CP/Honors Chemistry

Unit 3: Atomic Theory — Sections 4.1, 4.2, 4.3

Subatomic Particles

WARM-UP QUIZ

Students filled in the answers to these questions for homework assigned on Thursday, 09/06, and checked in class on Friday, 09/07.

1. What are the three subatomic particles? *1. protons, neutrons, electrons*
2. Where are the particles located in the atom? *2. p^+ and n^0 in nucleus, e^- in empty space surrounding nucleus*
3. What are the charges of the particles? *3. protons - positive; neutrons - neutral; electrons - negative*
4. What does amu stand for? *4. atomic mass unit*
5. What is the mass (in amu) of each particle? *5. p^+ - 1 amu; n^0 - 1 amu; e^- - 1/1840 amu*
6. Which of the subatomic particles is the lightest? *6. electron*
7. What is the charge of the nucleus? *7. positive*
8. Where is virtually all of the mass of the atom located? *8. in the nucleus*
9. What effect do protons have on each other? *9. like charges repel*
10. What effect do electrons have on each other? *10. like charges repel*
11. What keeps the electrons in the atom? *11. the electrostatic attraction between particles of opposite charges*
12. What is the symbol for each particle? *12. proton - p^+; neutron - n^0; electron -e*
13. What is the charge of an atom? *13. neutral*
14. What does the charge of an atom tell us about the number of protons and electrons?
    14. the number of electrons must equal the number of protons
15. How is the nucleus of a hydrogen atom different from the nuclei of other elements?
    15. the most common form (isotope) of hydrogen does not have neutrons

♦♦

Writing Activity #1 — **Due Date:** *Monday, 09/09/2012*

- ✓ Create a table indicating the symbol, location, charge, and relative mass (in amu) of the three subatomic particles. Label the table *Document A*.
- ✓ In a well-developed writing, compare and contrast the three subatomic particles. Use the table that you created as a supporting document and refer to it in your writing.

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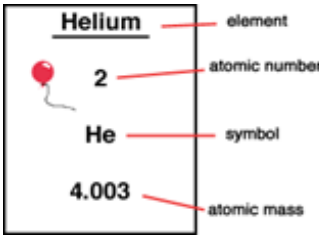
Atomic Structure

- Atoms make up *elements*, which are *pure substances that cannot be broken down into simpler substances*.
- Discovery of *118* elements have been reported.
- These elements are organized in the modern *periodic table*.
- The *atoms* in an element are *similar* to each other and *different* from those of all other elements.

Atomic Number

- The Periodic Table (PT) provides information about each element and organizes the elements in order of *increasing atomic number*.
- The atomic number appears *below the element name* on the periodic table.
  - Equal to *the number of protons, which is equal to the number of electrons*
  - Protons are responsible for the *identity* of the element. Electrons are responsible for the chemical *properties* and *behavior* of atoms.
  - Since atoms are neutral,

    atomic number = number of *protons* = number of *electrons*
- In the PT, the *element symbol* is given underneath its name and atomic number, followed by its *atomic mass*.



☑ Concept Check

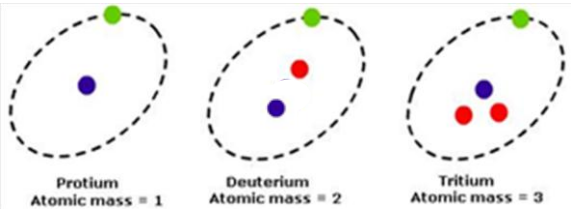
Students filled in the answers to the next ten questions using the periodic table and the previous notes.

Assume all atoms are neutral, unless otherwise stated.

1. What determines the identity of an atom? *protons*
2. What is the atomic number of aluminum? *13*
3. How many protons are in one atom of aluminum? *13*
4. How many electrons are in one atom of aluminum? *13*
5. What is the symbol for fluorine? *F* What is its atomic number? *9*
6. What is the symbol for sulfur? *S* How many protons does sulfur have? *16*
7. What is the symbol for sodium? *Na* How many electrons does sodium have? *11*
8. What is the element with atomic number 7? *nitrogen* What is its symbol? *N* How many protons and electrons does this element have? *7*
9. What is the name of the 30th element? *zinc* How many protons and electrons does this element have? *30* What is the charge of an atom of #30? *neutral, no charge*
10. What element is symbolized by K? *potassium* What is its atomic number? *19*

Isotopes

The *number of neutrons* in an atom of a particular element is not always the same.



