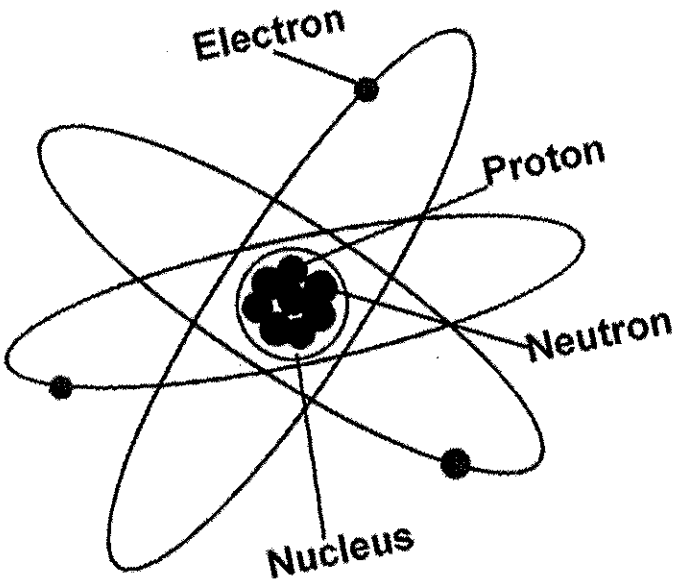
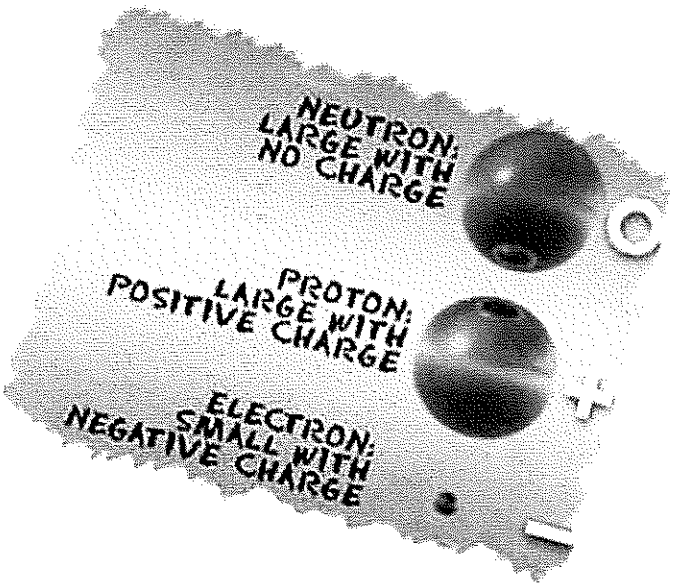
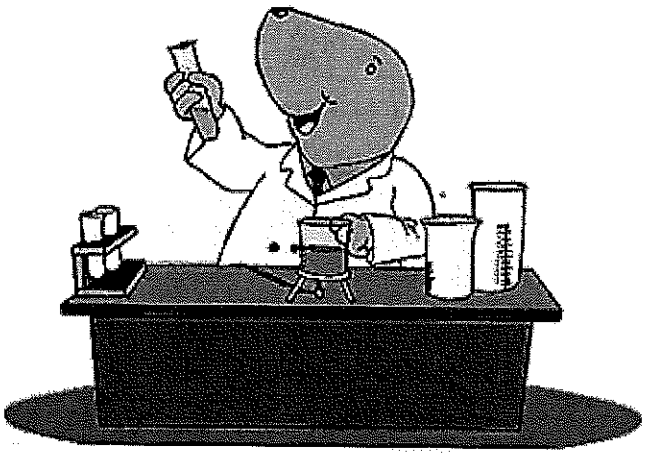
CP Chemistry

Chapter 3:
Atoms– The Building Blocks of Matter







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Chapter 3: Atoms – The Building Blocks of Matter
Reading Guide

3.1 - The Atom: From Philosophical Idea to Scientific Theory *(pgs. 63-67)*

Philosophical idea

1. Who was the first thinker to suggest the existence of the atom in 400 BCE and what does the Greek word "atom" actually mean?

