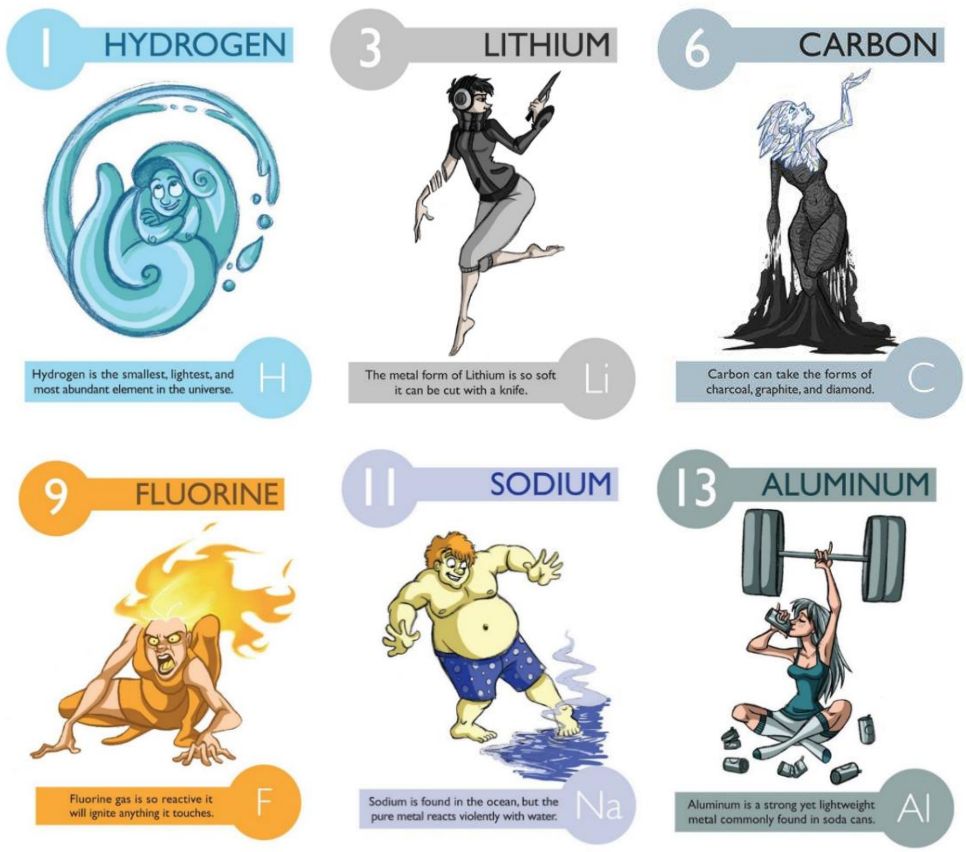
CHEMISTRY 30S

The Alchemist's Cookbook

UNIT 1 – ELEMENTS & COMPOUNDS



NAME:___________________________________

It is expected that the activities in this book are completed as they are performed in class. This book will be collected at the end of the unit and a mark will be given.

LET'S GET STARTED!

By the end of this unit, you should be able to:

- ✓ Write large and small numbers in scientific notation and perform calculations on them.
- ✓ Round numbers to the correct degree of accuracy using significant digit rules.
- ✓ Convert between common units of measurement using unit analysis method.
- ✓ Evaluate the atomic structure of atoms, ions, and isotopes and calculate average atomic mass of them.
- ✓ Write formulas and names for a variety of chemical compounds including complex ionic.
- ✓ Describe the concept of the mole and calculate the molar mass of various substances.
- ✓ Solve problems requiring conversions between moles, mass, volume, and number of particles.
- ✓ Determine the % composition of elements in a compound
- ✓ Determine the empirical formula of a compound from the % composition.
- ✓ Determine the molecular formula of a compound from the empirical formula and molar mass.

THIS UNIT WILL TAKE APPROXIMATELY 20 LESSONS TO COMPLETE AND WILL COUNT 20% TOWARDS YOUR FINAL MARK.

ACTIVITY #1 – WHAT DO YOU KNOW?

The following questions are THOUGHT QUESTIONS. This means that you are NOT supposed to ask Siri or "Google it" to find the answers. I want to know what's in your head, not whether you can steal the answer from the internet. Spend no more than 20 minutes attempting these problems

1. Atoms are made of PROTONS, NEUTRONS and ELECTRONS. Attempt to draw a picture of how these parts are arranged to form a CARBON atom.

2. How many different kinds of atoms are there in the world? Circle your answer. Explain briefly.

    a) just two
    b) about 50
    c) about 100
    d) thousands
    e) too many to count

    Explanation:

3. You probably know that SODIUM CHLORIDE is ordinary table salt while pure SILVER is a nice- looking shiny metal. I want you to make your best guess as to what the following substances would look like:

    f) PURE SODIUM would look like

    g) SILVER CHLORIDE would look like

4. Convert each of these values to GRAMS: Show your method. Explain your reasoning in each case. . .

   h) 100 MILLIGRAMS

   i) 0.2 KILOGRAMS

5. If **1.8 teaspoons** of sodium chloride **weighs 8.4 grams**, how much would **6.7 teaspoons** of sodium chloride weigh? *Note: show a mathematical calculation method here!*

6. Is there anything on Planet Earth that is not made of atoms? If yes, what would it be?

7. Who were alchemists and what were they trying to discover? (you can google this one if you don't know…)

ACTIVITY #2 – CAESAR'S LAST BREATH

Roman emperor Julius Caesar was murdered in 44 BC on the floor of the Senate by his colleagues. He is famous for his last words, 'Et tu, Brute?', as his friend Brutus joined in with Roman Senators to assassinate him and end his dictatorship. With this last gasp, Caesar exhaled his final breath of air into the atmosphere.

So, what happened to this breath? Did it just disappear? Are those gas molecules still out there in the air somewhere? What are the odds that you have ever interacted with them, even breathed them in? Let's find out.

1. One adult breath makes up about 0.0000000000000000001% of the atmosphere. Write this number in scientific notation.

2. The atmosphere can be estimated to contain approximately 8000000000000000000000 litres of air. Write this number in scientific notation.

3. One deep adult breath at standard temperature and pressure (STP is $0^{o}C$ and 101.3 kPa) fills a volume of about 1.0 litre and contains approximately 24 sextillion molecules (24000000000000000000000). Write this number in scientific notation.

4. Gases diffuse very quickly. The molecules in a single breath will cover the entire the planet within about 1-2 years. This means Caesar's 24 sextillion last breath molecules have spread out evenly around the world. Based on your answers to the previous two questions, use scientific notation long division to calculate the number of molecules of Caesar's last breath there are in every litre of atmospheric air

5. You breath about 20000 times a day. Calculate the number of molecules of Caesar breath you inhale in a day using scientific notation long multiplication. (Assume 1.0 litre per breath)

<u>ACTIVITY #3 – SCIENTIFIC NOTATION – WORKING WITH BIG & SMALL NUMBERS</u>

Remember…If moving the decimal makes the number <u>larger,</u> then the exponent gets **<u>smaller</u>**.

<u>Write the following numbers in scientific notation.</u>

1. 280 ______________
2. 933 ______________
3. 6521 ______________
4. 0.000 02 ______________
5. 0.000103 ______________
6. 0.0031 ______________
7. 0.025 ______________
8. 3254100 ______________
9. 60400 ______________
10. 35.7 ______________

<u>Write the following numbers in expanded notation.</u>

11. 3.4 x 10^{5} ______________
12. 1.057 x 10^{4} ______________
13. 7.9310 x 10^{-2} ______________
14. 3.27 x 10^{2} ______________
15. 9.8 x 10^{7} ______________
16. 1.001 x 10^{-5} ______________
17. 4.22 x 10^{6} ______________
18. 6.253 x 10^{-7} ______________
19. 5.0513 x 10^{-1} ______________
20. 1 x 10^{3} ______________

<u>PERFORM THE FOLLOWING CALCULATIONS WITHOUT A CALCULATOR. INCLUDE UNITS.</u>

21. (2 x 10^{7}m) x (3 x 10^{-4}m)

22. (4 x 10^{3} g) x (4 x 10^{3} g)

23. (5 x 10^{-2} kg) x (1 x 10^{-6} kg)

24. (7 x 10^{-3} mm) x (5 x 10^{-2} mm)

25. (2.5 x 10^{4} mg) x (3 x 10^{5} mg)

26. (6 x 10^{7} km) x (1.5 x 10^{8} km)

27. $\frac{(6 \times 10^{5}\ \text{g})}{(4 \times 10^{3}\ \text{s})}$

28. $\frac{(2 \times 10^{7}\ \text{m})}{(5 \times 10^{-8}\ \text{h})}$

29. $\frac{(7 \times 10^{-4}\ \text{km})}{(1 \times 10^{-6}\ \text{h})}$

30. $\frac{(2 \times 10^{8}\ \text{kg})}{(8 \times 10^{4}\ \text{cm}^{3})}$

ACTIVITY #4 – SIGNIFICANT DIGITS (SIG DIGS)

In chemistry, we try to get the most information we can get out of every measurement. Whenever we write down a number we've measured, the number of digits we use reflects the precision of the instrument we used to get it. This is important in science because when we read someone else's data, we like to know how much effort and care was taken in their measuring. If we use the wrong number of digits in our answers, we might fool people into believing that our work was more precise than it was, or vice versa. For example, a length written as 4 cm leads you to believe that the ruler used was pretty poor quality, since the best answer you could write was to the nearest whole centimeter. However, if that same length was written as 4.00 cm, you are led to believe that the ruler used was quite good quality, since it could measure to the nearest $1/100^{th}$ of a centimeter. It's like Goldilocks and the Three Bears…your measurements shouldn't be too precise, or not precise enough, but just right! To make sure we are being precise enough (and not too precise), we must follow a very specific set of rules. These rules are called significant digits. When measuring anything, the most important rule is to record all the numbers you are certain of from the measuring tool, and then write an extra digit that is an estimate. In this activity, you will be measuring various objects with various devices, and you must communicate your measurement correctly.

Station 1: Measuring Volume of a Liquid with a 50 mL Graduated Cylinder

Use the 50 mL cylinder at this station to find the following volume. Be sure to use the proper number of significant digits in your answers!

