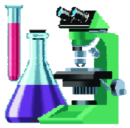
Matter Links: Grid Club
Science In Action
Matter and Chemical Change



***Science in Action Textbook* (pgs. 88-109)**

Unit 2 Matter and Chemical Change

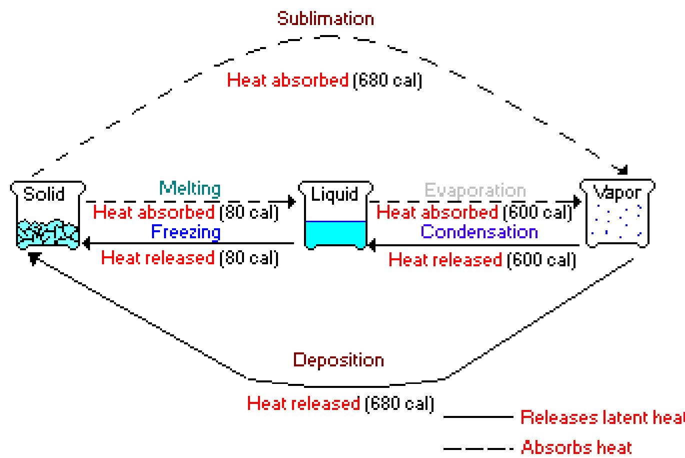
1.0 Matter can be described and organized by its physical and chemical properties.

1.1 Safety in the Science Classroom

Lab Safety Notes (Detailed)
Practice Safety Test

1.2 Organizing Matter

Matter exists in three states: solid, liquid, or gas.
Matter can undergo a change in state when energy is used or released.

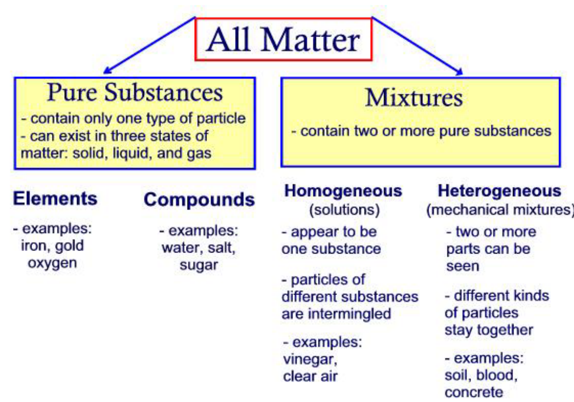


Properties are characteristics that can be used to describe a substance. These properties can be physical or chemical.

Physical properties (**sia p. 77**)
These can include: color, luster, melting point, boiling point, hardness, malleability, ductility, crystal shape, solubility, density and conductivity.

Chemical properties describe how a substance interacts with other substances. Chemical properties include: reaction with acids, ability to burn, reaction with water, behaviour in air and reaction to heat. A **chemical change** always results in the formation of a different substance, which has its own unique ‘different’ physical properties.

Pure Substance or Mixture?



The physical and chemical properties of a substance show us whether a substance is '**pure**' or a '**mixture**'.

A pure substance is made up of only one kind of matter and has its own unique set of physical properties.

Types of Pure Substances

- element

- cannot be broken down into any simpler substance

- compound

- is a combination of two or more elements in fixed proportions

A mixture is a combination of pure substances

Types of Mixtures

- mechanical (***heterogenous***)

- each substance in the mixture is visible

- solution (***homogeneous***)

- each substance is not clearly visible
(A substance dissolved in water is called an aqueous solution)

- suspension

- is a cloudy mixture in which tiny particles are held (suspended) with another substance, and can be filtered out

- colloid

- is also a cloudy mixture, but the particles are so small that they cannot be filtered out easily

1.3 Observing Changes in Matter

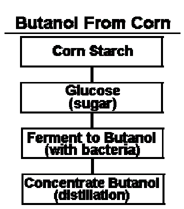
Matter can change from one form to another, or create new materials.
A **physical change** occurs when a material changes state.
A **chemical change** occurs when two or more substances react and create a new substance.