2. Why were the opinions of Aristotle and Democritus not considered scientific theories?

Evidence for Atomic Theory

3. Three basic laws that describe how matter behaves in chemical reactions.

Complete the following table:

Law	Define/Summarize
Law of Conservation of Mass	
Law of Definite Proportions	
Law of Multiple Proportions	

Dalton's Atomic Theory

4. Complete the following table by summarizing Dalton's atomic theory:

1.	
2.	
3.	
4.	
5.	

5. Explain where Dalton was incorrect with his atomic theory. *(page 65)*

3.2 – The Structure of the Atom *(pgs. 68-72)*

6. Define **atom**:

7. Draw a model showing the two regions of an atom in the space below. Label the nucleus and the electron region *(Note: read the top of pg. 68, then make your OWN drawing)*

Describe one conclusion made by each scientist that led to the development of the current atomic theory.

8. **Joseph John Thomson (J.J. Thomson)**
   - What experiment was performed?
   - What was found?
   - What was the plum pudding model? (bottom of pg. 69)

9. **Robert Millikan**
   - What experiment was performed?
   - What was found?

10. **Ernest Rutherford**
    - What experiment was performed?
    - What was found?

11. Define the following terms:

- **Proton –**
- **Neutron –**
- **Electron –**

12. **James Chadwick**
- Discovered the neutron in 1932

13. What is the nucleus of an atom and what subatomic particles does it contain?

14. What quantity determines an atom's identity?

15. What are **nuclear forces** and what is their role?

16. Define **atomic radius**:

17. From your reading and Figure 2.5 (below), compare the three subatomic particles in terms of location in the atom, mass, and relative charge.

Properties of Subatomic Particles

Particle	Symbols	Relative electric charge	Mass number	Relative mass (u*)	Actual mass (kg)
Electron	e^-, ${}^{0}_{-1}e$	−1	0	0.000 5486	9.109×10^{-31}
Proton	p^+, ${}^{1}_{1}H$	+1	1	1.007 276	1.673×10^{-27}
Neutron	n^o, ${}^{1}_{0}n$	0	1	1.008 665	1.675×10^{-27}

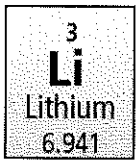
*1 u (unified atomic mass unit) = $1.660\,540 \times 10^{-27}$ kg

18. Since atoms are neutral, (total positive charge equals total negative charge) what can be said about the total number of protons and the total number of electrons in an atom?

3.3 – Counting Atoms *(pgs. 73-85)*

All atoms of an element must have the same number of protons, but not neutrons. If you change the number of protons you change the element.

19. Define **atomic number** (Z):



In the box to the right, the atomic number for Lithium is _____.

20. Define **Isotopes**:

In the boxes below draw the three isotopes of hydrogen. Show the protons, neutrons and area of electron cloud *(figure 3.2, pg. 74)*

Drawing			
Name			

21. Define **Mass Number**:

22. What are the two methods for describing isotopes?

a. Example:

b. Example:

23. Write the formula for finding the number of neutrons in an atom:

Answer the questions below about bromine-80. (Use Sample Problem A on pg. 75 to help you)

Mass number of bromine-80: _____ Atomic number of bromine: _____

Number of protons: _____ Number of electrons: _____

Number of neutrons = _____ – _____ = _____

Atomic mass is a relative measure

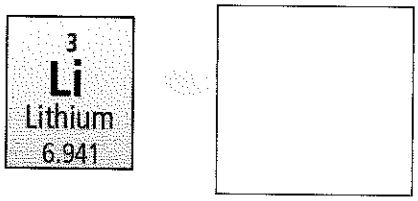
24. Define **unified atomic mass unit** (u):

25. Define **average atomic mass**:

Calculating Average Atomic Mass for Cu

26. Copper has two isotopes: Cu- 63 with an atomic mass of 62.92 u, and Cu-65 with an atomic mass of 64.92 u. Using the example on page 78, calculate the average atomic mass of Cu.

27. Using lithium as an example, create a periodic table box for Copper. Indicate the atomic number, chemical symbol, and the average atomic mass.



