Chemistry (0-1) Class Notes—Orientation to the Class: The Structure of Chemistry

Preassessment—On a 3 x 5 note card, tell me why you think it might be useful to create a visual organizational outline of a large amount of new material you are trying to learn.

A Functional Organizational Scheme of Chemistry

Learning Target

<u>what</u>: The student will understand the importance of being able to use an organizational framework—a graphic organizer—to organize course content in a useful, meaningful way

<u>why</u>: knowing WHAT YOU NEED TO KNOW, especially in the format of a graphic organizer, enhances learning

<u>how</u>: students will be able to list four or more reasons an organizational structure is important; students will be able to explain how each section of the chemistry organizer is related to the step above it; students will be able to state that EVERYTHING we do and learn about in this course rests on OBSERVATION

For a really good short article about how and when to use graphic organizers see https://www.cultofpedagogy.com/graphic-organizer/

<u>Why you want to do this</u>

You are going to learn a great deal of information this year related to the field of chemistry. Research overwhelmingly suggests that one of the best ways to begin to deal with such a large amount of information is to create an organizational structure—one that is visual—that organizes the information you will be learning, in a logical fashion. There are many reasons to do this—

(1) This allows you to _____
_____
_____
_____
_____
_____

(2) Having this map where the connections between each section "make sense" _____
_____

(3) As learning occurs you can _____

(4) Understanding WHAT you need to learn before learning it _____

My favorite way to organize large amounts of information related to a big topic is to start with a single major idea, and by asking a sequence of logical questions, expand the structure to smaller details. Many of the pieces you won't have a great deal of understanding of yet, but it's important that we create this structure right from the start anyway. Despite this, you'll find that even if you don't know what the pieces are exactly, their place in the structure WILL make sense.

There is no magic in how I create an organizational structure—you are more than welcome to create your own or find one on the internet you like better. In fact, if you go out to the internet and bring me a copy of a different version of a graphic organizer that organizes the content of a chemistry course, I may give you some extra credit. However, the one that I will model for you is the basis for the organization of the content of this course, and the one I will refer to as we move through the course.

Matter

Recognize right from the start, the thing that all of chemistry is built to describe is _____—that stuff that is all around us. What does it look like? What is it made of? What happens when it interacts with itself? . . . . ALL of chemistry is built on the idea of describing matter, so this is where we start—this is the first box in the organizer. **Matter is anything that has _____ _____ (vocab)**

Also recognize that to describe matter requires us to make _____. We will find observation is the single most important aspect of all of this, and in fact, in all of science—I will constantly be asking, "WHAT DO WE OBSERVE?"

Physical and Chemical Properties and Changes

It should make sense now that we have emphasized observation, all components of matter have_____ that we can identify and characterize through observation. More specifically, there are two types of properties that we are concerned with:

_____ properties are characteristics a substance exhibits by itself without changing into or interacting chemically with another substance. (vocab)

_____ properties are characteristics of a substance that become observable as it changes into or interacts chemically with another substance or substances. (vocab)

Physical and chemical properties are closely related to the concepts of physical and chemical _____.

> **<u>Physical changes</u> occur when a substance is altered in its physical properties, but not its chemical composition. (vocab)**
>
> **<u>Chemical changes</u> occur when a substance (or substances) is converted into a different substance (or substances). (vocab)**
>
> Chemical changes are synonymous with _____**.**

We will talk about properties and changes in much more detail later—for now lets just see how they fit into our organizer. Add physical and chemical properties and changes into the diagram as shown in the presentation or as seen on your final diagram.

Now notice, there is nothing here that you need to memorize, what we have so far just makes sense—we observe matter all around us and we see that it **has** properties (physical and chemical) and it **undergoes** changes (physical and chemical.

<u>Divisions of Matter</u>

Now that we have "placed" physical and chemical properties, how can we use these to expand the organizational structure. With respect to matter, what do physical and chemical properties allow us to do? _____

You are aware that matter can either consist of _____ _____, that is, quantities of matter with _____ _____, or, _____ of two or more pure substances (THERE ARE ONLY TWO CHOICES HERE—A SUBSTANCE IS EITHER PURE OR IT'S NOT PURE!)

Add these divisions into the organizer as shown in the presentation or as seen on final diagram. Again, notice, there is not really yet any need for memorization here—the scheme flows natrually from a logical thought process.

Now lets add a little more detail. You may be aware that pure substances are

either composed of atoms of a single type, that is, _____, or are composed of atoms of two or more types present in consistent ratios, that is, _____. (AGAIN, THERE ARE ONLY TWO CHOICES HERE—A PURE SUBSTANCE IS EITHER COMPOSED OF A SINGLE ELEMENT, OR, IT IS COMPOSED OF MORE THAT ONE ELEMENT IN IN PRESENT IN CONSTANT RATIOS!)

Add these divisions into the organizer as shown in the presentation or as seen on final diagram.

Before we take the next step, we need to make sure we are absolutely clear about the difference between compounds and mixtures. Why might there be confusion about the composition of these? _____

_____

So what's the difference????????

While a compound is certainly made from two or more elements, in a compound, the elements are--

_____

_____

_____

For example—in a water molecule two atoms of hydrogen are chemically bonded to one atom of oxygen, and this is the case no matter what water molecule you look at.

We also have hydrogen and oxygen present in the atmosphere. However, the hydrogen is not chemically bonded to the oxygen, and the amounts of hydrogen compared to the amounts of oxygen are not consistent throughout the atmosphere. The hydrogen and oxygen molecules in the atmosphere exist separated from each other. This means that they are present as a mixture, not a compound.

