CHEM 200/202

Professor Theresa Carlson
Office: GMCS-213B

All emails are to be sent to:
chem200@sdsu.edu

My office hours will be held on zoom via MSLC on **Mondays & Wednesday from 8:00 am to 10:00 am** or by appointment

HOW THE CLASS WILL WORK

Email (for all needs): ***chem200@sdsu.edu***
Website: **https://sdsuchem200.sdsu.edu/** (Website is meant for waitlisters and has everything except: grades and Turnitin. For the previous two items please find on Canvas when you are enrolled. **The CHEM 200 Website will close after Exam 1**)

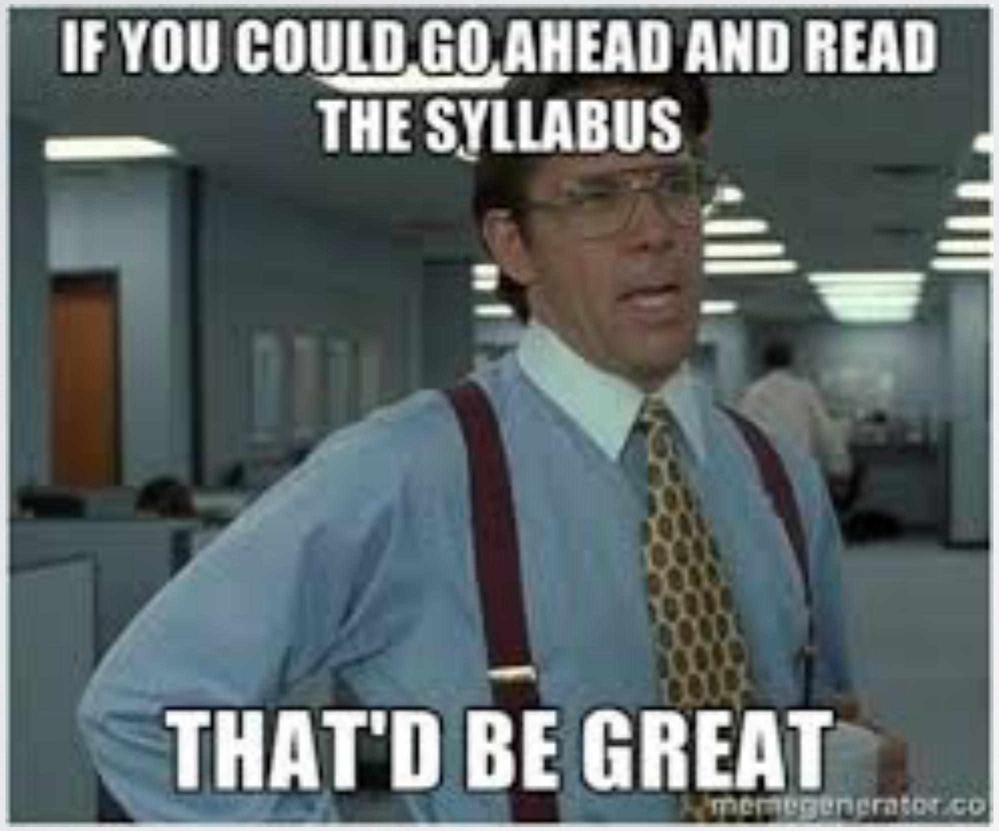
Instructor: Prof. Theresa Carlson, M.A.
Lecture: 11:00 AM – 11:50 AM MWF in ENS-280
Help Room (Zoom): 8:00 AM - 10:00 AM Mondays & Wednesdays **Zoom** ***via*** **https://mlc.sdsu.edu/**

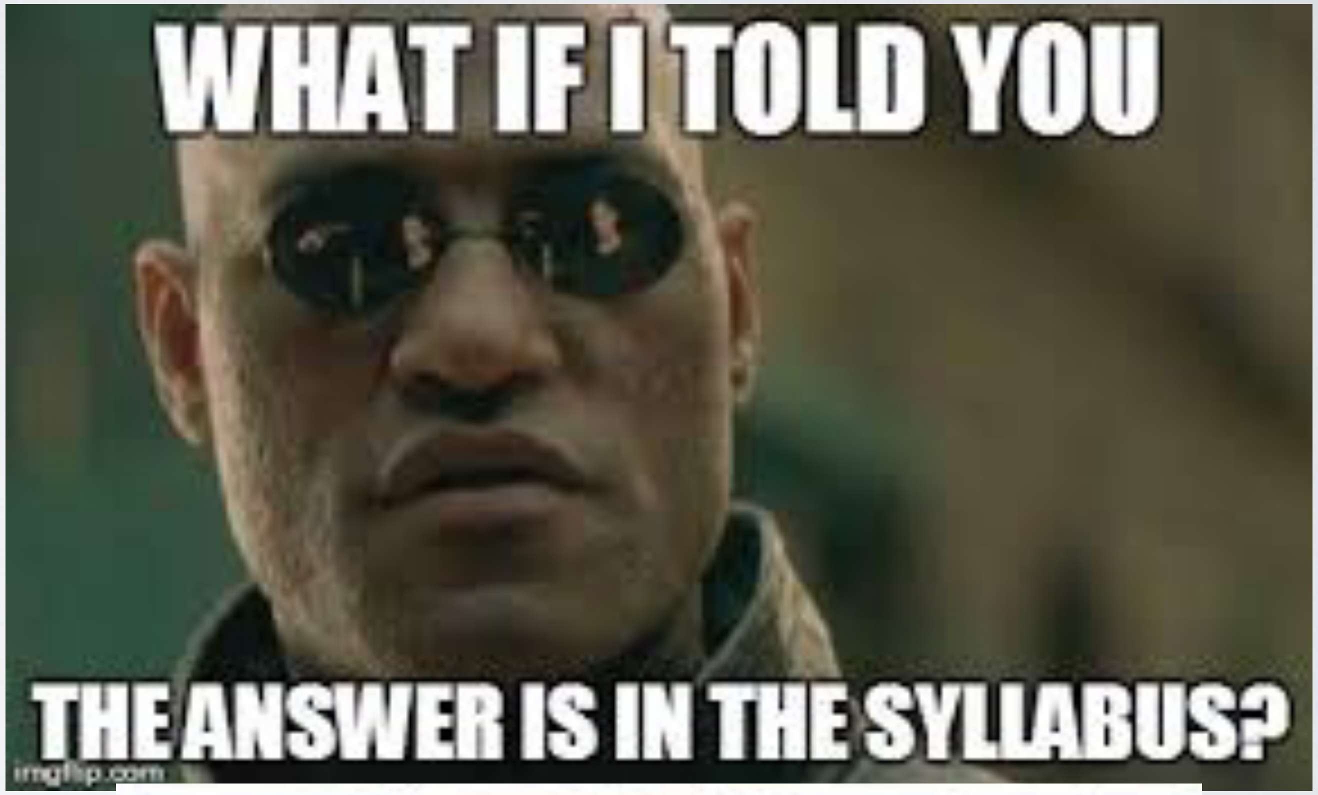
Lab Coordinator: Megan Bowles, M.A.
Help Room (Zoom): 9:00 AM - 11:00 AM Tuesdays **Zoom** ***via*** **https://mlc.sdsu.edu/**

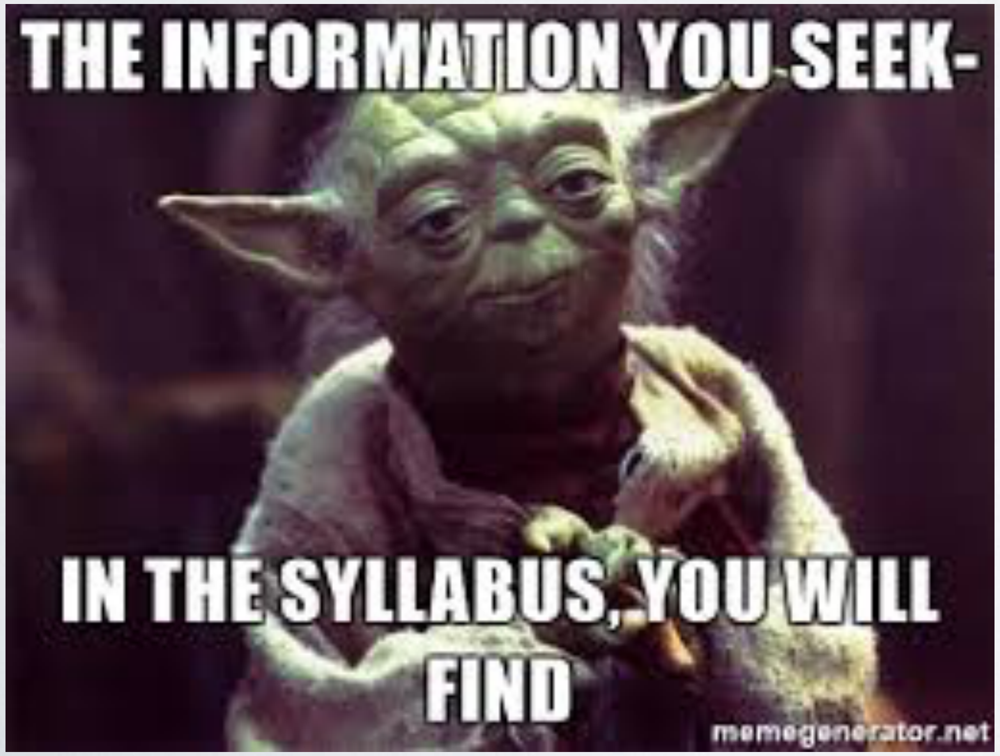
Mode of Instruction: Face-to-Face. Lectures will be recorded using Course Capture/Mediasite and available on Canvas. Attendance is strongly encouraged. There will be 40 points out of 43 points for lecture participation. Labs and Discussion (CHEM 200 only) sessions are in-person as well.

