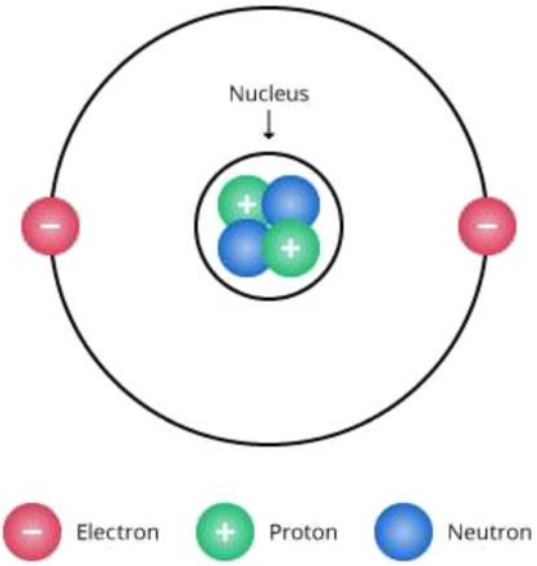
(KEY) Book 2 - Atomic Theory & Bonding

April 27, 2021 9:40 AM

science 10

unit 1: chemistry



book 2: atomic structure & bonding

name: Key block: _____

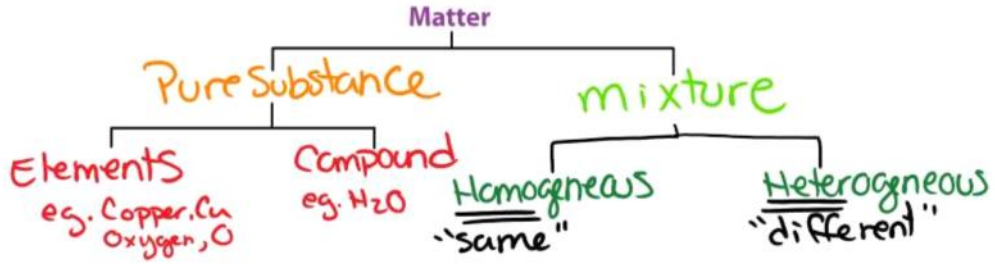
1

Review: The Classification of Matter

can measure (does NOT have mass + volume)

We currently classify everything in the physical world as either a form of Energy or a form of matter. (mass + volume)

Any solid, liquid, or gas is a form of matter. Matter can be further classified as shown:



Material	Definition	Examples
pure substance	• all the sample has the same properties	• water (H_2O) • sugar ($C_6H_{12}O_6$) • any element (eg. N, Cu, etc)
mixture	made up of 2+ substances	• salt water • air • cereal / trail mix / sand
atom	the smallest possible unit / form of an element	silver - all Ag atoms; oxygen gas - all O atoms
Molecule	cluster of 2+ atoms held together by bonds	water - H_2O; hydrogen gas - H_2 } generally covalent (all non-metals)
Ion	an atom or molecule with ⊕ or ⊖ charge	Na^+, Cl^-, NO_3^-
element	a substance that cannot be separated into simpler substances	eg. H_2
Compound	• made of 2+ atoms • different atoms	• salt: NaCl (ionic - metal + non-metal) • sugar: $C_6H_{12}O_6$ (covalent)
Particle	general term for a "piece of matter"	any of the above

The particles that make up materials are also forms of matter.

Chemists refer to all the particles of matter collectively as chemical species

Just as materials are classified, so are chemical species.

Chemical species can be classified as neutral atoms, molecules, or ions (+/-)

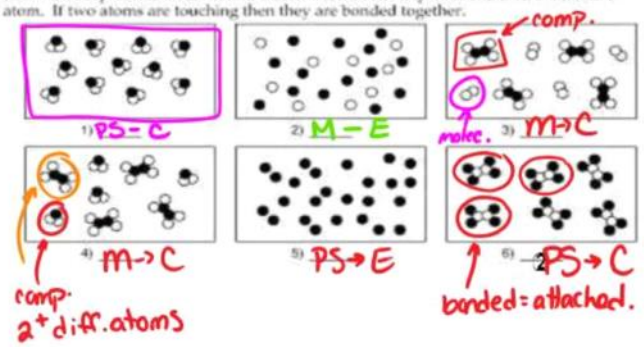
Atoms are composed of particles that can be classified as well.

Pure Substances

Classify each of the pictures below by placing the correct label in the blanks below:

E=Element C=Compound M=Mixture

Each circle represents an atom and each different color represents a different kind of atom. If two atoms are touching then they are bonded together.



Halogens (Group 17)

Noble gases (Group 18)

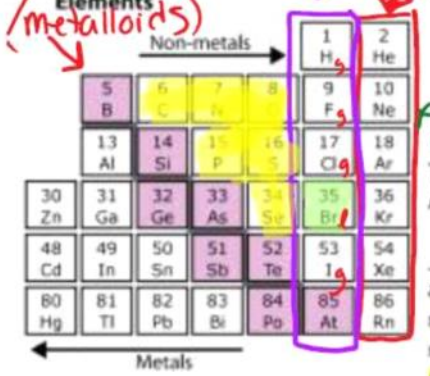
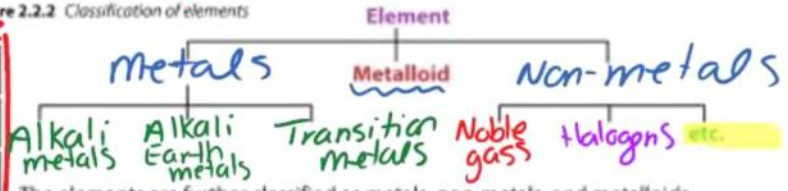


Figure 2.2.2 *Classification of elements*



The elements are further classified as metals, non-metals, and metalloids. About 80% of the elements are metals.

Hydrogen has properties that are in-between those of the metals and the non-metals. Although it has some chemical properties of metals, it has more in common with non-metals and is classified as a non-metal for most purposes.

Hydrogen is such a unique element that it is usually considered to be in a group of its own.

Metals are good conductors of both heat and electricity. They are also malleable *(can be pounded into thin sheets)*, ductile (can be drawn into wires), and lustrous. Alloy, mixtures containing metals, which are hard.

Non-metals are poor conductors of both heat and electricity. Many are gases at room temperature but in the solid phase their crystals are brittle and shatter easily.

↳ except for Br = Bromine which is liquid.

Moving up and to the RIGHT in the periodic table, there is a general trend toward Less metallic character from one element to the next. As a result, there is ***no sharp divide between the metals and non-metals.***

Instead, there is a group of elements called Metalloids that exhibit some metallic properties (although weakly) and some non-metallic properties. For example, Si is a semiconductor meaning that it conducts electricity but poorly.

↳ silicon (lustrous, soft)

Compounds

A compound of matter is a pure substance composed of **more than one** type of atom.

A compound can be decompounded (we say decomposed). "break apart"

$2NaCl \rightarrow 2Na + Cl_2$

$K_2CO_3 \rightarrow K_2O + CO_2$

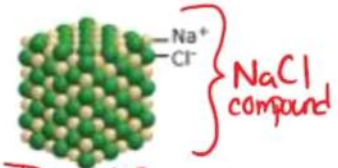
$2H_2O \rightarrow 2H_2 + O_2$

Decomposition is a type of chemical reaction in which a single compound reacts to produce 2 or more new substances.

They reassemble into two or more new groupings or patterns of the atoms.

Compounds are classified in several ways.

An Ion (⊕ ⊖) is a charged atom or group of atoms. Because ions are more stable than their corresponding neutral atoms, the atoms of many elements exist almost exclusively in nature as ions. Ionic compounds consist of positively and negatively charged ions held together by their opposite electrical charges into long range, symmetrical packing arrangements called ionic crystal lattices (Figure 2.2.4). The bond or attraction between oppositely charged ions is appropriately called an Ionic bond.



Ionic

Figure 2.2.4 *An ionic crystal lattice*

- strong bonds

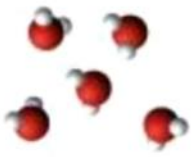


Figure 2.2.5 *A molecular compound*

Non-metal atoms can also become more stable by sharing valence (outer) electrons with each other, called a covalent **bond**.

A neutral group of covalently bonded atoms is called a molecule and compounds consisting of molecules are called **molecular compounds**.

Summary:

Any compound containing a metal is an ionic compound. (bonded to a non-metal)

Any compound containing only non-metals is a covalent except compounds containing the ammonium ion (NH_4^+) which are ionic.

List in Data Book

Polyatomic ion (NH_4^+, NO_3^-)

O has a charge, made of many atoms

"ion" "polyatomic"

PRACTICE

Sample Problem — Classifying a Compound as Ionic or Molecular

State whether each of the following is an ionic compound or a molecular compound:

(a) NaCl IC (b) $Cu(NO_3)_2$ IC (c) P_2O_5 CC

(IC) covalent (CC) ionic - metal + non-metal

covalent - all non-metals.

What to Think about	How to Do It
If the compound contains a metal or the ammonium ion then it is ionic, otherwise it is molecular.	
(a) Na is a metal	(a) NaCl is an ionic compound.
(b) Cu is a metal	(b) $Cu(NO_3)_2$ is an ionic compound.
(c) P and O are both non-metals	(c) P_2O_5 is a molecular compound.

Practice Problems — Classifying a Compound as Ionic or Molecular

1. State whether each of the following is an ionic compound or a molecular compound:

IC

(a) CO_2 covalent CC

(b) CaF_2 ionic

(c) C_3H_8 covalent

(d) $Mg_3(PO_4)_2$ ionic

(e) $Li_2Cr_2O_7$ ($Cr_2O_7^{-2}$) ionic

(f) NH_4Cl ionic

PART A - Atomic Structure, Isotopes & Atomic Mass

Each element is made up of very tiny particles called ATOMS, and each element is made up of just one particular type of atom, which is different to the atoms in any other element.

J.J Thomson discovered electrons and proposed the existence of a (+) particle. (proton)

It wasn't until **Rutherford's famous gold foil experiment** that the + proton was discovered, and atoms were thought to me mostly empty space. He named the *centre of atoms* the nucleus

Bohr improved on this model proposing that electrons move around the nucleus in specific layers called (electron) shells

It was James **Chadwick** who discovered particles with **no charge**, which he named neutrons

How many electrons?