- Definition: *isotopes are atoms of the same element, meaning they have the same number of protons, that have a different number of neutrons.*

  Same *identity*; different *masses*

  Same number of *protons* and *electrons*; different number of *neutrons*

- Neutrons are *responsible for the isotopes (or different forms) of an atom.*
- Isotopes can be identified by writing the *mass number* after the element name or symbol.

  Examples: *Hydrogen-1 or H-1, Hydrogen-2 or H-2, Hydrogen-3 or H-3*

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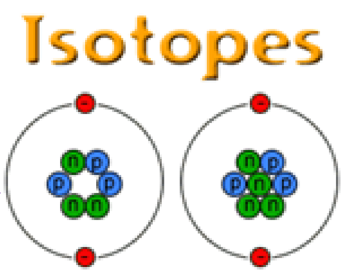
☑ Concept Check



Lithium-6 *Lithium-7*

- What element is shown in the diagram to the right? *lithium*
- How many protons and electrons are in each isotope? *<u>Note</u>: Not all electrons are shown.* *3 protons, 3 electrons*
- What determines the identity of the element? *p^+* Its behavior? *e^-*
- How many neutrons are present in each isotope? *3 in the 1st, 4 in the 2nd*
- What is the mass in amu for each isotope? *1st: 6 amu; 2nd: 7 amu*
- Write the name for each isotope under its diagram.

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Mass Number, Atomic Mass, and Average Atomic Mass

① The mass of an atom is made up of *the protons and neutrons in the nucleus*; the mass of *the electron is insignificant.*

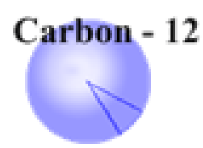
② Therefore,

  mass number = *# of protons + # of neutrons*

  Mass number is always a *whole* number and can be used with *atomic number* to calculate the number of *neutrons.*

  # of neutrons = *mass number - # of protons [AKA atomic number]*

③ Mass number does not indicate the *actual mass* of an atom. The mass of atoms measured in *grams* is extremely small.



④ More useful to work with *relative* atomic mass: *mass of atom expressed in atomic mass units (amu); mass of one atom in relationship to mass of another (C-12)*

  1 amu = *1/12 the mass of one atom of carbon-12* *(nearly equal to mass of proton or neutron)*

④ The average atomic mass is the *weighted average mass of the naturally occurring isotopes of an element.* Isotopes existing in greater *abundance* have a greater *effect in determining the average atomic mass.*

⑤ Due to weighted nature, atomic masses are *not whole numbers but decimals.* The average atomic mass appears *below* the element symbol on the Periodic Table.

⑥ Rounding the average atomic mass to the *nearest whole number* gives the *mass number* for the *most abundant* isotope of the element.

⑦ The average atomic mass can be calculated when given *atomic mass* and *percent abundance* of an element's naturally occurring isotopes.

Average Atomic Mass = *(mass of isotope$_1$)(% abundance as decimal)*
+ (mass of isotope2)(% abundance as decimal)
+ (mass of isotope$_3$)(% abundance as decimal)
etc.

Example: Find the weighted average mass of a football team if 92.0% of the players weigh 200. lbs. and 8.00% weigh 180. lbs.

Average mass = (*200. lbs*)(*.920*) + (*180. lbs*)(*.0800*)

Average mass = *184 lbs + 14.4 lbs = 198.4 lbs =* ***198 lbs*** *(to 3SF)*

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Practice. Calculate the average atomic mass for the two naturally occurring isotopes of copper: copper-63 and copper-65. The percent abundance for copper-63 is 69.2%, and its atomic mass is 62.9 amu. The percent abundance of copper-65 is 30.8%, and its atomic mass is 64.9 amu.

Avg mass = (62.9 amu)(0.692) + (64.9 amu)(0.308)

Avg mass = 63.516 amu

Avg mass = ***63.5 amu***

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Isotope Names

- All carbon atoms contain *6* protons because *carbon is atomic number 6*.
  - ¤ One isotope of carbon contains eight neutrons, giving it a mass number of *14* (*# protons* + *# neutrons*). The isotope name for this isotope of carbon is written as *Carbon-14* or *C-14*.
  - ¤ The carbon isotope containing seven neutrons is *Carbon-13* or *C-13*.