1. Volume of pipet (mL): ____________________________
2. Volume of Pen Cap (mL): ____________________________

Station 2: Measuring Volume of a Liquid with a 10 mL Graduated Cylinder

Use the 10 mL cylinder at this station to find the following volume. Be sure to use the proper number of significant digits in your answers!

1. Volume of pipet (mL): ____________________________
2. Volume of Pen Cap (mL): ____________________________

Station 3: Measuring Mass of a Solid with an Electronic Balance

Use the electronic balance at this station to find the following masses. Be sure to use the proper number of significant digits in your answers!

1. Mass of Penny (g): ____________________________
2. Mass of Paper Clip (g): ____________________________

Station 4: Measuring Mass of a Solid with a Triple Beam Balance

Use the triple beam balance at this station to find the following masses. Be sure to use the proper number of significant digits in your answers!

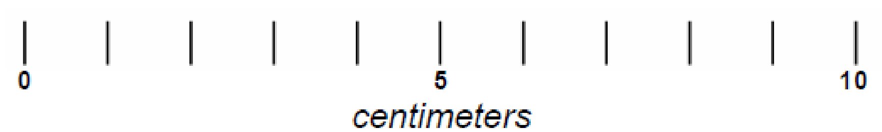
1. Mass of Penny (g): ____________________________

2. Mass of Paper Clip (g): ____________________________

Station 5: Measuring Length of an Object with a Ruler

Use the ruler printed below to find the following lengths. Be sure to use the proper number of significant digits in your answers!

Ruler:



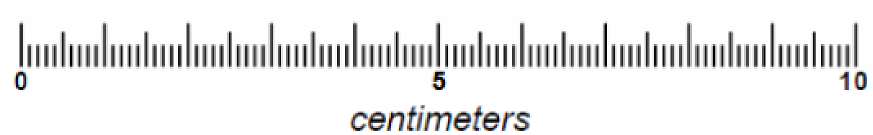
1. Length of Post-It Note (cm): ________________________

2. Length of Paper Clip (cm): ________________________

Station 5: Measuring Length of an Object with a Ruler

Use the ruler printed below to find the following lengths. Be sure to use the proper number of significant digits in your answers!

Ruler:



1. Length of Post-It Note (cm): ________________________

2. Length of Paper Clip (cm): ________________________

ACTIVITY #5 – ROUNDING ANSWERS CORRECTLY

1. Write the following in Standard Decimal and Scientific Notation. Circle and count the significant digits.

	Standard Decimal Notation Circle the significant digits.	How many significant digits?	Scientific Notation
a.	0.000250		
b.	2,000		
c.	0.02081		
d.	900.		
e.			2.150×10^{2}
f.			8.8×10^{-4}
g.			1.00×10^{-5}
h.			4.337×10^{6}

2. Perform the following calculations using your calculators EE or EXP function. Round your answer to the correct number of significant digits.

a. $(6.02 \text{ x } 10^{23})\ (8.65 \text{ x } 10^{4})$

b. $(6.02 \text{ x } 10^{23})\ (9.63 \text{ x } 10^{-2})$

c. $(5.6 \text{ x } 10^{-18})(\ 8.9 \text{ x } 10^{8})$

d. $\dfrac{(5.4 \text{ x } 10^{4})\ (2.2 \text{ x } 10^{7})}{4.5 \text{ x } 10^{5}}$

e. $\dfrac{(6.02 \text{ x } 10^{23})\ (-1.42 \text{ x } 10^{-15})}{6.54 \text{ x } 10^{-6}}$

f. $\dfrac{(6.02 \text{ x } 10^{23})\ (-5.11 \text{ x } 10^{-27})}{-8.23 \text{ x } 10^{5}}$

3. Multiply each of the following measurements together. Round your answer to the correct degree of accuracy using significant digit rules. Provide the correct units for the answer.

a. (17 m)(324 m) = ________________

b. (0.005 cm)(8888 cm) = ________________

c. (0.424 in)(0.090 in) = ________________

d. (0.050 m)(102 m) = ________________

e. (324000 cm)(12.00 cm) = ________________

4. Divide each of the following measurements. Round your answer to the correct degree of accuracy using significant digit rules. Provide the correct units for the answer.

a. 23.4 m ÷ 0.50 s = ________________

b. 0.960 g ÷ 1.51 mL = ________________

c. 12 km ÷ 3.20 h = ________________

d. 1200 m ÷ 12.12 m = ________________

ACTIVITY #6 – A BUTTLOAD OF FUN

The imperial system is a funny thing. There is actually a unit of measurement for wine casks called a "butt." That means if you fill the barrel up, you technically have a buttload of wine—though you'd probably just call it a full butt. Butt actually comes from "*botte*," a Medieval French and Italian word for boot. In Italy, at least, *botte* is still used to refer to a wine cask. At this point you're probably wondering just how much wine it takes to make a buttload. Use the following information to answer these questions:

The metric system is the tool of the Devil! My car gets forty rods to the hogshead, and that's the way I like it!

1 tun = 2 butts	1 butt = 2 hogsheads
1 tun = 3 puncheons	1 butt = 7 rundlets
1 hogshead = 2 barrels	1 puncheon = 2 tierces

Convert the following measurements using unit analysis:

1. How many butts does it take to fill 3.5 tuns?

2. How many hogshead's can be filled from 3 butts?

3. How many rundlets will fit into 1 hogshead?

4. How many tierces are required to fill 5 butts?

5. Which scenario contains the largest volume: 32 puncheons or 72 barrels? Prove it using dimensional analysis calculations! (Hint: convert both to a common sized barrel)

ACTIVITY #7 – UNIT ANALYSIS SUMMARY PROBLEMS.

The following conversions may be useful.

1 mi = 1.62 km	1 in = 2.54 cm	4 qt = 1 gallon	1 lb = 454 g
1 yd = 3 ft	1 ft = 12 in	1 qt = 946 mL	1 lb = 16 oz

Part A: One-Step Problems

A1.* How many kg are in 1640 g?	A2.* How many cm are in 19 inches?
A3. 14 oz is the same as how many lbs (pounds)?	A4.* How many g are in 16822 mg?
A5.* 4.80 qt is the same as how many mL?	A6. How many mmol are in 8.34 mol?
A7. How many L are in 0.74 cL?	A8. 15 ft is the same as how many yards?
A9. How many km are in 230 m?	A10.* How many grams are in 160 lbs?

Part B: Multi-Step Problems

B1.* How many kg are in 18 lbs?	
B2.* 2.70 ft is the same as how many cm?	
B3.* How many cg are in 0.13 oz?	

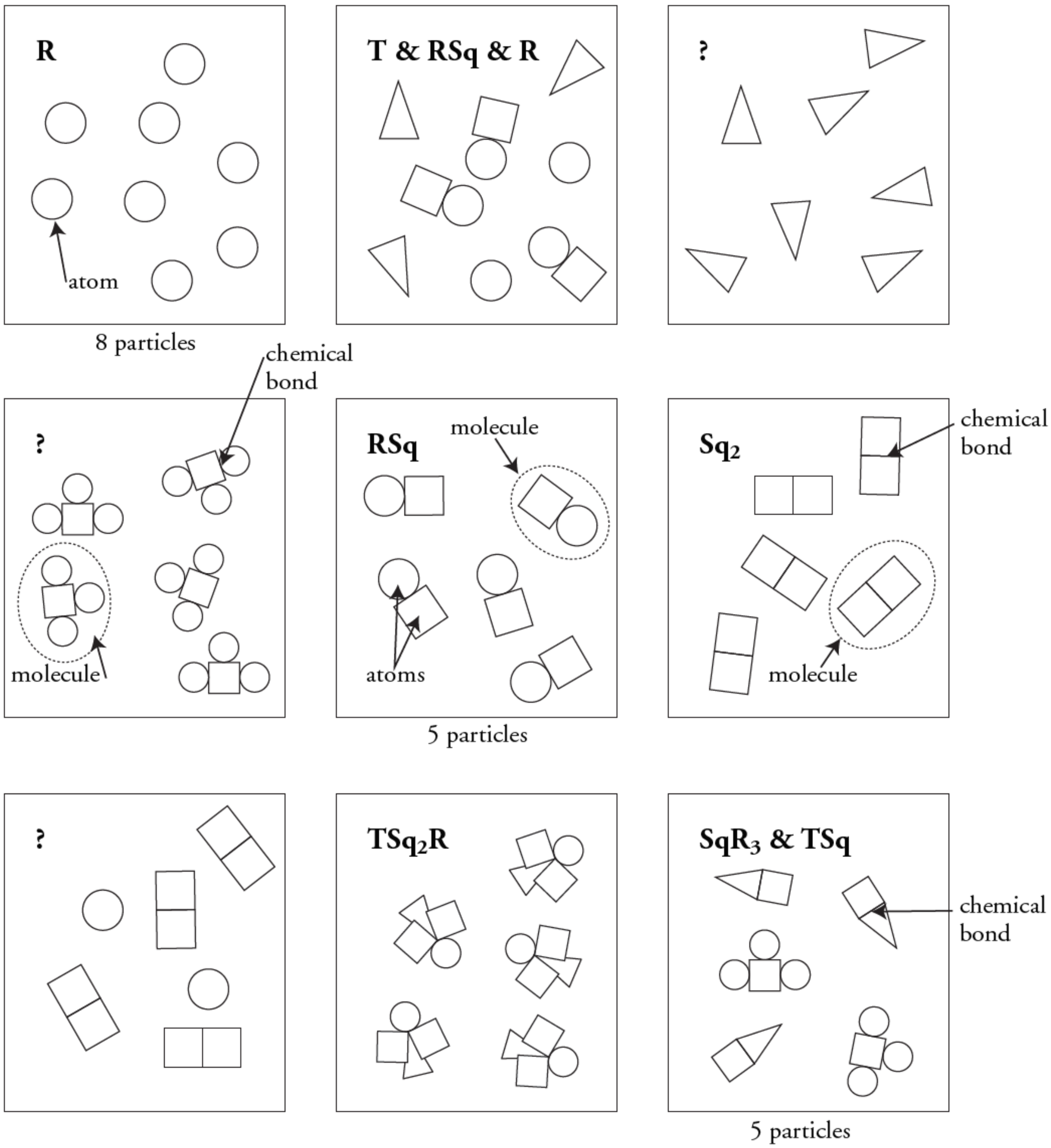
B4.	How many mL are in 3.2 gallons?	
B5.	How many deciliters (dL) are in 2.2 kL?	
B6.*	19 yards is the same as how many meters (m)?	
B7.	Convert 1892 cL (centiliters) to quarts.	
B8.	How many cg are in 0.488 mg?	
B9.*	How many oz are in 9080 mg?	
B10.*	How many feet are in 6.096 mm?	
Part D: Tricky Ones!		
D1.	How many m^3 are in 56 cm^3?	
D2.*	How many ft^2 are in 5.76 in^2?	
D3.*	Convert 0.28 g/cm^3 to g/m^3.	
D4.	How many cg/m^2 is 0.0044 mg/mm^2?	