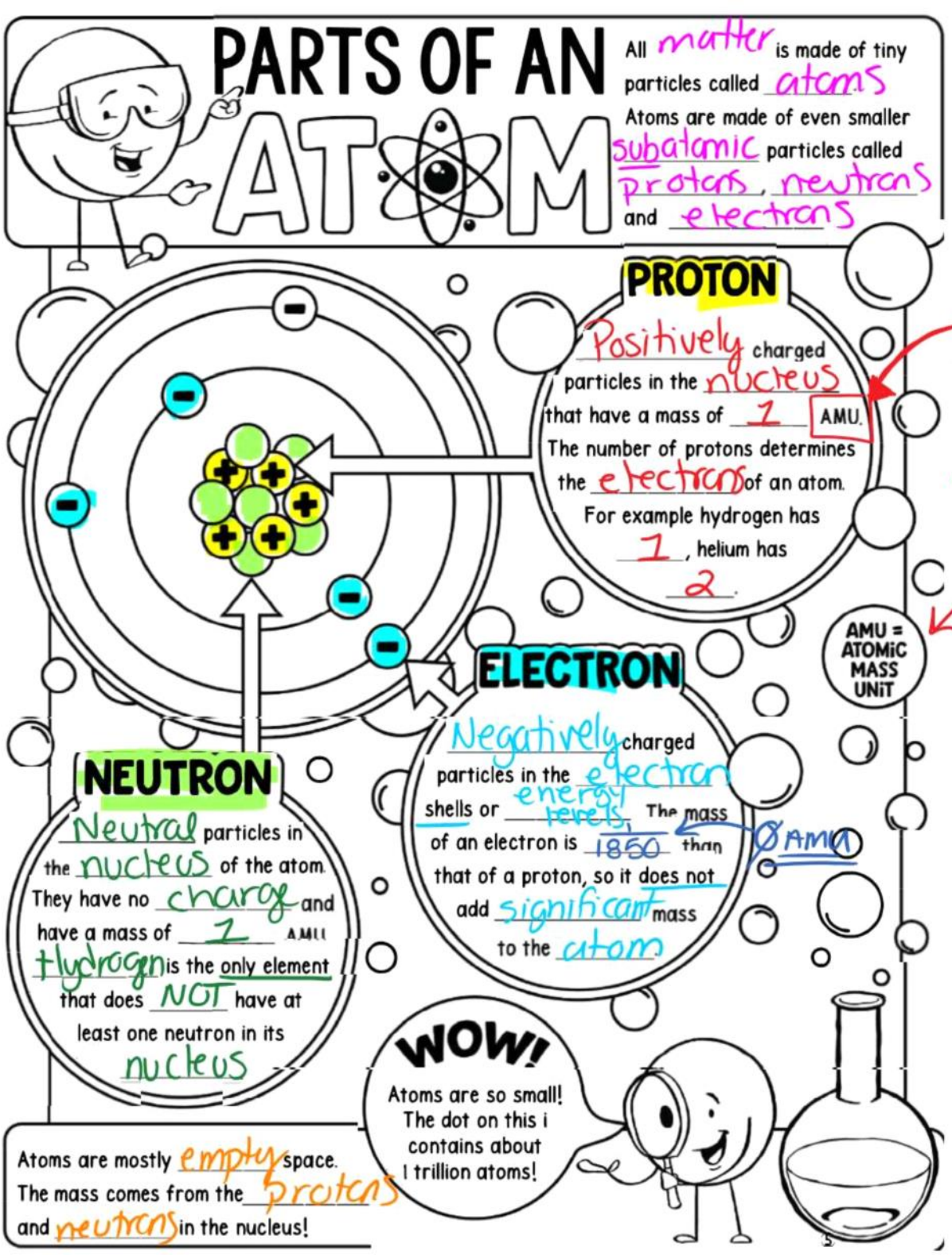
Atoms have no overall electrical charge and are neutral

This means atoms must have an EQUAL number of positive protons (+) and negative electrons (−) = Ø.

The number of electrons is therefore the same as the atomic number

Atomic number (Z) is the number of protons rather than the number of electrons, because atoms can lose or gain electrons but do not normally lose or gain protons

↳ number of protons is always the same.


PARTS OF AN ATOM
All matter is made of tiny particles called atoms
Atoms are made of even smaller subatomic particles called protons, neutrons and electrons
PROTON
Positively charged particles in the nucleus that have a mass of 1 AMU.
The number of protons determines the electrons of an atom.
For example hydrogen has 1, helium has 2.
Atomic mass unit
AMU = ATOMIC MASS UNIT
ELECTRON
Negatively charged particles in the electron shells or energy levels. The mass of an electron is 1850 than that of a proton, so it does not add significant mass to the atom.
Ø AMU
NEUTRON
Neutral particles in the nucleus of the atom. They have no charge and have a mass of 1 AMU.
Hydrogen is the only element that does NOT have at least one neutron in its nucleus
WOW!
Atoms are so small! The dot on this i contains about 1 trillion atoms!
Atoms are mostly empty space. The mass comes from the protons and neutrons in the nucleus!

THE ATOM

QUICK WATCH: Just How Small is an Atom? http://tinyurl.com/lcdvfzx

Analogy	My Guess (circle one)	Actual
If the atoms of a grapefruit were blown up to the size of blueberries, then the grapefruit would be the size of...	A basketball A school bus A box store (like Target) A large island (like Jamaica) The United States The Earth	The Earth
If an atom were blown up to the size of a football stadium, then its nucleus would be the size of...	A car A soccerball An apple A marble A pea	a marble
The density of an atom's nucleus is about the same as if you stuffed which of the following into a 1 foot by 1 foot by 1 foot-sized box.	An elephant A blue whale A box store (like Target) A metropolitan city (like Chicago) Every person on Earth's car	6.2 billion cars

ESSENTIAL QUESTION: What important information does the Periodic Table tell us about the atoms of elements?

TOPIC QUESTIONS:

1

What is an atom?

The smallest part of a chemical element that can exist.

MATTER

The word 'atom' comes from the Ancient Greek adjective 'atomos' which means *indivisible*.

The concept of an atom has changed over time. Analogies can help us understand the different models.

Billiard ball — Dalton (early 1800s)

Chocolate chip cookie — Thomson (late 1800s)

Cherry with a pit — Rutherford (early 1900s)

Solar system — Bohr (1900s)

Cotton ball — (1900s - present)

Schrodinger, Heisenberg, Einstein, and others

chem 11/12

2

What are the subatomic particles?

Protons are like the fingerprint of the atom. Every type of atom has a unique number of protons.

The root *sub* means: under

Particle Name	Protons	Neutrons	Electrons
Charge	+	ø	−
Symbol	p^+	n^0	e^-
Mass	1 amu	1 amu	ø amu

amu = Atomic Mass Unit

A tiny unit of mass used to measure the mass of subatomic particles.

Atomic Number (Z)

The number of protons in an atom is known as the atomic number or proton number.

- always the same for a particular element.
- **The number of protons identifies the element!**
- is also equal to the positive charge of the nucleus (*aka* the positive nuclear charge)

Example:

If an atom has **Z** = 12, then it MUST be an *atom* of magnesium
If an ion has **Z** = 41, then it MUST be an *ion* of Nb
If the nuclear charge of a species is +24, then it MUST *be an atom or ion of* Chromium (Cr)

The ***overall charge on an atom is zero*** because the number of protons = number of electrons

The charge on any ion = number of e⁻ electrons (negative) *or* protons (positive).

It is the smaller of the two numbers shown in most periodic tables. *(usually on top ... depends where you're looking)*

Mass Number (A)

mass number = number of protons + number of neutrons

Electrons have a mass of *almost zero*, which means that the mass of each atom results almost entirely from the number of protons and neutrons in the nucleus.

- **Does not appear in the periodic table!** *(not in this exact form)*
- Can be expressed in number of ways:

  Carbon-12 or C-12 or ^{12}C

- ***Does not*** uniquely identify the element!

e.g. ^{3}H : 1 p, 2 n , ^{3}He : 2 p, 1 n

The larger of the two numbers shown in most periodic tables, which you are probably familiar with is mass....actually shows the ***relative*** atomic mass (average of isotopes)

^{3}H = mass number = 3
^{3}He = " " = 3

} number of neutrons CAN change

round decimal number in periodic table

What's the mass number?

mass number = number of protons + number of neutrons

whole #

Atomic number

Atoms	Protons	Neutrons	Mass number
helium	2	2	4
copper	29	35	64
cobalt	27	32	59
iodine	53	74	127
germanium	32	41	73

How many neutrons?

neutrons = mass number − protons

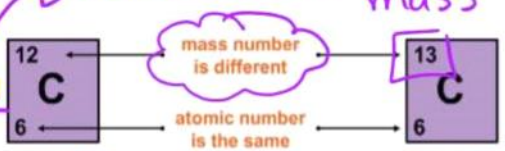
(mass number − atomic number)

Atoms	Mass number	Atomic number	Neutrons
helium	4	2	2
fluorine	19	9	10
strontium	88	38	50
zirconium	91	40	51
uranium	238	92	146.

What are isotopes?

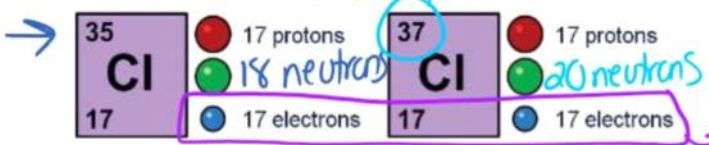
Isotope are atoms of the same element that contain different numbers of neutrons.

also different Atomic mass



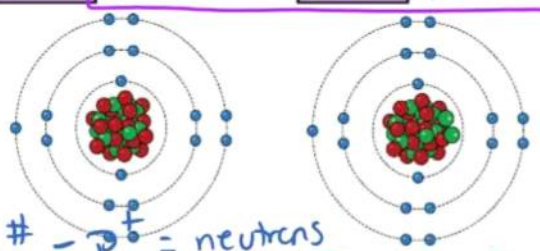
Isotopes of chlorine

About 75% of naturally-occurring chlorine is chlorine-35 (^{35}Cl) and 25% is chlorine-37 (^{37}Cl).



The reactivity of different isotopes of an element is identical because they have the ***same number*** of electrons.

The ***different*** masses of the atoms means that the physical properties of the isotopes are slightly different.

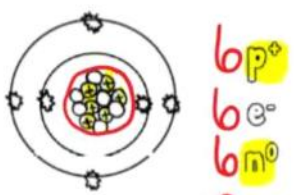


mass # − p+ = neutrons

35 − 17 = 18

37 − 17 = 20 neutrons.

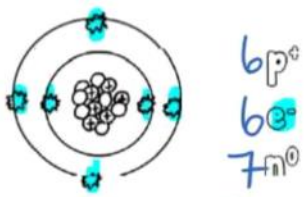
Atoms of the same element that have different numbers of neutrons.



6 p+, 6 e−, 6 n0

carbon - 12

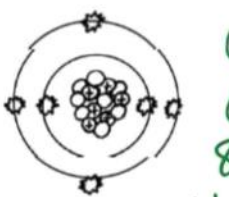
p+ + n0



6 p+, 6 e−, 7 n0

carbon - 13

6 p+ = atomic number = carbon



6 p+, 6 e−, 8 n0

carbon - 14

The total number of p+ + n0 in the nucleus

What does this number tell you?

8

Homework

Assignment #1: The Structure of Atoms
Worksheet pg 9

The Structure of Atoms

Complete the table

Sub-atomic Particle	Symbol	Location in the atom	Mass of particle
Proton	p^+	nucleus	1
Neutron	n^o	nucleus	1
Electron	e^-	shells (energy levels) around the nucleus.	ø

1. What two sub-atomic particles are located in the nucleus of the atom?
   protons + neutrons
2. What is the difference between the atomic number & the mass number of an element?
   the number of protons in an atom ↔ the number of protons + neutrons
3. Where is the majority of the mass located in an atom?
   the nucleus (p^+ and n^o)

Complete the table; the first two rows have been done for you. Use your periodic table to complete the rest.

same in a neutral atom.

Element	Symbol	Protons	Neutrons	Electrons
Lithium	Li	3	7-3=4	3
carbon	C	6	12-6=6	6
Sodium	Na	11	23-11=12	11
Aluminum	Al	13	27-13=14	13
Lead	Pb	82	207-82=125	82
Titanium	Ti	22	48-22=26	22
Zinc	Zn	30	65-30=35	30
Mercury	Hg	80	200-80=120	80
Chlorine	Cl	17	36-17=19	17
Tungsten	W	74	184-74=110	74

all neutral atoms (no ions)

pure substance

A substance that cannot be broken down into simpler substances by chemical means. An element is composed of atoms that have the same number of protons in their nucleus.