Draw a model of these two scenarios below:

We will spend a little more time later on making sure we really have this down but for now we can use this understanding to help us with our organizer.

Now lets put even a little more effort into this. If matter is not a pure substance, you can logically conclude that it must be a mixture of two or more pure substances. How might we further classify mixtures?

If the mixed particle sizes are atomic or molecular the particles are so small that we cannot tell by usual methods of observation that the mixture is not actually a pure substance—how does this affect the appearance of the mixture—it is _____. What is our main example of this type of mixture? _____.

If particles sizes are large enough, we can determine by more standard means of observation that the material we are viewing is, in fact, a mixture. We call these mixtures _____. If we require a microscope to make this determination—that is, the particle sizes are microscopic—we call these mixtures _____. If particles sizes are visible, we call these mixtures _____.

Add these divisions into the organizer as shown in the presentation or as seen on final diagram.

Two additional aspects of mixtures are important to recognize. One is the set of rules that governs how soluble a substance is in water—the topic of solubility. This necessarily involves the topic of concentration and molarity and will also involve the topic of chemical equilibrium.

The second is that a large part of the dealing with mixtures is how they can be separated.

Add to the organizer and lets also draw broken arrows from the physical and chemical properties area to the divisions of matter area to show that we understand that matter can divided in this way based on our knowledge of physical and chemical properties of substances.

States of Matter

Although chemistry deals with a broad range of physical properties and changes, the most important of these relate to states of matter and changes in these states. You are aware that the three main physical forms of matter are _____, _____, and _____.

What you may not be familiar with is the concept that the state of matter reflects the strengths of the _____ of attraction between particles and the amounts of _____ the particles contain. The theory that explains states of matter is called the _____ _____ theory. In particular, this theory helps explain the so-called gas laws—physical laws that describe the relationship between _____, _____, _____, and number of _____ in a gaseous sample.

Add to the organizer.

Lets also draw broken arrows from the physical properties and physical changes boxes to the physical states boxes to indicate that observation of these properties and changes help us to understand physical states of matter and changes between them.

Pure Substances

It is important to remember that, particularly for pure substances, all of these properties we are making such a big deal about arise, at least in part, because of the specific arrangement of the sub-atomic particles in each atom, especially the electrons. The implication is that if we make detailed enough observations regarding the properties of different substances, the clues present in our observations will guide us to an understanding of the structure of the atoms that make up these substances. Using this pattern of investigation we have learned a great deal about the structure of atoms and why they behave the way they do. Accordingly, a great deal of time is spent studying atomic structure and the major result of this, the periodic table, as well as trends of atomic properties across the periodic table. Always understand that the bizarre shape of the periodic table did not come about by accident, and that features of the table itself are major clues to atomic structure. We also normally spend a little time talking about nuclear structure.

Add to the organizer.

Chemical Reactions

Now we get away from all of the things that define matter and focus on what happens when matter interacts chemically—that is, undergoes chemical reactions. You're aware that these are interactions resulting in the change of one or more substances into one or more different substances, and their accompanying energy changes.

The types of reactions we normally study include oxidation-reduction reactions (synthesis, decomposition, replacement and combustion), precipitation reactions (double replacement), acid-base reactions, and covalent reactions.

Add to the organizer.

In order to be able to study these reactions we have to understand the system of chemical names and symbols utilized in characterizing these reactions. We also need to know how to balance and calculate mass and molar amounts of products and reactants participating—a topic called _____.

Add to the organizer.

Another major component is the understanding of the nature of chemical bonding (ionic vs. covalent vs metallic) and the energy changes associated with such bonding—what is the nature of the energy change that makes it desirable or not desirable for a bond to occur? For ionic bonding we focus on the energy changes associated with the formation of ions and their subsequent electrical attraction. With covalent bonding will focus not only on the energy changes associated with the sharing of one or more electron pairs, but also on bond geometry due to valence shell electron pair repulsion (VSEPR), and the necessity of formation of hybrid orbitals to explain some of the geometries observed. Metallic bonding is a type of bonding observed in metals in which valence electrons are so loosely held they form a "sea of electrons" which acts to hold the atoms together in a cohesive mass.

Add to the organizer

The last piece of the puzzle for reactions is the understanding of factors that determine how rapidly a reaction occurs. This is the topic of reaction kinetics.

Add to the organizer.

Lets also add a broken arrow from the chemical changes box to the reactions box to indicate that chemical changes refer to chemical reactions.

Thermodynamics and Equilibrium

Finally, there are two concepts that apply broadly not only to chemical changes, but also physical changes. The laws of thermodynamics must be applied not only to energy and entropy changes within chemical systems but also during physical changes. Recall that increases in entropy that occur because of physical changes like phase changes can make reactions spontaneous even if energy considerations related to chemical changes would otherwise make the reaction non-spontaneous. Also, because bonds or intermolecular forces of attraction can develop and be broken during both chemical and physical changes, and because this is usually a dynamic process, the concept of equilibrium can apply to both physical processes like dissolution as well as in chemical reactions.

Add to the organizer, and draw arrows from these to include both physical and chemical changes.

As I learn new things about chemistry and continue to teach it, I find that this "structure" becomes more and more firmly implanted in my brain and provides a very useful framework to put new information into. In case you might find this useful I've also included a couple of blank copies of this in your handout. Lets see if we can just quickly run through this without any help.

Postassessment—Your question of the day for the next class is to complete a blank graphic organizer through the division of matter stage.