Evidence that a chemical change has occurred includes:

- Change in colour
- Change in odour
- Formation of a gas
- Release or absorption of energy (heat)

Controlling Changes In Matter To Meet Human Needs

Freeze-drying allows food to be processed by removing the water (by freezing and sublimation) and then packaged to be **ready to eat** just by adding hot water. Biologists, to study plant cells and tissue, also use the freeze-drying method. It has also benefited scientists who need to restore ancient relics or documents that have been damaged by water.

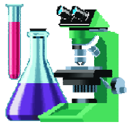


From Corn To Nail Polish Remover and Plastic Wrap?

Scientists are able to change other common materials into useful products.
Corn - makes soda pop bottles, removes paint or nail polish and **fuels some cars**.
These refined products are more environmentally friendly.

Check and Reflect **p. 109**

Assess Your Learning **p. 110-111**



Science in Action Textbook (pgs. 112-133)

Unit 2 Matter and Chemical Change

2.0 An understanding of the nature of matter has developed through observations over time.

2.1 Evolving Theories of Matter (pgs. 113-120) - Timeline

Year	Evolving Theory of Matter	3D Model
8000 B.C.	*(Stone Age) Matter was made up of solid material, which could be fashioned into tools.*	*Stone implements*
6000-1000 B.C.	*Chemists investigated the properties of only those materials that were of high value to humans. (gold and copper)*	Metals
4500 B.C	*(Bronze Age) The effect of heat on copper, lead to the creation of a strong material (bronze) for use as tools.*	Bronze tools
1200 B.C.	*(Iron Age) Iron combined with carbon to make steel, for even stronger tools.*	Steel
350 B.C.	*Everything was made out of Air – Water - Earth – Fire (atomos particles)*	Earth/Wind/Fire/Ice
1500	*Theory of Matter was based more on experimentation. (History of Alchemy)*	States of Matter
1660	*Particles can be compressed. (Boyle)*	Particles
1770	*System for the naming of chemicals was developed. (Lavoisier)*	Molecule
1780	*Air is necessary for combustion to occur.*	Molecules
1808	*Observation principles during experimentation.*	Dalton Model
1897	*Raisin bun model with charged particles.*	Raison bun
1904	*Negatively charged particles orbiting around nucleus.*	Rutherford
1922	*Electrons rotate randomly around the nucleus.*	Bohr

Today the 'quantum model' describes the atom as a cloud of electrons around a nucleus

2.2 Organizing the Elements (p. 122-125)

Finding a pattern in an unknown helps scientists to organize ideas and information. It also helps scientists to interpret what the information means and explain these ideas, based on what they have learned.

Looking for Patterns

Early chemists used **symbols** of the sun and the planets to identify the metallic elements known to them.

Metal	**gold**	**silver**	**iron**	**mercury**	**tin**	**copper**	**lead**
Symbol	○	☾	♂	Ŏ		♀	
Celestial Body	**Sun**	**Moon**	**Mars**	**Mercury**	**Jupiter**	**Venus**	**Saturn**

This later became a problem, when more elements were discovered, because they ran out of planets. **(History of Chemical Symbols). John Dalton** developed a new set of symbols in the early 1800's to improve communication between chemists.

Symbol	⊙	○	●	Ⓖ	Ⓢ	◌
Element	**hydrogen**	**oxygen**	**carbon**	**gold**	**silver**	**mercury**

Berzelius later revised **Dalton's** symbols by replacing them with letters, instead of pictures. He represented the elements by their first letter (capitalized), or their first two letters (first one capitalized and the second letter was lower case).

An Order for the Elements

Elements were listed in order of their atomic mass. **Atomic mass** is the mass of one atom of an element. It is represented in ***atomic mass units*** (**amu**).

John Newland's "***law of octaves***" identified the pattern in which the properties of the elements seemed to repeat at regular intervals, similar to the octave scale in music. Demitri Mendeleev later revised the pattern in 1869.