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☑ Concept Check

1. What is the isotope name for potassium with 21 neutrons? *Potassium-40*
2. What is the isotope name for oxygen with 9 neutrons? *Oxygen-17*
3. What does nitrogen-13 (or N-13) mean? *Nitrogen-13 or N-13 refers to the isotope of nitrogen with 6 neutrons in its nucleus.*

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Isotopic Notation

- Isotopic notation or isotope symbol: uses the element *symbol*, *atomic number*, and *mass number*.

$^{\text{mass number}}_{\text{atomic number}}\mathbf{X}$ $^{14}_{6}\mathbf{C}$ **[Carbon-14]**

Practice

1. For the carbon isotope above, find the
    a. Atomic number: *6*
    b. Number of protons: *6*
    c. Number of electrons: *6*
    d. Number of neutrons: *8*
2. Write the isotopic notation for neon-22. $^{22}_{10}Ne$
3. Write the isotope symbol for calcium with 26 neutrons. $^{46}_{20}Ca$
4. Write the name of the isotope having 8 protons and 9 neutrons. *oxygen-17 or O-17*
   Write its isotopic notation. $^{17}_{8}O$

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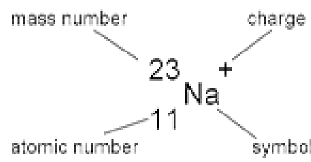
Charged Particles: Ions

- The nucleus of an atom has a *positive* charge. Why? *nucleus only contains positively charged protons and neutral neutrons*
- Electrons are *negatively* charged. Why is the atom electrically neutral? *Atoms have equal numbers of positively-charged protons and negatively-charged electrons.*
- Definition of *ion*: *charged atom, resulting from the loss or gain of electrons*
- Definition of *anion*: *negatively-charged ion due to gain of electrons (nonmetals)*

  Example: F Atomic # *9* = # of e^- F^- *gained* one electron
- Definition of *cation*: *positively-charged ion due to loss of electrons (metals)*

  Example: Mg Atomic # *12* = # of e^- Mg^{2+} *lost* two electrons
- Isotopic notations for ions show the *charge* in addition to the symbol, *atomic* number and *mass* number.



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Practice *Students completed the following practice during class.*

	# p^+	# e^-	# n^0	*Resembles (# e⁻)*
1. Mg^{2+}	*12*	*10*	*12*	*Neon*
2. Al^{3+}	*13*	*10*	*14*	*Neon*
3. N^{3-}	*7*	*10*	*7*	*Neon*
4. O^{2-}	*8*	*10*	*8*	*Neon*
5. F^-	*9*	*10*	*10*	*Neon*
6. P^{3-}	*15*	*18*	*16*	*Argon*
7. K^+	*19*	*18*	*20*	*Argon*
8. Cl^-	*17*	*18*	*19*	*Argon*

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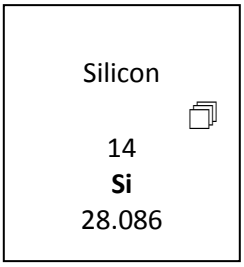
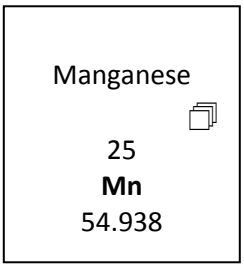
Identifying Characteristics of Atoms

Using the square for silicon from the Periodic Table, identify the following:



1. Element Symbol — 1. Si
2. Atomic Number — 2. 14
3. Number of Protons — 3. 14
4. Number of Electrons — 4. 14
5. (Average) Atomic Mass — 5. 28.086
6. Mass Number (round atomic mass to the nearest whole number) — 6. 28
7. Number of Neutrons — 7. 14
8. Write the isotopic notation for the most common isotope of silicon. — 8. $^{28}_{14}Si$

Using the square for manganese from the Periodic Table, identify the following:



1. Element Symbol — 1. Mn
2. Atomic Number — 2. 25
3. Number of Protons — 3. 25
4. Number of Electrons — 4. 25
5. (Average) Atomic Mass — 5. 54.938
6. Mass Number (round atomic mass to the nearest whole number) — 6. 55
7. Number of Neutrons — 7. 30
8. Write the isotopic notation for the most common isotope of manganese. — 8. $^{55}_{25}Mn$

Calculating Average Atomic Mass

Using the isotope data in the table below, calculate the average atomic mass and determine the identity of the element.

