

Chemistry : Chemical Processes



- What is Chemistry and Matter?

Chemistry is the study of matter, its properties and its changes or transformations.

Matter is anything that has mass and takes up space.

WHMIS

- Workplace Hazardous Materials Information System
- Why is it important?

WHMIS Symbols

CLASS A



Compressed Gas

CLASS B



Flammable and
Combustible
Material

CLASS C



Oxidizing
Material

CLASS D



1. Materials
Causing Immediate
and Serious Toxic
Effects



2. Materials
Causing Other
Toxic Effects



3. Biohazardous
Infectious Materials

CLASS E



Corrosive Material

CLASS F



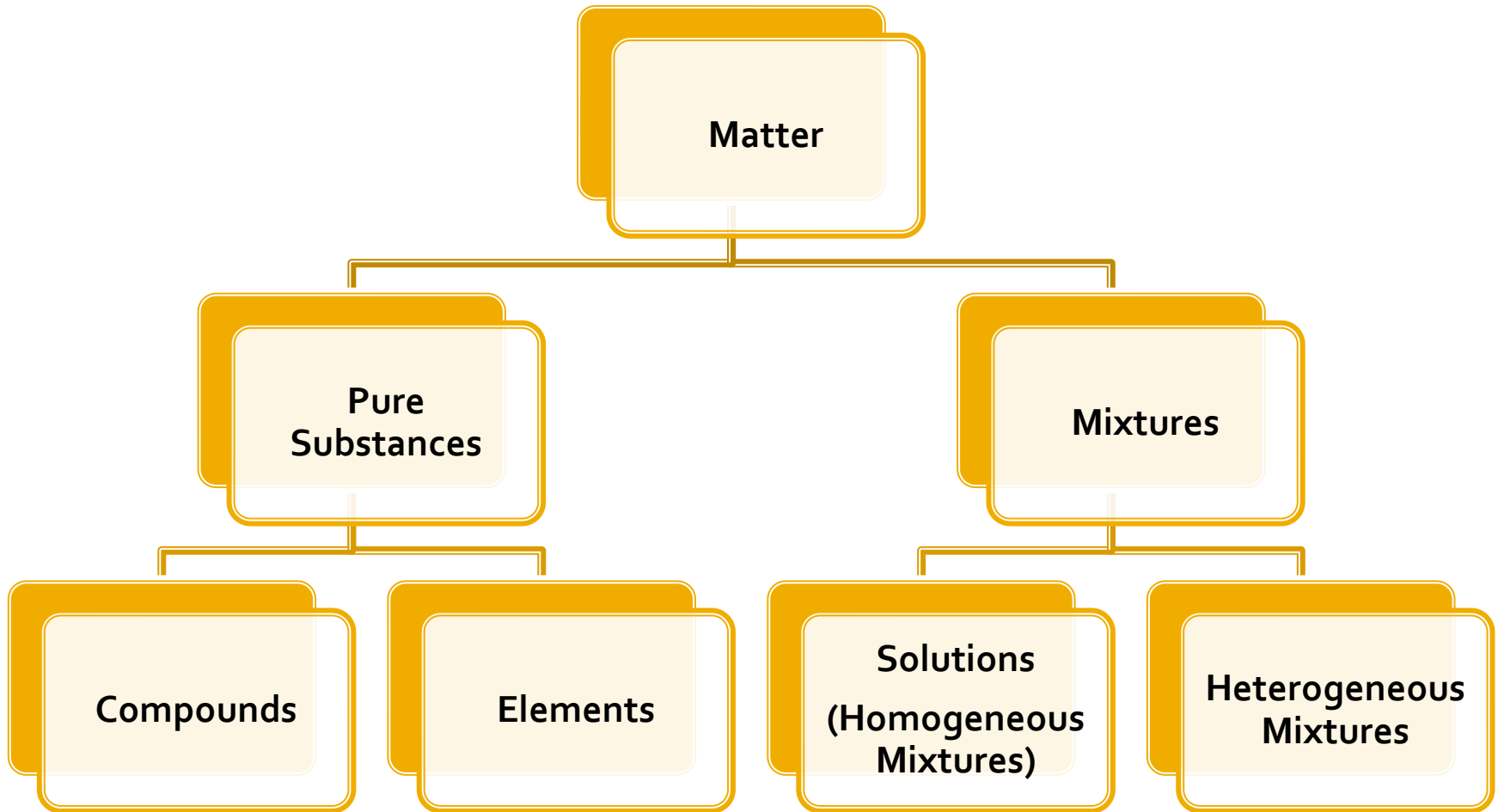
Dangerously
Reactive Material

WHMIS Classes and Hazard Symbols

Hazardous Household Product Symbols (HHPS)

- HHPS is used for products at home.
- WHMIS is used in the workplace.
- MSDS – Materials Safety Data Sheet
 - describes the hazards that are associated with the chemical (protective clothing, how to handle the chemical, how to clean up a spill).

Classification of Matter



Pure Substances

- How do we know that a sample of matter is a pure substance?
- A **pure substance** is made up of all the same particles.
- A pure substance also has constant properties. Example: pure water, aluminum foil.
- Pure substances can be either elements or compounds.

Elements

- Elements are pure substances that cannot be broken down into simpler substances.
- Elements contain only one kind of atom.
- Example: Oxygen, hydrogen, iron, etc.
(anything on the periodic table)

Compounds

- Compounds are pure substances that contain two or more different elements in a fixed proportion.
- Example: Water H_2O = *2 parts hydrogen to 1 part oxygen.*
Salt $NaCl$ = *1 sodium to 1 chlorine*

Mixtures

- A mixture is a substance made by combining two or more different materials in such a way that no chemical reaction occurs.