ELEMENTS

Every element has a unique Atomic number. It indicates the total number of protons in the nucleus of the atom. Normal atoms are electrically neutral, same number of protons as electron. So it is also the number of e⁻.

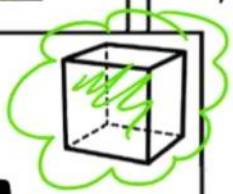
ATOMIC NUMBER

Every elements is abbreviated using a unique symbol of one or 2 letters. The first letter is always capitalized and if there is a second letter, it is lower case

Some are based on other languages, for example the symbol Fe is iron from the Latin "ferrium."

SYMBOL

12



Mg

Magnesium

24.305

ELEMENT NAME

Every element has a unique name. Many element names are very old and are based on other language. Chlorine is named after "khloros," the Greek word for "yellowish green." Newly discovered elements are named by the discoverer, but must be approved by an international committee.

ATOMIC MASS

Atomic mass is the mass of the protons and the neutrons in an atom. Every proton and neutron has a mass of 1 AMU. Electrons do NOT count towards the mass because they are tiny. The mass can be shown with a decimal because it is an average mass of the isotopes of that element.

You try:

What element's neutral atom has 17 electrons?

chlorine

How many neutrons are in a lithium atom?

4 neutrons

What do you think the cube symbol in the upper right means?

naturally a solid

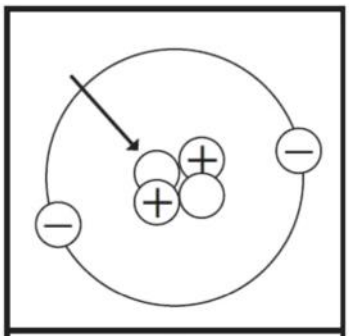
(s) = solid
(l) = liquid
(g) = gas

SHOW what you KNOW

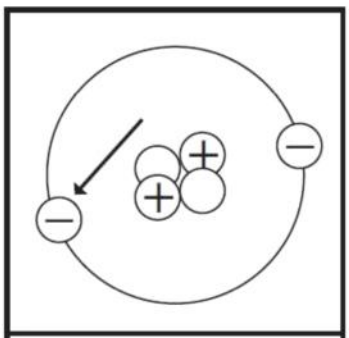
ATOMS & ELEMENTS

Homework **Assignment #2:** "Show what you know" pg 11 & "Practice" Questions pg 12

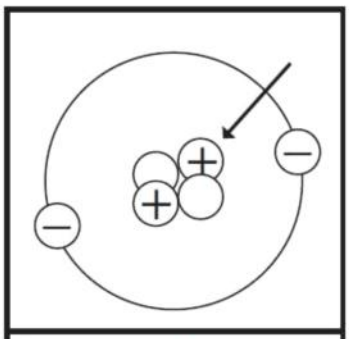
1. Identify each part of the atom.



A: neutron



B: electron



C: proton

2. An element is determined by the number of _____ in its nucleus (also known as its atomic number).

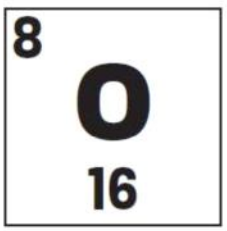
a. neutrons
b. electrons
● protons
d. gluons

3. Each chemical element is made up of only one kind of

● atom
b. molecule
c. electron
d. neutron

4. Chemists use letters of the alphabet as symbols for the elements.

5. A neutron is a particle with no charge.



6. What is the atomic number of this element? 8

7. How many neutrons does this element have? 8

8. What is the atomic mass of this element? 27

9. How many electrons does this element have? 13

10. Explain how you could identify what type of element the atom in question 1 is using the diagram and a periodic table.
Looking at the diagram, you can see that the atom has two protons. Knowing that the number of protons is the atomic number of the element, you would go to the periodic table and find element number "2," which is helium.

PRACTICE

KEY

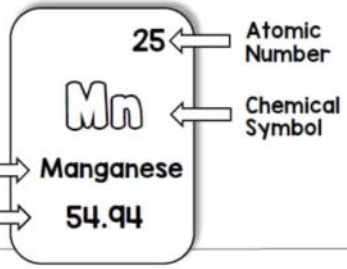
Match each item with the correct statement:

___C___ 1. The smallest particle of an element that retains the properties of that element	A. PROTON
___A___ 2. A positively charged subatomic particle	B. NUCLEUS
___D___ 3. A negatively charged subatomic particle	C. ATOM
___E___ 4. A subatomic particle with no charge	D. ELECTRON
___B___ 5. The central part of an atom containing protons and neutrons	E. NEUTRON

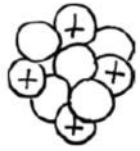
Match each item with the correct statement:

___C___ 1. Atoms with the same number of protons but different numbers of neutrons	A. ATOMIC MASS
___B___ 2. Total number of protons and neutrons in the nucleus	B. MASS NUMBER
___A___ 3. The weighted average of the masses of the isotopes of an element	C. ISOTOPE

Label each part of the Periodic Table square:



These are the nuclei of three different atoms. Write the isotopic notation for each (for example, Carbon - 13)



Beryllium - 9

Nitrogen - 13

Boron - 12

Complete the table below by referencing a periodic table. The first row has been completed as an example.

	Chemical Symbol	Atomic Number	Atomic Mass	Mass Number	Hyphenated Notation of Most Common Isotope	# of protons	# of electrons	# of neutrons (Show work : Mass Number - Atomic #)
Phosphorous	P	15	30.97	31	Phosphorous - 31	15	15	31 - 15 = 16
Aluminum	Al	13	26.98	27	Aluminum - 27	13	13	27 - 13 = 14
Potassium	K	19	39.10	39	Potassium - 39	19	19	39 - 19 = 20
Argon	Ar	18	39.95	40	Argon - 40	18	18	40 - 18 = 22
Lead	Pb	82	207.20	207	Lead - 207	82	82	207 - 82 = 125

Part B - Organization of the Periodic Table

Russian chemist Dimitri Mendeleev confidently predicted the properties of the chemical element germanium 15 years before it was discovered.

He was able to do this because all known elements had been arranged into a set of rows (periods) and columns (groups (families)) called the periodic table.

The periodic table below shows 112 elements. Scientists have reported the discovery of elements with atomic numbers up to 118. However, some of the discoveries have not been confirmed by the International Union of Pure and Applied Chemistry (IUPAC). Until they are, their existence is 'unofficial'. The properties of new elements are predicted before their discovery, just as they were in Mendeleev's time.

The observation that the ***physical and chemical properties of the elements recur*** at regular intervals when elements are listed in order of atomic weight is known as the Periodic Law. → by atomic number (p^+)

PERIODIC TABLE GROUPS (FAMILIES) LEGEND

- ALKALI METALS
- ALKALI EARTH METALS
- TRANSITION METALS
- NON-METALS
- METALLOIDS
- HALOGENS
- NOBLE GASES
- LANTHANIDE & ACTINIDE SERIES

Group (1)

metalloids

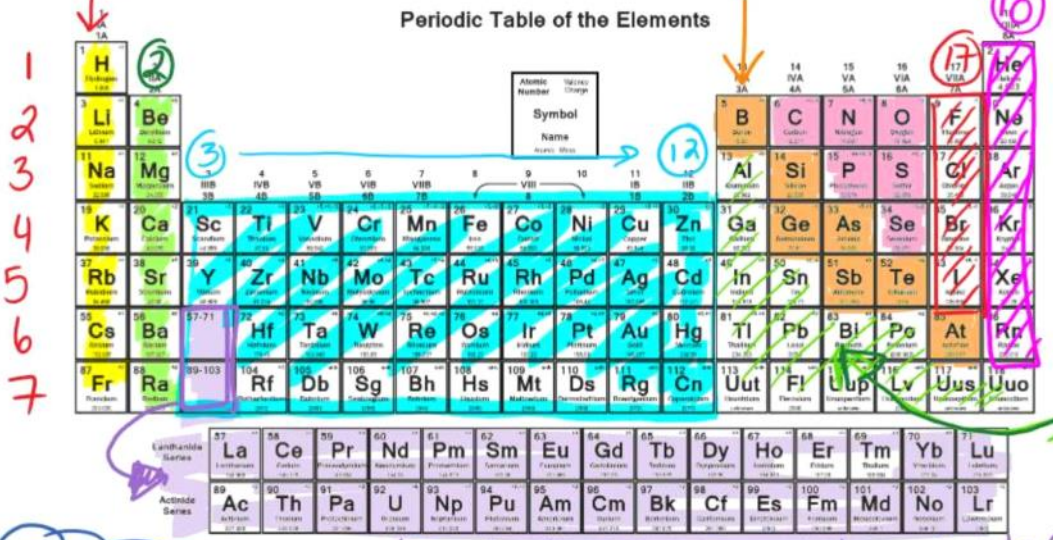
(18)

(17)

(2)

(3)

(12)



"Post-Transition metals"

(Technically Transition metals)

The period number refers to the number of the outermost shell containing electrons.

eg. group (1) has 1 e^- outer shell
group (2) has 2 e^- outershell
group (13) has 3 e^- outershell

Homework **Assignment #3:** "Periodic Table Scavenger Hunt" pg 14 + "Practice Questions" pg 15

Periodic Table Scavenger Hunt

Goal • Demonstrate your understanding of the periodic table.

What to Do

Use your periodic table to answer the following questions.

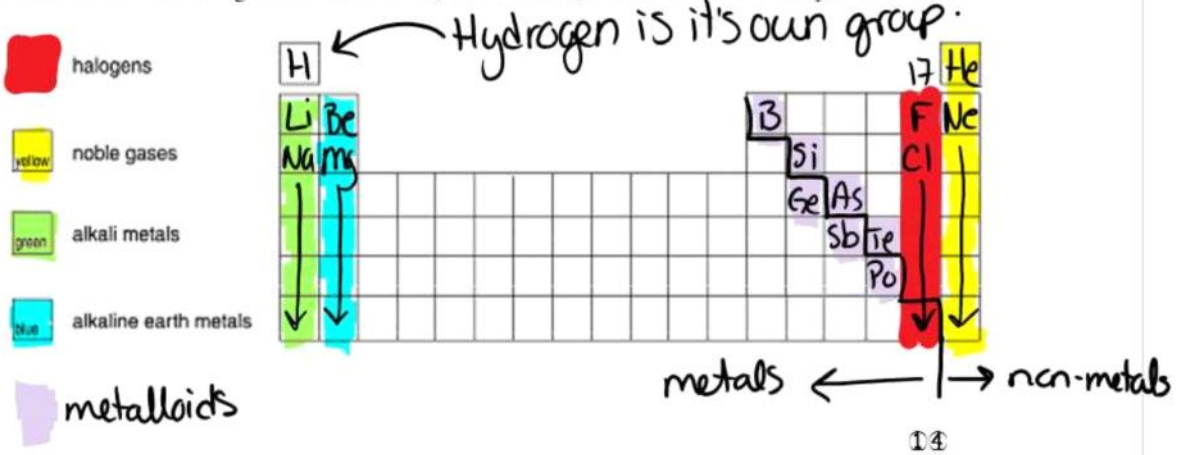
1. Identify each element.
   (a) The element in group 5 and period 5 Niobium (Nb)
   (b) Only halogen that is a liquid at room temperature and pressure Bromine (Br)
   (c) Alkali metal with the most massive atoms (largest size) Francium (Fr)
   (d) Synthetic element in period 5 Technitium (Tc)
   (e) Metal in group 16 and period 4 Selenium (Se)
   (f) Alkaline earth element with the least massive atoms (smallest) Beryllium (Be)
   (g) Noble gas that has atoms with 54 protons Xenon (Xe)

2. Complete the following table. The first row is completed as an example.

Name of Element	Atomic Number	Number of Protons	Number of Electrons
silicon	14	14	14
Oxygen	8	8	8
chromium	24	24	24
sodium	11	11	11
Aluminum	13	13	13
Potassium	19	19	19

= all the same in a NEUTRAL atom.