The Mole

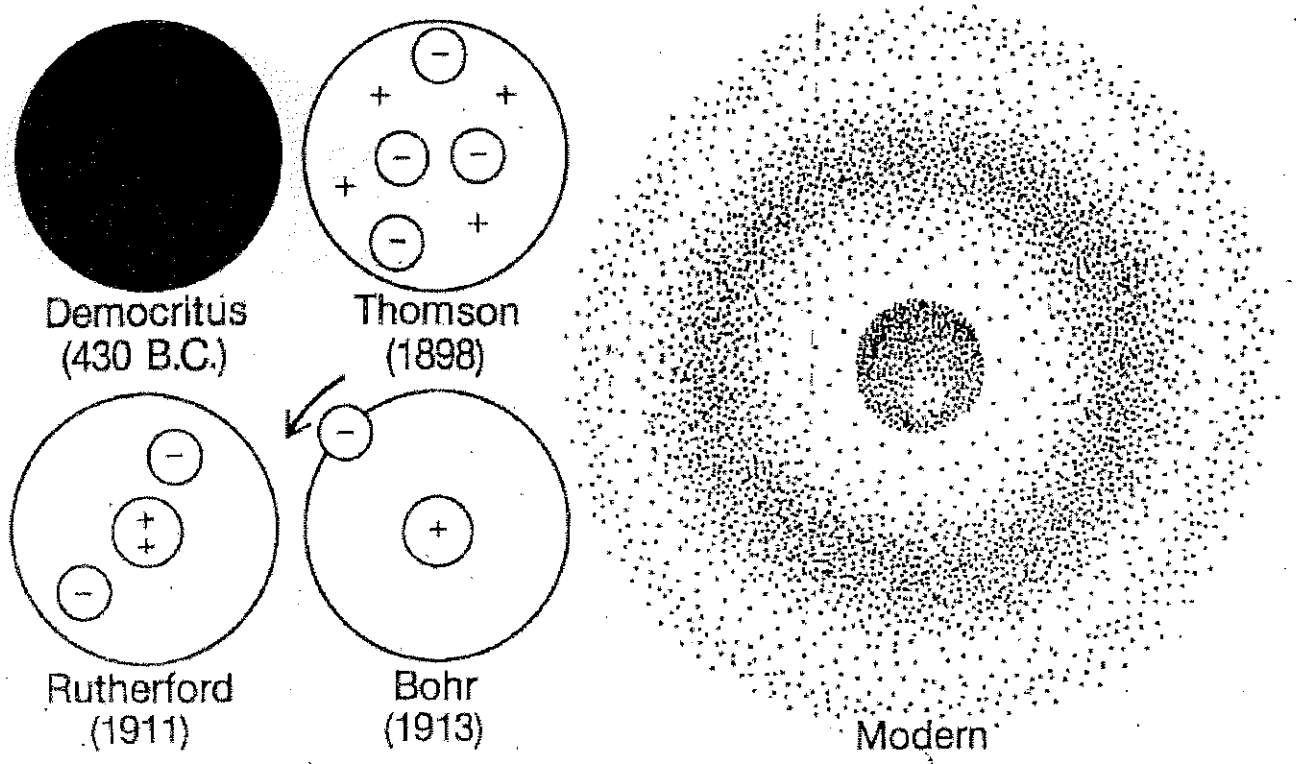
Define the following terms:

28. **Mole** -

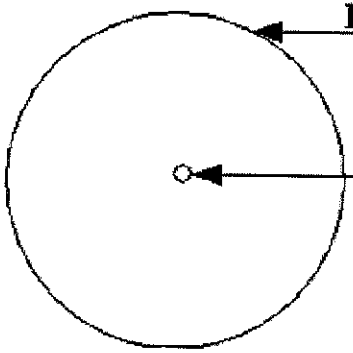
29. **Avogadro's number** -

30. **Molar Mass** -

The Developement of Atomic Theory



Atomic Structure



- Contains the electrons
- Makes up most of the volume of the atom
- Negatively charged (electrons are negative)
- Electrons are small and essentially have no mass, so the electron cloud is mostly empty space

- Contains the protons and neutrons
- Positively charged (positive protons, neutral neutrons)
- Small
- Contains all of the mass of the atom
- ***Extremely*** dense

	Where Found	*Charge*	*Mass Number*
Proton	Nucleus	+1	1
Neutron	Nucleus	0	1
Electron	Electron Cloud	-1	0

Definitions

- Atom: the smallest particle of an element that retains the properties of that element
- Atomic number: the number of protons in the nucleus of an atom
- Mass number: the total number of protons and neutrons in the nucleus of an atom
- Isotopes: Atoms of the same element that differ in mass number (differing numbers of neutrons)

Basic Electrostatics:

Opposite charges attract and identical charges repel

- Electrons and protons attract each other
- Protons repel other protons
- Electrons repel other electrons
- Neutrons are neutral and should neither repel nor attract any particles

Nuclear Forces:

Powerful short range forces in the nucleus that hold the nuclear particles (protons and neutrons) together. These forces overcome the electrostatic repulsion of protons.