Homogenous Mixture (Solution)

- Mixture where the two different substances that are combined together are mixed very well.
- Any portion of the sample has the same properties and composition.
- Example: Salt Water
Milk



Heterogeneous Mixture

- Mixture where the different parts or each substance can be separated physically.
- Different parts are visible.
- Example: Toppings on a Pizza
Chocolate chip cookie
Salad



- Salt
- Sugar
- Wood
- Rock
- Water
- Milk
- Plastic
- Glass
- Mercury
- Apple Juice
- Syrup
- Gold
- Air
- Oxygen
- Silver
- Cookies
- Cake
- Sand

Classify the following as:

a) pure or mixture

b) element, compound, heterogeneous or homogeneous mixture

Properties of Matter: Physical and Chemical

- A **Physical Property** is a characteristic of a substance.
- Changing the size or amount of the substance does not change the physical properties.

Physical Properties

- **Color** – red, green, white, etc.
- **Texture** – smooth, fine, coarse.
- **Taste** – sour, sweet, salty.
- **Odour** – what smell does the substance have?
- **States of matter** at room temperature:
 - solid, liquid, gas.

- **Malleable** is the ability of a solid to be hammered or bent into different shapes. Aluminum foil is malleable. Gold is malleable since it can be hammered into thin sheets.
- **Hardness** – the measure of the resistance of a solid to being scratched or dented
- **Luster** – How shiny is the substance?

List the Physical Properties

Baking soda is:

- ✓ solid at room temperature
- ✓ white in color
- ✓ crystal form
- ✓ dissolves easily in water.



Chemical Properties

- A chemical property is a behaviour that occurs when a substance changes to a new substance.
- For example:
 - Is the substance **combustible**?
 - Does the substance have a **reaction with acid**?
 - Does the substance **react with water**?

Physical Changes

1. Do not change the organization of subatomic particles of the sample of matter.
2. Can usually be undone quite easily.

Key: No new substance is created.

- Examples: melting ice, freezing water, dissolving salt into water, breaking a stick.

Chemical Changes

1. Change the organization of subatomic particles of the sample of matter.
2. Not easily undone – almost impossible

Key: New substance almost always formed.

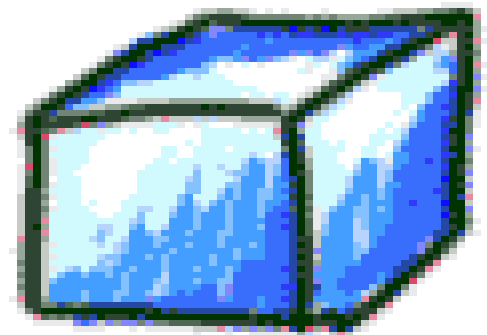
- Examples: burning wood, baking a cake, digesting food

Clues that a chemical change has occurred

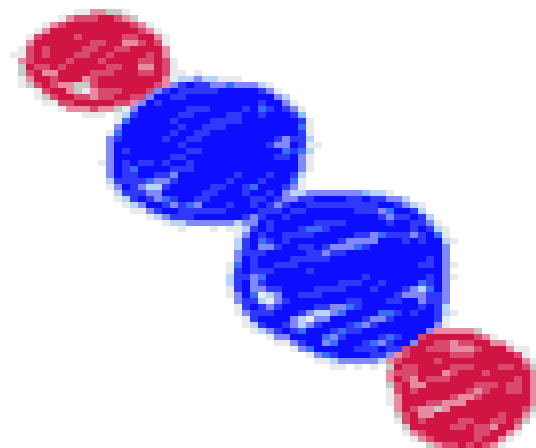
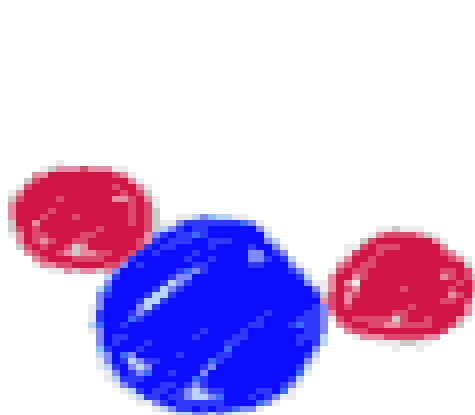
- A new color appears.
- Heat or light is given off.
- Bubbles of gas are formed.
- A solid material (called a precipitate) forms in a liquid.
- The change is difficult to reverse.

Chemical Change

- The starting materials are called reactants and the new materials produced are called products.
- REACTANTS → PRODUCTS



PHYSICAL CHANGE OF
WATER INTO ICE



CHEMICAL CHANGE OF
WATER INTO
HYDROGEN PEROXIDE

Physical Changes

- Here are some examples of physical changes:

Melting popsicle



Broken Twig

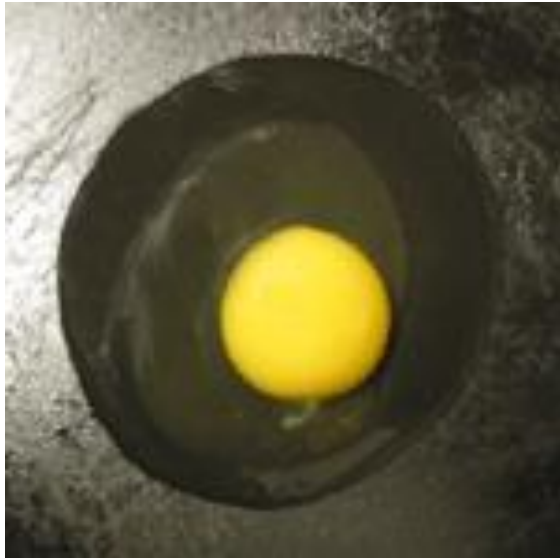




Chemical Change

- Here are some other examples of chemical changes:

Raw egg becomes cooked egg



Cake mix becomes cake



Steel becomes rust



Your Turn



Chemical or Physical Changes

Chemical or Physical ?