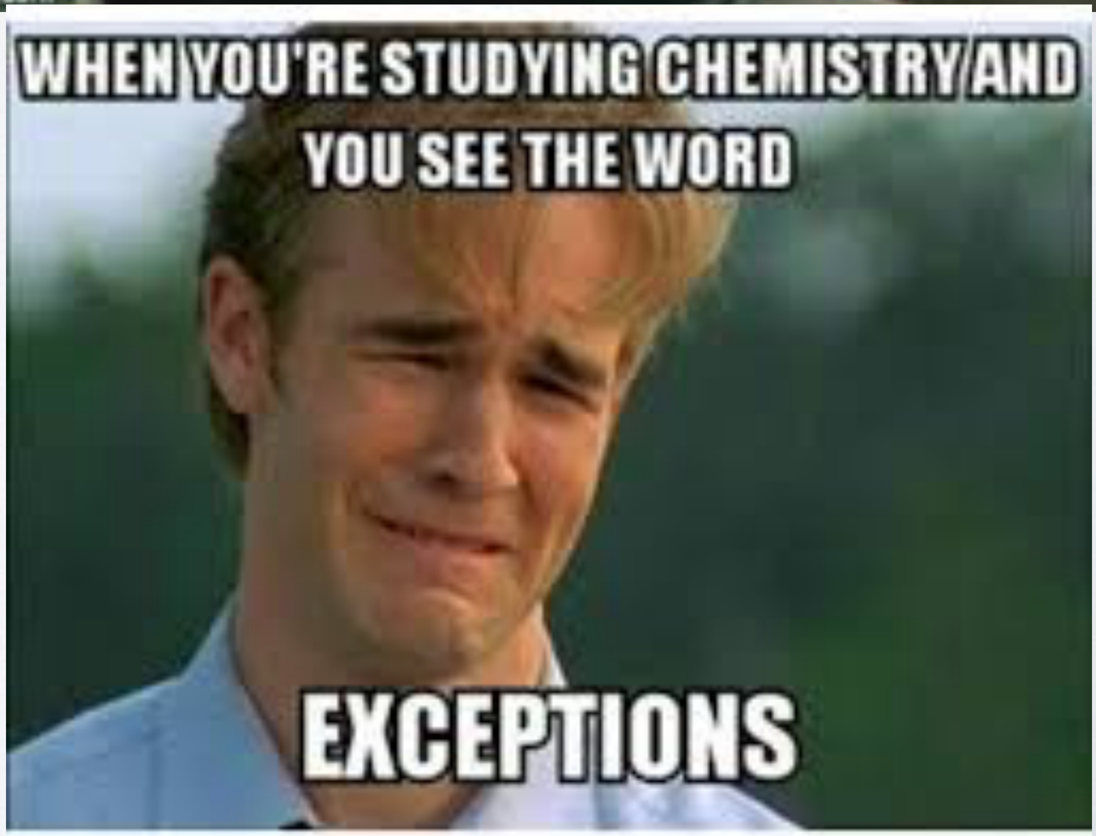
Exams will take place online via OWL.

PLEASE READ THE SYLLABUS









IMPORTANT ANNOUNCEMENTS

1. Email chem200@sdsu.edu ONLY unless its regarding lab or discussion which then you need to email your respective TA.

2. Follow the directions in adding OWL that Theresa provided you in Module 1.0 > Adding OWL (READ). She made a video and has a pdf file with directions.

3. **There is no course key for OWL.**

4. **Read the announcements and emails that Theresa, Megan, or your TAs sends out.**

5. Again read the syllabus. A lot of questions are being asked that are in the syllabus. For example, emailing when the lab will be and what will take place can be answered by the syllabus. In the syllabus there is a lab schedule, read, use it, and print it out.

6. And for good measure read the announcements before sending out emails. The majority (98%) of questions can be answered by: the syllabus, videos Theresa has made, and in the announcements.

UPCOMING IMPORTANT DATES

- Safety Quiz due **Friday, February 3rd at 11:59 pm** (in OWL Lab & Canvas), *must pass with >60% to do in-person labs*
- How to write a lab notebook and prelab due **Sunday, February 5th at 11:59 pm**
- Volumetric Prelab due **Sunday, February 5th at 11:59 pm**
- Volumetric Lab Report due **Sunday, February 12th at 11:59 pm**
- Chapter 1-4 Chapter Problem Sets in OWL Lecture due **Thursday, February 9th at 11:59 pm** (**Start Now)**
- Chapter 1-4 Chapter Assessments in OWL Lecture is **Thursday, February 9th at 11:59 pm** (**Start Now**); 2 chances, no time limit
- Exam 1 starts at **3 pm Friday, February 10th and will close on Saturday, February 11th at 3pm** in OWL Lecture; Chapters 1-4. You have 24hrs. *Only 2 hrs once you start; be sure to give yourself a full 2 hr time slot.*

SUPPLEMENTAL INSTRUCTION (SI)

- Study sessions lead by former CHEM 200/202 students that excelled in the previous semesters class.
- Occur 15+ times a week.
- Free to access, no reporting to faculty.

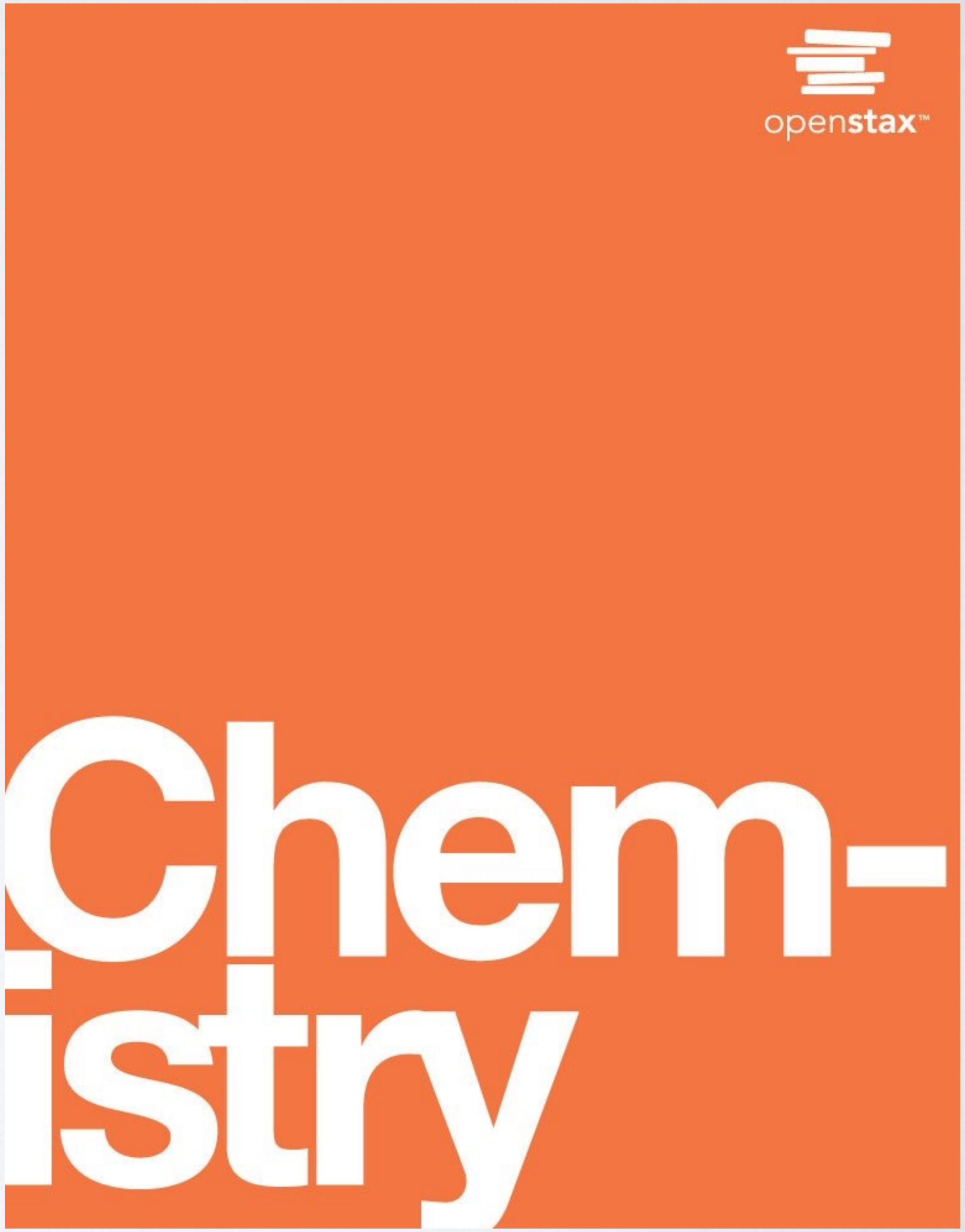
THE MATH AND SCIENCE LEARNING CENTER (MSLC)

Students are encouraged to make use of The Mathematics and Statistics Learning Center (MSLC) for free STEM tutoring, located in the Love Library, Room 328. For a full list of courses tutored, please visit the MSLC website: https://mlc.sdsu.edu/ .