ACTIVITY #8 – WHAT'S THE MATTER?

Why?

Look at the things in this room. They are all matter. That matter may be pure or it may be a mixture. Can you tell by looking at it? What if you looked at it under a microscope? Then could you tell? Something that looks pure may not really be pure. It depends on what type of particles an object or substance is made of. In this activity we will explore how the smallest chemical units of matter determine whether something is classified as an element, a compound, or a mixture.

Model 1 — Atoms, Particles, and Molecules



1. Locate the circled molecule of **RSq** in Model 1.
   a. Find a second **RSq** molecule and circle it.
   b. How many atoms are in a molecule of **RSq**?

2. Find and circle a molecule of **TSq_2R** in Model 1.
   a. How many different types of atoms are found in a molecule of **TSq_2R**?
   b. How many Sq atoms are in a molecule of **TSq_2R**?

3. Locate the drawing labeled **SqR_3 & TSq** in Model 1.
   a. How many different types of atoms are found in the sample of **SqR_3 & TSq**?
   b. How many different types of molecules are found in the sample of **SqR_3 & TSq**?

4. When two atoms are touching in the drawings of Model 1, what is holding the atoms together?

5. As a group, discuss the following questions and record your answers:
   a. Can a *particle* be a single atom?
   b. Can a *particle* be a molecule?
   c. How many particles are in the drawing representing **T & RSq & R** in Model 1?
   d. What is your group's definition of the word "particle" as it is used in chemistry?

6. Compare the codes listed at the top of each drawing in Model 1 with the shapes in that box.
   a. What do the letters **R**, **Sq,** and **T** in the codes represent?
   b. What do the small numbers (subscripts) in the codes represent?
   c. When atoms are touching, how is that communicated in the code?
   d. What is the common characteristic of the samples in which an ampersand (&) is used?
   e. In Model 1 there are three drawings that are labeled with a question mark. Write codes to properly label these drawings.

STOP

Read This!

Matter is classified as a **pure substance** when all of the particles are identical. Matter is classified as a **mixture** if there are different types of particles present.

8. Identify which drawings from Question 7 are pure substances and which are mixtures. List the codes for the drawings in the appropriate places below.

Pure Substances		Mixtures
____________	____________	____________
____________	____________	____________
____________	____________	____________

9. How are the codes (chemical formulas) for pure substances different from those for mixtures?

10. As a team, take the set of pure substances drawings from Question 8 and sort them into two new groups, those containing only one type of atom and those with two or more types of atoms.

Read This!

Elements are defined as pure substances made from only one type of atom. **Compounds** are defined as pure substances made from two or more types of atoms.

11. Identify which drawings from Question 10 are elements and which are compounds. List the codes for the drawings in the appropriate places below.

Elements	Compounds
____________	____________
____________	____________
____________	____________

12. How are the codes (chemical formulas) for elements different from those for compounds?

13. Use what you have just learned about chemical formulas to identify each of the following as an element, a compound or a mixture.

a. Br_2 *b.* $NaHCO_3$ *c.* $C_6H_{12}O_6$ & H_2O

d. Cu & Zn *e.* CO_2 *f.* Al

14. Explain the difference between:

a. An atom and an element.

b. A molecule and a compound.

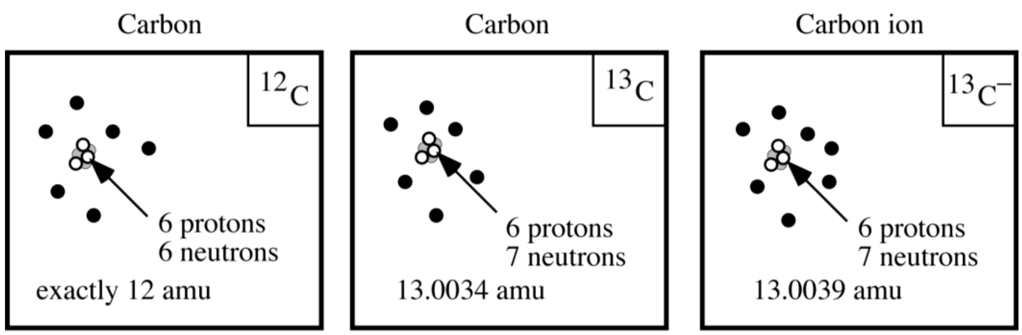
ACTIVITY #9 – BREAKING DOWN THE ATOM

Model #1: VISUAL REPRESENTATIONS OF THE ELEMENT CARBON.

● electron (–)
○ proton (+)
● neutron (no charge)

1 amu = 1.6606×10^{-24} g

The **nucleus** of an atom contains the protons and the neutrons.



^{12}C and ^{13}C are **isotopes** of carbon.

ANALYZE THE MODEL:

1. How many protons are found in ^{12}C? ^{13}C? $^{13}C^{-}$?
2. How many neutrons are found in ^{12}C? ^{13}C? $^{13}C^{-}$?
3. How many electrons are found in ^{12}C? ^{13}C? $^{13}C^{-}$?

CONCLUSIONS

4. What is the relationship between the mass number of an element and the number of protons and neutrons it contains? Provide a mathematical expression for determining the number of neutrons in an element.
5. What structural feature distinguishes a neutral atom from an ion? Provide a mathematical expression for calculating the charge on an ion.
6. What structural feature is different in isotopes of carbon?

SUMMARY

How many electrons, protons, and neutrons are found in each of the following?

	^{24}Mg	$^{23}Na^{+}$	^{35}Cl	$^{35}Cl^{-}$	$^{56}Fe^{3+}$	^{15}N	$^{16}O^{2-}$	$^{27}Al^{3+}$
# of p^{+}								
# of n^{o}								
# of e^{-}								

ACTIVITY #10 – ATOMIC STRUCTURE PROBLEMS.

1. Determine the number of protons, neutrons, and electrons present in each of the following:

   a. $^{40}Ca^{2+}$ b. $^{128}Te^{2-}$ c. $^{52}Cr^{3+}$

2. Write atomic notation for neutral atoms of the following:

   a. Bromine-79 b. gold-197 c. thorium-232

3. Complete the following table for atoms and ions:

Notation	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
^{95}Mo					
		79	34		36
	47	109			46
$^{232}Th^{4+}$					
			83	126	83

4. Write the atomic notation for the following <u>neutral atoms</u>:

   a. An atom with 78 protons and 117 neutrons

   b. An atom with a mass of 237 having 90 electrons

   c. An atom with 69 electrons and 100 neutrons

5. Write the atomic notation for the following <u>charged ions:</u>

   a. A 3+ cation with 80 electrons and 127 neutrons

   b. A 1- anion with 54 electrons and 78 neutrons

   c. An ion with 66 electrons, 69 protons, and 100 neutrons

6. Consider an atom of iodine (atomic number 53) that has a mass of 126.

   a. How many protons does the atom have?

   b. How many electrons are there in the atom?

   c. How many electrons are in the nucleus of the atom?

   d. How many neutrons does this atom have?

   e. A different atom of iodine has a mass number of 128. What is the only difference between this atom and the iodine atom with a mass of 126?

7. Use the following mass spectrometry data to calculate the average atomic mass of magnesium.

Isotope	Mass of Atom in amu	Percent Abundance in Nature
magnesium-24	23.9850	78.99
magnesium-25	24.9858	10.00
magnesium-26	25.9826	11.01

8. Naturally occurring Ni is found to have the following approximate isotopic abundance:

^{58}Ni	68%
^{60}Ni	26%
^{62}Ni	4.0%
^{61}Ni	2.0%

Calculate the average atomic mass of Ni to two decimal places.

ACTIVITY #11 – CHEMICAL NOMENCLATURE.

Introduction

Writing formulas and naming compounds can be confusing because there are different types of compounds that follow different rules. Additionally, some compounds (H_2O, NH_3, CH_4, etc.) simply have ***common names*** that must be memorized.

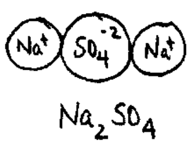
The two types of compounds we will focus on are ***ionic compounds*** (formed from positive and negative ions) and ***covalent compounds*** (molecular compounds). You must recognize the ***type*** of compound before you try to name it. [Note: + ion = "cation" and – ion = "anion".]

	Ionic	**Covalent**
Formula	+ ion before – ion ex: NaCl $(NH_4)_2SO_4$ Al_2S_3	usually the farthest left non-metal atom goes first ex: CO_2 N_2O PCl_3
Naming	Name of cation + name of anion sodium chloride ammonium sulfate aluminum sulfide	First element is simply name of element. Second element name ends with "ide". Use prefixes. carbon dioxide dinitrogen monoxide phosphorus trichloride

I) Ionic Compounds w/Pictures:

For each of the following salts, draw IONIC PICTURES to show the ionic bonding in the salt and then write the chemical FORMULA for the salt. *Hint: charges of transition metals (Fe, Zn, Ag, etc.) can be found on the* back *of your periodic table in your green booklet!*

a) sodium sulfate



b) lithium sulfide

c) zinc iodide

d) silver chromate

e) potassium carbonate

f) magnesium hydroxide

g) sodium phosphate

h) aluminum nitrate

i) lead(II) acetate

j) iron(III) oxide (*also called ferric oxide*)

II) Ionic Compounds w/o Pictures

	Cl^-	NO_3^-	S^{2-}	CO_3^{2-}	N^{3-}	PO_4^{3-}	OH^-
Na^+							
NH_4^+							
Sn^{2+}							
Mg^{2+}							
Al^{3+}							
Sn^{4+}							

Cation	**Anion**	**Formula**	**Name**
Cu^{2+}	OH^-		
Ba^{2+}	SO_4^{2-}		
NH_4^+	$Cr_2O_7^{2-}$		
Ag^+	$C_2H_3O_2^-$		
Fe^{3+}	S^{2-}		

III) Covalent Compounds

mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca

The Magnificent Seven! (write formulas for the following diatomic elements. Include states of matter for each: (s) = solid, (l) = liquid, (g) = gas)

Name	**Formula**
nitrogen gas	
oxygen gas	
flourine gas	
chlorine gas	
liquid bromine	
solid iodine	
hydrogen gas	

Fill in the Blanks:

Name	**Formula**	**Name**	**Formula**
	CCl_4		HBr
	P_4O_{10}		N_2F_4
	ClF_3		XeF_3
	BCl_3		PI_3
	SF_4		SCl_2

IV) Mixing It Up!