Cutting a piece of wood.



Chemical or Physical ?

Chewing of food



Chemical or Physical ?

Rusting Nail



Chemical or Physical ?

Ice Melting



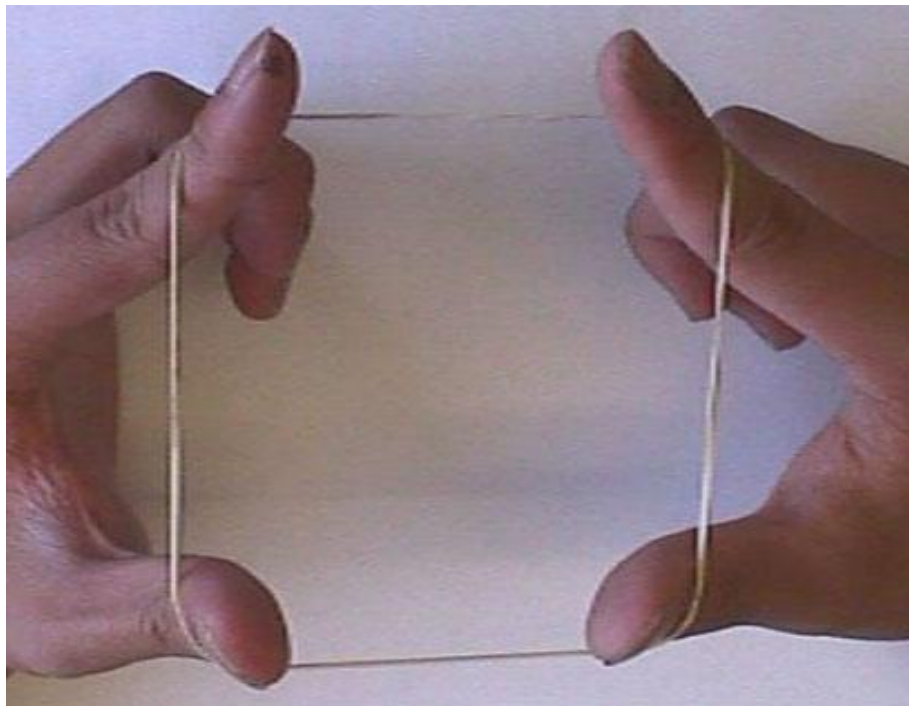
Chemical or Physical ?

Burning a Match



Chemical or Physical ?

Stretching a Rubber Band



Chemical or Physical ?

Breaking a Stick



Chemical or Physical ?

Tarnishing Silver



Chemical or Physical ?

Ripening Tomatoes



Chemical or Physical ?

Water Boiling



Chemical Tests

Used to identify unknown substances.

Examples:

1. Oxygen gas is indicated if glowing splint bursts into flame
2. Carbon Dioxide is present if limewater solution turns milky. (white precipitate)

Chemical Tests

Examples:

3. Hydrogen gas is present if flaming split makes a "pop."
4. Water vapor is present if cobalt chloride paper changes from blue to pink

Assignment

Questions: Page 175 # 1 – 12

Page 179 # 1, 2, 3, 4, 5, 8

The Atom

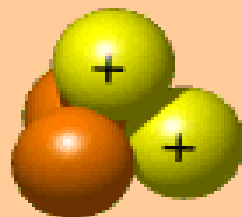
Atoms are made out of three basic particles:



Protons – carry a positive charge



Neutrons – carry no charge

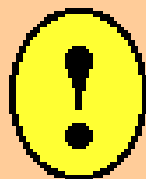


**Protons and Neutrons join together to form
the Nucleus – the central part of the atom**



**Electrons – carry a negative charge
and circle the nucleus**

Click on a particle to learn more about it



Fun Facts

Electrons

- Negatively charged (-)
- Almost have no mass ($1/1836^{\text{th}}$ mass of protons & neutrons)
- Located around the outside of the nucleus

Proton

- Same mass as neutrons
- Positively charged (+)
- Located in center of atom (nucleus)
- Number of protons in an atom is equal to the elements atomic number.