3. Shade in the following chemical families, as indicated, on the outline of the periodic table.



Review: The Chemical Elements

Self–Test: For each of the following, give the name of the element if the symbol is given and give the symbol if the name is given.

(a)	sodium	Na	(k)	cadmium	Cd
(b)	K	potassium	(l)	Be	Beryllium
(c)	thallium	Tl	(m)	arsenic	As
(d)	Hg	Mercury	(n)	Mo	Molybdenum
(e)	silicon	Si	(o)	platinum	Pt
(f)	Kr	Krypton	(p)	Cu	Copper
(g)	fluorine	F	(q)	tungsten	W
(h)	Cr	Chromium	(r)	Pb	Lead
(i)	sulphur	S	(s)	astatine	At
(j)	Cs	Cesium	(t)	B	Boron.

Part C - Valence electrons & Ion Formation

We will learn the naming of compounds made from metals and non-metals. = ionic compounds

Indicate the sections on the periodic table below that contain:

METALS **NON-METALS** **METALLOIDS** **TRANSITION METALS**

The compounds used in the examples and exercises which follow are selected from the metals in white boxes (below) and the nonmetals in shaded boxes. The elements in outlined boxes are not used in any of the examples or exercises which follow (although you should know the names and symbols for later purposes).

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra																

not reactive "inert"

form ⊖ charges → non-metal

metal form ⊕ charges ←

Ions & Charges

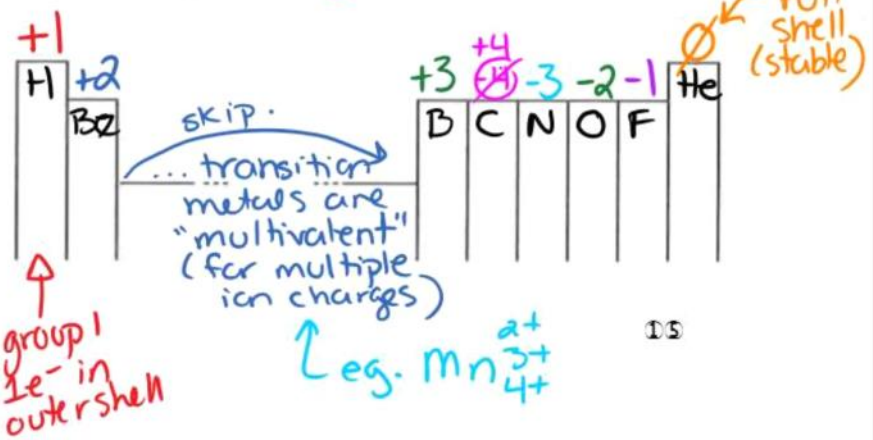
Going across the periodic table, there are trends in the charges of the ions formed by the elements in the columns.

What charge do metals form?

positive ⊕

What charge do non-metals form?

negative ⊖



Valence Electrons

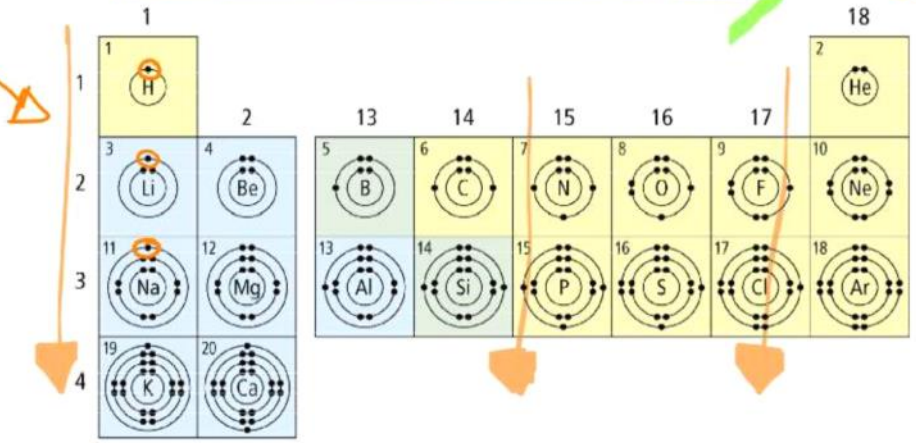
Valence Electrons are the electrons in the outermost shell **of an atom.**

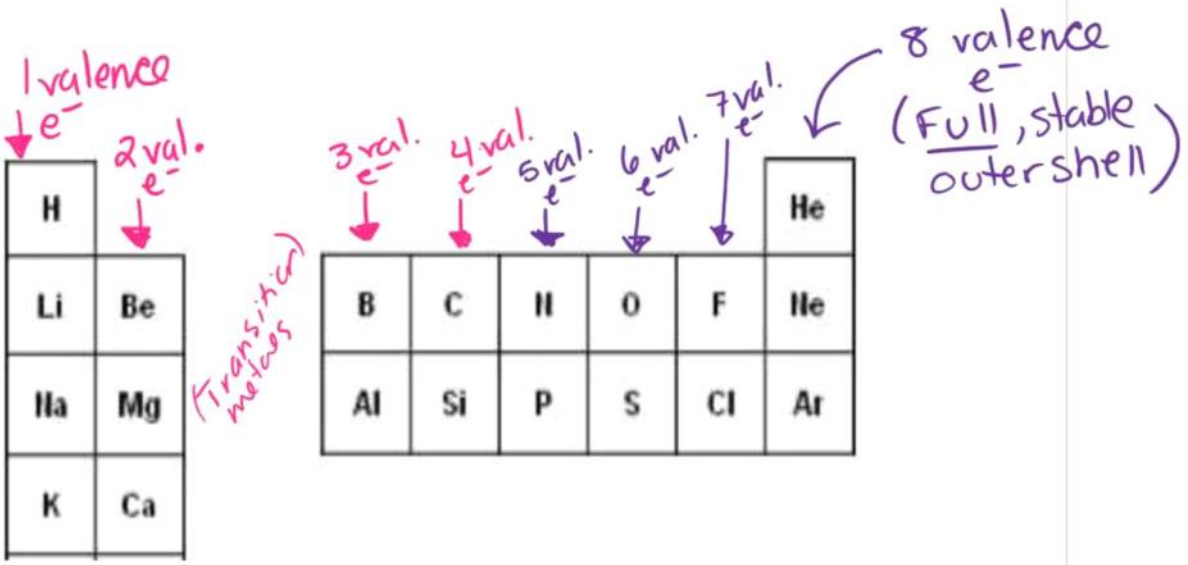
Consider the Bohr Diagrams of the first 20 Elements, what patterns do you notice in the number of valence electrons as you go ***LEFT to RIGHT across a period?***

the number of valence e⁻ increases (by one time)

What pattern do you notice as you go ***TOP to BOTTOM down a group/family?***

even though the number of shells increases, the number of valence e⁻ is the same.





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Ion Formation

When atoms gain or lose electrons, they become electrically charged particles called ions.

Metal atoms, for example, LOSE electrons to form (+) charged ions called cations.

Many metals can form a cation only in one way. → means it has more p+ than e-

For example, aluminum forms a cation by losing three electrons to become Al^{3+}.

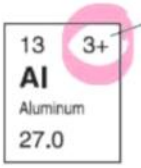
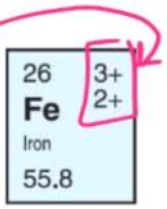


Figure 4.4A Aluminum forms a 3+ ion as a result of losing three electrons.

Some metals are multivalent, which means they can form ions in ***more than one way***, depending on the chemical reaction they undergo.

For example, iron is a multivalent element because it can lose 2 or t3 electrons to become Fe^{2+} ions and Fe^{3+} ions.



Look at the periodic table. Which metals are multivalent?

Transition metals.

Many non-metals also form ions. However, since non-metal atoms, with very few exceptions, gain electrons, they form (−) ions called anions.

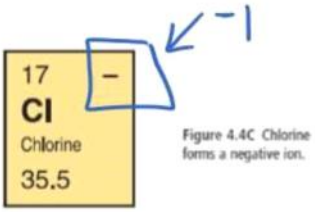
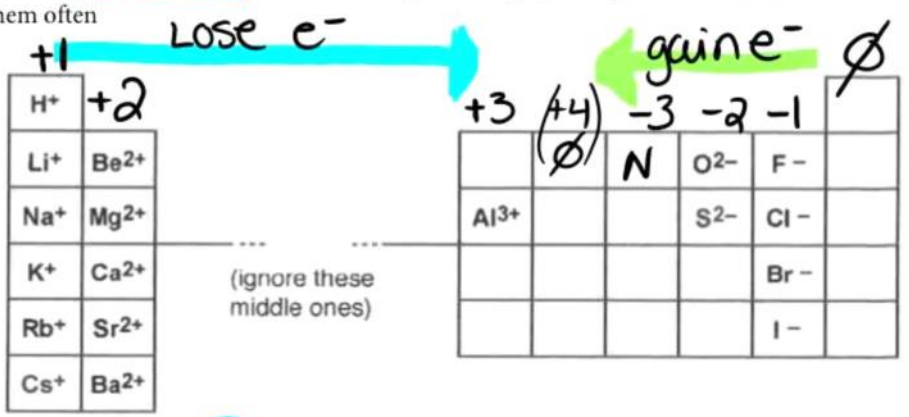


Figure 4.4C Chlorine forms a negative ion.

For example, the periodic table shows that chlorine will form a −1 ion.

This happens when a chlorine atom gains one electron. → means now Cl has a "full outer shell" (8e⁻)

You should become **VERY** familiar with the following ion charges, as they are the most common...and you will use them often



IMPORTANT: Metals form (+) ions

Nonmetals form (−) ions

"mono" = one
"atomic" = atoms } "one-atom"

Naming Monatomoic Metal & Non-Metal Ions:

Naming monatomic metal ions: Use the name of the metal and add the word "ion"

Example: Sodium metal (Na) forms the Na^+ => "sodium ion"
Aluminum metal (Al) forms the Al^{3+} => aluminum ion

1 I
2 II
3 III
4 IV
5 V
6 VI
7 VII
8 VIII
9 IX
10 X

The Stock System of naming metal ions: If a metal ion has more than one possible charge, the charge is indicated by a ROMAN numeral, immediately following the name.

Example: Fe^{3+} = iron (III) ion, Fe^{2+} = iron (II) ion, U^{6+} = uranium (VI) ion, U^{3+} = uranium (III) ion

Multivalent Ions: most ***transition metals*** are multivalent, meaning they have more than 1 stable state.

EXERCISES: *(Complete the following questions in the space provided below)*

2. Write the names of the following ions using the Stock system of notation.
(a) Cu^+ (b) Cr^{3+} (c) W^{6+}

a) Copper(I) ion b) Chromium(III) ion c) Tungsten(VI) ion

3. Write the formula of the following ions to show their charges.
(a) cobalt(III) ion (b) nickel(II) ion (c) vanadium(V) ion

metal charge
Co^{3+} Ni^{2+} V^{5+}

Naming monatomic non-metal ions: Take off the original ending of the element's name and put on an "ide" (DO NOT add the word "ion")

(The ending **ide** means the ion has a negative charge and has no attached atoms such as oxygen included with the ion.)

