Chemistry 1301

Week of September 5, 2022: Protons, Neutrons, and Electrons

Hi! My name is Kristiana Kasper, and I'm the master tutor for Gen Chem I this fall! Each week, I'll be compiling these resources, which summarize key topics that have been covered in the classroom. I'll also host group tutoring sessions every **Wednesday, 6:30-7:30 pm**, in the basement of the Sid Richardson building (Room 074). Come stop by and say hi! We'll go over topics of y'all's choice and work some practice problems.

Key Words: Atom, Molecule, Reaction, Scientific Method, Fundamental Chemical Laws, Dalton's Atomic Theory, Proton, Isotope, Nuclide Symbol, Weighted Average, Electron, Thomson's Cathode Ray Tube Experiment, Plum Pudding Model, Millikan's Oil Drop Experiment, Rutherford's Gold Foil Experiment, Planetary Model, Ion (Cation, Anion), Significant Figures, Dimensional Analysis

(How to use "Key Words" sections: One great way to study is to write, on a blank piece of paper, everything you remember about a certain topic, and then return to notes/resources and check your work!)

Highlight 1: Chemistry is the study of _____

Key Words: Atom, Molecule, Reaction, Scientific Method, Fundamental Chemical Laws, Dalton's Atomic Theory, Proton

Check your understanding: *See last page for answers.*

Which is bigger, an atom or a molecule?

When the way that atoms are attached to each other changes, a chemical _____ has taken place.

When using the scientific method, observations allow the generation of a _____, which guides experimental design.

What is the difference between a theory and a law?

What is the law of conservation of mass?

What is the difference between the law of definite proportions and the law of multiple proportions?

What are the components of Dalton's atomic theory, and which of them are accepted today?

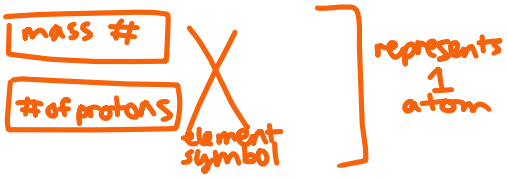
When you change the number of ____, you get a different element.

Highlight 2: An **isotope** is a *version* of an atom of an element with a certain number of _____.

Key Words: Nuclide Symbol, Weighted Average

Key point: Each element can have multiple isotopes. In other words, *atoms exist that have the same number of _____ but a different number of _____*!

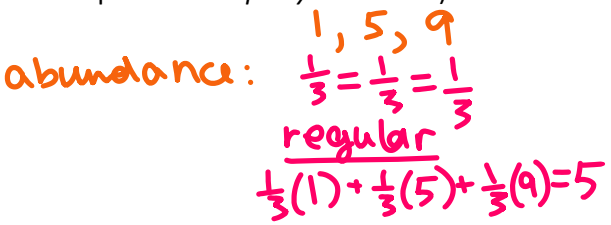
Each atom can be represented using a nuclide symbol, which contains 3 parts—the element symbol, the number of protons, and the mass number.



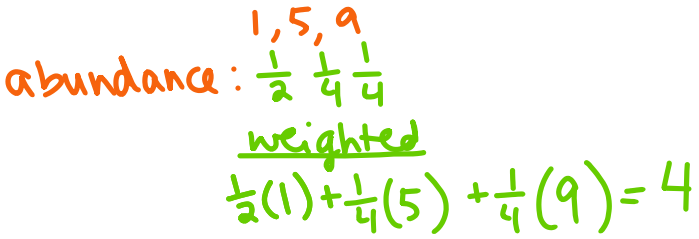
If different atoms of an element can have different masses, how is possible to list masses on the periodic table? And why are they decimals? The answer: listed atomic masses are *weighted averages*.

A weighted average is different from a regular average because it allows the most commonly occurring data to have more of an impact on the calculation. In other words, a mass that accounts for 50% of all of an element's atoms will affect the average more than a mass that describes 10%... it will affect the average *5x more*, to be exact! How is this accomplished? Each mass is multiplied by the fraction representing its abundance, and then everything is added up.