Neutron

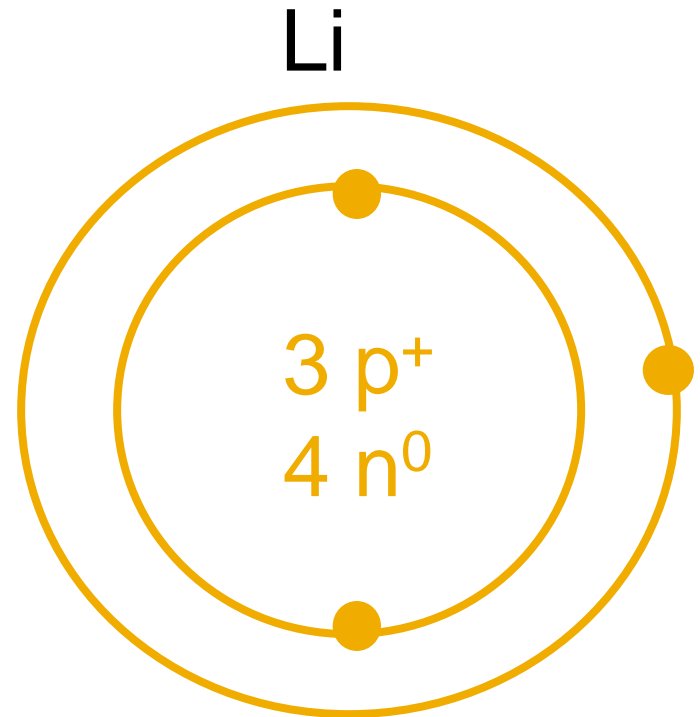
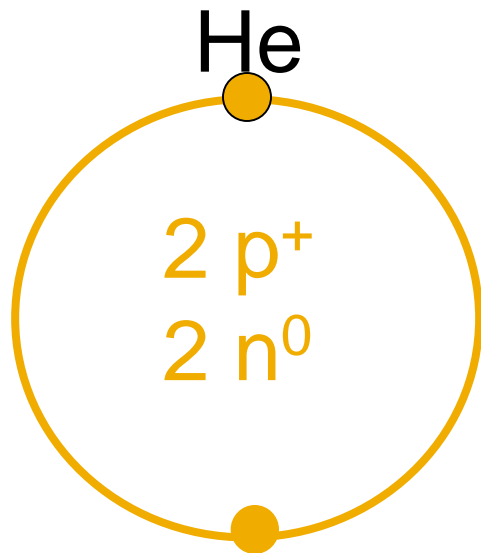
- Same mass as proton
- No charge
- Located in nucleus
- Number per atom may vary – but is similar to number of protons

Bohr's Planetary Model of the Atom

- Bohr suggested that:
- Electrons move around the nucleus in circular paths called **orbits**, like planets around the sun.
- Each electron has a definite amount of energy.
- The order of filling of electrons in the first three orbits is 2, 8, 8.
- Electrons are more stable when they are at the lower energy.

Bohr - Rutherford Diagrams

1. Find the # of protons, neutrons, and electrons
2. Draw protons (p^+), (n^0) in circle (i.e. “nucleus”)
3. Draw electrons around in shells - 2,8,8 are the numbers of electrons allowed in the rings for the first 20 elements



Lewis Dot Diagrams

- Used to easily show the outer level electrons (valence electrons) of atoms.

Step 1: Determine the valence electrons

Group 1 - 1

2 - 2

13 - 3

14 - 4

15 - 5

16 - 6

17 - 7

18 - 8

- Step 2: Write the element symbol and a dot for each valence electron.

*** each side can hold 2 valence electrons.
They go in one at a time before pairing up.

- Example:

Nitrogen - group 15 - 5 valence electrons

- Lewis dot diagram worksheet
- Draw Bohr Rutherford diagrams for:
 - Silicon
 - Beryllium
 - Oxygen
 - Potassium
 - Phosphorus

The Periodic Table

Periodic table of the elements

group 1* Ia**	2 IIa											13 IIIa	14 IVa	15 Va	16 VIa	17 VIIa	18 0
1 H												5 B	6 C	7 N	8 O	9 F	10 Ne
3 Li	4 Be											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
11 Na	12 Mg	3 IIIb	4 IVb	5 Vb	6 VIb	7 VIIb	8 VIIIb	9 VIIIb	10 VIIIb	11 Ib	12 IIb	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	113 *** (Uub)	114 *** (Uut)	115 *** (Uuq)	116 *** (Uuh)		
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 *** (Uub)	113 *** (Uut)	114 *** (Uuq)	115 *** (Uup)	116 *** (Uuh)		
lanthanide series 6		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
actinide series 7		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

* Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).

** Numbering system widely used, especially in the U.S., from the mid-20th century.

*** Discoveries of elements 112–116 are claimed but not confirmed. Element names and symbols in parentheses are temporarily assigned by IUPAC.

- Elements are arranged to help us to explain and predict physical and chemical properties.

- Period – elements in the same row; rows are numbered from top to bottom
- Family – elements in the same column; these elements have similar properties

Elemental Families:

- tend to have similar chemical and physical properties

1. Alkali Metals – shiny, silvery metals, compounds soluble in water
2. Alkaline Earth Metals – shiny, silvery metal, compounds insoluble in water
3. Transition Metals – center columns
4. Halogens – non-metals, react readily with alkali metals
5. Noble Gases - nonreactive

Elemental Families

- Tend to have similar physical and chemical properties.
 - Found in same vertical column.
1. Alkali Metals – shiny, silvery metals, compounds soluble in water
 2. Alkaline Earth Metals – shiny, silvery metal, compounds insoluble in water
 3. Transition Metals – center columns
 4. Halogens – nonmetals, react readily with alkali metals
 5. Noble Gases - nonreactive

Alkali Metals

- The elements that occupy the far left column of the periodic table are called Alkali Metals.
- Called Group 1 elements
- These elements are extremely reactive.

Alkali Earth Metals

- Found in group 2.
- Form compounds that are often insoluble in water.

Halogens

- Halogens occupy the 17th column of the periodic table. (F, Cl, Br, I, At)
- These elements are the most reactive non-metals.
- All halogens are poisonous elements that react readily with sodium and other alkali metals.

Metalloids

- Metalloids are elements that possess both metallic and nonmetallic properties.
- They are found in different groups on the far right side of the periodic table.
- Examples: Silicon, boron, germanium, arsenic, selenium, antimony, tellurium, polonium, and astatine are all metalloids.