Formula	**Name**
$CsCl$	
PCl_5	
K_2S	
$NiSO_4$	
ClF_3	
OF_2	
$Al(OH)_3$	
NCl_3	
$(NH_4)_3PO_4$	

Formula	**Name**
	carbon dioxide
	ammonium carbonate
	sulfur dichloride
	calcium iodide
	boron trifluoride
	phosphorus triiodide
	magnesium perchlorate
	potassium permanganate
	aluminum phosphate

ACTIVITY #12 – MR. TOAD & MOLEY

Mr. Toad and Moley, while waiting for their tea on a Sunday afternoon in Toad Hall, had the following conversation:

Moley: What's a word that describes a very large number of somethings?

Mr. Toad: A dozen.

Moley: How many somethings are in a dozen?

Mr. Toad: Twelve somethings, no more and no less.

Moley: And what if you have a dozen dozens?

Mr. Toad: Then you would have a gross. A gross contains 144 somethings, so that is a dozen dozens.

Moley: And if you had 144 nothings?

Mr. Toad: Then you would have a gross of nothings. For a gross of anything, be it somethings or nothings, would contain 144 things.

Moley: But what if you have a dozen dozen dozens?

Mr. Toad: Then you would have a dozen gross. Or is it a dozen grosses?

Moley: So there is no special word to describe a dozen dozen dozens?

Mr. Toad: That is correct. A dozen dozens is a gross, but a dozen dozen dozens has no special name.

Moley: Then we shall make up a name! We shall call it a TOAD. A dozen dozen dozens is now called a TOAD.

Mr. Toad: How splendid! Now when I order buttons for my waistcoats, I shall be able to order a TOAD instead of a dozen gross. I shall get 1728 buttons in either case, for a dozen gross is 12 times 144, which equals 1728, and a TOAD is a dozen dozen dozen, which is also 1728.

Moley: And what if you had a truly incredible number of things, such as 600 million million billion somethings?

Mr. Toad: Then you would have. . . . a MOLE!

Moley: A MOLE!!!

Mr. Toad: Yes, a MOLE. I hereby decree that whenever a person shall encounter 600 million million billion of anything, he shall be justified in saying that he has just seen a MOLE of the somethings that he has encountered.

Moley: I shall be careful to remember this the next time I see 600 million million billion somethings, though it may be some time before I encounter such a large number of things!

Mr. Toad: Indeed, it may well be so. But when you do, you shall be justified in saying, "There goes a MOLE of those things!"

And with that, the two friends sat down to enjoy their tea.

Questions:

1. According to Mr. Toad's decree, there are ***600 million million billion*** individual things in a mole. Attempt to write out this number (in longhand). Then write the number using SCIENTIFIC NOTATION. *(Note: a million has 6 zeros, a billion has 9 zeros).*

Longhand =
Scientific notation =
This value (the number of molecules in one mole) is called **Avogadro's number**.

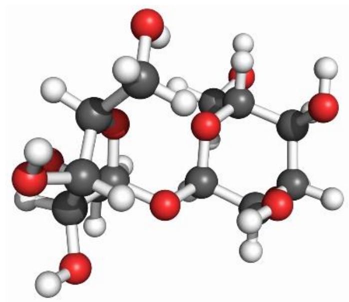
2. Although they did not realize it, both **Mr. Toad** and **Moley** were confronted with MOLES of molecules in their cups of tea. A typical cup of tea contains about 10 MOLES of water molecules!

   a. How many WATER MOLECULES are in a typical cup of tea if it contains 10 MOLES of H_2O? *Note: show a calculation using* ***scientific notation*** *that answers this question. Consider using unit analysis in your calculation method.*

   b. Into his cup of tea, **Moley** stirs in 1/20th of a MOLE of sugar molecules (a heaping teaspoon).

      i. How many sugar molecules has **Moley** added to his tea? *Express in scientific notation and label your answer appropriately!*

      ii. The formula for one molecule of table sugar is $C_{12}H_{22}O_{11}$. Using your answer from (i), calculate how many carbon atoms there are in the sugar molecules added the cup of tea? How about hydrogen atoms? *Consider using unit analysis in your calculation method.*



   c. Which would contain **more molecules**: a MOLE of sugar molecules or a MOLE of water molecules?

CHALLENGE:

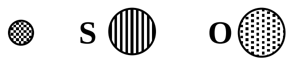
If you had a MOLE of water molecules, and you counted 1 molecule each second, how many years would it take you to count the entire mole of water molecules?

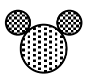
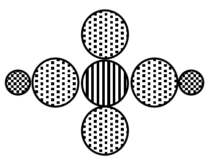
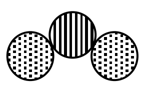
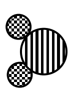
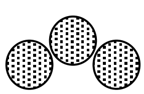
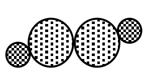
ACTIVITY #13 – HOW HEAVY IS A MOLE?

1. Write the mass of 1 mole (6.02×10^{23}) of atoms of each element in g/mol.

H	C	S	O	Ca	N	Na	Cl

2. Complete the following table.

Key: H S O 

	One Molecule	Formula	Mass of 1 Mole of Molecules (g/mol)
(a)			
(b)			
(c)			
(d)			
(e)			
(f)			

3. Complete the following table. Show all work!

	Compound	Name (if you don't know, look it up)	Mass of 1 Mole of Molecules (g/mol)
(a)	NaOCl		
(b)	N_2O		
(c)	CO_2		
(d)	CH_3COOH		
(e)	CH_3OH		
(f)	$Ca(OH)_2$		
(g)	$Ca(NO_3)_2$		

ACTIVITY #14 – MOLE CONVERSIONS

Difficulty Level 1

1 mole = 6.02 x 10^{23} molecules = 22.4 L (@ STP)

1. Calculate the mass of 1.58 moles CH_4. [molar mass CH_4 = 16.00 g/mol]

   Known: 1.58 moles CH_4
   Unknown: ? g CH_4

   1.58 moles CH_4 × ________ =

2. What volume will 7.29 moles of CO_2 gas occupy at STP?

   Known: 7.29 moles CO_2
   Unknown: ? L CO_2

   7.29 moles CO_2 × ________ =

3. How many molecules are there in a 0.00583 mole sample of H_2O?

   Known: 0.00583 moles H_2O
   Unknown: ? molecules H_2O

   0.00583 moles H_2O × ________ =

4. What mass of CO_2 gas occupies a volume of 100 liters at STP? [molar mass CO_2 = 44.01 g/mol]

   Known: 100. Liters CO_2
   Unknown: ? g CO_2

   100. Liters CO_2 × ________ × ________ =

5. How many molecules are in a 35.0 gram sample of H_2O? [molar mass H_2O = 18.02 g/mol]

   Known: 35.0 g H_2O
   Unknown: ? molecules H_2O

   35.0 g H_2O × ________ × ________ =

6. What volume will 5.25 x 10^{22} molecules of CH_4 occupy at STP?

   Known: 5.25 x 10^{22} molecules CH_4
   Unknown: ? L

   5.25 x 10^{22} molecules CH_4 × ________ × ________ =

Difficulty Level 2

1 mole = 6.02 x 10^{23} molecules = 22.4 L (@ STP)

1. Calculate the mass of 7.23 moles CH_4. [molar mass CH_4 = 16.0 g/mol]

2. What volume will 9.35 moles of CO_2 gas occupy at STP?

3. How many molecules are there in a 0.0752 mole sample of H_2O?

4. What mass of CO_2 gas occupies a volume of 10.8 Liters at STP? [molar mass CO_2 = 44.0 g/mol]

5. How many molecules are in a 1.44 gram sample of H_2O? [molar mass H_2O = 18.0 g/mol]

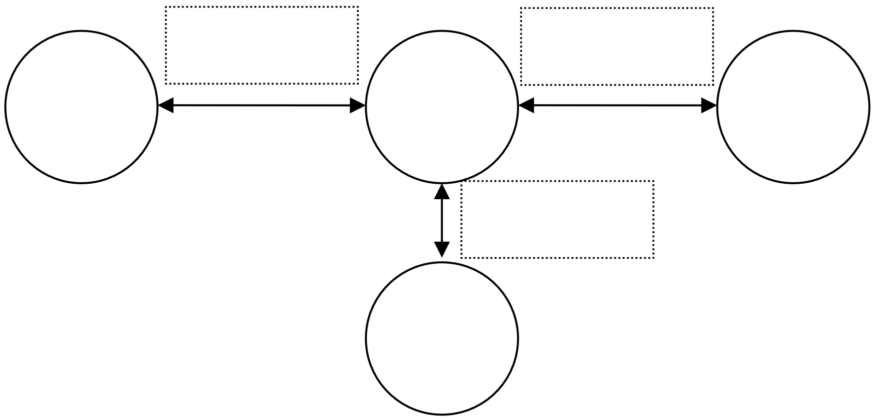
6. What volume will 1.21 x 10^{24} molecules of CH_4 occupy at STP?