Atomic Number and Mass Number WS

How are the *atomic number* and the *number of protons (*gives identity)* related to each other?

How do the *number of protons*, *number of neutrons*, and the *mass number* relate to each other?

When atoms of the same element have a different mass number, they are called _____.
In order for the mass to vary, the atom has the same number of _____ but a different number of _____.

Directions: Complete the following chart and answer the questions below.

Element Name	Atomic Number	Number of Protons	Number of Neutrons	Mass Number
Carbon				12
	8		8	
Hydrogen				1
		6		14
Hydrogen			2	
Nitrogen				14
			1	2
Cesium			82	
	11		12	
		47		108
Tungsten			110	
			45	80
		24		52
			89	152
Silver				107

Atomic Structure WS

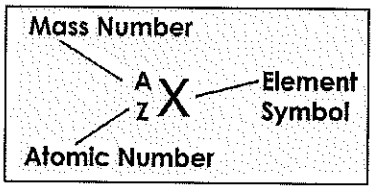
Directions: Use the periodic table of elements to help you fill in the blanks.

Element	Atomic Number	# of Protons	# of Neutrons	# of Electrons	Mass #
Copper		29	35		
Tin			69	50	
	53				127
Uranium				92	238
		19	20		
Lithium		3			7
	8		8		
Gold					197
		16			32
Silver	47				108
Chromium			28	24	
			32	27	59

Isotope Notation

Any given element can have more than one isotope. To distinguish between the different isotopes of an atom, the element is named with its mass number, for example, lithium-7. Remember that the **mass number** is the number of protons and neutrons added together. When symbols are used to represent an isotope, the mass number is written next to the symbol on the top left. The atomic number is written on the bottom left. Recall that the **atomic number** is the number of protons the element has and identifies an element.

EXAMPLES:



Lithium-7

$^{7}_{3}Li$ 3 protons 4 neutrons

Answer the following questions about atoms:

1) The identity of the atom is determined by the number of _____.
2) The particle(s) found inside the nucleus are: _____.
3) The number of protons and neutrons combinded is called the _____.
4) In large atoms, the number of protons is _____ than the number of neutrons.
5) The number of protons is also called the _____.
6) Isotopes have the same number of _____, but different numbers of _____.
7) The number of protons found in a sulfur atom is _____.
8) The number of neutrons found in an aluminum-27 atom is _____.
9) The number of electrons found in a zinc atom is _____.
10) The name of the element with 82 protons is _____.

Give the symbols (like the examples shown above) for the nuclides described by the following particles. Be sure to include the atomic number and the mass number.

11) 92 protons, 145 neutrons ----------
12) 8 protons, 10 neutrons ----------
13) 82 protons, 125 neutrons ----------
14) 80 protons, 119 neutrons ----------
15) 20 protons, 20 neutrons ----------
16) 22 protons, 23 neutrons ----------
17) 18 protons, 22 neutrons ----------
18) 25 protons, 32 neutrons ----------

Determine the number of protons and neutrons in the follwing atoms.

19) $^{10}_{5}B$ # protons: _____ # neutrons: _____

20) $^{15}_{7}N$ # protons: _____ # neutrons: _____

21) $^{79}_{34}Se$ # protons: _____ # neutrons: _____

22) $^{119}_{50}Sn$ # protons: _____ # neutrons: _____

23) $^{165}_{66}Dy$ # protons: _____ # neutrons: _____

24) ^{56}Fe # protons: _____ # neutrons: _____

25) ^{151}Sm # protons: _____ # neutrons: _____

26) ^{195}Pt # protons: _____ # neutrons: _____

27) ^{126}Te # protons: _____ # neutrons: _____

28) ^{35}Cl # protons: _____ # neutrons: _____

29) ^{107}Ag # protons: _____ # neutrons: _____

30) $^{93}_{41}?$ # protons: _____ # neutrons: _____ identity: _____

Atomic Number, Mass Number, & Isotopes

Directions: Complete the following information for each isotope.