Noble Gases

- Noble Gases are the elements that occupy the far right column of the periodic table.
(He, Ne, Ar, Kr, Xe, Rn)

Also Called inert gases because Noble gases generally do not form compounds.

All gases at room temperature.

Properties of Metals and Non Metals

METALS

- Shiny
- Malleable
- Conductors
- Most of them react with acid
- Mostly solids

NON METALS

- Dull
- Brittle
- Mostly insulators
- Do not react with acid
- Solids, liquids and gases at room temperature.

Periodic Table Activity

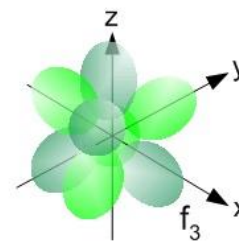
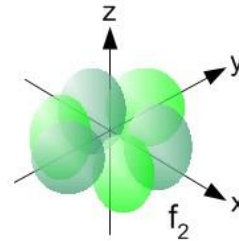
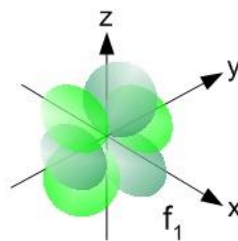
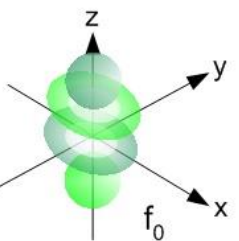
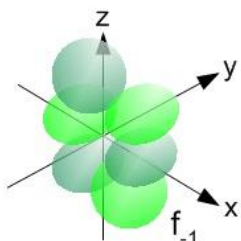
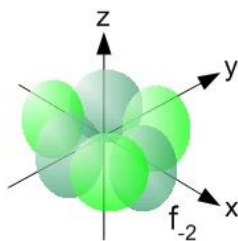
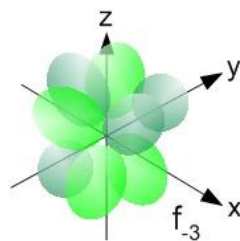
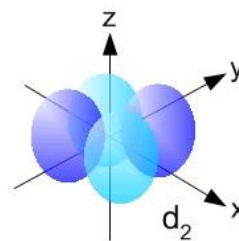
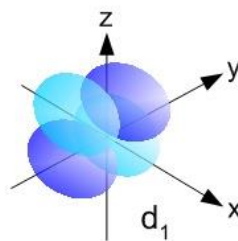
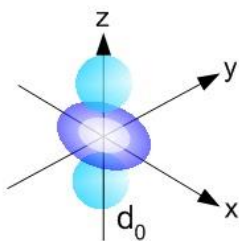
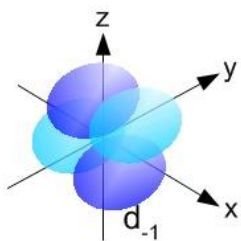
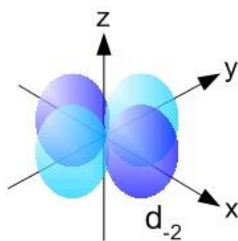
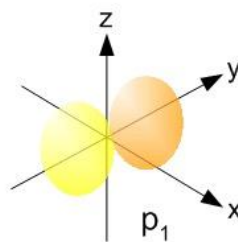
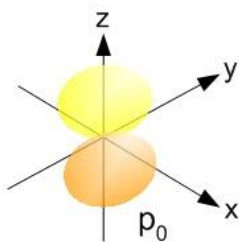
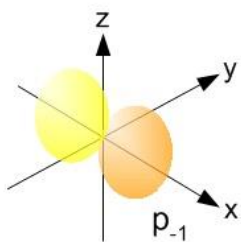
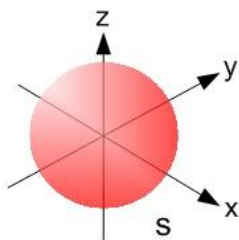
1. Name elements:
 - 1-30, 35, 47, 50, 53, 56, 79, 80, 82
2. Label the following families:
 - Noble Gases
 - Halogens
 - Alkali Metals
 - Alkaline Earth Metals
 - Transition Metals