ACTIVITY #15 – MOLE CONVERSION SUMMARY PROBLEMS

1. Using a Periodic Table, find the molar mass for the following compounds. (Show your work.)

Compound	Molar Mass	Compound	Molar Mass
CO_2		H_2O	
N_2O		CH_4	

2. Draw the Mole Map for CO_2. Put a circle around the number that is different for H_2O.



3. Consider carbon dioxide, CO_2.

(a) Calculate the number of CO_2 molecules in 1.5 moles.

(b) Find the number of moles of CO_2 in a 24.9 g sample of CO_2.

(c) Find the volume that 35.0 g CO_2 occupy at STP.

4. Consider water, H_2O.

(a) Calculate the number of H_2O molecules in 0.65 moles

(b) Find the volume of 5.1 moles H_2O.

(c)	Find the number of H_2O molecules of a 1.40 L sample of H_2O gas at STP.	

5. Consider dinitrogen monoxide, N_2O.

(a)	Find the number of moles in 4.25 L of N_2O at STP.	
(b)	Find the mass of 0.75 moles of N_2O.	
(c)	Find the mass of 3.25×10^{22} molecules N_2O.	

6. A 2.4-mole sample of an unknown compound has a mass of 192 g. Find the molar mass of the compound.

7. A 13.4-L sample of an unknown gas at STP has a mass of 9.6 g. Find the molar mass of the gas.

8. A 38.4-g sample of a gas contains 4.82×10^{23} molecules. Find the molar mass of the gas.

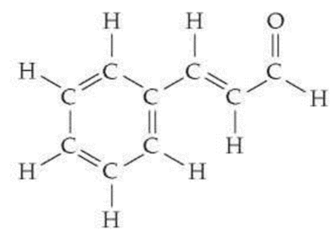
ACTIVITY #16 – PERCENT COMPOSITION

It is useful to determine how much of a compound's mass is made up of each element. Water, H_2O, for example has a molar mass of 18.0 g/mol. The H's mass is 2(1.0) = 2.0 g/mol. The O's mass is 16.00 g/mol.
We can set up **fractions** for each element: $H = \frac{2.0}{18.0} = 0.112 = 11.2\%$. $O = \frac{16.0}{18.0} = 0.888 = 88.8\%$.
This is called the **percent composition**. The fraction composition is a good in-between step.
Determine the fraction and percent composition of each element below (answer to one decimal place):

1. H_2SO_4			
2. $Ca(OH)_2$			
3. $HC_2H_3O_2$			
4. CO_2			

Use the following information to answer the next 6 questions

Cinnamaldehyde is the molecule that gives cinnamon its distinctive flavor. A structural diagram of its structure is shown here.


Cinnamaldehyde

5. Write the <u>chemical formula</u> for this molecule ($C_xH_xO_x$).

6. Calculate the <u>molar mass</u> of this chemical compound. Show your work.

7. Calculate the <u>% composition</u> of each element in cinnamaldehyde.

8. A cinnamon stick contains 0.236 g of cinnamaldehyde molecules. Calculate the number of <u>moles</u> of cinnamaldehyde in the stick.

9. A chemist dissolves 0.050 mol of cinnamaldehyde in a solvent. What <u>mass</u> of molecules did she use?

10. A drop of cinnamon-flavored solution contains 4.7×10^{18} molecules of cinnamaldehyde. What <u>mass</u> does this equate to?

ACTIVITY #16 – WELL THAT MAKES CENTS!

The Canadian government stopped minting pennies in 2012. Before 1997, a Canadian penny was made mostly of copper. Between 1997 and 1999, in an attempt to save money, they started making the pennies mostly out of zinc instead. Zinc is a highly reactive metal with hydrochloric acid. Copper does not react with hydrochloric acid. In this activity, you will attempt to determine the % composition of copper and zinc in a Canadian penny

Data:

Observations:

	1997-1999 Penny
Beginning mass (g)	
Ending mass (g)	
Volume of HCl used (mL)	

Calculations

Question	**1997-1999 Penny**
How many grams of zinc reacted from the penny?	
How many grams of copper remained after reaction?	
What is the percent composition by mass of zinc in the penny?	
What is the percent composition by mass of copper in the penny?	

CHALLENGE!

In 1997, the price of copper was around $1.20 per pound and the cost of zinc was about $0.45 per pound. The Canadian mint produced 549,868,000 pennies in 1997. Assuming pre-1997 pennies were pure copper, how much money did the Royal Canadian Mint save in 1997 by switching to the Cu/Zn penny? (1 kg = 2.21 lbs = 1000 g)

ACTIVITY #18 – THE STRANGE CASE OF MOLEAIR FLIGHT 1023

At 6:02 AM, you and your team of medical examiners are called to the scene of a small airplane crash in a remote location. The plane shows evidence of a precrash explosion. Eight victims are found at the scene, but none are identifiable by witnesses, dental records, or DNA evidence. One victim was murdered prior to the plane crash. The flight manifest shows the names and some information about the victims. You must use the available tools and information to identify each victim. You must also solve the murder mystery.

The Plane

A section of the plane has been blown apart by an explosion. It appears as if the explosion happened before the crash. Residue from the explosion site shows the following elemental analysis: 37.01% carbon; 2.22% hydrogen; 18.5% nitrogen; 42.27% oxygen

Passenger Manifest

The passenger manifest lists the following passengers who boarded the flight at takeoff.

Amadeo Oldere - Pilot with a secret heart condition

Norm Anderson - Suspected terrorist

Archie Starr - Retired teacher addicted to diet drinks

Lisa Johnson - Unemployed, depressed, environmental engineer

Bill (Cadillac) Jackson - Suspected drug dealer

Bob (Reno) Henderson - Pro athlete **just suspended** for drug use

Jim LeClaire - Baker

Connie Majors – Pharmacist

Possible Compounds:

Dimatracine (antidepressant)	$C_{10}H_{13}N$
Acetaminophen (over the counter pain killer)	$C_8H_9NO_2$
Nitroglycerin (Explosive or heart medication)	$C_3H_5N_3O_9$
Thiobromine (chocolate)	$C_7H_8N_4O_2$
Vanillin (vanilla)	$C_8H_8O_3$
Codeine (Prescription pain killer)	$C_{18}H_{21}NO_3$
Trinitrotoluene (TNT) Explosive (dynamite)	$C_7H_5N_3O_6$
Curare (poison)	$C_{40}H_{44}N_4O$
Strychnine (Rat poison)	$C_{21}H_{22}N_2O_2$
Cocaine (Narcotic drug)	$C_{17}H_{21}NO_4$
Aspartame (Artificial sweetener)	$C_{14}H_{18}N_2O_5$
Aspirin (over the counter pain killer)	$C_9H_8O_4$

DETERMINE THE EMPIRICAL FORMULA OF THE RESIDUE FOUND ON THE EXPLOSION SITE:

The Victims

The following table presents the information obtained from laboratory tests of all the victims. Remember that the bodies were not identifiable, so hopefully we can gain some clues as to the passengers' identity based on this laboratory data.

Victim # and Name	Sample Location	Percent Composition				Compound Name/Formula
		Carbon	Hydrogen	Oxygen	Nitrogen	
1	Blood sample	67.31%	6.98%	21.10%	4.62%	
2	On face of victim	63.15%	5.30%	31.55%	-	
	Stomach contents	46.66%	4.48%	17.76%	31.1%	
3	In tablets found in victim's pocket	72.15%	7.08%	16.03%	4.68%	
4	In pocket and in blood sample	15.87%	2.22%	63.41%	18.15%	
5	Blood sample	75.42%	6.63%	9.57%	8.38%	
	Clothing	37.01%	2.22%	42.27%	18.5%	
6	Pocket	57.14%	6.16%	27.18%	9.52%	
7	Pocket	80.48%	7.45%	2.68%	9.39%	
	Pocket	81.58%	8.90%	-	9.52%	
8	Pocket	60.00%	4.48%	35.53%	-	
	Pocket	63.56%	6.00%	21.17%	9.27%	

<u>SHOW THE CALCULATIONS YOU PERFORMED TO IDENTIFY THREE OF THE VICTIMS ABOVE:</u>

ACTIVITY #19 – LAB SAFETY GUIDELINES & EXPECTATIONS

1. The laboratory is a place for serious work. Maintain a wholesome, businesslike attitude at all times. The rules on this page are to be read, learned, and practiced. Points will not be given for following the rules, but points will be lost by not following them.

2. Never, under any circumstances, attempt unauthorized experiments. Accidents and trouble will be avoided by following this simple rule.

3. **Always wear protective goggles when in the laboratory**... from the moment you enter the lab to collect materials until the time you have finished cleaning up. Contact lens wearers must know the added dangers of contact lenses. Handle all chemicals at arms length.

4. Any accident involving even a minor injury must be reported to the instructor at once. Beware of hot glass. Hot glass looks like cold. Watch for small chips and cracks on glassware.

5. All books, coats, and other personal effects should remain at your desk and never be found at your laboratory station. Place books on seats on lab days and arrange chairs to provide an easy exit in case of emergency.

6. Do not touch, taste, or smell chemicals unless directed to do so. When observing the odor of a substance, do not hold your face directly over the container. Fan a little of the vapor toward yourself by sweeping your hand over the top of the container. (wafting)

7. When heating a test tube, start heating gently by moving the tube in and out of the heat source. Be aware of how easily liquids start to boil. Do not point your test tube at your neighbor or yourself when heating substances therein. A suddenly formed bubble of vapor may eject the contents violently and dangerously.

8. Smother any fires with a towel. Know the location of the fire extinguisher, fire blanket, and eyewash in the laboratory. Know how to use the sink as an eyewash. As a rule, wash eyes for 15 minutes. Fire blanket may be used to smother fires or act as a dam for spilled liquids.

9. When diluting concentrated acid, pour the acid slowly and carefully into the water with constant stirring to dissipate the heat of solution which can cause the solution to boil and splatter. Never add the water to the acid. "Always do just as you oughter, add the acid to the water."

10. If an acid or other chemical is spilled on your skin, wash it off immediately with water. If an acid or base is spilled on the counter or on your clothing, neutralize it and then wipe it up with water.
    Acid on clothing
        use baking soda (a weak base) to neutralize
    Base on clothing
        use vinegar (a weak acid) to neutralize

11. Throw all solids to be discarded into waste buckets or as directed by teacher... never into the sinks where it will clog the drains. Liquids are emptied into the sinks and washed down with water unless special handling is required... special waste containers will be indicated.

