases are: neon, helium, xenon, argon.

2. Compounds

Compounds are made by combining more than one type of atoms together in some fixed mass ratio. If the mass ratio of each atom type is fixed, then so is the numerical ratio of the atoms.

Example: Table sugar (sucrose) will have the ratio of 6 carbon atoms to 12 hydrogen atoms to 6 oxygen atoms (6:12:6) no matter how much sugar is weighed out.

Historically, compounds have been classified into organic and inorganic compounds. For the most part, general chemistry only focuses on inorganic compounds. Naming organic compounds which contain carbon and hydrogen is saved for second year Organic chemistry courses.

3. Nomenclature is based on the microscopic nature of atoms and how they are bonded together

There are roughly two types of compounds: those composed of ions and those composed of atoms linked together into a molecule. On the macroscopic level, molecules and ionic compounds exhibit fundamentally different characteristics.

Because ionic compounds form a lattice – a geometric repeating of an arrangement of atoms – the ionic compound cannot be interpreted as a distinct unit, particularly in the solid state. The chemical formula of ionic compounds will represent the smallest repeating unit in an ionic lattice. In other words, there is no distinct NaCl unit in a measured amount of sodium chloride.

Molecules on the other hand can form a distinct unit. There is a distinct molecule of $C_6H_{12}O_6$ in a cup of sugar.

4. You must know the difference between metal and non-metal elements

Molecular compounds are composed of nonmetals and are uncharged. They can be solid, liquid or gases.

A metal loses one or more electrons to become a cation and the nonmetal gains one or more electrons to become an anion. Ionic compounds are composed of ions and are usually solids.

You must know that ions and atoms are fundamentally different particles: atoms have the same number of electrons and protons and are electrically neutral. Ions have an imbalance between the number of electrons and protons and are charged.

We can represent this difference on paper by always including the charge of the ion. For example, the symbol K^+ indicates the lack of 1 electron in the potassium atom. Just remember that while K^+ is different from K by 1 electron, its physical and chemical properties are radically different.

5. Recognizing ionic compounds

There are a couple of ways you can recognize that you have an ionic compound:

If a compound contains a metal, be very suspicious that it could be an ionic compound.
If a compound contains a metal and a nonmetal it is most probably an ionic compound.

6. Writing binary ionic compounds into formulas (writing is different than naming)

The term "binary compounds" refer to compounds containing 2 elements in a XY form. NaCl is a binary compound, while HSO_4 is not.

Metals, when combined with nonmetals, tend to lose electrons to become a charged ion called a cation. The nonmetals tend to gain electrons to become anions.

Use the trends in the periodic table to obtain the charge of ions. You don't have to memorize each ion.

Group I metals lose one electron to become univalent cations (form +1 cations).
Group II metals lose two electrons to become divalent cations (form +2 cations).
Group VII nonmetals gain one electron to become univalent anions (form -1 anions).
Group VI nonmetals gain two electrons to become divalent anions (form -2 anions).

Examples:

Group I: Na^+
Group II: Mg^{2+}
Group VII: Cl^-
Group VI: O^{2-}

You can also memorize some of the more common anions in cations like Al^{3+} in Group III, and N^{3-} and P^{3-} in Group V.

When writing the compound, the symbol of the anion goes first and the cation second.

Problem 1: Write the formula for potassium fluoride.

Answer:

- K is potassium and it is in group 1, so K^+.
- F is fluorine and is in group 7, so F^-.
- Combine together with anion placed first.
- This gives us KF.

Use the principle that ionic compounds are always electrically neutral. Determine the number of ions of each type needed to generate an electrically neutral compound.

K has a +1 charge and F has a -1 charge. Their sum is zero which makes the compound electrically neutral.

Problem 2: Write the formula for aluminum oxide.

Answer:
- Al is aluminum and it is in group 3 producing a +3 charge.
- O is oxide and is in group 6 producing a -2 charge.
- Combine together with anion first. This gives us AlO.
- To make electrically neutral, we will need 2 Al and 3 O.
- The formula is Al_3O_2.

