CHE 1301

Basic Principles of Modern Chemistry I

Week 3

Hi! Thanks for checking out the weekly resources for Chemistry 1301! This resource covers topics typically taught by professors during the 3rd week of classes.

Visit our website, https://baylor.edu/tutoring, to sign up for appointments and check out additional resources for your course! You'll find helpful links with the following titles:

- "Online Study Guide Resources" – The pace of your course may vary slightly from what's shown in this document. If you don't see the topics you're learning right now, use this link to find the weekly resources for the rest of the semester.
- "How to Participate in Group Tutoring" - See if there is a Chemistry 1301 group tutoring session being hosted this semester. These are weekly question/answer sessions taught by our master tutors!
- "View tutoring times for your course" or "Schedule a private 30-minute appointment!"

You can also give us a call at (254)710-4135, or drop in! Our hours are Monday-Thursday 9 am – 8 pm on class days.

KEY WORDS: Element, Isotope, Atomic Mass, Key Experiments, Significant Figures, Dimensional Analysis

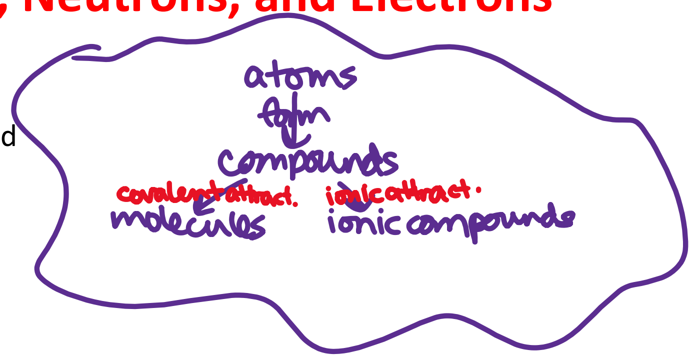
TOPIC OF THE WEEK: Protons, Neutrons, and Electrons

Here are some important definitions:

Atom: smallest unit into which matter can be divided

Compound: combination of atoms

Molecule: covalent compound



Chemical change: material shows different properties, because **connections between atoms have changed**

Physical change: material shows different properties, but connections have atoms have *not* changed

Hypothesis: generated, based on observations, to guide experimental design

Theory: explanation of phenomena that can be used as a model for making predictions

Law: describes a pattern in phenomena but does not explain

- Law of Conservation of Mass: 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: same elements combine in different ways [to get different compounds] they will do so in whole number ratios

Dalton's atomic theory: Dalton's atomic theory (article) | Khan Academy

- All matter is made of **indivisible atoms**
    - Today's update: atoms are made of **subatomic particles** called protons, neutrons, and electrons
- Atoms can be classified according to their "**elements**;" atoms of a given element have the **same mass and properties**
    - Today's update: atoms of the same element can have different masses, because of different **isotopes**!
- If you **combine different types of atoms**, you'll get "**compounds**."

Changing the number of **protons** gives different **elements**.

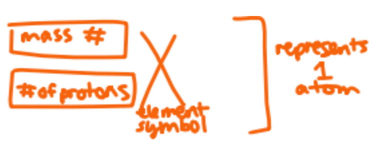
Changing the number of **neutrons** gives different **isotopes**.

Changing the number of **electrons** gives different **charges**.

Highlight 1: Different Number of Neutrons

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

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.)

1, 5, 9

abundance: $\frac{1}{3} = \frac{1}{3} = \frac{1}{3}$

regular

$$\frac{1}{3}(1) + \frac{1}{3}(5) + \frac{1}{3}(9) = 5$$

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

1, 5, 9

abundance: $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{4}$

weighted

$$\frac{1}{2}(1) + \frac{1}{4}(5) + \frac{1}{4}(9) = 4$$

And this is the type of average that is listed in the periodic table!

Highlight 2: 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 Charge to mass ratio of electron (measured how much force	Plum pudding: positive sphere with negative electrons

	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

Ions

Just as changing the number of *protons* yields a different element, and changing the number of *neutrons* 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

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.

Dimensional analysis

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

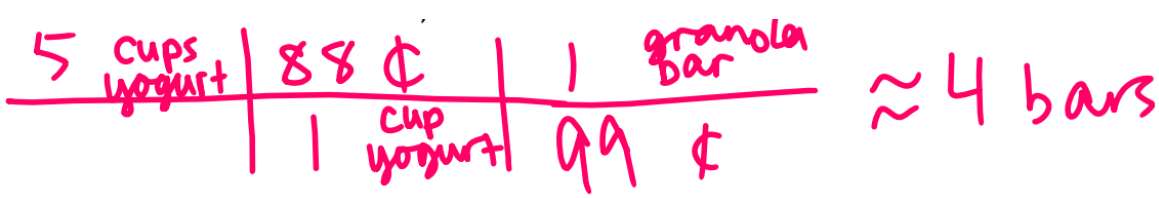
Here’s an example: Yogurt costs 88 cents per cup. Granola bars cost 99 cents each. If I buy 5 cups of yogurt, how many granola bars could I have bought for the same cost?

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.



How do you know which number goes on top?

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.

Check Your Understanding

1. Say that you were given the following information for a newly discovered element. What should be its listed atomic mass?
    a. Weights of isotopes (and their relative abundances): 5.40 g (30%), 5.33 g (20%), 5.44 g (50%)
2. Calculate, rounding according to sig fig rules. 3.20*04.180
3. 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

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Things You May Struggle With

1. It is a common misconception that a law is certain, but a theory is not certain. This is not true!
2. Remember: all atoms of an element do not have the same mass. There are different isotopes that have different masses; this is why the mass in the periodic table has to be an average. Specifically, it is a weighted average.
3. Keep in mind that not all theories that you're learning are the ones accepted today. The ideas proposed by Rutherford and Dalton about the movement of electrons were not totally accurate. Today, we know that there are regions in which electrons are *likely* to be found…but there are not specific locations or orbits along which electrons are *guaranteed* to be found.
4. Calculating weighted averages: Be sure to multiply by decimals, not percentages. Convert if necessary!
5. 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.
6. 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.

That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to Check Your Learning are below.

1. 5.41 g. See Highlight 3 for rules on rounding!
2. 13.4 (3 sig figs * 4 sig figs = 3 sig figs)
3. 100 g HCl (MW_{HCl} = 36.463 g)