(Fun fact: calculating a regular average is like calculating a weighted average with the assumption that all data points are *equally abundant*.)



But say that all data points are *not equally abundant*. It would be much more representative to calculate their weighted average:



And this is the type of average that is listed in the periodic table! Say that you were given the following information for a newly discovered element. What should be its listed atomic mass?

Weights of isotopes (and their relative abundances): 5.40 g (30%), 5.33 g (20%), 5.44 g (50%)

Topic of the Week: Electrons

Key Words: Thomson's Cathode Ray Tube Experiment, Plum Pudding Model, Millikan's Oil Drop Experiment, Rutherford's Gold Foil Experiment, Planetary Model, Ion (Cation, Anion)

Visit this link: Discovery of the electron and nucleus (article) | Khan Academy to fill in this table:

Experiment	Discovery (facts about the atom)	Atomic model (if applicable)
Thomson		
Millikan		
Rutherford		

Ions

Just as changing the number of _____ yields a different element, and changing the number of ____ yields a different isotope, changing the number of electrons yields a different ion.

The addition of an electron yields an **anion** (negatively charged ion), because electrons have a negative charge.

The removal of an electron yields a **cation** (positively charged ion).

Highlight 3: Useful Skills

Key words: Significant Figures, Dimensional Analysis

Sig Figs

Not all digits are important to include in an answer. The number of digits in your answer should depend on how many digits were in the numbers that you started with—if someone were to start with numbers that are accurate to 2 decimal points but give an answer with 4 decimal points, the calculation would make the measurements look more precise than they were.

Dr. Vasut told my class this joke: A tourist in a history museum asked a member of the museum staff, "How old is this dinosaur fossil?" "12 million 9 years old," replied the staff member. "That's awfully specific," the tourist returned. "How did you calculate that so precisely?" "Well," said the staff member, "When I started working here, I asked how old the dinosaur skeleton was, and they told me '12 million.' That was 9 years ago."

...the 9, though it makes mathematical sense, is not significant.

Sig fig rules to memorize:

	Round answer to
Addition and subtraction	Lowest number of decimal places
Multiplication and division	Lowest number of sig figs

And how do you determine the number of sig figs?

1. Non-zero numbers are always significant.
2. Zeroes are significant if:
    a. They are surrounded by nonzero numbers

b. There is a decimal, and the zeroes are after the decimal point

Rule of thumb: If there is a decimal, start at the left, and move to the right until you reach a nonzero number. All the rest of the digits are significant. If there is not a decimal, start at the right, and move to the left until you reach a nonzero number. Then, start at the left and do the same. All the rest of the digits are significant.

Try: Calculate, rounding according to sig fig rules. 3.20*04.180

<u>Dimensional analysis</u>

The key here is to start with the end in sight. This is a good general problem-solving strategy too! Think: "What are they asking me for" (A)? Then, "What information might I use to get there" (B)? "Is there information that I am given that I could use to get to B?" In other words, work backwards.

C→B→A

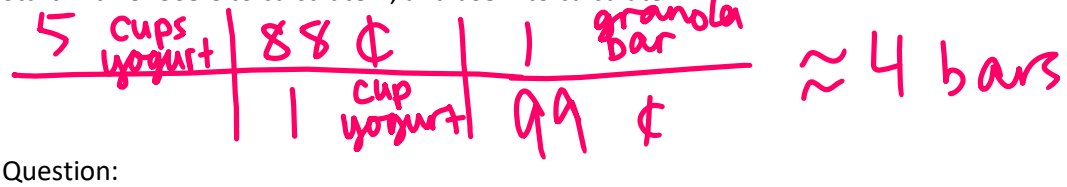
Here's an example: Yogurt costs 88 cents per cup. Granola bars cost 99 cents each. If I buy 5 cups of yogurt, how many granola bars could I have bought for the same cost?

A: What are they asking me for? A number of granola bars.

B: How could I know the number of granola bars? If I knew how much money total I had.

C: How could I know how much money total I had? If I knew how many cups of yogurt I bought.