Finding a Pattern

Mendeleev collected the 63 elements known at the time and arranged them according to their properties (which he wrote on a file card). He arranged the cards into a 'solitaire-like' table. By sorting and arranging the elements in this way, Mendeleev was able to identify gaps where elements, not yet discovered, would be able to fit.

			Ti=50	Zr=90	?[2]=180
			V=51	Nb=94	Ta=182
			Cr=52	Mo=96	W=186
			Mn=55	Rh=104,4[3]	Pt=197,4[4]
			Fe=56	Ru=104,4	Ir=198
			Ni=Co=59	Pd=106,6	Os=199
H=1[5]			Cu=63,4	Ag=108	Hg=200
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?[6]=68	Ur=116[7]	Au=197?
	C=12	Si=28	?[8]=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	J=127[9]	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207
		?[10]=45	Ce=92[11]		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

2.3 The Periodic Table Today (Periodic Table Video Notes)

About 112 elements are known today.
They are organized into what is called **'The Periodic Table of Elements'**
In 1875 gallium was discovered and proved that Mendeleev's organization of the elements worked, because it fit in where he had placed a (**?**). The next (**?**) was not replaced until 1939 when francium was discovered.

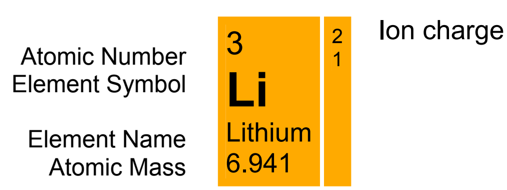
Understanding the Periodic Table (Web Elements.com)

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

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
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

Horizontal rows are called **periods** (*numbered* 1-7)
Vertical columns form a **group**, or **family** of elements (*numbered* 1-18)
[**Different versions**] http://chemlab.pc.maricopa.edu/periodic/foldedtable.html
Los Alamos Periodic Table
Visual Elements (Flash Version)

Useful Information On Each Element



Other Names for Elements

Patterns of Information In The Periodic Table

All the elements in a **group** (or column) are called **families.**

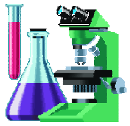
Metals, Non-metals and metalloids
Groups
Periods

Other Interesting Patterns

Alkali metals
(Group 1): **The Alkali Earth Metals**, all react with water in the following manner
2 Li + H_2O ---> H_2 + 2 LiOH
2 Na + H_2O ---> H_2 + 2 NaOH
2 Fr + H_2O ---> H_2 + 2 FrOH
Halogens
(Group 8): The **Noble Gases**, don't react with other elements.

Check and Reflect **p. 134**

Assess Your Learning **p. 136-137**



Science in Action Textbook (pgs. 139-153)

Unit 2 Matter and Chemical Change

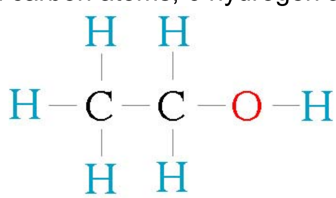
3.0 Compounds form according to a set of rules.

3.1 Naming Compounds (pgs. 139-142)

As you learned in the last section (*The Periodic Table*), each element has a chemical name. The combination of elements to form **compounds** has a **chemical name** and a **chemical formula**. The formula identifies which elements and how many of each are in the compound.

For example:

ethanol (C_2H_6O) has **2** carbon atoms, **6** hydrogen atoms and **1** oxygen atom



To determine the name, a standardized chemical naming system, or **nomenclature**, is used. Guyton de Morveau in France developed it in 1787. The metal name is always first. Since 1920, the **IUPAC** (*International Union of Pure and Applied Chemistry*) is responsible for determining the appropriate name for each compound.

Interpreting Chemical Names and Formulas From Compounds

If you know the formula for a compound you can determine its chemical name – if you know its name, you can determine its formula.

Write the **chemical formula** as determined by the **name** of the compound.