Element name	Element symbol	Ion name	Ion symbol
~~fluorine~~	F	fluoride	F^-
~~chlorine~~	Cl	chloride	Cl^-
~~bromine~~	Br	bromide	Br^-
~~iodine~~	I	iodide	I^-
~~oxygen~~	O	oxide	O^{2-}
~~sulphur~~	S	sulphide	S^{2-}
~~nitrogen~~	N	nitride	N^{3-}
~~phosphorus~~	P	phosphide	P^{3-}

show ⊖ charge
Group 17 -1
Group 16 -2
Group 15 -3
sulfur

Polyatomic Ions

Recall that a molecule (e.g. CO_2, H_2O [all non-metals neutral]) is a neutral group of covalently bonded atoms.

nitrite NO_2^-
sulphite SO_3^{2-}

A **polyatomic ion** is a charged group of covalently bonded atoms so it's like a molecule except that it has a ⊕ or ⊖ charge.

nitrate NO_3^-
sulphate SO_4^{2-}

They are relatively stable species that often remain intact in chemical reactions.

Many polyatomic ions are oxy-anions, consisting of an atom of a given element and some number of oxygen atoms.

NOTE **The names & formulae of these are provided in your DATA BOOKLET.**

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Homework Assignment #4: Trends in Ions Table ⬇ pg 19

Complete the following table: (+) → lost e⁻ (−) → gained e⁻

in the ion

Name of Element	Atomic Number	Ion Charge	Number of Protons	Number of Electrons
Neon Ne	10	∅	10	10
Cobalt Co	27	2^+ or 3^+	27	Co^{2+} 25 Co^{3+} 24
Gold Au	79	1^+ or 3^+	79	Au^{+} 78 Au^{3+} 76
Chlorine Cl	17	1^-	17	18
Thorium Th	90	4^+	90	86
Lead Pb	82	2^+ or 4^+	82	Pb^{2+} 80 Pb^{4+} 78
Nickel Ni	28	2^+ or 3^+	28	Ni^{2+} 26 Ni^{3+} 25
Chromium Cr	24	2^+ or 3^+	24	Cr^{2+} 22 Cr^{3+} 21
Silicon Si	14	∅	14	14
Tungsten W	74	6^+	74	68

non-metals like C and Si in Group 14 DO NOT form ions

Part D - Electron Configuration, Bohr + Lewis Dot Diagrams

ELECTRONIC CONFIGURATION

The electronic configuration of an element is an ordered list of the number of electrons in each shell. The electronic configuration is determined from the atomic number of the element, which is the same as the number of protons in the nucleus of each atom. (... and e⁻ if it's a neutral atom)

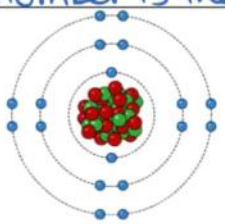
In a ***neutral atom***, the total number of electrons is the same as the number of protons.

In an **ion**, the total number of electrons is the the number of protons + or - electrons based on the charge.

- cation (+) have lost e⁻ → means the number of protons is same, e⁻ decreased
- anion (-) have gained e⁻ → the proton number is the same, e⁻ increased.

Each shell holds a different maximum number of electrons:

- 1st shell = 2 electrons
- 2nd shell = 8 electrons
- 3rd shell = 8 electrons



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Electrons & Bonding...

Knowledge of the electron shell structures of atoms helps us to understand how compounds like sodium chloride (table salt) form. When atoms react with each other to form compounds, it is the electrons in the outer shell that are important in determining the type of reaction which occurs.

In 1919, Irving Langmuir suggested that the **noble gases do not react** to form compounds because they have a *stable electronic configuration* of 8 electrons in their outer shell.

Most other atoms react because their electron arrangements are less stable than those of the noble gases.

Atoms **become more stable** when they attain an electron arrangement that is the same as that of the noble gases. gaining or losing e⁻

Chemical reactions can allow atoms to obtain this arrangement.

Element	Symbol	Atomic number	Electronic configuration
Oxygen	O	8	2,6
Fluorine	F	9	2,7
Neon	Ne	10	2,8
Sodium	Na	11	2,8,1
Magnesium	Mg	12	2,8,2
Sulfur	S	16	2,8,6
Chlorine	Cl	17	2,8,7
Argon	Ar	18	2,8,8
Potassium	K	19	2,8,8,1

# of e⁻ in each shell

FULL outer shell

FULL shell

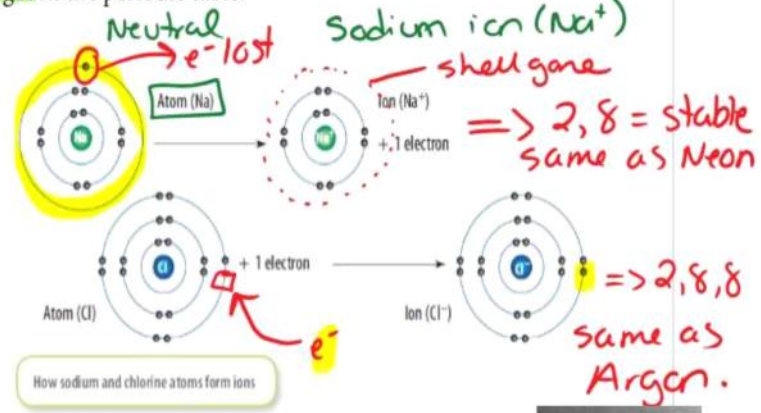
The table above shows that the stable electron arrangements of the two noble gases Neon and Argon show 8 electrons in their outer shells.

The atoms of the other elements must Gain or lose electrons *(ie: form ions and ionic bonds, or share-covalent bonds)* to attain full outer shells. In this way they become **more stable,** ending up with the electron arrangement of the nearest noble gas in the periodic table.

The diagram on ther ight shows how sodium and chlorine atoms lose and gain electrons respectively to form ions.

Note that the sodium atom becomes a Na^+ cation and that the chlorine atom becomes a Cl^- anion

RULE: *when non-metals form ions, the suffi x '-ide' is used.*

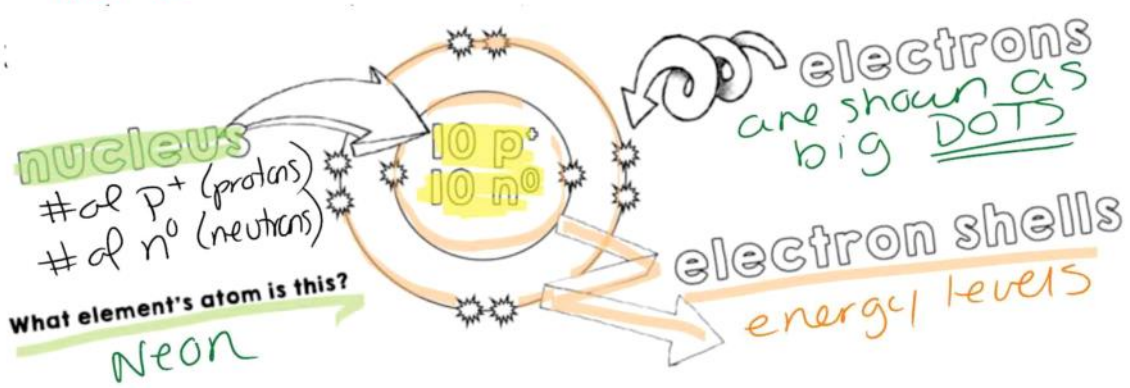


How sodium and chlorine atoms form ions

Bohr Diagrams

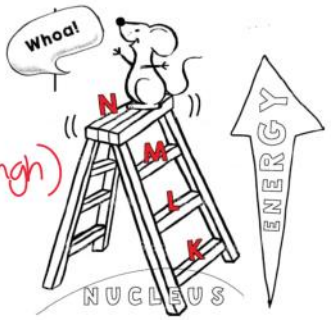
A Bohr diagram is a diagram that shows how many electrons are in each shell surrounding the nucleus. The Bohr diagram is named in honour of Niels Bohr, a Danish physicist who developed several models for showing the arrangement of electrons in atoms.

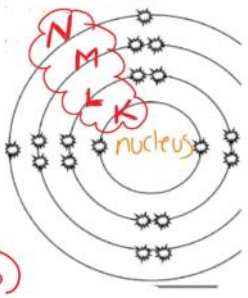
1. Parts of a Bohr Diagram



2. How does an Electron's location Correspond to its energy?

- Imagine climbing a ladder As you go up each rung, you gain more and more POTENTIAL energy (PE=mgh)
  - This is similar to the way in which electrons have MORE energy as they orbit further away from the nucleus
- The shells of an atom are named K, L, M, and N going from closest to furthest from the nucleus





3. How do electrons Fill the electron shells? (energy levels)

NOTE: Once the atoms get larger than Calcium (#20) things start to get more complicated!

Electrons fill the K shell (level 1) first. The K shell is FULL when it has 2 TWO electrons.

Remaining electrons fill the L shell (level 2) next. The L shell is FULL when it has EIGHT 8.

Any remaining electrons fill the M shell (level 3) next. For the first 20 elements, the M shell is full when it has EIGHT electrons.

If there are still remaining electrons, they fill the N shell (level 4). The N shell is full when it has EIGHT electrons.

SHELL	energy LEVEL	# of electrons to be 'FULL'
K	1	2
L	2	8
M	3	8 (18)
N	4	8 (32)

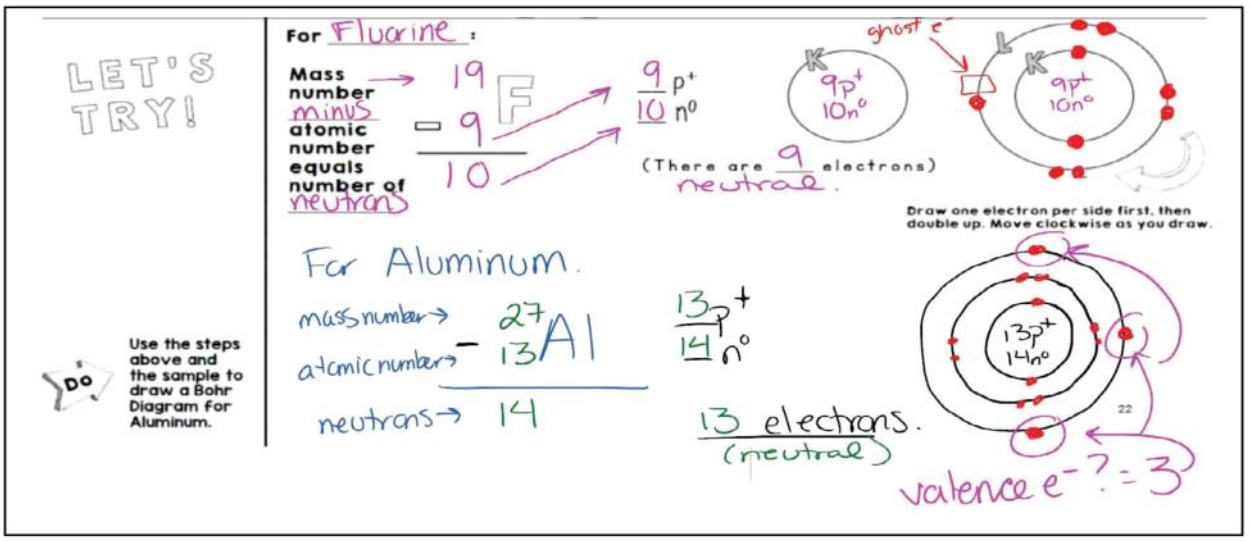
DO Fill in the table above.