Questions

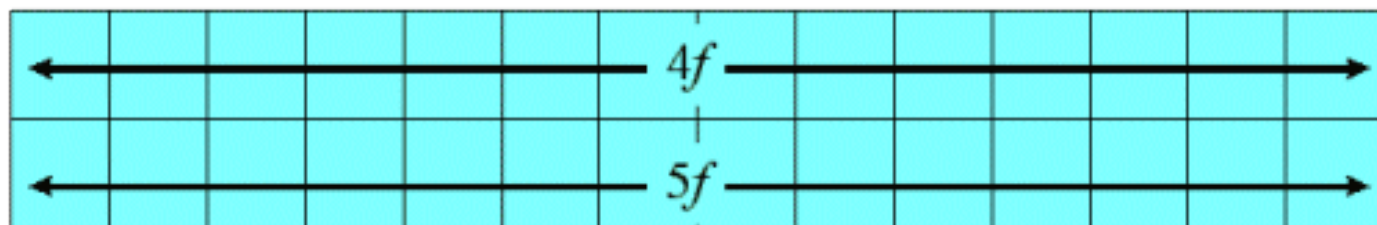
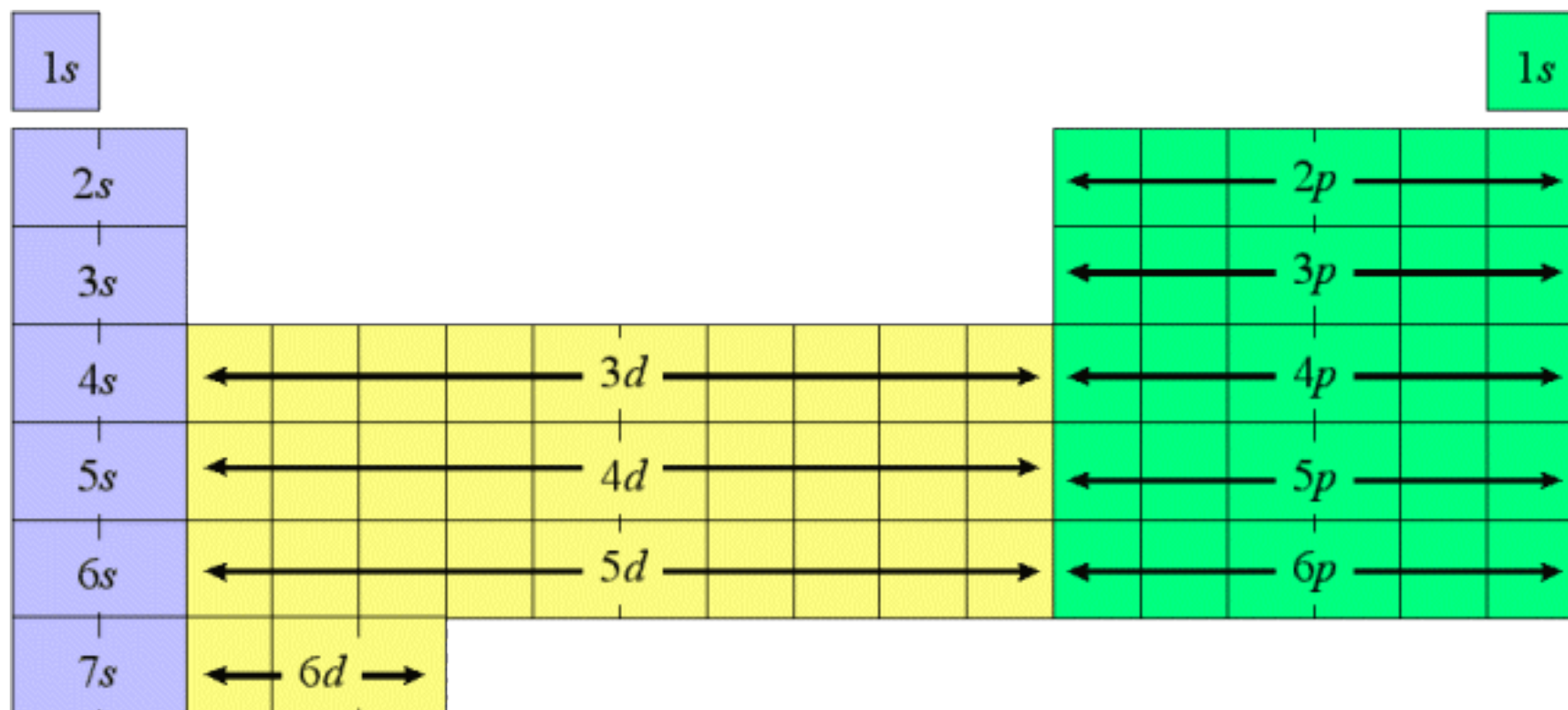
Questions Page 187 # 1 (a-d), 2,

Electron Configuration

- We now know that electrons actually do not live in circular paths – they travel in 3-dimensional spaces called orbitals.
- Every orbital can hold ONLY 2 electrons.
- The way electrons fill up the orbitals in an atom is very specific – this is called the ELECTRON CONFIGURATION



- The orbitals match up with the periodic table in a specific way...



Rules for Electron Configuration

- Each orbital can hold 2 electrons MAX
- If an orbital has its maximum number of electrons, they must spin opposite ways
- In any one level, you must HALF fill every orbital with one electron before you put 2 in any

Let's Try:

- Write the electron configuration for sodium:
- Write the electron configuration for chlorine:

- Write the electron configuration for zinc
- Write the electron configuration for uranium

Ionic Compounds

- Metals and non-metals combine to form ionic compounds by transferring electrons.
- Metal atoms lose electrons to form positive ions. (**cation**)
- Non-metal atoms gain electrons to form negative ions. (**anion**)
- Metals are found to the LEFT of the staircase.

Name some ions

What is the ion formed by sodium?

What is the ion formed by chlorine?

What is the ion formed by oxygen?

What are the ions formed by copper?

Polyatomic Ions

- Polyatomic ions are ions that are made from MANY atoms

Common Polyatomic Ions

ion	name	ion	name
NH_4^+	ammonium	CO_3^{2-}	carbonate
NO_2^-	nitrite	HCO_3^-	hydrogen carbonate
NO_3^-	nitrate	ClO^-	hypochlorite
SO_3^{2-}	sulfite	ClO_2^-	chlorite
SO_4^{2-}	sulfate	ClO_3^-	chlorate
HSO_4^-	hydrogen sulfate	ClO_4^-	perchlorate
OH^-	hydroxide	$\text{C}_2\text{H}_3\text{O}_2^-$	acetate
CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$\text{Cr}_2\text{O}_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
H_2PO_4^-	dihydrogen phosphate	O_2^{2-}	peroxide

Writing Formulae For Ionic Compounds

■ Rules

- Write the symbol and charge for each ion
- Criss cross the charges (get rid of negative signs)
- If the charges are the same, drop them
- If the charges can be reduced, reduce them