$^{4}_{2}He$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

$^{56}_{26}Fe$

element: _____

atomic #: _____

#protons: _____

neutrons: _____

electrons: _____

$^{27}_{13}Al$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

$^{40}_{20}Ca$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

$^{20}_{10}Ne$

element: _____

atomic #: _____

#protons: _____

neutrons: _____

electrons: _____

$^{14}_{6}C$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

$^{19}_{9}F$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

$^{1}_{1}H$

element: _____

atomic #: _____

#protons: _____

neutrons: _____

electrons: _____

$^{2}_{1}H$

element: _____

atomic #: _____

protons: _____

neutrons: _____

electrons: _____

Isotope Calculation Notes:

Weighted Average Example:

1) On the first day of school, Maggie's Geometry teacher told the class that all grades would be calculated by the weighted average system seen below:

   Participation: 15% Homework: 20% Quizzes: 25% Tests: 40%

   At the end of the first marking period, Maggie is not sure if she is passing the class. She needs to know what her overall weighted average is. Below are Maggie's average grades for each component of the class. Let's help her calculate her MP1 grade!

Maggie's MP1 Averages	
Participation	70
Homework	74
Quizzes	72
Tests	66

Formula:

Avg. atomic mass =

[(rel. abundance isotope A) x (mass isotope A)]

+ [(rel. abundance isotope B) x (mass isotope B)]

+ [(rel. abundance isotope C) x (mass isotope C)]

...etc

Relative Abundance = $\frac{\%\ \text{abundance}}{100}$

Average Atomic Mass Calculations (application of a weighted average)

2) Magnesium has three naturally occurring isotopes: 78.70% of Mg exists as Magnesium-24 (23.985 amu)l 10.03% exist as Magnesium-25 (24.986 amu), and 11.17% exist as Magnesium-26 (25.983 amu). What is the average atomic mass of Magnesium?

Practice Problems:
Isotopes, Percent Abundance, and Atomic Mass

For most elements, samples found in nature are a mixture of two or more isotopes of the element. The percentage by mass of each isotope in the mixture does not change from sample to sample. The atomic masses of the elements listed on the periodic table do not show the atomic mass of any one particular isotope of an element. Rather, the periodic table shows an average mass of all the naturally occurring isotopes of an element. The average is weighted to take into account the abundance (frequency) of each isotope in nature.

1. The synthetic radioactive element technetium is used in many medical studies. Give the number of electrons, protons, and neutrons in an atom of technetium-99.

2. Cobalt has three radioactive isotopes used in medical studies. Atoms of these isotopes have 30, 31, and 33 neutrons respectively. Give the *nuclear* symbol for each of these three isotopes.

3. Silicon has three isotopes with 14, 15, and 16 neutrons respectively. Give the *hyphenated* symbols of these three isotopes.

4. A sample of chlorine consists of 75.4% chlorine-35 (isotopic mass 35.0 amu) and 24.6% chlorine-37 (isotopic mass = 37.0 amu). What is the average atomic mass of chlorine?

5. Use the table below to calculate the average atomic mass if the elements copper and magnesium. As shown in the table, naturally occurring copper is a mixture of two isotopes, while naturally occurring magnesium is a mixture of three isotopes. After you have determined the atomic mass of each element, compare your results with the atomic masses listed for these elements on the periodic table.

Element	Isotopes in a Naturally Occurring Mixture	% Abundance of each Isotope	Mass of each Isotope (amu)	"Weighted Average" for each Isotope	Average Atomic Mass (amu)
Copper	$^{63}_{29}Cu$	69.09%	62.9298	_____ + _____	= _____
	$^{65}_{29}Cu$	30.91%	64.9278		

Element	Isotopes in a Naturally Occurring Mixture	% Abundance of each Isotope	Mass of each Isotope (amu)	"Weighted Average" for each Isotope	Average Atomic Mass (amu)
Magnesium	$^{24}_{12}Mg$	78.70%	23.9850	_____ + _____ + _____	= _____
	$^{25}_{12}Mg$	10.13%	24.9858		
	$^{26}_{12}Mg$	11.17%	25.9826		

Isotopes

Directions: Give the number of protons, neutrons, and electrons for each of the following elements. (*Note*: You will need to round atomic masses to the nearest whole #.)