12. Always read the labels twice before taking anything from a bottle... many chemicals have similar names. Use as little chemical as is convenient to perform your experiment or fill your apparatus... you can always come back for more. NEVER return unused chemicals to the dispensing bottle to prevent contamination.

13. The electronic balances are expensive and somewhat fragile. Do not press on balance pan (they are not designed to move). Balances must be calibrated by the first person to use them each period. Never place chemicals directly on balance pans... they chemically react with many of the salts we used in class. A quarter sheet of notebook paper makes a good weighing paper.

14. Keep an eye on your neighbor while in the laboratory to see that she or he is also obeying the rules... remember, the accident that harms you may not be your own.

15. Keep your apparatus and lab station clean always. Wipe up spills since YOU know what those spills are... acid and water look the same to the next student using that station. The student who picks up and sets up the apparatus needs to return the apparatus to the same place. Keep the goggle box neat.

I have read and understand the above rules.
I agree to follow these rules and maintain a wholesome, businesslike attitude in the laboratory.

__________________	__________________	__________
Student Signature	Parent Signature	Date

ACTIVITY #20 – DEMO LAB: EMPIRICAL FORMULA OF MAGNESIUM OXIDE

An empirical formula gives the simplest whole number ratio of the different atoms in a compound. The empirical formula does not necessarily indicate the exact number of atoms in a single molecule. This information is given by the molecular formula, which is always a simple multiple of the empirical formula.

In this experiment, you will determine the empirical formula of a magnesium-oxygen product, a compound that is formed when magnesium metal reacts with oxygen gas. According to the law of conservation of mass, the total mass of the products must equal the total mass of the reactants in a chemical reaction. Therefore,

$$\text{mass Mg} + \text{mass } O_2 = \text{mass } Mg_xO_y$$

Since you will measure the mass of magnesium and the magnesium-oxygen product, you will be able to calculate the mass of oxygen consumed during the reaction. Then, the ratio between the moles of magnesium and the moles of oxygen consumed can be calculated. Finally, the empirical formula can be written based on this ratio.

Procedure:

Watch the following video and record the measurements in the chart below.

https://tinyurl.com/2nfd5d7

Data & Results

mass of crucible + lid	
mass of crucible + lid + Mg	
mass of crucible + lid + Mg_xO_y	

1. Calculate the mass of magnesium used in the reaction.

2. Calculate the mass of magnesium oxide formed in the reaction.

3. Calculate the mass of oxygen that reacted with the magnesium during the reaction. (Hint: The mass of the magnesium and oxygen must equal the mass of the magnesium oxide produced.)

Analysis of Results:

4. Calculate the % composition of the Mg_xO_y compound.

5. Determine the empirical formula of the Mg_xO_y compound.

6. The compound you created is ionic. Based on the ionic charges of each element, write the theoretical formula for magnesium oxide below.

7. Does your experimental empirical formula agree with this formula? If so, great job! If not, think of some reasons why it doesn't.

   Hint #1…don't say human error! Imagine you did this lab perfectly according to the procedure. You still might not get a perfect answer! What are some errors beyond your control that might have influenced your results? What are some improvements that could be made to the lab that might improve your results?

   Hint #2… The literature value for the %Mg in this magnesium-oxygen compound is 60.3%. Is your value higher or lower? What experimental errors might specifically account for this type of deviation?

Summary Questions:

1. A piece of iron wool weighing 85.65 g was combusted in oxygen. 121.63 g of iron oxide was produced. Determine the % composition and empirical formula of the iron oxide produced.

2. A 50.51 g sample of a compound made from phosphorus and chlorine is decomposed. Analysis of the products showed that 11.39 g of phosphorus atoms were produced. What is the % composition and empirical formula of the compound?

3. When 2.5000 g of an oxide of mercury, (Hg_xO_y) is decomposed into the elements by heating, 2.405 g of mercury are produced. Calculate the % composition and empirical formula.

ACTIVITY #21 –EMPIRICAL & MOLECULAR FORMULA PRACTICE PROBLEMS

1. Ethanoic acid is the main ingredient in all the different types of vinegar. It is a member of a group of molecules called "carboxylic acids". Its more common name is acetic acid and it has a molar mass of 60.06 g/mol. It is made of three elements – 40.0% carbon, 53.3% oxygen, and the remainder is hydrogen. Determine the empirical and molecular formula of this chemical.

2. Vitamin C is a water-soluble vitamin that is found in many fruits and vegetables. Since it is soluble in water, our bodies don't store this vitamin – much of it gets excreted out in our urine. Because of this, we need to include it regularly in our diets by eating fruits and veggies! Vitamin C molecules are made of 3 elements – 40.92% carbon, 54.51% oxygen, and the rest are hydrogen. If Vitamin C has a molar mass of 176.12 g/mol, what is it's empirical and molecular formula?

3. Ibuprofen is a headache remedy found in Advil and other pain-relieving medications. Analysis shows that it is composed of 75.69% carbon, 15.51% oxygen, and 8.80% hydrogen. If the molar mass of ibuprofen is 206 g/mol, what is its empirical and molecular formulas?

ACTIVITY #22 – LAB: THAT'S SOME HIGH QUALITY H_2O!

Hydrated ionic compounds have water molecules trapped within their crystal structures. For each compound, there is a characteristic amount of water attached for every formula unit of the ionic compound. For example, a common salt is cobalt(II) chloride, $CoCl_2$. When the salt precipitates out of a solution, six water molecules are trapped for every formula unit of $CoCl_2$. This creates the hydrated compound, $CoCl_2 \cdot 6\,H_2O$. Its name is cobalt(II) chloride hexahydrate.

If the salt is heated, the water of hydration can be driven out of the crystals to create an anhydrous form of the salt (literally, the salt with "no water").

$CoCl_2 \cdot 6\,H_2O$ (s)	→	$CoCl_2$ (s)	+	$6\,H_2O$ (g)
Hydrated Salt		Anhydrous Salt		Water Vapour

As you know, you can use the periodic table to determine the molar mass of a compound. Water molecules have two atoms of hydrogen (1.01 g/mol) and one atom of oxygen (16.00 g/mol) … so the **molar mass of water molecules is 18.02 g/mol.**

For $CoCl_2 \cdot 6\,H_2O$, there is 1 atom of cobalt (58.93 g/mol), 2 atoms of chlorine (35.45 g/mol each) and 6 water molecules (18.02 g/mol each). So the formula mass of cobalt(II) chloride hexahydrate is calculated below:

1 x Co	= 1 x 58.93 g/mol	= 58.93 g/mol Cobalt
2 x Cl	= 2 x 35.45 g/mol	= 70.90 g/mol Chlorine
6 x H_2O	= 6 x 18.02 g/mol	= 108.12 g/mol Water
		237.95 g/mol Cobalt(II) Chloride Hexahydrate

Since there was 108.12 g/mol water in the molar mass, we can calculate the percent water in the compound:

$$\%\, Water\ in\ CoCl_2 \cdot 6H_2O = \frac{108.12\ g/mol}{237.95\ g/mol}\ x\ 100\% = 45.44\%$$

If you measure the mass of the hydrated salt before heating and the mass of the anhydrous salt after heating, you can determine the mass of water that escaped. From these measurements, you can experimentally determine the percent composition of water in the compound and compare it to the expected value. Using the same masses, you can also determine the empirical formula of the hydrate by comparing moles of water that escaped to moles of salt that remain.

In this experiment, you will be given an unknown hydrate. Its identity could be one of the salts listed in the pre-lab. The purpose of the experiment is to determine the percent water in your hydrate and the empirical formula of the compound and use them to identify your salt from this list.

Pre-Lab:

Fill in the chart below:

Name of Possible Hydrates	Formula of Hydrate	Molar Mass of Hydrate	% Composition of **Water** in Compound
Barium Chloride Dihydrate			
Copper(II) Sulfate Pentahydrate			
Magnesium Sulfate Heptahydrate			
Sodium Carbonate Decahydrate			

Show Work Below:

Procedure

1. Record the letter of your assigned hydrate. (X, Y or Z)

2. Set up a metal support stand and place a large Bunsen burner on its base. Attach a ring to it as shown, approximately two inches above the top of a larger Bunsen burner. Put a clay triangle on the ring.

3. Obtain a crucible from the front of the lab with an appropriately sized lid. Be sure the crucible is clean and dry.

4. Take the crucible without its lid to an electronic balance. Record the mass of the empty crucible.

5. Add approximately 2 g of your assigned unknown hydrated salt to your crucible. Record the mass of the crucible with the hydrated salt.

6. Return to your bench and place the crucible on the clay triangle as shown. Place its lid upside down on the crucible (different from the picture!), but leaving a small gap so that water vapour can escape during heating.

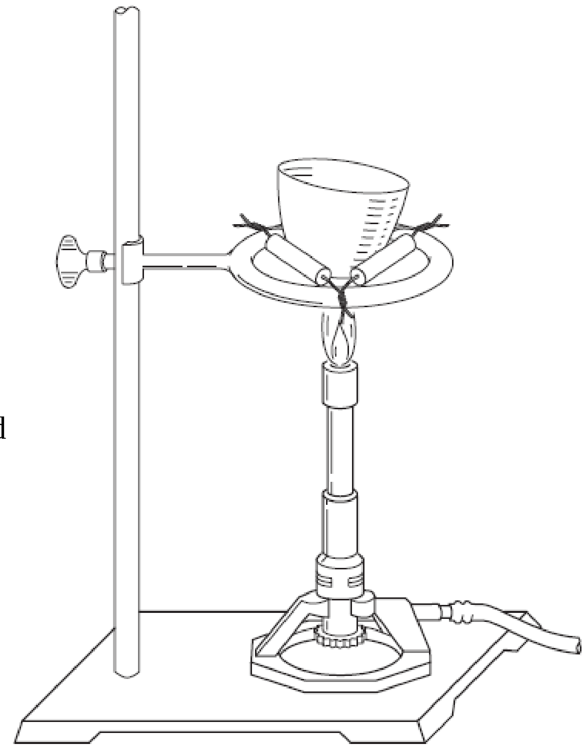


Figure 1 *Heating a hydrate in a crucible*

7. Gently heat the crucible with your Bunsen burner for about 5 minutes … moving the burner in and out underneath the crucible.