EXAMPLE:

- Sodium chloride

Example:

- Calcium fluoride

Example:

- Copper (II) nitride

Example:

- Barium sulfate

Example:

- Magnesium nitrate

Naming Ionic Compounds

- Rules:

- Write the name of each ion in order
- If the metal ion has two charges, indicate which charge is used with a roman numeral
- 1 = I
- 2 = II
- 3 = III
- 4 = IV
- 5 = V

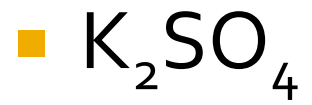
Example:



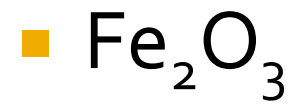
Example:

- ZnO

Example:



Example:



Molecular Compounds

- Made of 2 NON METALS!
- Molecular Compounds contain **neutral groups of atoms** called molecules.
- Covalent bonds are created when **nonmetal atoms** and their outside valence rings share electrons that hold atoms together.

- Diatomic molecules are made from **two similar atoms** creating a covalent bond.

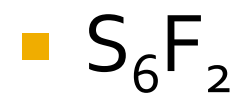
■ Example:	Symbol	Formula	State
■ Hydrogen	H	H ₂	gas
■ Oxygen	O	O ₂	gas
■ Nitrogen	N	N ₂	gas
■ Fluorine	F	F ₂	gas
■ Chlorine	Cl	Cl ₂	gas
■ Bromine	Br	Br ₂	liquid
■ Iodine	I	I ₂	solid

- Atoms of different elements can also form covalent bonds.
- Combining capacity of a nonmetal is a measure of the number of covalent bonds that it will need to form a stable molecule. This number replaces the ionic charge for writing formulas.

WE USE PREFIXES TO IDENTIFY THE NUMBER OF ATOMS IN MOLECULAR COMPOUNDS

- 1 – mono
- 2 – di
- 3 – tri
- 4 – tetra
- 5 – penta
- 6 – hexa
- 7 – hepta
- 8 – octa
- 9 – nona
- 10 - deca

Example:



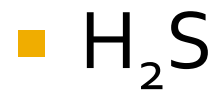
EXAMPLE:

- CO_2

EXAMPLE:



EXAMPLE:



EXAMPLE:

- Tetracarbon pentasulfide

Example:

- Dinitrogen hexafluoride

Example:

- Xenon heptachloride

Chemical Reactions

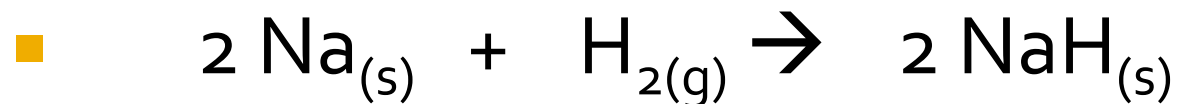
- The combination of substances to produce different substances
- $A + B \rightarrow C + D$
- A and B are the starting materials or REACTANTS
- C and D are the final materials or PRODUCTS

5 Types of Chemical Reactions

- Combustion
- Decomposition
- Formation/Synthesis/Combination
- Single Replacement
- Double Replacement

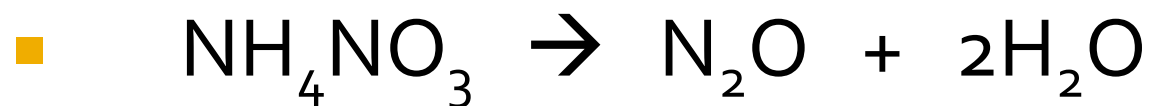
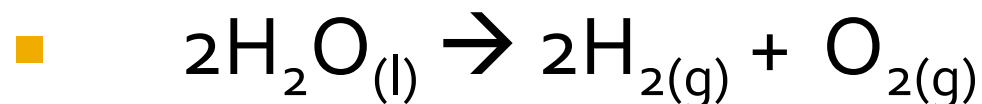
Formation/Synthesis/Combination

- The creation of a compound from elements
- Example:



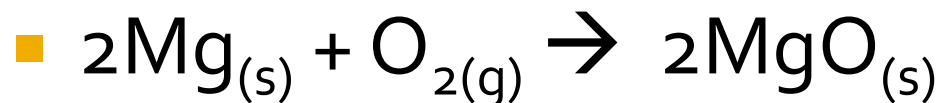
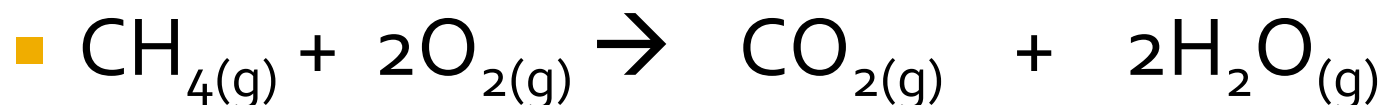
Decomposition Reaction

- Breaking down a single substance into two or more substances



Combustion Reaction

- When a substance is reacted with oxygen (burns in the presence of oxygen)
- Produces the most common oxides of reactants