The MSLC is supported by your student success fee. We strongly encourage you to use this wonderful, free resource. Some students believe that they shouldn't need to ask for help, but research has shown that the average grade for students who attend the MLC is almost one full grade higher than those who don't seek such support.

TEXTBOOK

- **Openstax Chemistry**
- **PDF is Free!***
- **Redshelf (in Canvas) is an interactive ebook for FREE!**
- Free for Kindle
- Available from iBooks ($4.99)



QUESTION

While being driven from Philadelphia to Atlanta, a distance of about 1250 km, a 2014 Lamborghini Aventador Roadster uses 213 L gasoline.

(a) What (average) fuel economy, in miles per gallon, did the Roadster get during this trip?

(b) If gasoline costs $3.80 per gallon, what was the fuel cost for this trip?

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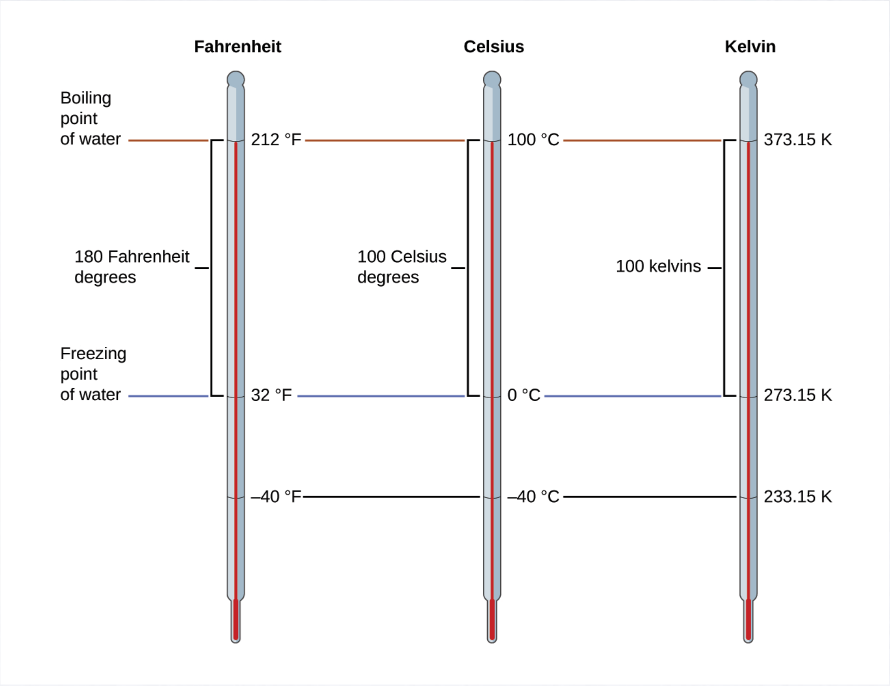
(a) 13.8 mpg

(b) $214

TEMPERATURE SCALES

- **Kelvin (K)** - The "Absolute temperature scale", begins at zero and only has positive values
- **Celsius (°C)** - The principal scientific temperature scale
- **Fahrenheit (°F)** - Not used scientifically, used in some countries for weather reports.



Relative temperatures:

Water freezes at:

32°F

0°C

273.15 K

Water boils at:

212°F

100°C

373.15 K

TEMPERATURE CONVERSIONS

$T_{°C} = 5/9\ (T_{°F} - 32)$

$T_K = T_{°C} + 273.15$

$T_{°C} = T_K - 273.15$

QUESTION

Baking a ready-made pizza calls for an oven temperature of 450 °F. If you are in Europe, and your oven thermometer uses the Celsius scale, what is the setting? What is the kelvin temperature?

QUESTION

Baking a ready-made pizza calls for an oven temperature of 450. °F. If you are in Europe, and your oven thermometer uses the Celsius scale, what is the setting? What is the kelvin temperature?

232 °C

505 K

CAPTER 2 - ATOMS, MOLECULES AND IONS

If an atom could be expanded to the size of a football stadium, the nucleus would be the size of a single blueberry. (credit middle: modification of work by “babyknight”/ Wikimedia Commons; credit right: modification of work by Paxson Woelber)

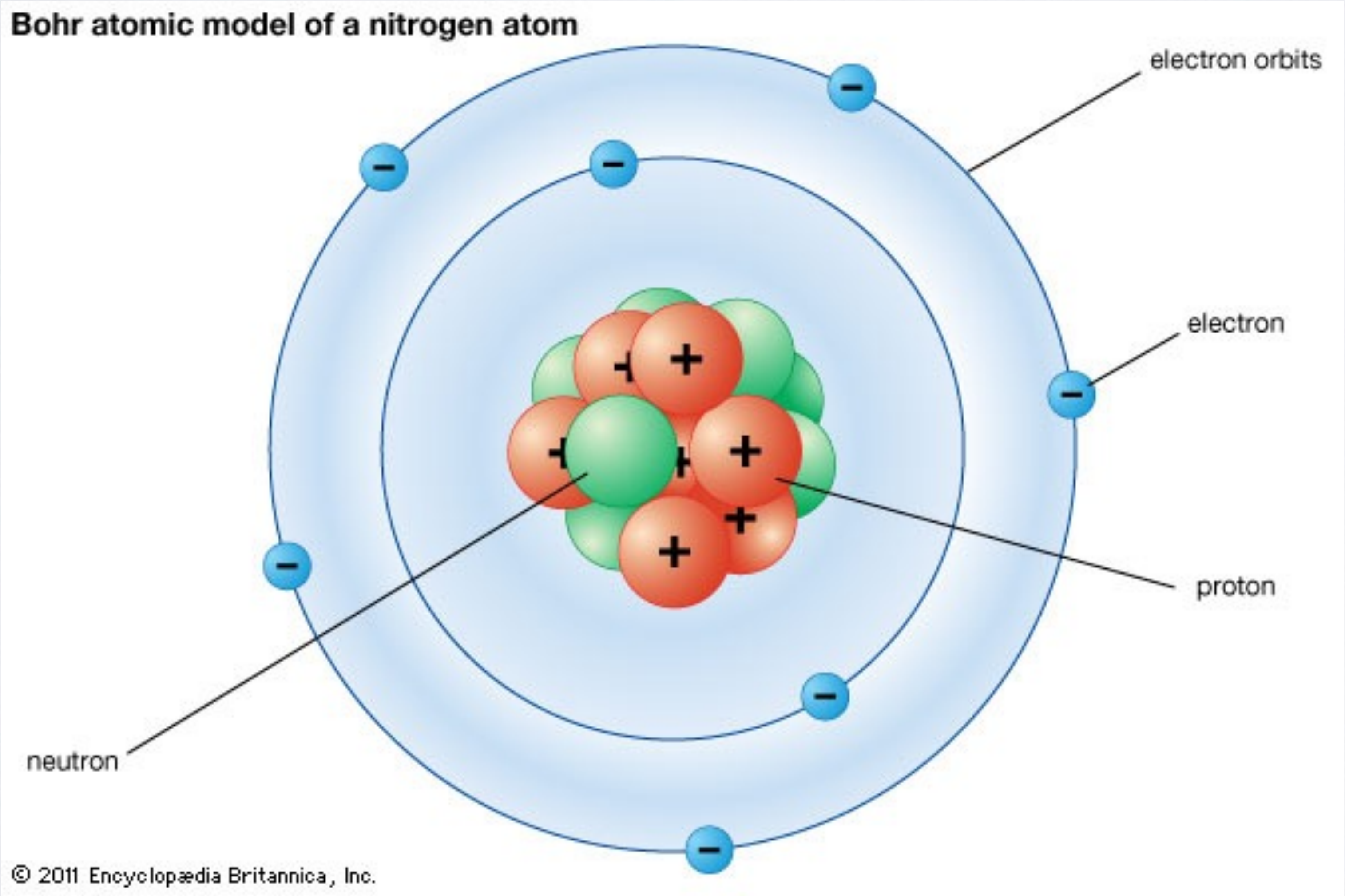
ATOMIC THEORY

John Dalton

- All Matter is made of Atoms.
- Atoms of an element are identical
- Atoms can engaged in chemical reactions.
- Atoms can not be destroyed nor be created.
- Atoms are indivisible.