8. After 5 minutes, heat strongly for another 10 to 12 minutes. If you need to adjust the lid or position of your crucible do so using the crucible tongs from your drawer. The crucible will be VERY HOT … do not touch it or its lid!!

9. Let the crucible cool in the clay triangle for a couple of minutes. Then carefully remove its lid using the crucible tongs and place the hot lid on the base of your metal support stand. Then carefully place the hot crucible also on the base of the support stand. **DO NOT PUT A HOT CRUCIBLE OR ITS LID ON THE BENCH TOP!**

10. After it has cooled sufficiently, take your crucible without its lid to the same electronic balance and record the mass of the crucible with the anhydrous salt.

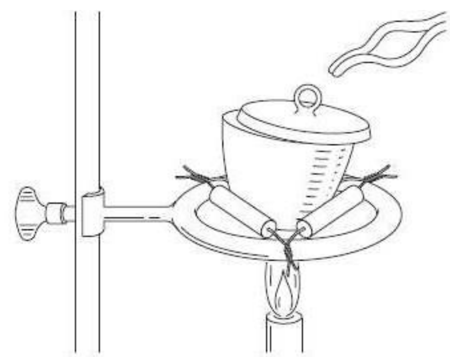


Figure 2 *Position of a crucible cover for heating*

The mass should have dropped … why is that??

11. Rinse the contents of the crucible down the drain before returning it. Disassemble your apparatus and put everything away.

Data & Results

Mass of Empty Dry Crucible, g	
Mass of Crucible with Hydrated Salt, g	
Mass of Crucible with Anhydrous Salt after Heating, g	

Analysis of Results

1. Calculate the mass of your hydrated salt prior to heating.

2. Calculate the mass of your anhydrous salt after heating.

3. Calculate the mass of water that escaped.

4. Calculate the percent water in your hydrated salt. Compare it to the possible compounds from the pre-lab. Which sample do you think you were given?

5. Calculate the number of moles of anhydrous salt left behind.

6. Calculate the number of moles of water that escaped.

7. What is the ratio of moles of water to moles of salt? Compare your ratio to the ratio in the formula of the compound you think you were given. What do you notice?

LAB RELATED PRACTICE PROBLEMS

1. Cupric chloride, $CuCl_2$, when heated to 100°C is dehydrated. If 0.235 g of $CuCl_2 \cdot x\ H_2O$ gives 0.185 g of $CuCl_2$ on heating, what is the value of *x*?

2. The "alum" used in cooking is potassium aluminum sulfate hydrate, $KAl(SO_4)_2 \cdot x\ H_2O$. To find the value of *x*, you can heat a sample of the compound to drive off all the water and leave only $KAl(SO_4)_2$. Assume you heat 4.74 g of the hydrated compound and that the sample loses 2.16 g of water. What is the value of *x*?

3. If "Epsom salt," $MgSO_4 \cdot x\ H_2O$ is heated to 250°C, all the water of hydration is lost. On heating a 1.687-g sample of the hydrate, 0.824 g of $MgSO_4$ remains. What is the formula of Epsom salt?

ACTIVITY #23 – UNIT TEST REVIEW

TOPIC 1: GENERAL CHEMISTRY SKILLS

Convert the following numbers to scientific notation. Keep the same number of significant digits.

5280 = ________________ 20000 = ________________

0.0009 = ________________ 153 = ________________

8900000 = ________________ 0.0920 = ________________

The following calculations were performed on a calculator. Round the answer provided to the correct number of significant digits and provide the correct unit for the answer.

(3.24 m)(5.63 m) = 18.2412 The answer should be ________________

(46 L)(12 L) = 552 The answer should be ________________

654 g ÷ 32 cm^3 = 20.4375 The answer should be ________________

TOPIC 2: UNIT ANALYSIS

Use unit analysis and your knowledge of the metric system to convert each of these units. Provide your answer in scientific notation and round it to the correct number of significant digits.

825 mL = ________________ kL

52 km = ________________ mm

Complete the following chart

	^{32}S	^{33}S	$^{32}S^{2-}$
Number of Protons			
Number of Neutrons			
Number of Electrons			

The atomic mass of sulphur on the periodic table is listed as a decimal number (32.1 amu), not a whole number like in the examples in the chart. Explain how this is possible.

TOPIC 5: MOLAR MASSES

For each of the following, name or write the formula of the chemical and determine the mass of 1 mole (6.02×10^{23} particles) of that substance.

CO_2	KCl
$AgNO_3$	$Cu(NO_3)_2 \cdot 5H_2O$
CO	O_2
Dinitrogen pentoxide	chlorine gas
Magnesium nitrate	ammonium phosphate
Iron(III) sulphate	calcium nitrite

TOPIC 4: ISOTOPES

Different isotopes of sulphur can be used for different purposes. One isotope (Sulphur-32) makes a good fertilizer for plants, whereas another (Sulphur-34) is used for medical/therapeutic purposes. The percent abundance of all of the common isotopes of sulphur are shown below. Calculate the average atomic mass of Sulphur and compare it to your periodic table.

Sulphur-32: 94.99% Sulphur-33: 0.75% Sulphur-34: 4.25 %

TOPIC 5: MOLE CONVERSIONS

Remember…1 mole of a chemical = the molar mass of that chemical = 22.4 L of gas = 6.02 x 10^{23} particles

Convert the following using the method learned in class. Show the cancellation of units.

5.44 x 10^{26} atoms Co to moles.

2.4 moles CO_2 to molecules.

4.56 x 10^{24} molecules CO_2 to moles.

10.9 moles $CuSO_4$ to particles.

0.266 mol C_6H_{12} to volume of gas

135.3 g $CaSO_4$ to moles

1.2 x 10^{-4} mol Fe to mass

250. g $MgCl_2$ to particles

0.269 mol P_2O_5 to volume of gas

500. g H_2O to moles

25.3 mol $C_6H_{12}O_6$ to mass

100. g H_2O to particles

the mass of 4.56 x 10^{25} atoms of Sr

the number of particles in 200. g $Al_2(SO_4)_3$

the mass of 6.33 x 10^{20} molecules of CO_2

the number of **H atoms** in 5.02 g of CH_4

TOPIC 8: LAB WORK

A student collects the following data from an experiment:

Mass of dry beaker	119.325g
Mass of dry beaker and Mg before reaction	121.229g
Mass of dry beaker and Mg after reaction	120.612g

Calculate the mass, moles, and atoms of Mg that reacted in this experiment.

TOPIC 9: % COMPOSITION

Calculate the percentage composition by mass of each element in the following compounds:

$ZnSO_4$ $Al_2(CO_3)_3$ $Ca_3(PO_4)_2$

TOPIC 10: EMPIRICAL FORMULAS

Methamphetamine, MDMA, or commonly called ecstasy is an illegal drug from a family called “entactogens”; which literally means in Greek, “touching within”. This drug is considered to be a mood elevator that is: 59.506 % C, 8.0135 % H, 6.9424 % N, 7.934 % O, and 17.604 % Cl. Calculate the **empirical formula** for MDMA.

9, 10-diehydro-6-methylergoline-8-carboxylic acid (LSD) a drug with psychomimetic properties is 71.6 % C, 6.03 % H, 10.4 % N, and 11.9 % O. If the molecular mass of the compound is 268.16 g/mol, calculate the **empirical and the molecular formula**.

TOPIC 12: MORE LAB WORK!

A small piece of aluminum was combusted in air in a crucible and the following results were obtained:

Mass of Crucible	24.350 g
Mass of Crucible + Aluminum	29.644 g
Mass of Crucible + Aluminum oxide	34.350 g

Use the results above to determine the empirical formula of the aluminum oxide.

TOPIC 13: EVEN MORE LAB WORK!

Barium chloride is a hydrated ionic compound with the formula $BaCl_2 \cdot x\ H_2O$. A sample of the salt was heated in a crucible and the following results were obtained:

Mass of Crucible	21.440 g
Mass of Crucible + Hydrated salt	33.605 g
Mass of Crucible + Anhydrous salt	31.805 g

What is the compete empirical formula for the hydrated barium chloride?

Fundamental Constants

Name	Symbol	Value
Speed of light in a vacuum	c	3.00×10^8 m/s
Magnitude of charge of electron	e	1.602×10^{-19} C
Planck's constant	h	6.626×10^{-34} J·s
Boltzmann constant	k	1.381×10^{-23} J/K
Avogadro's number	N_A	6.022×10^{23} particles/mol
Gas constant, SI	R	8.314 L·kPa/mol·K
Gas constant	R	0.08206 L·atm/mol·K
Mass of electron	m_e	9.109×10^{-31} kg
Mass of proton	m_p	1.673×10^{-27} kg
Mass of neutron	m_n	1.675×10^{-27} kg
Faraday constant	$\mathfrak{F}$ or F	96 485 C/mol e^-

International System (SI) Units

Physical Quantity	Name of Unit	Symbol
	base units	
Length (l)	Meter	m
Mass (m)	Kilogram	kg
Time (t)	Second	s
Temperature (T)	Kelvin	K
Electric Current (I)	Ampere	A
Luminous Intensity (φ)	Candela	cd
Amount of Substance	Mole	mol
	derived units	
Area (A)	square meter	m^2
Volume (V)	cubic meter	m^3
Frequency (ν)	Hertz	Hz [s^{-1}]
Speed, velocity (v)	meter per second	m/s
Force (F)	Newton	N [kg·m/s^2]
Pressure (P)	Pascal	Pa [N/m^2]