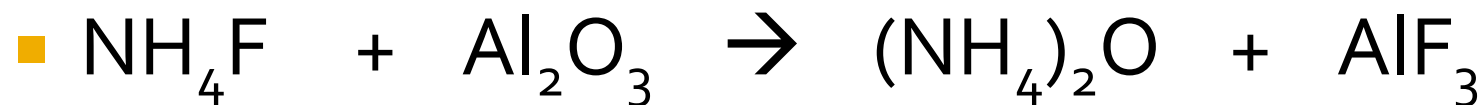


Single Replacement Reaction

- A compound reacts with an element, cations switch places.
- $2\text{Na} + \text{CaCl}_2 \rightarrow \text{Ca} + 2\text{NaCl}$
- $\text{Zn}(\text{OH})_2 + 2\text{K} \rightarrow 2\text{KOH} + \text{Zn}$

Double Replacement Reaction

- Two compounds react, cations switch places



Name the type of reaction



ACIDS AND BASES

■ Acids

- Taste sour
- Dissolve in water
- Good conductors of electricity
- Very reactive

■ Bases

- Bitter tasting
- Dissolve in water and feel SLIPPERY
- Good conductors of electricity
- Also called **alkaline**

Formulas for Acids

Acids often have “H” at the beginning of chemical formula

Table 1 Examples of Some Common Acids		
Common name	Formula	Source or use
vinegar (acetic acid)	$\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$	salad dressing
citric acid	$\text{HC}_6\text{H}_7\text{O}_7(\text{aq})$	oranges, lemons
ascorbic acid	$\text{HC}_6\text{H}_7\text{O}_8(\text{aq})$	Vitamin C
lactic acid	$\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$	sour milk
carbonic acid	$\text{H}_2\text{CO}_3(\text{aq})$	carbonated drinks
acetylsalicylic acid (ASA)	$\text{HC}_9\text{H}_7\text{O}_4(\text{aq})$	Aspirin
sulfuric acid	$\text{H}_2\text{SO}_4(\text{aq})$	car batteries

Formulas for Bases

Bases often have "OH" at the end of chemical formula

Table 2 Examples of Some Common Bases		
Common name	Formula	Use
sodium hydroxide	$\text{NaOH}_{(\text{aq})}$	drain cleaner
potassium hydroxide	$\text{KOH}_{(\text{aq})}$	soap, cosmetics
aluminum hydroxide	$\text{Al}(\text{OH})_{3(\text{aq})}$	antacids
ammonium hydroxide	$\text{NH}_4\text{OH}_{(\text{aq})}$	ammonia window cleaner
sodium bicarbonate	$\text{NaHCO}_{3(\text{aq})}$	baking soda
potassium sulfite	$\text{K}_2\text{SO}_{3(\text{aq})}$	food preservative

Testing Acids and Bases

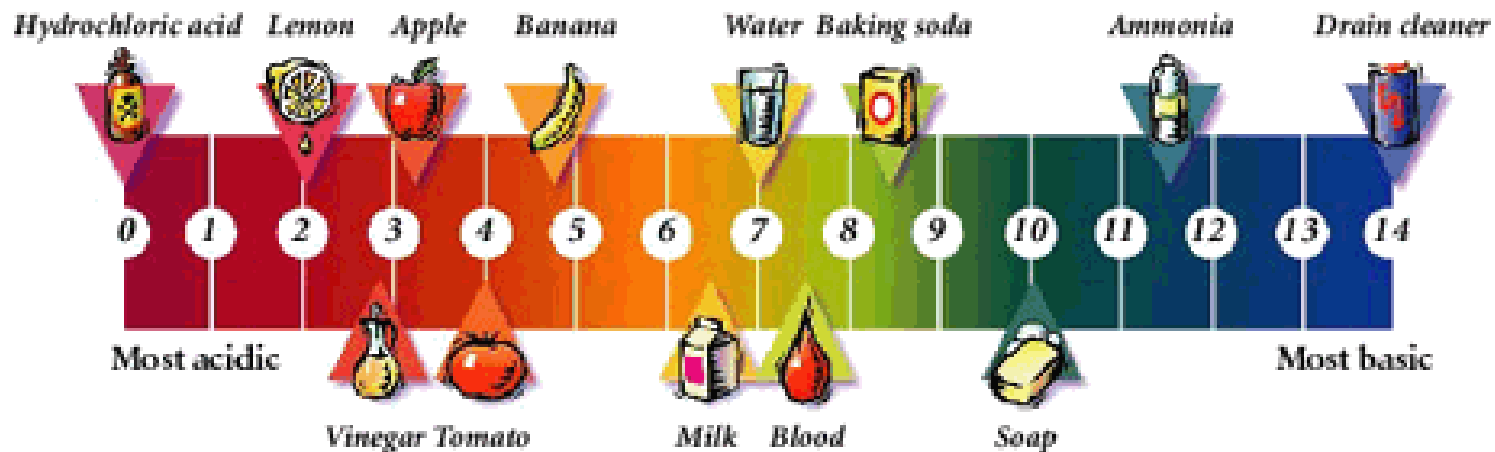
- Dissolve unknown substance in water and use litmus paper or an acid base indicator
- Litmus paper
 - Acids turn blue litmus paper red
 - Bases turn red litmus paper blue
- Acid Base indicator (there are many)
 - Phenolphthalein turns is clear when exposed to acids, but is pink when exposed to a base

The pH Scale

- Scientists use the **pH Scale** to measure how acidic or basic substances are
- Important because concentrated acids and bases are dangerous and can eat through skin, etc.

- The scale ranges from 0 – 14
 - Acids have a pH between 0 and 7
 - Bases have a pH between 7 and 14
 - PURE WATER has a pH of 7 and is NEUTRAL

The pH Scale



- If an acid has a very low pH (like 2) it is very concentrated.
- If a base has a very high pH (like 13) it is very concentrated.

- Pg 292 q 1, 4

- Pg 295 q 3, 4, 6