Problem 3: What is the name of V_2O_5?

Answer:
- Oxygen is usually known to have a -2 charge since it belongs to Group VI.
- There are 5 oxygen ions so the total negative charge contributed to the compound is: (-2)(5) = -10
- To maintain electrical neutrality, the total positive charge that is needed is +10.
- Since there are 2 vanadium ions each vanadium ion must have a charge of +5.
- Thus the name of this compound is vanadium (V) oxide.

7. Naming ionic compounds

Here are some basic rules:
- The cation takes its name from the name of the element (Na^+ is called sodium).
- The anion is named by using the root of the elemental name and adding the ending –ide.
- The subscripts do not impact the name.

Example: What is the name of MgF_2 ?

Answer: Magnesium fluoride

Some ions (mostly cations) can have different charges. For instance, copper can form a +1 cation in one bonding situation and a +2 cation in another. When the cation can assume multiple charges, such as many of the transition metal ions, the charge of the cation is indicated using a Roman numeral. Just remember that the Roman numeral refers to charge, not number of cations.

Example: What is the formula for copper (I) chloride?

Answer: Cu must be +1, Cl is -1 in order to make the compound electrically neutral, therefore the chemical formula is CuCl.

Example: What is the formula for copper (II) chloride?

Answer: Cu must be +2, Cl is -1 but we have 2 of them to make -2. This makes the compound electrically neutral. The formula is $CuCl_2$.

8. You have to know some exceptions:

Hydrogen:

- When hydrogen combines with a metal, it acts like a nonmetal and forms a hydride, a univalent anion (i.e. LiH or Lithium hydride).
- When hydrogen combines with a nonmetal, it acts like a metal and forms the univalent hydrogen cation (i.e. HBr or Hydrogen bromide).

Oxygen:

- Oxygen is usually a divalent anion. Sometimes, oxygen is a univalent anion (i.e. H_2O_2 or hydrogen peroxide).

9. Naming Binary Molecular Compounds

- First recognize a molecular compound; make sure no metal is present in the binary compound.
- Use the full elemental name for X.
- For Y use the root of the elemental name and add the ending –ide (you can see by these two rules that molecular compounds are named like ionic ones).
- For X and Y, use the below prefixes to represent the number of atoms present.

Greek prefixes correspond to the number of Ys:

mono:	one
di:	two
tri:	three
tetra:	four
penta:	five
hexa:	six
septa:	seven
octa:	eight
nona:	nine
deca:	ten

Problem 1: What is the name of N_2O?

Answer: Dinitrogen oxide

Problem 2: What is the name of CO?

Answer: Carbon monoxide

- Please note that the prefix mono- is never used for the first Y atom.
- For pronunciation purposes, the latter "o" in mono is dropped when combined with an element starting with a vowel. In similar situations sometimes the "a" in the prefix is also dropped.

10. Writing Binary Molecular Compounds

Example: Given a name, write the chemical formula.

Problem: Dioxygen difluoride

Answer: O_2F_2

Problem: Tetraphosphorous decoxide

Answer: P_4O_{10}

11. Memorize your Polyatomic Ions

Polyatomic ions are a combination of 2 chemical species: molecular species and an ionic species. The entire polyatomic species is charged; it can be a polyatomic anion or cation (most of the ones you will see in general chemistry are anions).

Just don't get confused if you don't see a metal (i.e. NO_3^-); polyatomic ions can bond with other polyatomic ions, other monatomic cations, and other monatomic anions to from ionic compounds. For example NH_4NO_3 contains no metals but is an ionic compound formed from two polyatomic ions. NH_4 is the cation (+1 charge) and NO_3 is the anion (-1 charge).