(After element #20, the M and N shell can actually hold 18 and 32 electrons...but for now we won't worry about that.)

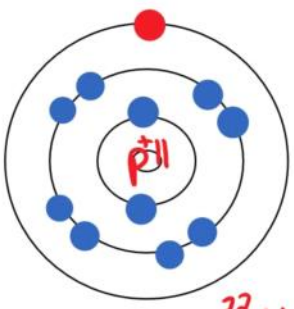
2 8 8 8 (chem II) extension

Drawing a Bohr Diagram

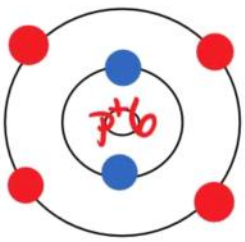
1. Write the element's symbol with the mass number at the TOP left and the atomic number at the BOTTOM left
2. Calculate the number of neutrons in the atom. Write the number of protons (p^+) and neutrons (n^0) as the nucleus
3. Ask yourself: How many electrons does the neutral atom have? } same as protons
4. Draw the K shell. Fill the K shell with the first 2 electrons. Make your electrons nice and BIG!
5. Continue drawing each shell and filling with electrons until you have accounted for all the atom's electrons.



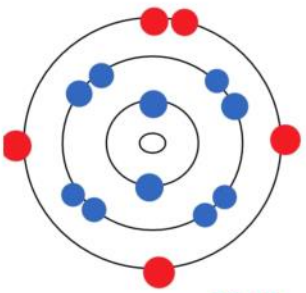
For each element write the **number of protons (p+) in the center**, draw the **inner electrons blue** & the **valence (outer) electrons red**. The circles represent **possible** electron shells.



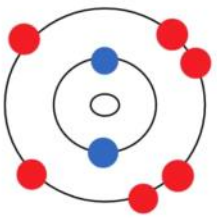
Sodium (Na) $^{22}_{11}Na$
$p^+ = 11$ $n^0 = 11$



Carbon (C) $^{12}_{6}C$
$p^+ = 6$ $n^0 = 6$



Phosphorus (P) $^{30}_{15}P$
$p^+ = 15$ $n^0 = 15$



Oxygen (O) $^{16}_{8}O$
$p^+ = 8$ $n^0 = 8$

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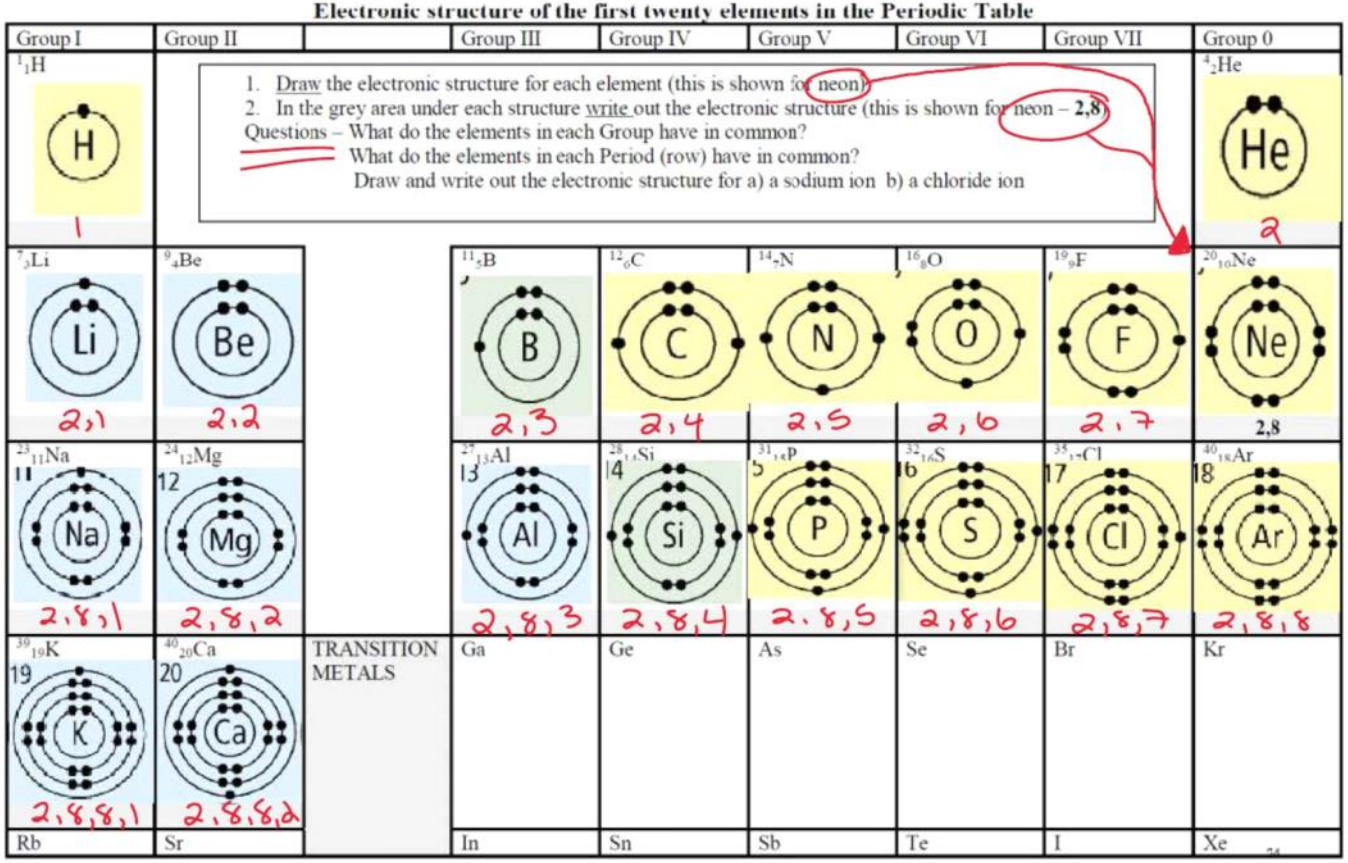
Homework **Assignment #5 Electronic Structure of Atoms: Practicing Bohr Diagrams pg 23**

Electronic structure of the first twenty elements in the Periodic Table



QUESTIONS:

WHAT DO THE ELEMENTS IN EACH GROUP HAVE IN COMMON?

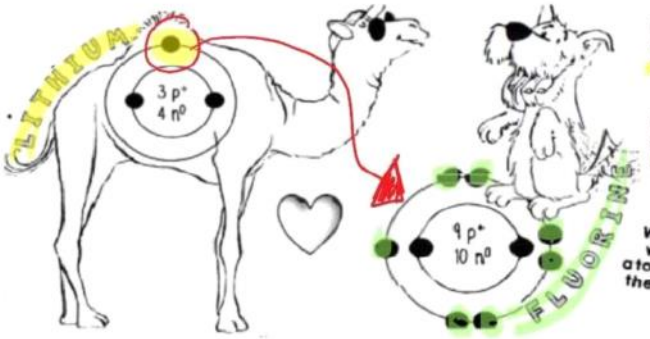
the elements in each group (column) have the same number of electrons in their outermost shell (same number of VALENCE ELECTRONS)

WHAT DO THE ELEMENTS IN EACH PERIOD HAVE IN COMMON?

the elements in each period (row) have the same number of CORE ELECTRONS (full inner shells) and the same number of total electron shells. as you move across the table from L-->R you are adding 1 more electron into the valence shell.

Drawing a Lewis Dot Diagram *(electron dot diagram)*

- Valence electrons are the electrons in the outermost shell of an atom.
- They are important because they indicate the atoms reactivity with other atoms (chemical reactions)
- The outermost electrons have the most energy. (remember the ladder)



How many valence electrons does the Lithium atom have? 1

How many valence electrons does the Fluorine atom have? 7

Why will the Fluorine atom want to 'take' the Lithium atom's valence electron? Will the Lithium atom be 'happy'?

Then both Li and F have FULL valence shells

What is another way to represent the valence electrons of an atom?

LEWIS DOT DIAGRAMS

A Lewis Dot Diagram shows ONLY the valence electrons of an atom.

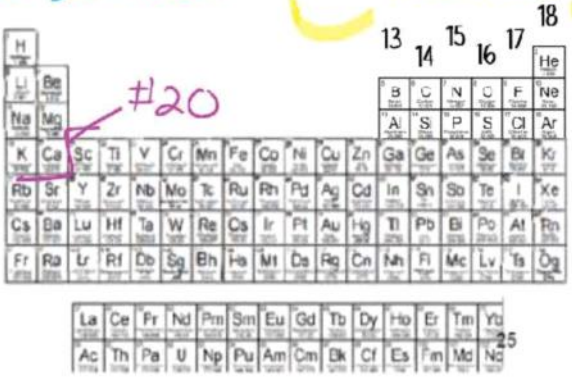
For elements # 1 through # 20, there is a 'secret trick' for knowing how many valence electrons an atom has. Look at the element's group NUMBER on the Periodic Table.

Group #1 elements have 1 valence electron,
group #2 elements have 2 valence electrons,
and for groups 13 through 18,
'drop the one' from the number to determine the number of valence electrons!
For example, carbon is in group # 14 so it has 4 valence electrons.

13 = 3 valence e⁻

'DROP THE ONE'

#20



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PRACTICE

LET'S TRY!

KEY

1						18
H	2	13	14	15	16	17	He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

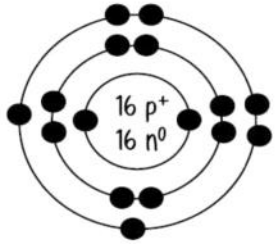
DO

Write the group number above each group. Then draw the Lewis Dot Diagram for each element.

Why doesn't Helium follow the 'drop the one' rule?

Helium only has 2 electrons so it can only have 2 valence electrons. However, it is still classified with group 18 because all of group 18's atoms have a full valence shell. Helium's valence shell, its K shell, is full with just 2 electrons.

SUM IT UP!



1. This is a Bohr Diagram of a Sulfur atom.
2. How many shells does this atom have? 3
3. What is the shell closest to the nucleus called? K
4. How many electrons does this shell have? 2
5. Is this shell full? yes

6. What is the name of the second shell from the nucleus? L
7. How many electrons does this shell have? 8
8. Is this shell full? yes

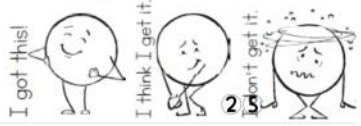
9. What is the name of the third shell from the nucleus? M
10. How many electrons does this shell have? 6
11. Is this shell full? no
12. Altogether, how many electrons does this atom have? 16
13. Is another shell needed? no
14. How many more electrons would this atom need to have a full outer shell? 2

15. Draw the Lewis Dot Diagram for the atom: S
16. How can you quickly double-check your diagram?
    Sulfur is in Group 16... drop the one to get 6.
17. How many shells do 2 electrons need? 1
18. How many shells do 10 electrons need? 2
19. How many shells do 20 electrons need? 4

Write True or False to answer each statement:

20. Every atom has at least two electron shells. false (H and He have just 1)
21. The L shell always has 8 electrons. false (atoms of elements #3 - 9 don't)
22. If there is an L shell, it means that the K shell is full. true
23. The outermost electrons of an atom are called Lewis electrons. false (valence)

How are you feeling about the basics of Modeling Atoms? Circle one:



Homework **Assignment #6:** Lewis Diagrams/Bonding Worksheet pg 27

Lewis Diagrams / Bonding Worksheet

1. Draw electron dot diagrams for the following atoms:

a. C

b. H

c. Na

d. Cl

e. P

f. Kr

g. Fr

h. Mg

i. Al

j. O

2. Draw electron dot diagrams for the following ions:

a. $[Na]^{+}$

b. $[Cl]^{-}$

c. $[Fr]^{+}$

*charges outside of square brackets

d. $[Mg]^{2+}$

e. $[Si]^{4+}$

3. Complete the following table by drawing both the Bohr diagram and the Lewis diagram for each element *(assume it is an atom and not an ion of that element).*

Name of element	Bohr diagram	Lewis diagram
carbon	p+6	C
oxygen	p+8	O
lithium	p+3	Li
chlorine	p+17	Cl

26

Patterns of Electron Arrangement in Periods

The p_____ number of an element equals the number of occupied _____ of its atoms.