BOHR'S MODEL OF ATOM

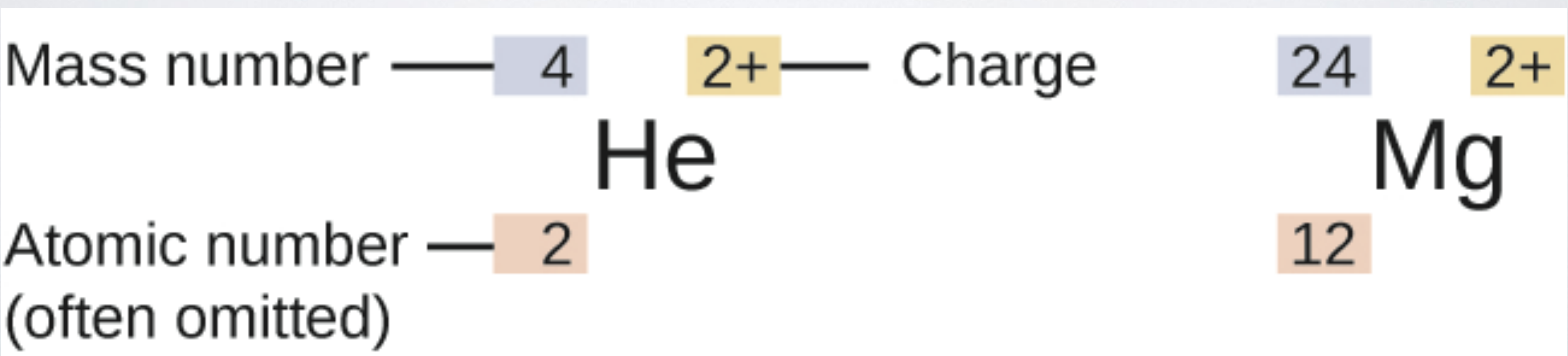
- Electron orbit the nucleus like planets orbit the sun



Niels Bohr

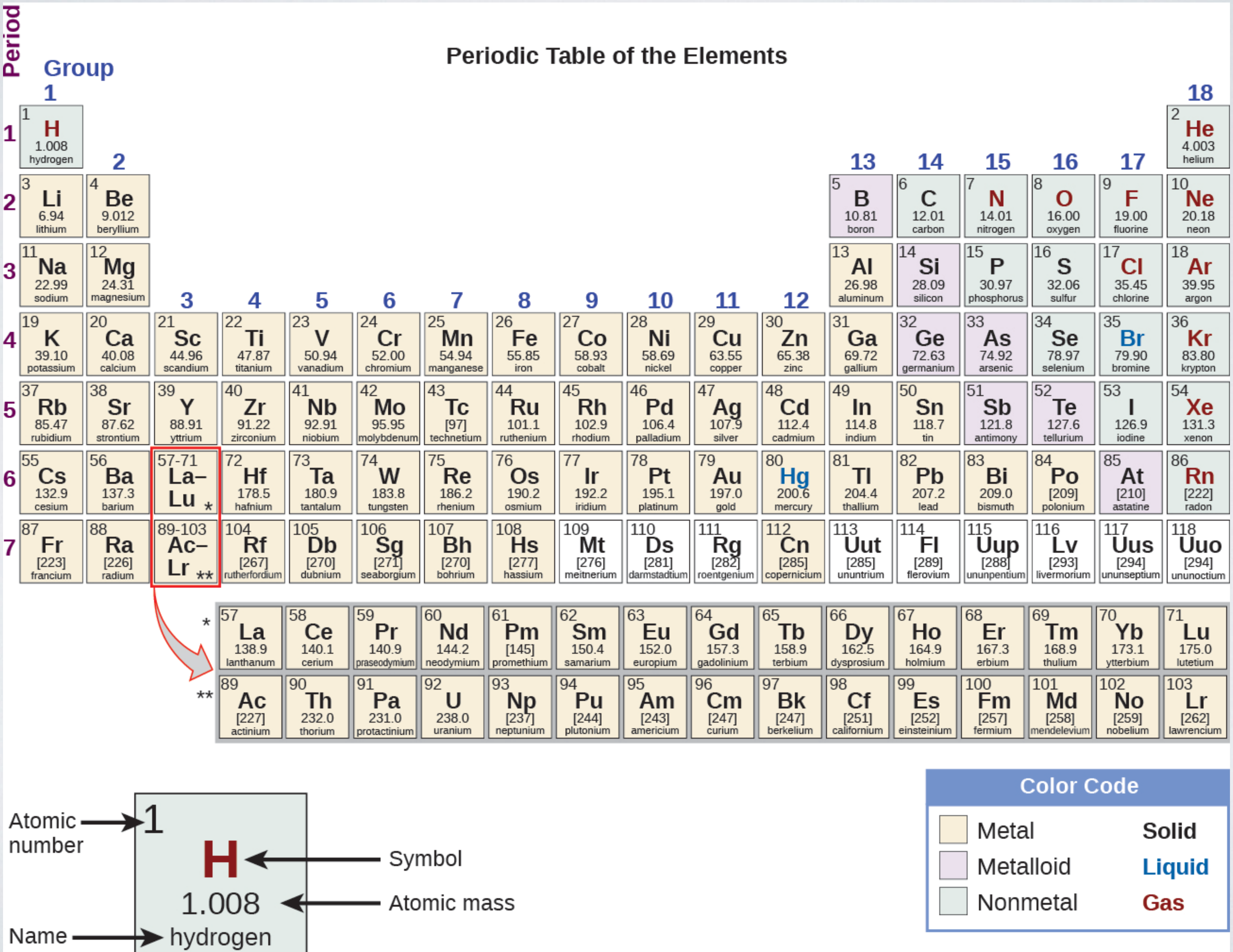
ATOMIC STRUCTURE AND SYMBOLISM

- Atomic Number (Z) = number of protons
- Atomic Mass (A) = number of protons + number of neutrons
- A - Z = number of neutrons
- Charge: Proton (+1), Electron (-1), Neutron (0)



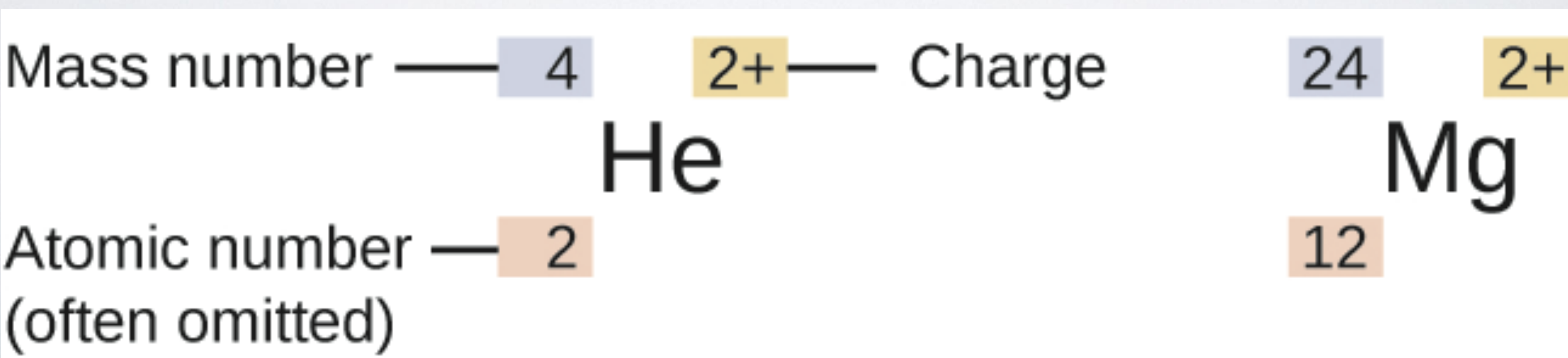
Note: Mass number and atomic number are displayed differently in Periodic Table

THE PERIODIC TABLE



ISOTOPES & ATOMIC MASS

- Isotopes are variants of atoms, which have a different number of neutrons in the nucleus.
- This influences the average mass of the atom (which is listed on the periodic table).
- Some elements only have one isotope (monoisotopic, ^{9}Be, ^{19}F, ^{23}Na)



PERCENT ABUNDANCE

This exercise will lead you to verify that the average atomic mass of magnesium is 24.31 amu, based on the following information:

isotope	mass (amu)	percent abundance
^{24}Mg	23.985042	78.99%
^{25}Mg	24.985837	10.00%
^{26}Mg	25.982593	11.01%

The average atomic mass is the weighted average of the atomic masses of all isotopes.

$$\text{atomic mass} = \sum_{\substack{\text{all} \\ \text{isotopes}}} \text{atomic mass} \times \text{fractional abundance}$$

What is the fractional abundance of ^{24}Mg?

AVERAGE MASS

The element **indium** has an atomic weight of **115** and consists of two stable isotopes **indium-113** and **indium-115**.

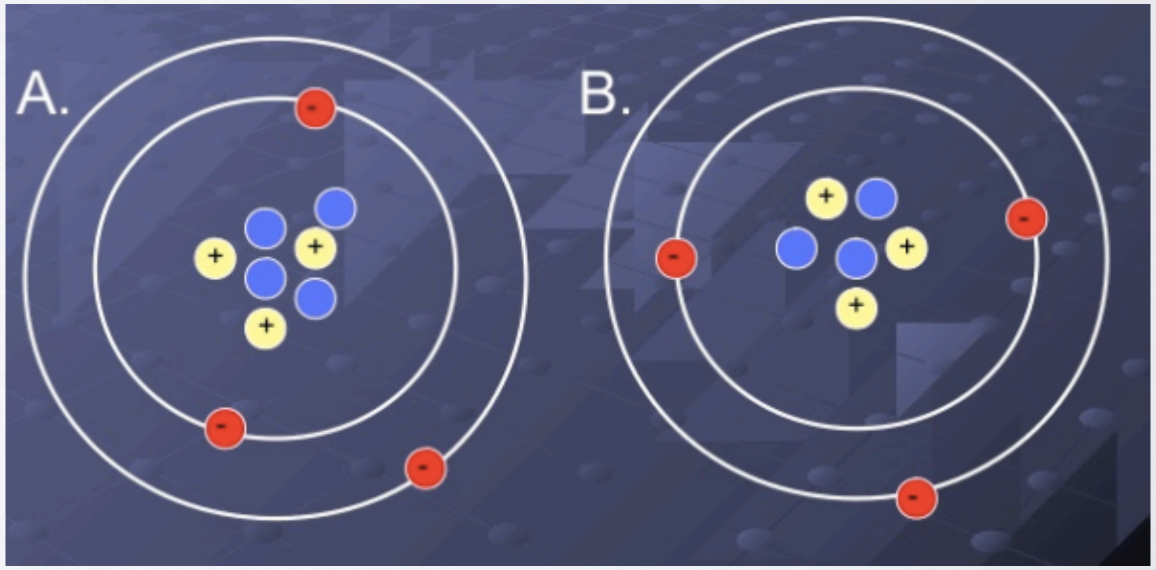
The isotope **indium-113** has a mass of **113** amu and a percent natural abundance of **4.28** %.
The isotope **indium-115** has a percent natural abundance of **95.7** %.