List of Ions You Need to Memorize

Formula	Charge	Name
Hg_2^{2+}	+2	Mercury (I)
NH_4^+	+1	Ammonium
NO_2^-	-1	Nitrite
NO_3^-	-1	Nitrate
SO_3^{2-}	-2	Sulfite
SO_4^{2-}	-2	Sulfate
HSO_4^-	-1	Hydrogen sulfate (bisulfite is used as a common name)
OH^-	-1	Hydroxide
CN^-	-1	Cyanide
PO_4^{3-}	-3	Phosphate
HPO_4^{2-}	-2	Hydrogen phosphate
$H_2PO_4^-$	-1	Dihydrogen phosphate
NCS^-	-1	Thiocyanate
CO_3^{2-}	-2	Carbonate
HCO_3^-	-1	Hydrogen carbonate (bicarbonate is the common name)
ClO^-	-1	Hypochlorite
ClO_2^-	-1	Chlorite
ClO_3^-	-1	Chlorate
ClO_4^-	-1	Perchlorate
$C_2H_3O_2^-$	-1	Acetate

MnO_4^-	-1	Permanganate
$Cr_2O_7^{2-}$	-2	Dichromate
CrO_4^{2-}	-2	Chromate
O_2^{2-}	-2	Peroxide
$C_2O_4^{2-}$	-2	Oxalate

Problem 1: What is the name of $NaNO_2$?

Answer: Since the name of NO_2 is nitrite, it must be sodium nitrite.

Problem 2: What is the formula of calcium carbonate?

Answer: Carbonate is CO_3 with a -2 charge, and calcium has a +2 charge since it is from Group II. So the formula is $CaCO_3$

Problem 3: What is the formula of iron (III) oxide?

Answer:
- Fe is iron and O is oxide.
- Fe is a transition metal and can form different charged atoms.
- The correct charge on Fe is +3 given by the Roman numeral.
- Putting the first and second parts together we get, FeO.
- Now check for electrical neutrality. O forms a -2 anion, and there are 3 of them making a total charge of -6. In order to achieve electrical neutrality, the 2 Fe atoms must form +3 cations making a total of +6.
- Iron (III) oxide is written as Fe_2O_3.

Using parentheses when 2 subscripts are together:

Problem 4: Iron (III) nitrate.

Answer:
- Fe is iron and nitrate is NO_3.
- Putting the first and second parts together we get $FeNO_3$.
- The charge on Fe is +3 given by the Roman numeral, while the charge on NO_3 is -1 from memory of the polyatomic list.
- To make this compound electrically neutral we will need 1 Fe atoms and 3 NO_3. The formula is $Fe(NO_3)_3$.

Please print out the following Nomenclature Map and use it to solve problems.

Naming Chemical Formulas

Step 1: Do you have two elements combined (a binary compound in an XY form)?

Yes →

Step 2: Is a Metal present?
Use the organization of the Periodic Table to help you. For example, Groups IA & IIA, are metals. Groups 6A and 7A are nonmetals. Transition metals are located in the middle region. You might have to memorize the type of other elements like B, Al, P, and N.

No →

Step 3: Since no metal is present, you most likely have a binary molecular compound (2 nonmetals).

Use the full elemental name for the first part (X).

For the second part (Y) use the prefixes attached to the elemental name with the ending -ide.

Prefixes are used to convey the number of atoms present for both X and Y.

Mono: one
Di: two
Tri: three
Tetra: four
Penta: five
Hexa:six
Septa: seven
Octa: eight
Nona: nine
Deca: ten

Example: N_2O_4
Dinitrogen tetroxide
(in order to aid pronunciation, notice that it is not dinitrogen tetraoxide)

The prefix mono- is never used for the first element of the formula (i.e. CO_2 is not called monocarbon dioxide).

Yes →

Step 4: Since you have a metal, you most likely have an ionic compound consisting of a metal cation and a nonmetal anion.

Ask yourself, Does the metal form one type of cation?

Example: Group I and II metals usually only form 1 cation, like Na forms only Na^+. Most transition metals like Cu can form other cations like Cu^+ and Cu^{2+}. Most range from +2 to +4.

Yes →

Step 5: Follow these Rules for Naming:

Rule 1: Name cation first, anion second.