	Element	# Protons	# Neutrons	# Electrons
1.	Hydrogen			
2.	Oxygen			
3.	Vanadium			
4.	Uranium			
5.	Argon			

Directions: Calculate the weighted average atomic mass of each element from its isotopes. Assume that each isotopic mass is the whole number which is given.

6. **Sulfur:** ^{32}S = 95.0%; ^{33}S = 0.76%; ^{34}S = 4.22%; ^{36}S = 0.014%

7. **Magnesium:** ^{24}Mg = 78.7%; ^{25}Mg = 10.13%; ^{26}Mg = 11.17%

8. **Nickel:** ^{58}Ni = 68.274%; ^{60}Ni = 26.095%; ^{61}Ni = 1.134%; ^{62}Ni = 3.593%; ^{64}Ni = 0.904%

Isotopes: Average Atomic Mass Calculations

Directions: Calculate the average atomic masses. Round all answers to <u>two decimal places</u>.

1. Rubidium has two common isotopes, ^{85}Rb and ^{87}Rb. If the abundance of ^{85}Rb is 72.2% and the abundance of ^{87}Rb is 27.8%, what is the average atomic mass of rubidium?

2. Uranium has three common isotopes. If the abundance of ^{234}U is 0.01%, the abundance of ^{235}U is 0.71%, and the abundance of ^{238}U is 99.28%, what is the average atomic mass of uranium?

3. Titanium has five common isotopes: ^{46}Ti (8.0%), ^{47}Ti (7.8%), ^{48}Ti (73.4%), ^{49}Ti (5.5%), ^{50}Ti (5.3%). What is the average atomic mass of titanium?

4. Explain why atoms can have different isotopes. In other words, how is it that helium can exist in three different forms and still be the same element?

Molar Mass Worksheet

Directions: Find the molar masses of the following elements. Round your answers to TWO decimal places and be sure to include the proper units!!!