Example: the two elements in period _____, hydrogen and helium, have a _____occupied shell. The first shell of an atom can have a maximum of _____electrons.

The elements in period _____ all have ***two occupied shells***. For each element in period 2, the first shell, which is closest to the nucleus, has a full set of _____electrons. As you move from left to right across period 2, one more _____is added to the second shell of each atom. Notice that neon, the last element in period 2, has a full set of _____electrons in its second shell.

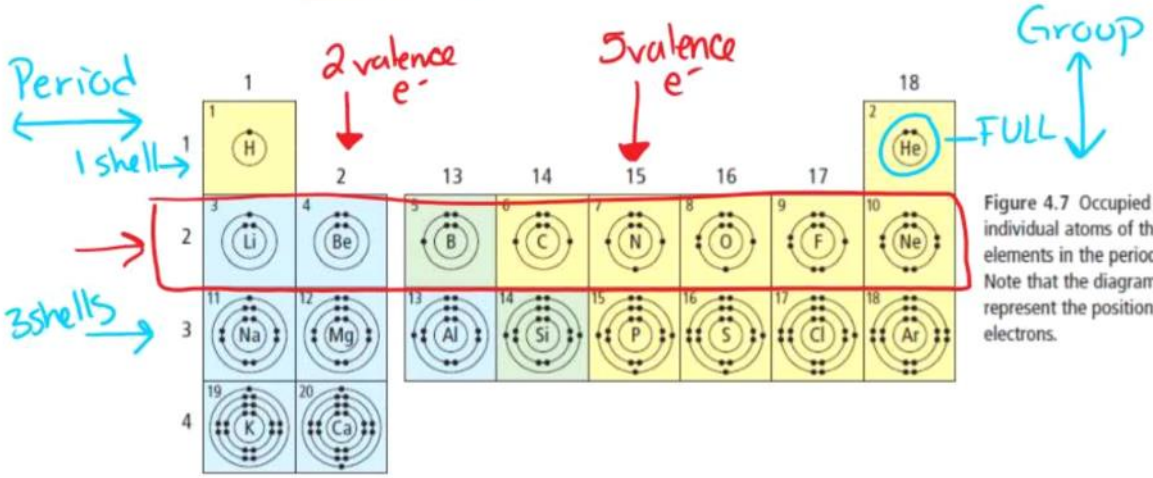


Figure 4.7 Occupied shells for individual atoms of the first 20 elements in the periodic table. Note that the diagrams do not represent the position or path of electrons.

Patterns of Electron Arrangement in Groups

The outermost shell that contains electrons is called the _____.

The electrons in the valence shell are called the _____electrons.

Valence electrons are involved in _____.

FOR EXAMPLE...

- The atoms of each element in group 1, hydrogen, have only _____ electron in their valence shell.
- Group 2 elements have _____electrons in their valence shell.
- Group 13 elements have _____ electrons in their valence shell.
- Group 14 has _____electrons, and so on through group 18.
- All group 18 elements have filled valence shells. Helium has two electrons filling its valence shell. Neon and argon each have eight electrons, or a stable octet, filling their valence shell.

NOTE: that electrons can exist singly or in pairs. Electrons in ***completed shells*** (except for hydrogen) appear in pairs.

28

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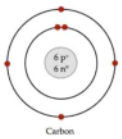
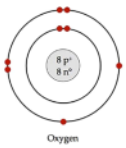
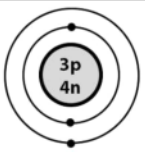
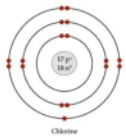
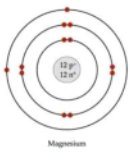
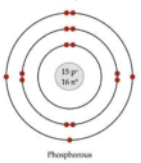
Homework **Assignment #7: Bohr Diagrams + Lewis Diagrams Worksheet pg 29**

Bohr Diagrams and Lewis Diagrams

Goal • Practise drawing Bohr diagrams and Lewis diagrams.

What to Do

Complete the following table by drawing both the Bohr diagram and Lewis diagram for each element. The first row is completed as an example.

Name of Element	Bohr Diagram	Lewis Diagram
carbon		
oxygen		
lithium		
chlorine		
magnesium		
phosphorus		

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Part E - Forming Compounds & Chemical Bonding

When two atoms move close together, their valence electrons interact. A chemical bond forms between the atoms if the new arrangement of atoms and electrons is stable.

The stability of an atom, ion, or compound is related to its energy. Lower energy states are more stable.

The *lowest energy* is achieved when the atoms in the compound have the same arrangement of valence electrons as a noble gas *(full electron shell)* to which they are closest in the periodic table.

When an atom forms a compound, it may acquire a valence shell like its closest noble gas in one of three ways:

1. Atoms of metals may LOSE e⁻ to other atoms, forming cation (+)
2. Atoms of non-metals may GAINe⁻ electrons from other atoms, forming a anion (-) } ionic bond
3. Atoms may SHARE electrons. *(covalent bonding)*

TYPES OF BONDS

A) IONIC BOND: an ionic compound contains a Positive ion (cation ⊕) and a negative ion (anion ⊖). In ionic bonding, one or more electrons transfers from each atom of the *metal* to each atom of the *non-metal*.

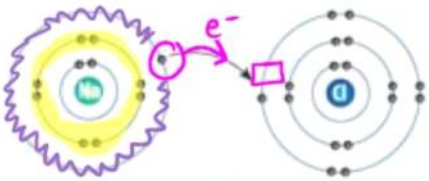
metal → e⁻ → non-metal

Cl 17e⁻

"shells"

Bohr Diagram:

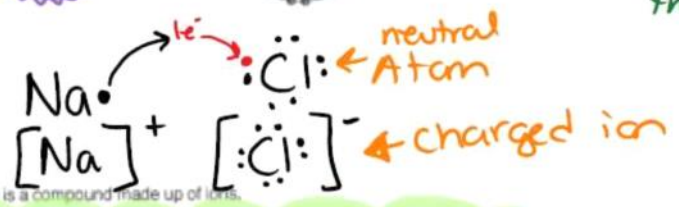
Na 11e⁻



Na loses 1e⁻, because Cl gains that 1e⁻

Lewis Structure:

" DOT "



Definition: An **IONIC COMPOUND** is a compound made up of ions.

IMPORTANT: Compounds are **NEUTRAL MOLECULES.** Therefore
(the sum of the "+" ion charges in the molecule) = (the sum of the "–" ion charges in the molecule)

The translation of a chemical name into a chemical formula is a simple process with three rules.

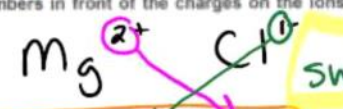
1. **Write the formula for the positive ion first and write the formula for the negative ion second.** (In a chemical name, the **POSITIVE** ion is ***always*** written **FIRST** and the **NEGATIVE** ion is ***always*** **SECOND.** All you do is translate the words in the chemical name into ions in the order they are given.)

   For example: **Magnesium chloride**

   Mg^{+2} Cl^{-}

2. **"Criss–cross" the numbers in front of the charges on the ions. ...and DROP!**

   For example:



SWAP + DROP!

Ratio of Atoms: 1 : 2

1 × Mg 2 × Cl ⟹ $MgCl_2$

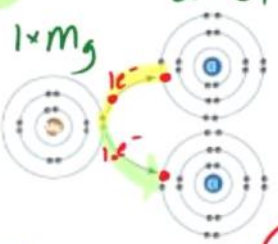
Chemical Formula

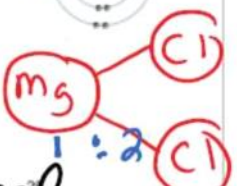
little numbers tellus how many of each atom

2 × Cl

1 × Mg

Bohr →





29

B) COVALENT BOND:

The atoms of many non-metals share electrons with other non-metal atoms.

In covalent bonding, atoms overlap slightly, and one unpaired electron from each atom will pair together.

Both atoms are attracted to the same ***pair of electrons***, forming a covalent bond. → must have 2e⁻

A covalent compound is formed when non-metallic atoms ***share electrons*** to form covalent bonds.

A covalent molecule is a ***group of atoms*** in which the atoms are bound together by sharing one or more pairs of electrons. 2+

The pair of electrons involved in a covalent bond are sometimes called the bonding pair.

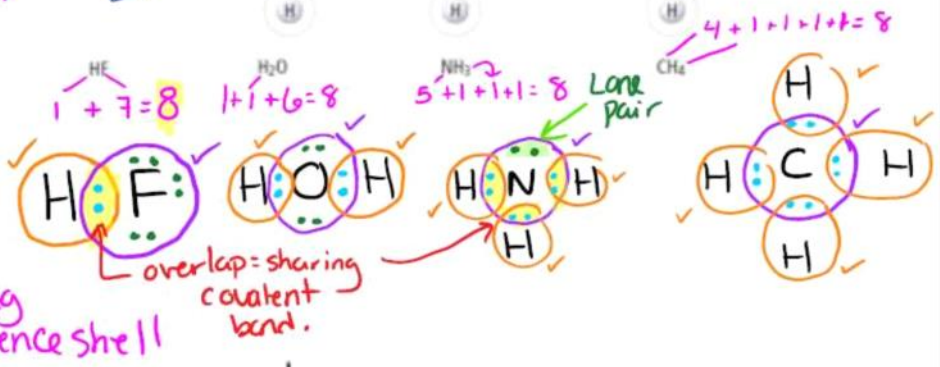
A pair of electrons in the valence shell that is ***not used in bonding*** is sometimes called a lone pair *(unpaired)*.

Bohr Diagram:

1. Total number of valence e⁻
2. Atom in lowest # in center (if any)

Lewis Structure: if equal → side by side

3. 2e⁻ per bond
4. Place remaing e⁻ to fill valence shell



Properties of Ionic Compounds

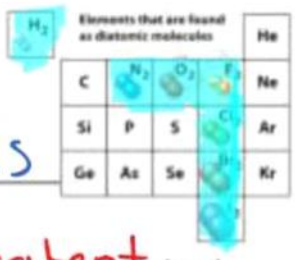
- metal + non-metal
- ⊕ and ⊖ ions
- solid at room temp.
- bonds are strong, so melting points are very high
- dissolve in water to form solutions
- conduct electricity

Properties of Covalent Compounds

- electron sharing
- all non-metals.
- gases and liquids at room temp.
- weaker bonds, low melting point.
- DO NOT conduct electricity
- most are insoluble. (doesn't dissolve) ↵ 31

2 - atoms

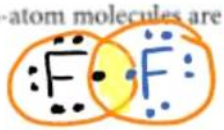
DIATOMIC MOLECULES



You can use Lewis diagrams to help explain why some of the non-metals elements exist as ***diatomic molecules.***

A diatomic molecule is a pair of atoms that are joined by covalent bonds.

Diatomic elements form this way because the two-atom molecules are more stable than the individual atoms.