Rule 2: A monoatomic cation takes the name of its parent element. K^+ is called potassium.

Rule 3: For the monatomic anion, add -ide to the root of the elemental name. Cl^- is chloride

Ex: NaCl is called sodium chloride; Al_2O_3 is called Aluminum oxide

No →

Step 6: Follow these Rules:

Rule 4: When naming, specify the charge on the metal using Roman numerals. Maintain electrical neutrality.

Example: Fe_2O_3
Fe is iron and O is oxide. Fe is a transition metal and can form different charged atoms. The correct charge on Fe can be deduced from O. O forms a -2 anion, and there are 3 of them making a total charge of -6. In order to achieve neutrality, the 2 Fe atoms must form +3 cations making a total of +6. Fe_2O_3 is called iron (III) oxide.

No →

Step 7: Is a Polyatomic Ion(s) Present, and if so what is its name?

Must memorize database of polyatomic ions.

Yes →

Step 8: If you have only 1 polyatomic ion, then the accompanying single cation or anion should be named by the rules in Steps 5 & 6

If you have 2 polyatomic ions, use their given names.

No →

Procedures for naming these compounds will be described in later courses like Organic Chemistry or in later chapters like acid-base chemistry

Problems: Naming Chemical Formulas

Problem 1: What is the name of NaCl?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Na is a metal.
Step 4: Na forms one type of cation (+1) since it is in Group I.
Step 5: Remember –ide ending, so name is sodium chloride.

Problem 2: What is the name of $CoBr_2$?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Co is a metal.
Step 4: No, Co does not form one type of cation. Because it is a transition metal it can form more than one type.
Step 6: The type of cation can be deduced from looking at the anion, Br. Br forms a -1 anion, and there are two of them making a total charge of -2. In order to achieve electrical neutrality, Co must form a +2 cation. The name is Cobalt (II) bromide.

Problem 3: What is the name of NO?

Step 1: Yes, this is a binary compound.
Step 2: No, N is not a metal.
Step 3: The name is nitrogen monoxide (please note that it is not mon<u>oo</u>xide).

Problem 4: What is the name of NH_4Cl?

Step 1: This is not a binary compound.
Step 7: The polyatomic cation ammonium is present.
Step 8: Ammonium only forms 1 type of cation so use Step 5.
Step 5: The name is ammonium chloride.

Do It Yourself (DIY) Problems

Problem 5: What is the name of MgO?

Problem 6: What is the name of $CaCl_3$?

Problem 7: What is the name of HgO?

Problem 8: What is the name of PbI_2?

Problem 9: What is the name of ZnS?

Problem 10: What is the name of SF_6?

Problem 11: What is the name of PCl_5?

Problem 12: What is the name of $Mn(OH)_2$?

Problem 13: What is the name of $NaC_2H_3O_2$?

Problem 14: What is the name of NH_4OH?

Problem 15: What is the name of $C_6H_{12}O_6$?

Problem 16: What is the name of NH_4OCN?

Problem 17: What is the name of $HC_2H_3O_2$?

Problem 18: What is the name of H_2O_2?

Problem 19: What is the name of CH_4?

Problem 20: What is the name of H_2SO_4?

Answers to DIY Problems

Problem 5: What is the name of MgO?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Mg is a metal.
Step 4: Mg forms one type of cation (+2) since it is in Group II.
Step 5: The name is magnesium oxide.

Problem 6: What is the name of $CaCl_3$?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Ca is a metal.
Step 4: Ca forms one type of cation (+2) since it is in Group II.
Step 5: The name is calcium chloride.

Problem 7: What is the name of HgO?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Hg is a metal.
Step 4: No, Hg forms does not form one type of cation. Because it is a transition metal it can form more than one type.
Step 6. The type of cation can be deduced from looking at the anion, O. O forms a -2 anion. In order to achieve electrical neutrality, Hg must form one +2 cation. The name is Mercury (II) oxide.