What is the mass of **indium-115**? [   ] amu

ISOTOPIC ABUNDANCE CALCULATION

- The average mass for lithium (Li) is 6.94 g/mol. The isotopes of lithium are ^{6}Li and ^{7}Li with respective masses of 6.0151 amu and 7.0160 amu.

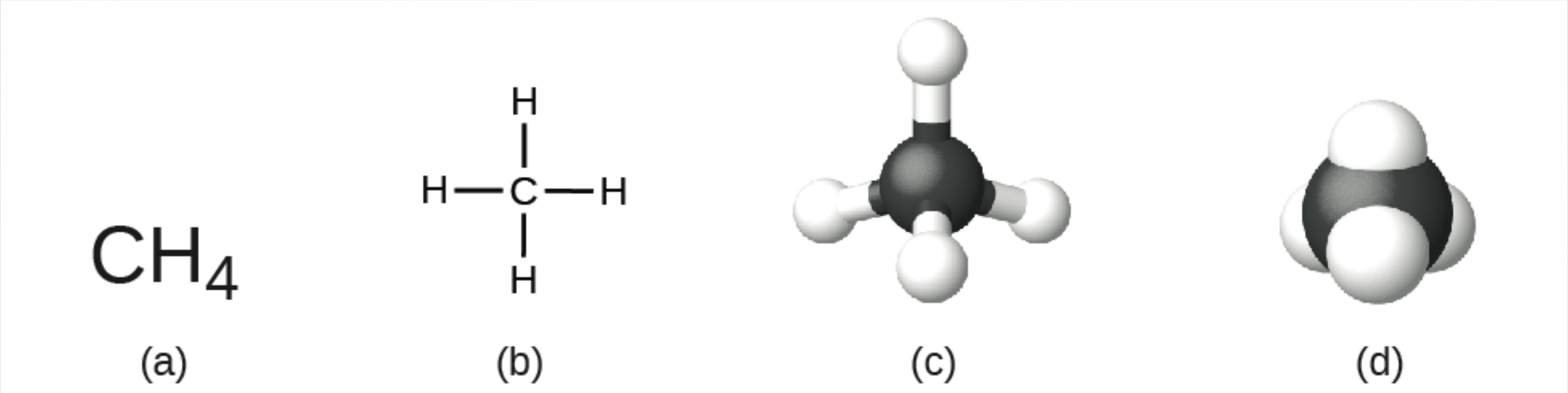
- Given this information, what is the abundance of each of the isotopes?



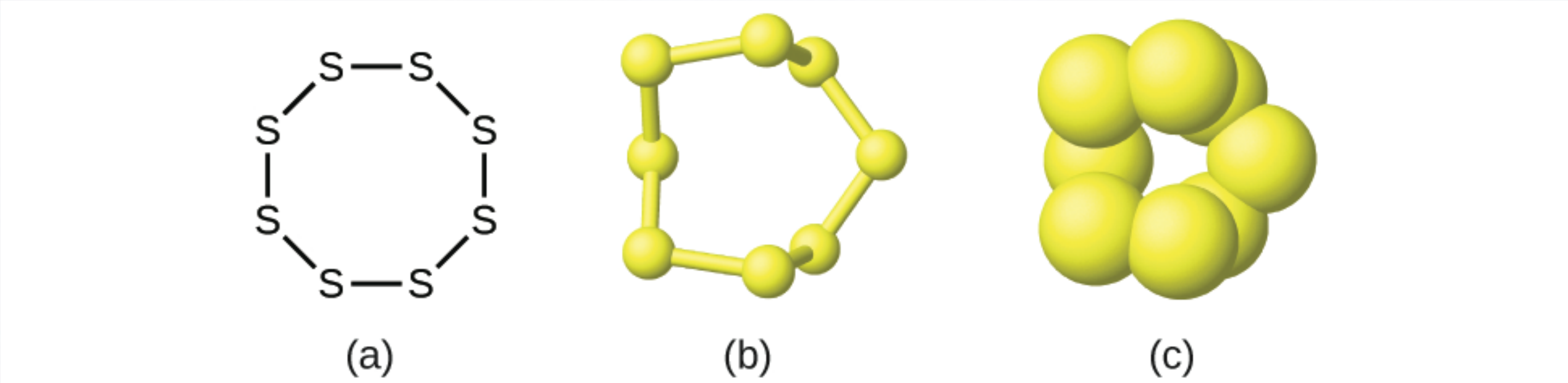
CHEMICAL LANGUAGE

- Chemistry, like most fields of study, has a unique language which conveys significant information to those who understand it.
- Elements (Na, Cl) - letters of the language
- Chemical Formulas (NaCl) - words of the language
- Chemical Equations ($2Na_{(s)} + Cl_{2(g)} \rightleftharpoons 2NaCl_{(s)}$) - sentences of the language

CHEMICAL FORMULAS



A methane molecule can be represented as (a) a molecular formula, (b) a structural formula, (c) a ball-and-stick model, and (d) a space-filling model. Carbon and hydrogen atoms are represented by black and white spheres, respectively.



A molecule of sulfur is composed of eight sulfur atoms and is therefore written as S_8. It can be represented as (a) a structural formula, (b) a ball-and-stick model, and (c) a space-filling model. Sulfur atoms are represented by yellow spheres.

MOLECULAR VS. EMPIRICAL FORMULA

- **The molecular formula** is the actual number of atoms of each type in a molecule.
- Water: H_2O
- Hydrogen peroxide: H_2O_2
- Glucose: $C_6H_{12}O_6$

- **The empirical formula** is the smallest whole number ratio of all atoms in an atom.
- Water: H_2O
- Hydrogen peroxide: HO
- Glucose: CH_2O

EMPIRICAL FORMULA

- The utility of the empirical formula arises in determining the composition of a substance.
- Elemental analysis techniques can tell chemists what mass of a given element is present in a sample.
- But elemental analysis does not give molecular information.
- Glucose ($C_6H_{12}O_6$) and formaldehyde (CH_2O) have the same ratio of atoms (empirical formulas).

QUESTION

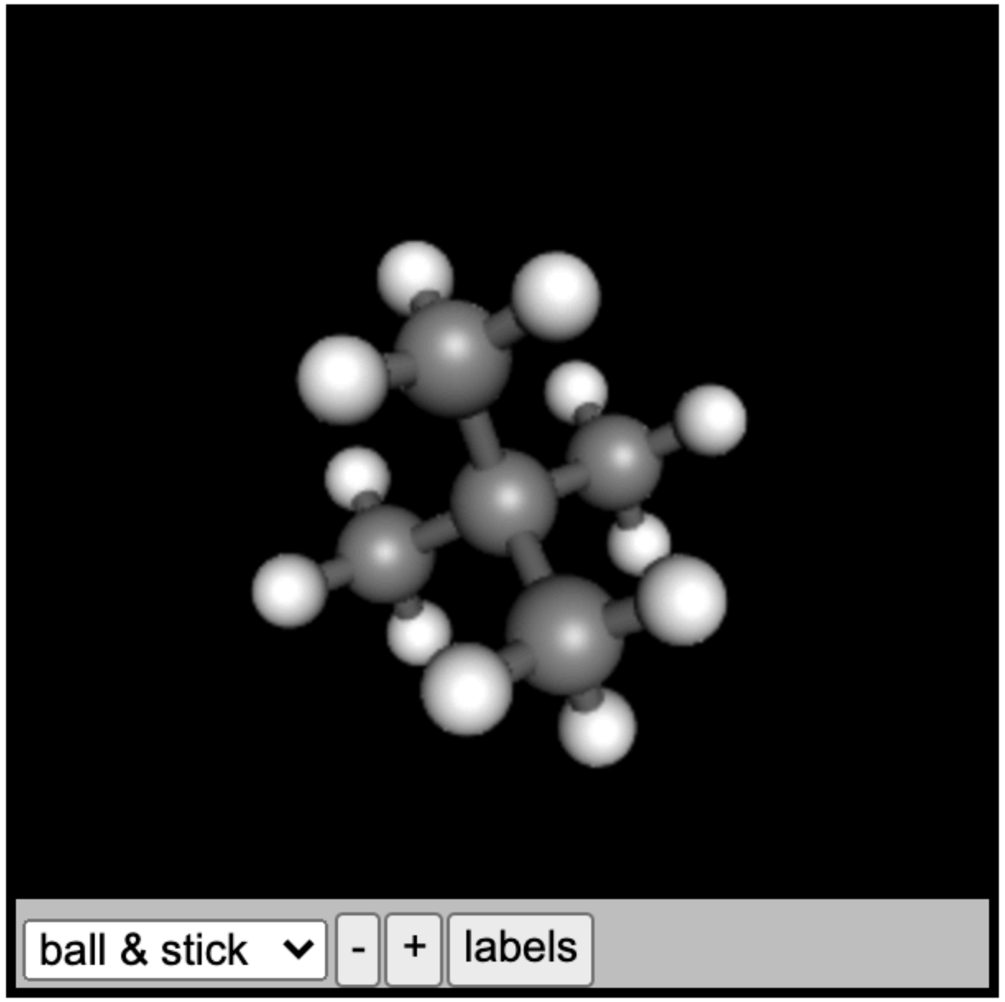
How many atoms of carbon, hydrogen, and oxygen are present in a single molecule of citric acid?