For example, fluorine gas is diatomic.

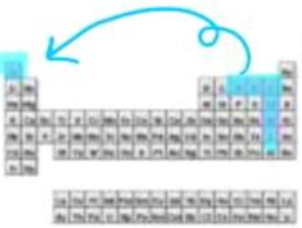
By joining together to form F_2, each fluorine atom can achieve a full valence shell of 8 electrons

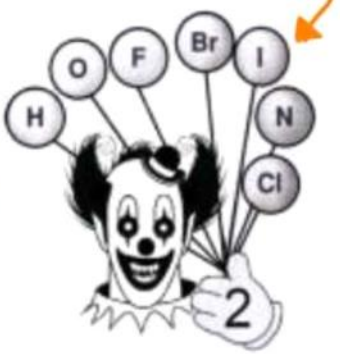
Other diatomic elements are hydrogen (H_2), nitrogen(N_2), oxygen (O_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2).

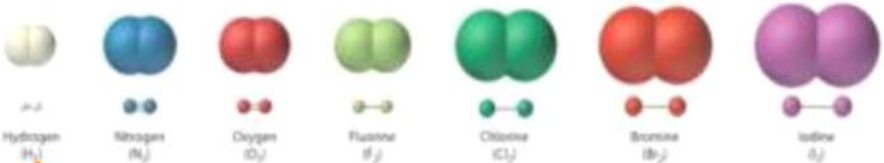
Name of the scary clown

The HOFBrINCl Elements:

- There are 7 naturally occurring elements that, when found in nature, exist as diatomic molecules.
- The atoms will not exist alone, they **bond** to each other.
- This means they must ***always*** be written with a subscript of 2.







always have 2

Homework **Assignment #8: "Check your Understanding" pg 32**
please complete on a separate page

Check Your Understanding

Checking Concepts

1. (a) What is one property that protons and neutrons have in common?
   (b) What is one property that is different for protons and neutrons?
2. Which two subatomic particles are nearly equal in mass?
3. Which subatomic particle is nearly equal to the masses of the other two subatomic particles added together?
4. A bucket full of water has both mass and volume. Referring to the subatomic particles, explain what accounts for most of the:
   (a) mass of the water
   (b) volume of the water

5. Explain how an atom is composed of charged particles yet can have an overall charge of zero.
6. (a) What is the value of the nuclear charge on a neon atom?
   (b) How is the nuclear charge determined?
7. Copy and complete the following chart in your notebook.

	Element	Atomic Number	Number of Protons	Number of Electrons
(a)	Pb	82		
(b)			8	
(c)				30
(d)	Fe			
(e)		47		
(f)				17

8. For each of Cs, S, Kr, C, Fe, and Hg, name its:
   (a) period
   (b) group
9. List four chemical family names, working from left to right across the periodic table.

Understanding Key Ideas

10. Name the subatomic particle(s) that best fit each of the following descriptions.
    (a) has a negative charge
    (b) has an electric charge
    (c) surrounds the nucleus in a regular pattern
    (d) has an electric charge of zero
    (e) is present in the nucleus
    (f) The number of this particle is always the same as the atomic number.
11. How is a covalent compound different from an ionic compound?
12. Compare a Bohr diagram and a Lewis diagram. Explain how they are:
    (a) similar
    (b) different
13. Draw Bohr diagrams for:
    (a) diatomic molecules H_2 and F_2
    (b) covalent compounds H_2O and HCl
    (c) ionic compounds KF and Li_2O
14. Draw Lewis diagrams for:
    (a) diatomic molecules H_2 and F_2
    (b) covalent compounds H_2O and HCl
    (c) ionic compounds NaF, $BeCl_2$ and Li_2O

Pause and Reflect

Think back over the information you have learned about atoms in this section. Illustrate and explain your understanding of the current model for the atom. How have your ideas changed from your earlier understanding of the atom?

Answer KEY:

1 a) both protons and neutrons are about the same mass. They are both subatomic particles and are both found in the nucleus.

b) Protons and neutrons have different electric charges

2. Proton + neutron

3. The neutron is nearly equal to the mass of the proton plus the mass of the electron.

4. a) protons and neutrons
b) Electrons

5. The charges of all the subatomic particles in the atom add up to zero

6 a) 2+

b) The nuclear charge equals the number of protons in the nucleus *(called the "positive nuclear charge")*

7.

	Element	Atomic Number	Number of Protons	Number of Electrons
(a)	Pb	82	82	82
(b)	O	8	8	8
(c)	Zn	30	30	30
(d)	Fe	26	26	26
(e)	Ag	47	47	47
(f)	Cl	17	17	17

Note: these are all neutral atoms (not ions) so # protons = # electrons

8.

Element	(a) Period	(b) Group
Cs	6	1
S	3	16
Kr	4	18
C	2	14
Fe	4	8
Hg	6	12

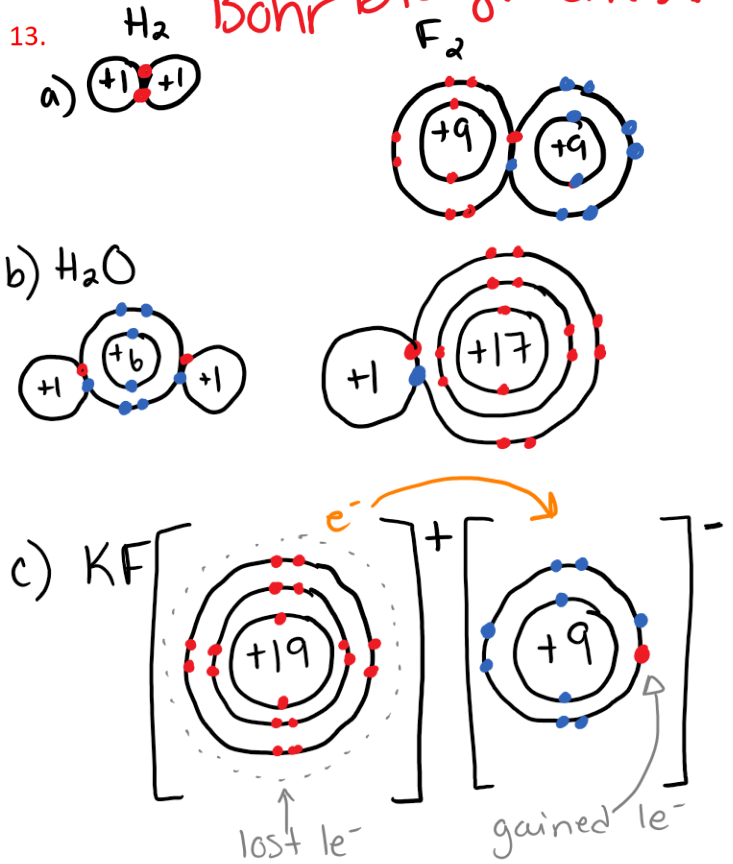
9.Alkali Metals, Alkali Earth Metals, Halogens, Noble Gasses

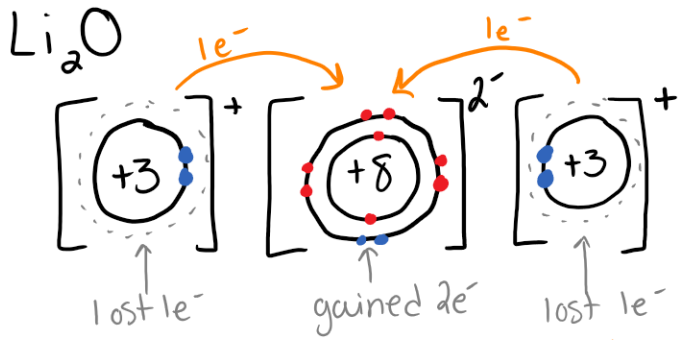
10 a) electron b) proton, electron c) electron d) neutron e) proton, neutron f) proton

11. In a covalent compound, atoms bond together by sharing a pair of electrons. In an ionic compound. In an ionic compound, ions form as a result of the transfer of electrons and then ions of opposite charge (+ and -) attract to each other.

12. a) Bohr + Lewis diagrams are similar in that they BOTH show the valence electrons and they show how bonds form.
b) They are DIFFERENT in that Bohr diagrams show the entire electron configuration, they show ALL the atoms in each electron shell (energy level). Where as Lewis diagrams show only the valence electrons.

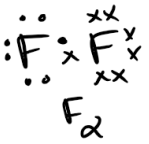
13. Bohr Diagrams:

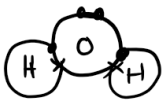




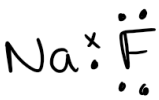
*Note: in ionic compounds, electrons are transferred from the ⊕metal ion to the ⊖non-metal ion

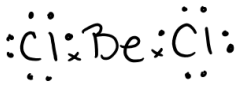
14. Lewis Diagrams

a) H_2 

b) H_2O 

HCl 

c) NaF 

$BeCl_2$ 

Li_2O 

ANSWER KEY FOR ASSIGNMENT #8

"CHECK YOUR UNDERSTANDING QUESTIONS"

SECTION 4.1 ASSESSMENT, p. 183

Check Your Understanding Answers

Checking Concepts

1. (a) Both protons and neutrons are about the same mass. Students may have also mentioned that they are both subatomic particles and are both found in the nucleus.
   (b) Protons and neutrons have different electric charges.
2. Proton and neutron
3. The neutron is nearly equal to the mass of the proton plus the mass of the electron.
4. (a) Protons and neutrons
   (b) Electrons
5. The charges of all the subatomic particles in an atom add up to zero.
6. (a) 2+
   (b) The nuclear charge equals the number of protons in the nucleus.
7.

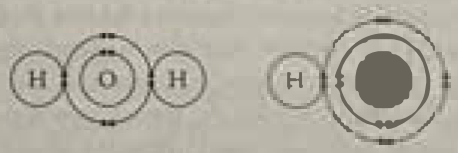
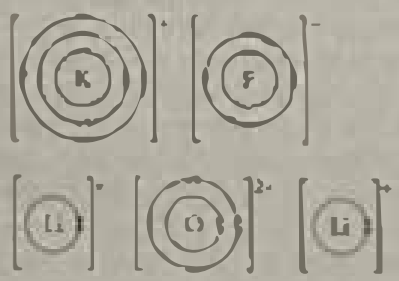
	Element	Atomic Number	Number of Protons	Number of Electrons
(a)	Pb	82	82	82
(b)	O	8	8	8
(c)	Zn	30	30	30
(d)	Fe	26	26	26
(e)	Ag	47	47	47
(f)	Cl	17	17	17

8.

Element	(a) Period	(b) Group
Cs	6	1
S	3	16
Kr	36	36
C	2	14
Fe	4	8
Hg	6	12

9. For example: alkali metals, alkaline earth metals, halogens, noble gases

Understanding Key Ideas

10. (a) Electron
    (b) Proton, electron
    (c) Electron
    (d) Neutron
    (e) Proton, neutron
    (f) Proton
11. In a covalent compound, atoms bond together by sharing a pair of electrons. In an ionic compound, ions form as a result of the transfer of electrons, and then ions of opposite charge attract each other.
12. (a) Bohr and Lewis diagrams are similar in that they show the valence electrons and how they result in bond formation.
    (b) They are different in that Bohr diagrams show all the atoms in each atom or ion, while Lewis diagrams show only valence electrons.
13. (a) 
    (b) 
    (c) 
14. (a) H—H :F—F:
    (b) H—O—H H—Cl
    (c) [Na]+ [:F:]− [Li]+ [:O:]2− [Li]+ [:Cl:]− [Be]2+ [:Cl:]−