Start with C. Use C to calculate B, and use B to calculate A.



Question:

How do I know which number goes on top?

Answer:

Units, except those that will be part of your answer, should cancel. If cups of yogurt are on top, multiply by "88 cents / 1 cup of yogurt." If cups of yogurt were on the bottom, you would multiply by "1 cup of yogurt / 88 cents."

Think, "If I have [insert first piece of information given], how will I get [second piece of information]?" For example, "If I have 5 cups of yogurt, how much will it cost?" Well, it will cost 88 cents *per* cup of yogurt… that means that the number of cups of yogurt should be multiplied by 88 cents.

Try: If you have 3 moles of NaOH in your flask, and you need to add 1 mol of HCl for every mol of NaOH, how many grams of HCl should you add? Hint: Calculate molar mass.

Common Errors:

A law is certain; a theory is not. T/F

All atoms of an element have the same mass. T/F

The theories proposed by Rutherford and Dalton are accepted today as completely accurate. T/F

Calculating weighted averages: Be sure to multiply by decimals, not percentages. Convert if necessary!

Sig figs: Zeroes after a decimal point are always significant, even if they come after all the nonzero numbers! The zeroes in 2.300 are significant, because they show how precise the measurement was.

Dimensional analysis: Double-check that units have cancelled properly. If they did not cancel properly, one of the ratios likely needs to be flipped, or another ratio needs to be included.

Answers:

Highlight 1: Atoms

Check your understanding:

molecule, reaction, hypothesis,

theory= explanation of phenomena that can be used as a model for making predictions, law = describes pattern in phenomena but does not explain,

mass cannot be created or destroyed,

law of definite proportions=refers to one compound/this compound's ratio of composition will always be the same, law of multiple proportions = if same elements combine in different ways [to get different compounds] they will do so in whole number ratios,

Check out this link: * Dalton's atomic theory (article) | Khan Academy

protons

Highlight 2: Neutrons

Key point: protons, neutrons

Weighted average: 5.41 g. See Highlight 3, Useful Skills, for rules on rounding!

Topic of the Week (Electrons)

Experiment	Discovery (facts about the atom)	Atomic model (if applicable)
Thomson: Cathode Ray Tubes	A **negatively charged particle** comprises the cathode rays (patterns of deflection are consistent with being negative) *credited with discovery of the electron	Plum pudding: positive sphere with negative electrons

	Charge to mass ratio of electron (measured how much force necessary to get the cathode ray to move) = -1.76 x 10^8 C/g	
Millikan: Oil Drop Experiment	**Charge of an electron** = -1.6 x 10^{-19} C Given charge:mass ratio and charge, mass could be calculated = 9.1 x 10^{-28} g	
Rutherford: Gold Foil Experiment	Discovery of different types of particles… especially significant was his discovery of **alpha particles** & the knowledge that a ray of alpha articles is bent by an electric field. Presence of a **nucleus** with positively charged particles (when alpha particles were fired at gold foil, the plum pudding model predicted that they would go straight through. Most of them did, but not all, indicating the presence of a small, positively charged presence that today we call the nucleus)	Rutherford's atomic theory: Most mass = in nucleus Most volume = empty space **Planetary model**: electrons revolve around nucleus # protons = # electrons

Ion fill-in-the-blank: protons, neutrons

Highlight 3 (Useful Skills)

Sig figs: 13.4 (3 sig figs * 4 sig figs = 3 sig figs)

Dimensional analysis: 100 g HCl (MW_{HCl} = 36.463 g)

Common Errors: F, F, F

Coming up next week: **Quantum Mechanical Model/Photoelectric Effect, Bohr Model and energy change between quantum levels, Heisenberg Uncertainty, Quantum Numbers & Electron Configuration, Aufbau Principle, Hund's Rule, Pauli Exclusion Principle, Periodic Trends**

And that's it for this time! Thanks so much for reading, I hope this was helpful! And I hope to see you this Wednesday at 6:30 in Sid Rich Room 074:) Have a great week!