Citric acid: $C_3H_5O(CO_2H)_3$

Carbon			Hydrogen			Oxygen		
1	2	3	1	2	3	1	2	3
4	5	(6)	4	5	6	4	5	6
7	8	9	7	(8)	9	(7)	8	9

EMPIRICAL AND MOLECULAR FORMULA

In the following model for the **2,2-dimethylpropane** molecule, carbon is in gray and hydrogen is in white:



The molecular formula for **2,2-dimethylpropane** is:

(Enter the elements in the order: C, H, N, O.)

PERIODIC TABLE OF THE ELEMENTS

Groups

Periods

	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.008																		2 He 4.003
2	3 Li 6.941	4 Be 9.012												5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31												13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08		21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62		39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	48 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57-70 *	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [209]	85 At [210]	86 Rn [220]
7	87 Fr [223]	88 Ra [226]	89-102 **	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [277]	109 Mt [268]									

Metals | Non Metals

* Lanthanoids	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
** Actinoids	89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

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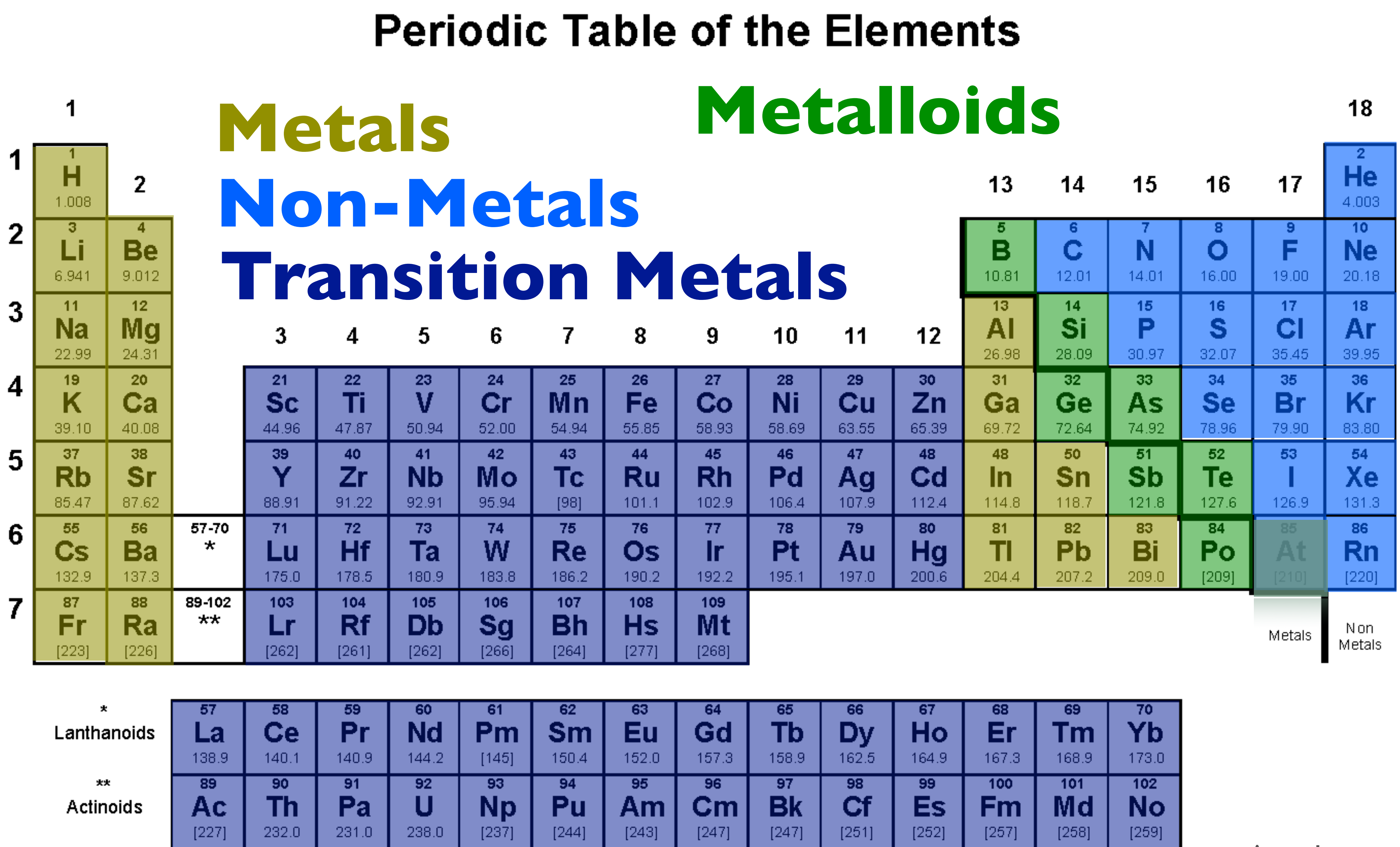

At is
a metalloid

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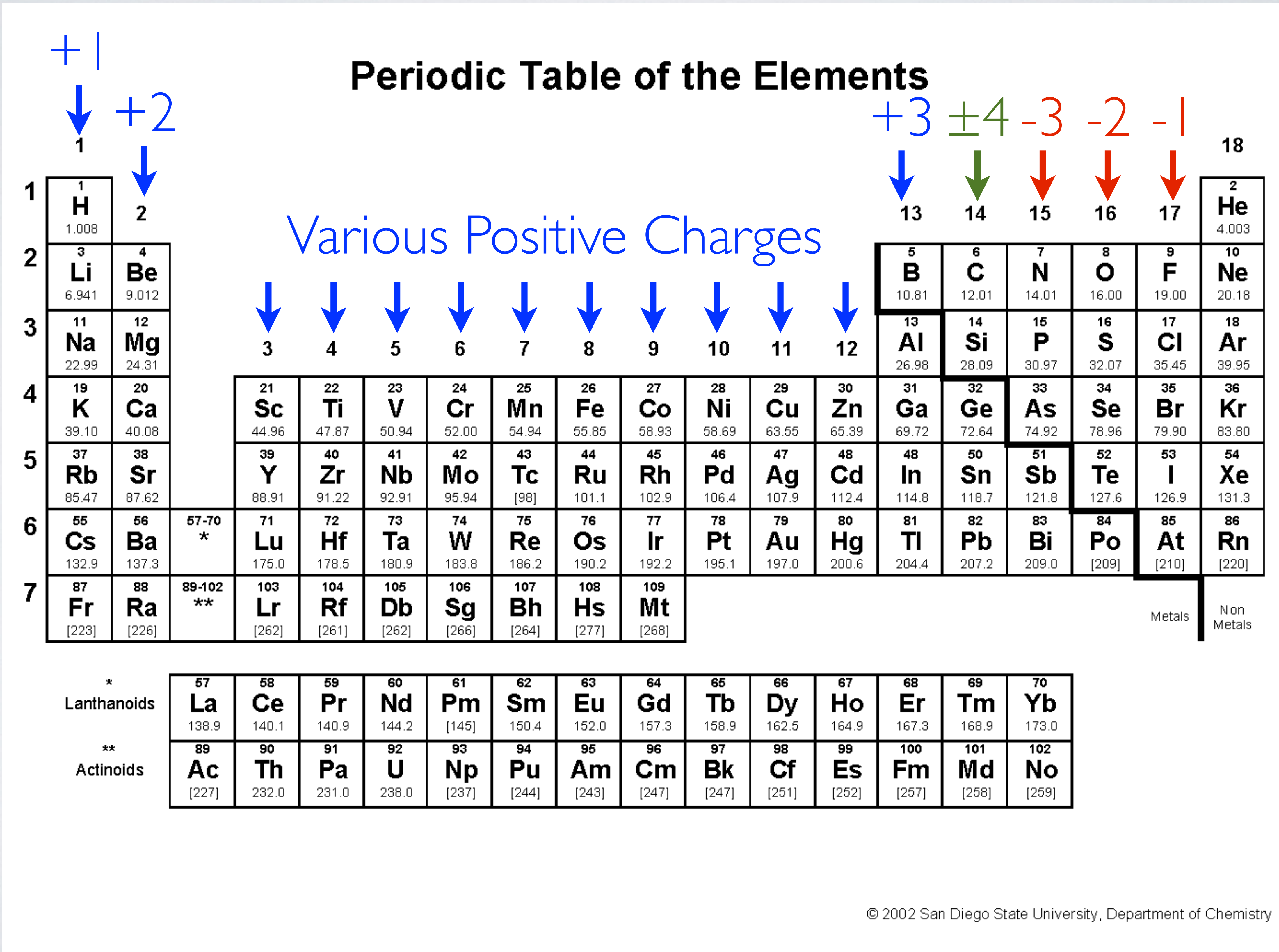
IONIC CHARGES



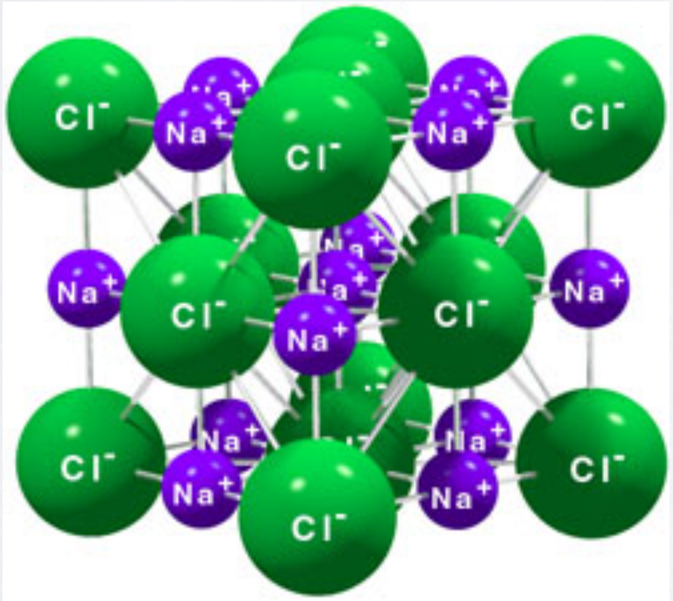
CHEMICAL BONDING

- Bonds form between atoms when they share electrons.
- Not all atoms share electrons in the same way; some are "generous" others are "selfish".
- The types of atoms forming the bond define the type of bond.
- **Ionic compounds** - metal + non-metal - electrons transferred to one element from the other.
- **Covalent compounds** - non-metals only - electrons are shared between atoms.