Common SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-2}	centi	c
10^9	giga	G	10^{-3}	milli	m
10^6	mega	M	10^{-6}	micro	μ
10^3	kilo	k	10^{-9}	nano	n
			10^{-12}	pico	p
			10^{-15}	femto	f

e.g. 1 km = 1 x 10^3 m *e.g. 1 μg = 1 x 10^{-6} g*

PERIODIC TABLE OF IONS

TABLE OF POLYATOMIC IONS					
acetate	CH_3COO^-	dihydrogen phosphate	$H_2PO_4^-$	oxalate	$C_2O_4^{2-}$
arsenate	AsO_4^{3-}	hydrogen carbonate	HCO_3^-	perchlorate	ClO_4^-
arsenite	AsO_3^{3-}	hydrogen oxalate	$HC_2O_4^-$	periodate	IO_4^-
benzoate	$C_6H_5COO^-$	hydrogen sulfate	HSO_4^-	permanganate	MnO_4^-
borate	BO_3^{3-}	hydrogen sulfide	HS^-	peroxide	O_2^{2-}
bromate	BrO_3^-	hydrogen sulfite	HSO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	hydroxide	OH^-	pyrophosphate	$P_2O_7^{4-}$
chlorate	ClO_3^-	hypochlorite	ClO^-	sulfate	SO_4^{2-}
chlorite	ClO_2^-	iodate	IO_3^-	sulfite	SO_3^{2-}
chromate	CrO_4^{2-}	monohydrogen phosphate	HPO_4^{2-}	thiocyanate	SCN^-
cyanate	CNO^-	nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$
cyanide	CN^-	nitrite	NO_2^-	POSITIVE POLYATOMIC IONS	
dichromate	$Cr_2O_7^{2-}$	orthosilicate	SiO_4^{4-}	ammonium	NH_4^+
				hydronium	H_3O^+

KEY: atomic number — 26; symbol — Fe; ion charge — Fe^{3+}; ion name (IUPAC) — iron (III); Fe^{2+} iron (II)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H^+ hydrogen																1 H^- hydride	2 He helium
3 Li^+ lithium	4 Be^{2+} beryllium											5 B boron	6 C carbon	7 N^{3-} nitride	8 O^{2-} oxide	9 F^- fluoride	10 Ne neon
11 Na^+ sodium	12 Mg^{2+} magnesium											13 Al^{3+} aluminum	14 Si silicon	15 P^{3-} phosphide	16 S^{2-} sulfide	17 Cl^- chloride	18 Ar argon
19 K^+ potassium	20 Ca^{2+} calcium	21 Sc^{3+} scandium	22 Ti^{4+} titanium (IV) / Ti^{3+} titanium (III)	23 V^{3+} vanadium(III) / V^{5+} vanadium (V)	24 Cr^{3+} chromium (III) / Cr^{2+} chromium (II)	25 Mn^{2+} manganese(II) / Mn^{4+} manganese(IV)	26 Fe^{3+} iron (III) / Fe^{2+} iron (II)	27 Co^{2+} cobalt (II) / Co^{3+} cobalt (III)	28 Ni^{2+} nickel (II) / Ni^{3+} nickel (III)	29 Cu^{2+} copper (II) / Cu^+ copper (I)	30 Zn^{2+} zinc	31 Ga^{3+} gallium	32 Ge^{4+} germanium	33 As^{3-} arsenide	34 Se^{2-} selenide	35 Br^- bromide	36 Kr krypton
37 Rb^+ rubidium	38 Sr^{2+} strontium	39 Y^{3+} yttrium	40 Zr^{4+} zirconium	41 Nb^{5+} niobium (V) / Nb^{3+} niobium(III)	42 Mo^{6+} molybdenum	43 Tc^{7+} technitium	44 Ru^{3+} ruthenium(III) / Ru^{4+} ruthenium(IV)	45 Rh^{3+} rhodium	46 Pd^{2+} paladium(II) / Pd^{4+} paladium(IV)	47 Ag^+ silver	48 Cd^{2+} cadmium	49 In^{3+} indium	50 Sn^{4+} tin (IV) / Sn^{2+} tin (II)	51 Sb^{3+} antimony(III) / Sb^{5+} antimony(V)	52 Te^{2-} telluride	53 I^- iodide	54 Xe xenon
55 Cs^+ cesium	56 Ba^{2+} barium	57 La^{3+} lanthanum	72 Hf^{4+} hafnium	73 Ta^{5+} tantalum	74 W^{6+} tungsten	75 Re^{7+} rhenium	76 Os^{4+} osmium	77 Ir^{4+} iridium	78 Pt^{4+} platinum(IV) / Pt^{2+} platinum(II)	79 Au^{3+} gold (III) / Au^+ gold (I)	80 Hg^{2+} mercury (II) / Hg_2^{2+} mercury (I)	81 Tl^+ thallium (I) / Tl^{3+} thallium(III)	82 Pb^{2+} lead (II) / Pb^{4+} lead (IV)	83 Bi^{3+} bismuth(III) / Bi^{5+} bismuth(V)	84 Po^{2+} polonium(II) / Po^{4+} polonium(IV)	85 At^- astatide	86 Rn radon
87 Fr^+ francium	88 Ra^{2+} radium	89 Ac^{3+} actinium															

58 Ce^{3+} cerium	59 Pr^{3+} praseodymium	60 Nd^{3+} neodymium	61 Pm^{3+} promethium	62 Sm^{3+} samarium(III) / Sm^{2+} samarium(II)	63 Eu^{3+} europium (III) / Eu^{2+} europium (II)	64 Gd^{3+} gadolinium	65 Tb^{3+} terbium	66 Dy^{3+} dysprosium	67 Ho^{3+} holmium	68 Er^{3+} erbium	69 Tm^{3+} thulium	70 Yb^{3+} ytterbium(III) / Yb^{2+} ytterbium(II)	71 Lu^{3+} lutetium
90 Th^{4+} thorium	91 Pa^{5+} protactinium(V) / Pa^{4+} protactinium(IV)	92 U^{6+} uranium (VI) / U^{4+} uranium (IV)	93 Np^{5+} neptunium	94 Pu^{4+} plutonium(IV) / Pu^{6+} plutonium(VI)	95 Am^{3+} americium(III) / Am^{4+} americium(IV)	96 Cm^{3+} curium	97 Bk^{3+} berkelium(III) / Bk^{4+} berkelium(IV)	98 Cf^{3+} californium	99 Es^{3+} einsteinium	100 Fm^{3+} fermium	101 Md^{2+} mendelevium (II) / Md^{3+} mendelevium (III)	102 No^{2+} nobelium(II) / No^{3+} nobelium(III)	103 Lr^{3+} lawrencium

The Periodic Table of the Elements

Average relative masses are rounded to two decimal places.

Element name → Mercury
Atomic # → 80
Symbol → Hg
Avg. Mass → 200.59

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 H 1.01																		Helium 2 He 4.00
Lithium 3 Li 6.94	Beryllium 4 Be 9.01												Boron 5 B 10.81	Carbon 6 C 12.01	Nitrogen 7 N 14.01	Oxygen 8 O 16.00	Fluorine 9 F 19.00	Neon 10 Ne 20.18
Sodium 11 Na 22.99	Magnesium 12 Mg 24.31												Aluminum 13 Al 26.98	Silicon 14 Si 28.09	Phosphorus 15 P 30.97	Sulfur 16 S 32.07	Chlorine 17 Cl 35.45	Argon 18 Ar 39.95
Potassium 19 K 39.10	Calcium 20 Ca 40.08		Scandium 21 Sc 44.96	Titanium 22 Ti 47.88	Vanadium 23 V 50.94	Chromium 24 Cr 52.00	Manganese 25 Mn 54.94	Iron 26 Fe 55.85	Cobalt 27 Co 58.93	Nickel 28 Ni 58.69	Copper 29 Cu 63.55	Zinc 30 Zn 65.39	Gallium 31 Ga 69.72	Germanium 32 Ge 72.61	Arsenic 33 As 74.92	Selenium 34 Se 78.96	Bromine 35 Br 79.90	Krypton 36 Kr 83.80
Rubidium 37 Rb 85.47	Strontium 38 Sr 87.62		Yttrium 39 Y 88.91	Zirconium 40 Zr 91.22	Niobium 41 Nb 92.91	Molybdenum 42 Mo 95.94	Technetium 43 Tc (97.91)	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.91	Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	Indium 49 In 114.82	Tin 50 Sn 118.71	Antimony 51 Sb 121.76	Tellurium 52 Te 127.60	Iodine 53 I 126.90	Xenon 54 Xe 131.29
Cesium 55 Cs 132.91	Barium 56 Ba 137.33	57-70 *	Lutetium 71 Lu 174.97	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.95	Tungsten 74 W 183.84	Rhenium 75 Re 186.21	Osmium 76 Os 190.23	Iridium 77 Ir 192.22	Platinum 78 Pt 195.08	Gold 79 Au 196.97	Mercury 80 Hg 200.59	Thallium 81 Tl 204.38	Lead 82 Pb 207.20	Bismuth 83 Bi 208.98	Polonium 84 Po (208.98)	Astatine 85 At (209.99)	Radon 86 Rn (222.02)
Francium 87 Fr (223.02)	Radium 88 Ra (226.03)	89-102 **	Lawrencium 103 Lr (262.11)	Rutherfordium 104 Rf (265.12)	Dubnium 105 Db (268.13)	Seaborgium 106 Sg (271.13)	Bohrium 107 Bh (270)	Hassium 108 Hs (277.15)	Meitnerium 109 Mt (276.15)	Darmstadtium 110 Ds (281.16)	Roegentium 111 Rg (280.16)	Copernicium 112 Cn (285.17)	Nihonium 113 Nh (284.18)	Flerovium 114 Fl (289.19)	Moscovium 115 Mc (288.19)	Livermorium 116 Lv (293)	Tennessine 117 Ts (294)	Oganesson 118 Og (294)

*lanthanides	Lanthanum 57 La 138.91	Cerium 58 Ce 140.12	Praseodymium 59 Pr 140.91	Neodymium 60 Nd 144.24	Promethium 61 Pm (145)	Samarium 62 Sm 150.36	Europium 63 Eu 151.97	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.93	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.93	Erbium 68 Er 167.26	Thulium 69 Tm 168.93	Ytterbium 70 Yb 173.05
**actinides	Actinium 89 Ac (227.03)	Thorium 90 Th 232.04	Protactinium 91 Pa 231.04	Uranium 92 U 238.03	Neptunium 93 Np (237.05)	Plutonium 94 Pu (244.06)	Americium 95 Am (243.06)	Curium 96 Cm (247.07)	Berkelium 97 Bk (247.07)	Californium 98 Cf (251.08)	Einsteinium 99 Es (252.08)	Fermium 100 Fm (257.10)	Mendelevium 101 Md (258.10)	Nobelium 102 No (259.10)