Mass (amu)	Percent Abundance
49.946	4.3%
51.941	83.8%
52.941	9.5%
53.939	2.4%

Avg atomic mass = (49.946 amu)(0.043)
+ (51.941 amu)(0.838)
+ (52.941 amu)(0.095)
+ (53.939 amu)(0.024)

Avg atomic mass = 51.998167 amu = **52.998 amu**

The element is most likely chromium.

Practice

What is the atomic number for thallium? 81 — What is the element symbol? Tl

How many protons are in an atom of radium? 88 — How many electrons? 88

How many protons are in an atom of cerium? 58 — How many neutrons? 82

Explain (using complete sentences) how to determine the number of neutrons an atom contains if its mass number and atomic number are known.
The mass number indicates the sum of the number of protons and neutrons in an atom. If atomic number, or number of protons, is known as well as the mass number, subtracting the atomic number from the mass number will give the number of neutrons.

What is the mass number of potassium-39? __39__ How many neutrons are in P-39? __24__

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☑ Concept Check

1. Lithium, which has an atomic mass of 6.9408 amu, has two naturally occurring isotopes, Li-6 and Li-7. Which isotope occurs in greater abundance? *Li-7*
2. Chlorine has two naturally occurring isotopes, Cl-35 and Cl-37. The average atomic mass of chlorine is 35.453 amu. Which isotope occurs in greater abundance? *Cl-35*
3. How do you determine which isotope is in greater abundance (*when not given percent abundance*)? *When percent abundance is not given, rounding the average atomic mass from the periodic table to the nearest whole number gives the mass number of the most abundant isotope.*

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Writing Activity #2

Due Date: *Friday, 09/27/2012*

✓ Your assigned element: *Different elements assigned to students in class*

✓ In a well-developed writing piece, explain the terms atomic number, atomic mass, and mass number. Use your assigned element as a specific example to support your explanation. Be sure to include the number many protons, neutrons, and electrons an atom of your assigned element would have.

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Writing Activity #3

Due Date: ____________________

✓ Compare the following isotopes:

$^{12}_{6}C$		$^{13}_{6}C$		$^{14}_{6}C$	
Atomic #	6	Atomic #	6	Atomic #	6
Mass #	12	Mass #	13	Mass #	14
# Protons	6	# Protons	6	# Protons	6
# Neutrons	6	# Neutrons	7	# Neutrons	8
# Electrons	6	# Electrons	6	# Electrons	6

✓ In a well-developed paragraph, thoroughly explain how these isotopes are similar and how they are different. Use specific details from the carbon examples to support your explanation.

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ESSENTIAL VOCABULARY

ANION	ATOMIC NUMBER	ION	NEUTRON
ATOM	CATION	ISOTOPES	NUCLEUS
ATOMIC MASS	ELECTRON	MASS NUMBER	PROTON
ATOMIC MASS UNIT			

ESSENTIAL VOCABULARY

ATOMIC ORBITAL	ENERGY SUBLEVELS	PHOTON
ATOMIC EMISSION SPECTRUM	EXCITED STATE	PRINCIPAL ENERGY LEVEL
AUFBAU PRINCIPLE	GROUND STATE	PRINCIPAL QUANTUM NUMBER
ELECTRON CONFIGURATION	HUND'S RULE	QUANTUM
ELECTRON DOT STRUCTURE (LEWIS DOT DIAGRAM)	PAULI EXCLUSION PRINCIPLE	QUANTUM MECHANICAL MODEL
		VALENCE ELECTRONS

ESSENTIAL VOCABULARY

ALPHA PARTICLE	NUCLEAR FUSION	RADIOACTIVITY
ALPHA RADIATION	NUCLEAR REACTION	RADIOCHEMICAL DATING
BETA PARTICLE	NUCLEONS	RADIOISOTOPES
BETA RADIATION	PENETRATING POWER	STRONG NUCLEAR FORCE
GAMMA RAY	RADIATION	TRANSMUTATION
NUCLEAR EQUATION	RADIOACTIVE DECAY	TRANSURANIUM ELEMENTS
NUCLEAR FISSION		
NUCLEAR FUSION		