NAMING IONIC COMPOUNDS

NaCl - Sodium chloride

metal non-metal



http://www.chemistry.wustl.edu

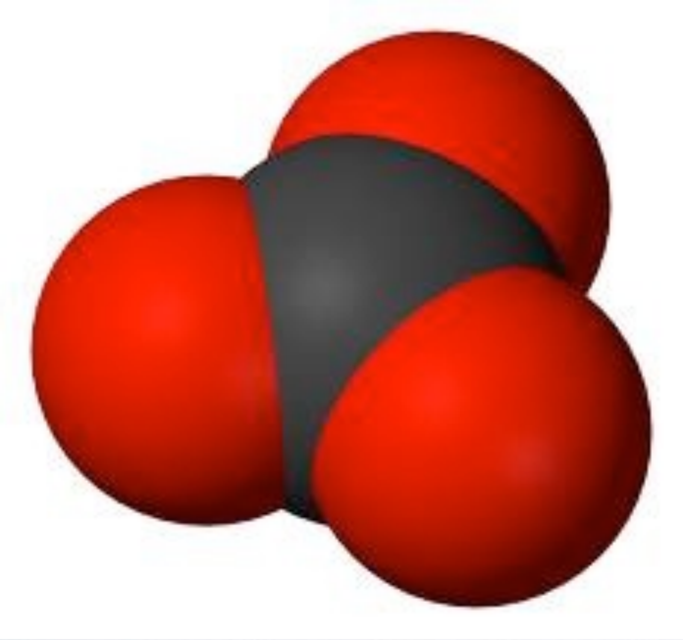
- Na^+ and Cl^- combine in a 1:1 ratio
- NaCl is the only compound that can form from sodium and chlorine

POLYATOMIC IONS

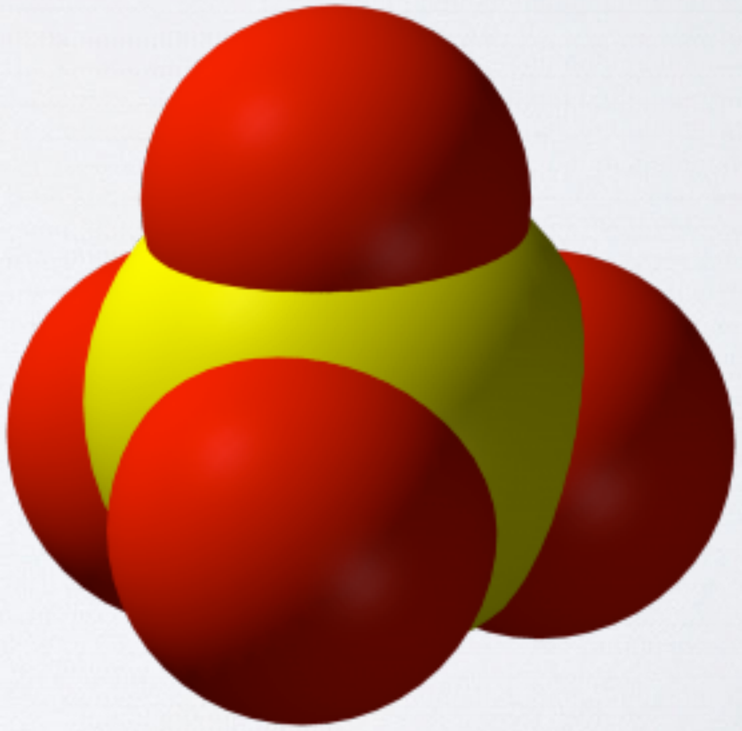
Ions that are comprised of more than one atom; the atoms remain bound together.

See Canvas for the polyatomic ions you need to know

Carbonate ion: CO_3^{2-}



Sulfate ion: SO_4^{2-}



NAMING COVALENT COMPOUNDS

PCl_3 - Phosphorous trichloride   Both non-metals

The naming convention specifies the relative number of atoms - there may be more than one possible ratio of atoms

PCl_5 - Phosphorous pentachloride

S_2Cl_2 - Disulfur dichloride

CALCULATE THE FORMULA MASS, NUMBER OF MOLES OF COMPOUND AND EACH ATOM

0.1488 g of H_3PO_4

78.452 g of $Al_2(SO_4)_3$

2.12 g of KBr

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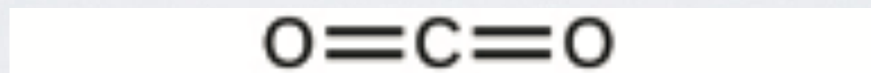
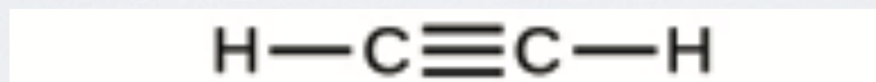
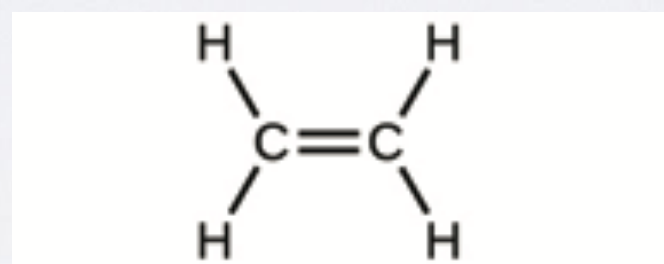
- Hydrogen peroxide: H_2O_2
- Glucose: $C_6H_{12}O_6$

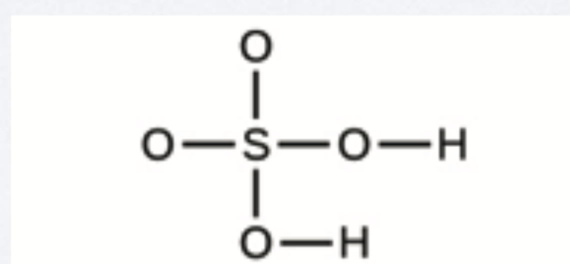
- **The empirical formula** is the smallest whole number ratio of all atoms in an atom.
- Water: H_2O
- Hydrogen peroxide: HO
- Glucose: CH_2O

WRITE THE MOLECULAR & EMPIRICAL FORMULAS









DETERMINING THE MOLECULAR FORMULA FROM THE EMPIRICAL FORMULA

- In order to calculate the molecular formula from the empirical formula we need more information about the compound. Typically this will involve the formula mass of the compound.

- Example:

  - Nicotine contains 74.02% C, 8.710% H and 17.27% N. A 40.57 g mass of nicotine contains 0.2500 mol. What is the molecular formula?

Use the References to access important values if needed for this question.

A compound is found to contain **31.42** % **sulfur** , **31.35** % **oxygen** , and **37.23** % **fluorine** by mass.

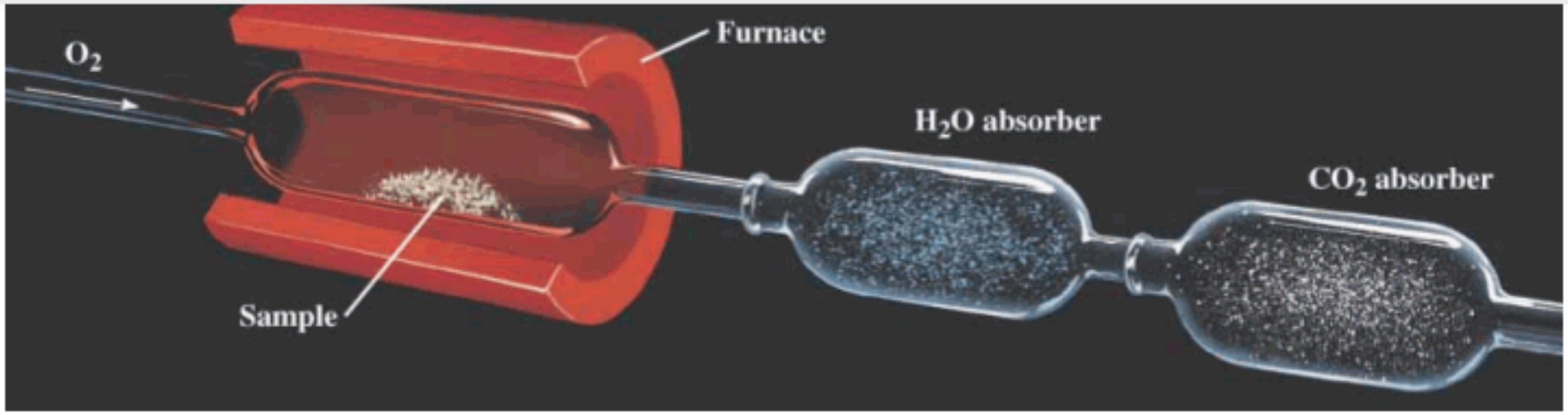
To answer the question, enter the elements in the order presented above.