Problem 8: What is the name of PbI_2?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Pb is a metal.
Step 4: No, Pb does not form one type of cation. Because it is a transition metal it can form more than one type.
Step 6: The type of cation can be deduced from looking at I, the anion. I forms a -1 anion, and there are two of them making a total charge of -2. In order to achieve electrical neutrality, Pb must form a +2 cation. The name is Lead (II) iodide.

Problem 9: What is the name of ZnS?

Step 1: Yes, this is a binary compound.
Step 2: Yes, Zn is a metal.
Step 4: Yes, Zn does not form one type of cation. Because it is a transition metal it can form more than one type (Zn can form +2 and +1 cations, though the +1 is very rare).
Step 6: The type of cation can be deduced from looking at S, the anion. S forms a -2 anion, therefore Zn must form a +2 cation. The name is zinc sulfide.

Problem 10: What is the name of SF_6?

Step 1: Yes, this is a binary compound.
Step 2: No, S is not a metal.
Step 3: There are 6 F atoms so we must use hexa. The name is sulfur hexafluoride.

Problem 11: What is the name of PCl_5?

Step 1: Yes, this is a binary compound.
Step 2: No, P is not a metal.
Step 3: There are 5 Cl atoms so we must use penta. The name is phosphorous pentachloride.

Problem 12: What is the name of $Mn(OH)_2$?

Step 1: No, this is not a binary compound.
Step 7: Yes, the polyatomic anion hydroxide is present.
Step 8: Since Mn is a transition metal and can form more than one cation, Step 6 must be followed.
Step 6: The charge on the cation can be deduced from hydroxide which is a -1. Since there are 2 hydroxides, the total charge is -2. Therefore Mn must be -2. The name is manganese (II) hydroxide.

Problem 13: What is the name of $NaC_2H_3O_2$?

Step 1: No, this is not a binary compound.
Step 7: Yes, a polyatomic anion is present $C_2H_3O_2^-$ and it is called acetate.
Step 8: Since sodium only forms 1 cation, we must follow step 5.
Step 5: The name is sodium acetate.

Problem 14: What is the name of NH_4OH?

Step 1: No, this is not a binary compound.
Step 7: Yes, 2 polyatomic ions are present, ammonium and hydroxide.
Step 8: Since we have 2 polyatomics, the name is ammonium hydroxide.

Problem 15: What is the name of $C_6H_{12}O_6$?

Step 1: This is not a binary compound.
Step 7: This compound is covered by nomenclature rules in Organic Chemistry. Its common name is sugar or sucrose.

Problem 16: What is the name of NH_4OCN?

Step 1: This is not a binary compound.
Step 7: This compound is covered by nomenclature rules in Organic Chemistry.

Problem 17: What is the name of $HC_2H_3O_2$?

Step 1: This is not a binary compound.
Step 7: Yes, a polyatomic ion, acetate is present.
Step 8: Must use step 5 since H can form only 1 cation.
Step 5: The name is hydrogen acetate. This is an exception since it goes by its common name, acetic acid. This compound can also be written as $C_2H_4O_2$ or more commonly as CH_3COOH. This substance is reviewed in Organic Chemistry.

Problem 18: What is the name of H_2O_2?

Step 1: Yes, this is a binary compound.
Step 2: No, a metal is not present.
Step 3: The name is dihydrogen dioxide. This is an exception. The systematic name is almost never used. It is referred to as hydrogen peroxide.

Problem 19: What is the name of CH_4?

Step 1: Yes, it is a binary compound.
Step 2: No, a metal is not present.
Step 3: The name is hydrogen tetrahydride. This is an exception. This compound is called methane and is discussed extensively in Organic Chemistry.

Problem 20: What is the name of H_2SO_4?

Step 1: This is not a binary compound.
Step 7: Yes, a polyatomic ion is present; sulfate.
Step 8: Must use step 5 since hydrogen forms only 1 cation.
Step 5: The name is dihydrogen sulfate. Once again this name is never used; the common name sulfuric acid is universally preferred instead. For historical reasons many acids are called by their common names.

Please print out the following Nomenclature Map and use it to solve problems.