1) Chlorine: _____

2) Potassium: _____

3) Beryllium: _____

4) Iron: _____

5) Boron: _____

6) Carbon: _____

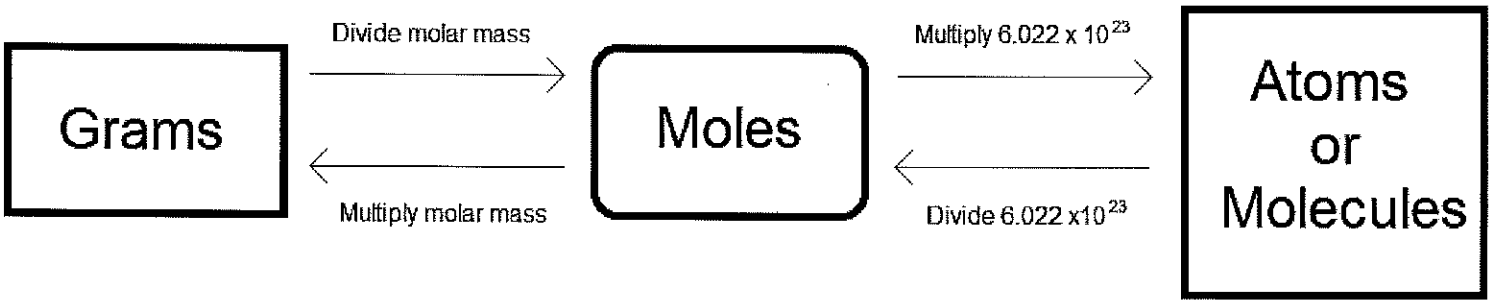
7) Magnesium: _____

8) Uranium: _____

9) Sulfur: _____

10) Hydrogen: _____

Examples: Molar Mass and Conversions



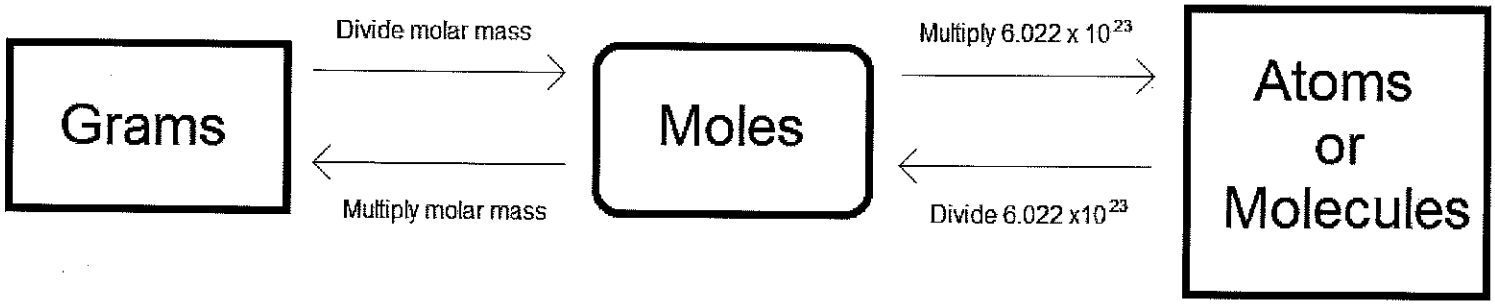
Example Calculations (with dimensional analysis):

1. **Grams → Moles**
   Find the number of moles in 92.2 g iron.

2. **Moles → Grams**
   Calculate the mass, in grams, of 0.250 moles of sodium.

3. **Moles → Atoms**
   Calculate the number of atoms in 3.2 moles of carbon.

Examples: Molar Mass and Conversions



Directions: Complete the following calculations (with dimensional analysis) using the examples on the previous page as your guide:

4. **Atoms → Moles**
   Find the number of moles in 1.25×10^{23} atoms of magnesium.

5. **Grams → Atoms**
   Calculate the number of atoms in 60.0 g of neon.

6. **Atoms → Grams**
   Calculate the mass, in grams, of 3.24×10^{22} atoms of aluminum.

Moles, Atoms, and Grams WS

Directions: Complete the following calculations (with dimensional analysis).

1. How many moles are there in 450 grams of Na?

2. How many moles are there in 7.5×10^{23} atoms of S?

3. How many grams are there in 1.3 moles of Cu?

4. How many moles are there in 2.3×10^{12} atoms of P?

2 Step Conversions: Moles, Atoms, and Grams

Directions: Complete the following calculations (with dimensional analysis).
Note: All conversions must go through the mole – it is the only way to connect atoms and grams!

1. How many atoms are there in 24 grams of K?

2. How many grams are there in 2.3×10^{24} atoms of silver?

3. How many grams are there in 7.4×10^{23} atoms of Li?

4. How many atoms are there in 48 grams of boron?

Atoms: The Building Blocks of Matter

MIXED REVIEW

SHORT ANSWER: Answer the following questions in the space provided.

1. The element boron, B, has an atomic mass of 10.81u according to the periodic table. However, no single atom of boron has a mass of exactly 10.81u. How can you explain this difference?

2. How did the outcome of Rutherford's gold-foil experiment indicate the existence of a nucleus?

3. Ibuprofen, $C_{13}H_{18}O_2$, that is manufactured in Michigan contains 75.69% by mass carbon, 8.80% hydrogen, and 15.51% oxygen. If you buy some ibuprofen for a headache while you are on vacation in Germany, how do you know that it has the same percentage composition as the ibuprofen you buy at home?

4.Complete the following table:

Element	Symbol	Atomic #	Mass #	# of protons	# of neutrons	# of electrons
Sodium			22			
	F	9	19			
			80		45	
			40	20		
		1			0	
			222			86

PROBLEMS: Write the answer on the line to the left. Show all your work in the space provided.

5. _____ a. How many moles are there in 1.51×10^{24} atoms of lithium?

_____ b. How many atoms are there in 595.5 g of uranium?

_____ c. How many moles are present in 107 g of sodium?

6. A certain element exists as three natural isotopes, as shown in the table below.

Isotope	Mass (amu)	Percent natural abundance	Mass number
A	19.99244	90.51	20
B	20.99395	0.27	21
C	21.99138	9.22	22

Calculate the average atomic mass of this element. Which element on the periodic table is this?