QUESTION 1:

The empirical formula for this compound is ______ .

QUESTION 2:
The molar mass for this compound is **102.1** g/mol.

The molecular formula for this compound is ______ .



A **3.270** gram sample of an organic compound containing C, H and O is analyzed by combustion analysis and **4.793** grams of CO_2 and **1.962** grams of H_2O are produced.

In a separate experiment, the molar mass is found to be **60.05** g/mol. Determine the empirical formula and the molecular formula of the organic compound.

Enter the elements in the order C, H, O

empirical formula =

molecular formula =

MOLARITY

- **Molarity** is the most common measurement of concentration used in chemistry.
- Molarity is the measure of the number of moles of a **solute** per liter **solution**
- Molarity is expressed as **mol/L** or **M**.
- Molarity can also be expressed with **prefixes**:
  - 2 mM = 2×10^{-3}M; 3.4 μM = 3.4×10^{-6}M; 7.8 nM = 7.8×10^{-9}M

CONCENTRATION CALCULATIONS

How many moles of hydrogen chloride are in 0.0365 L of a 2.00 M HCl solution?

How many grams of HCl are present in that solution?

CONCENTRATED & DILUTE SOLUTIONS

- Concentrated solutions have more *solute* per unit volume than dilute solutions.
- Concentrated solutions can be made dilute by adding more *solvent*.
- Dilute solutions can be made more concentrated by adding more *solute*, or by removing (selectively) more *solvent*.

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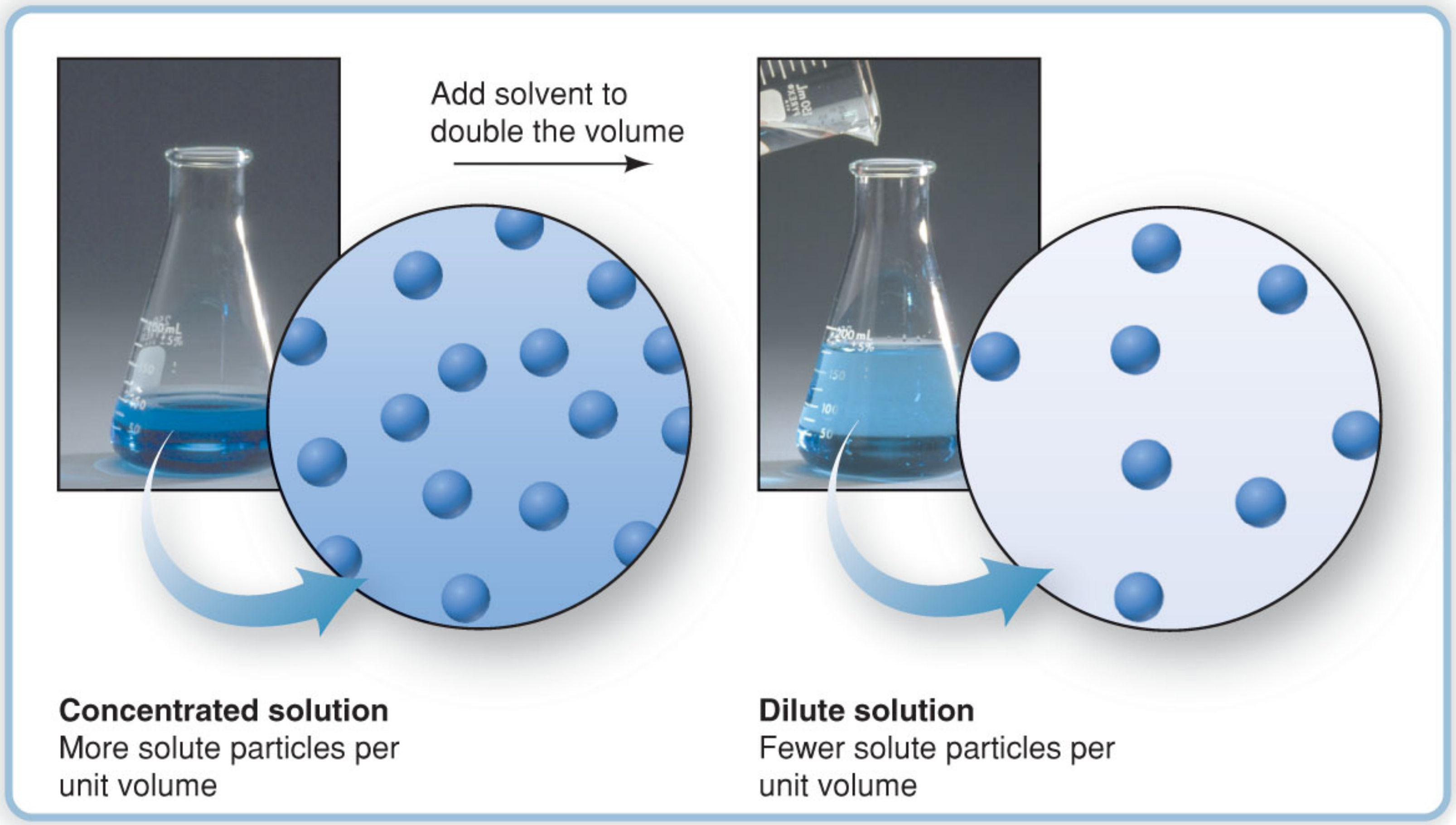

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DILUTIONS CALCULATIONS

- Solutions often need to be **diluted** to obtain the **desired concentration**, from a higher concentration stock solution.
- Calculations for dilutions require us to determine the total **number of moles** involved in the dilution.
- M_1V_1 = # of moles = M_2V_2

QUESTION

Take 25.00 mL of a 0.0400 M $KMnO_4$ solution.

Dilute the 25.00 mL solution to 1.000 L with water.

What is the resulting molarity of the diluted solution?

0.00100 M $KMnO_4$

QUESTION

Which one of the following solutions is the most dilute?

A: 0.500 M HCl solution

B: 0.50 L of solution containing 0.40 moles of HCl

C: 75 mL of solution containing 0.40 moles of HCl

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A: 0.500 M HCl solution

B: 0.50 L of solution containing 0.40 moles of HCl

$0.40 \text{ mol} \div 0.50 \text{ L} = 0.80 \text{ M} > 0.50 \text{ M}$

C: 75 mL of solution containing 0.40 moles of HCl

$0.40 \text{ mol} \div 0.075 \text{ L} = 5.3 \text{ M} > 0.50 \text{ M}$

QUESTION

Each of the following salts are soluble in water. Which will produce the largest number of ions, per mole, of dissolved solute?

Answers

A	Aluminum chloride	$AlCl_3$: 4 moles of ions
B	Sodium chloride	$NaCl$: 2 moles of ions
C	Ammonium nitrate	NH_4NO_3 : 2 moles of ions
D	Sodium sulfate	Na_2SO_4 : 3 moles of ions
E	Calcium nitrate	$Ca(NO_3)_2$: 3 moles of ions

QUESTION

What is the total concentration of ions in a 0.10 M iron(III) sulfate solution?

<u>Answers</u>

A 0.10 M

B 0.20 M

C 0.30 M

D 0.40 M

E 0.50 M

$$Fe_2(SO_4)_3 \longrightarrow 2Fe^{3+} + 3SO_4^{2-}$$

0.10 M $\quad$ 2(0.10 M) + 3(0.10 M) = 0.50 M

OTHER UNITS OF CONCENTRATION

- Concentrations are used to express the amount of solute in a solution, this can be done in more ways than just molarity (mol/L).
  - Mass percent (w/w%)
  - Volume percent (v/v%)
  - Mass-volume percent (w/v%)
  - Parts per million (ppm) and parts per billion (ppb)

EXPRESSING CONCENTRATION IN PERCENTAGES

- The expression of concentration as a percentage is very similar to how percentage grades are expressed.

- The key is to use the proper units for each calculation.

Mass percent (w/w%)

$$\text{mass percentage} = \frac{\text{mass of component}}{\text{mass of solution}} \times 100\%$$

Volume percent (v/v%)

$$\text{volume percentage} = \frac{\text{volume solute}}{\text{volume solution}} \times 100\%$$

ppm and ppb

$$\text{ppm} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6 \text{ ppm}$$

$$\text{ppb} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^9 \text{ ppb}$$

MASS % PROBLEM

A throat spray is 1.40% by mass phenol, C_6H_5OH, in water. If the solution has a density of 0.9956 g/ml, calculate the molarity of the solution.

PPM/PPB PROBLEM

The EPA monitors lead (Pb) in tap water to ensure that it does not exceed 15 ppb. What is this concentration in ppm? At this concentration what mass of lead (in μg) would be contained in a typical glass of water (300. mL)? The density of water is 1.00 g/mL.

CONVERSION AMONG CONCENTRATIONS

A solution consists of **73.9** g of **potassium bromide (KBr)**, **113.1** g water, and has a volume of **137** mL.

Calculate the weight percent of **KBr**, the molality of **KBr**, the mole fraction of **KBr**, and the molarity of **KBr** in the solution.

weight percent = [ ] %

molality = [ ] m

mole fraction = [ ]

molarity = [ ] M

$$\text{molality } (m) = \frac{\text{moles of solute}}{\text{kg solvent}}$$