(If a poly atomic ion is part of the formula, keep the poly-atomic ion intact)

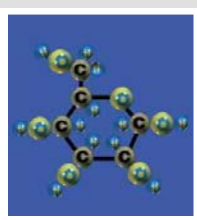
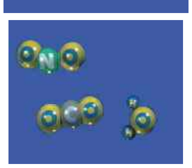
Aluminum oxide	2 - Al	3 - O	Al_2O_3
Calcium nitrite	1 - Ca	2 - NO_2	$Ca(NO_2)_2$
Sodium Chloride	1 - Na	2 – Cl_2	NaCl

If the compound contains a metal the compound is ionic.

If the compound does not contain a metal, it is molecular.

Write the **name** of the compound as determined by the **chemical formula**.

Al_2O_3	2 - Al	3 - O	Aluminum oxide
$Ca(NO_2)_2$	1 - Ca	2 - NO_2	Calcium nitrite
NaCl	1 - Na	2 – Cl_2	Sodium Chloride

Chemical Name & Physical State	Atomic model	Chemical Formula
Glucose (s) - solid		**$C_6H_{12}O_6$** The chemical formula for glucose tells us that each molecule is made of 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.
Nitrogen dioxide (g) - gas **Carbon dioxide** (g) - gas **Water** (l) – liquid		**NO_2** **CO_2** **H_2O**

(aq) – **aqueous solution** This is used when substances are dissolved in water.
A saltwater solution would be **NaCl** (aq)

3.2 Ionic Compounds (pgs. 144-148)

Sodium Chloride (table salt) – **NaCl** – is an **ionic compound**. Ionic compounds are pure substances formed as a result of the attraction between particles of opposite charges, called **ions**.

Properties of ionic compounds

- **High melting point**
- **Good electrical conductivity**
- **Distinct crystal shape**
- **Solid at room temperature**

When the ionic compound is dissolved in water, the metal (**Na**) and nonmetal (**Cl_2**) form an aqueous solution of ions. An ion is an atom or group of atoms that has become electrically charged through ***a loss or gain of electrons***. (see Table **sia** p. 146)

Ion Charges
A superscript (**+**) or a (**–**) are used to indicate the charge. **Na^+** and **Cl^-**
Some ions can also form when certain atoms of elements combine. These ions are called **polyatomic** ions (*poly* meaning "*many*"). Polyatomic atoms are a group of atoms acting as one.

Example:

1 carbon atom reacting with 3 oxygen atoms produces
1 carbonate group of atoms, which act as one. **CO_3^{2-}**

Then, when carbonate ions react with calcium atoms they produce calcium carbonate, or limestone. **Ca CO_3^{2-}**

Naming Ionic Compounds
Two rules:

1. The chemical name of the metal or positive ion goes first, followed by the name of the non-metal or negative ion.
2. The name of the non-metal negative ion changes its ending to **ide**.

NB: *one exception* – Where negative ions are polyatomic ions, the name remains unchanged.
Some elements with *more than one ion charge* use a roman numeral in its chemical name to clearly show which ion is being used. **Cu(II)SO_4** (Copper II Sulfate)

Using Ion Charges and Chemical Names To Write Formulas

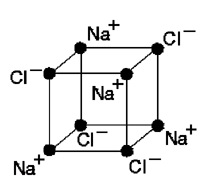
Step 1 – Print the metal element's name, symbol and ion charge, then the non-metals name, symbol and ion charge
Step 2 – Balance the ion charges (the positive ion must balance with the negative ion
Step 3 – Write the formula by indicating how many atoms of each element are in it.

Ca^{2+} Cl^{1-}
Ca^{2+} Cl^{1-} Cl^{1-}
$CaCl_2$

Ion Charges and the Periodic Table

Patterns:	ion charge
Alkali metals	1+
Halogens	1 -
Generally elements in a group all have the same ion charge (most consistency at either end of the table)	

All ionic compounds model ***distinct*** (different) ***crystal shapes***.



3.3 ## Molecular Compounds (pgs. 150-153)

When ***non-metals*** combine, they produce a pure substance called a **molecule**, or **molecular compound**. They can be solids, liquids, or gases at room temperature.

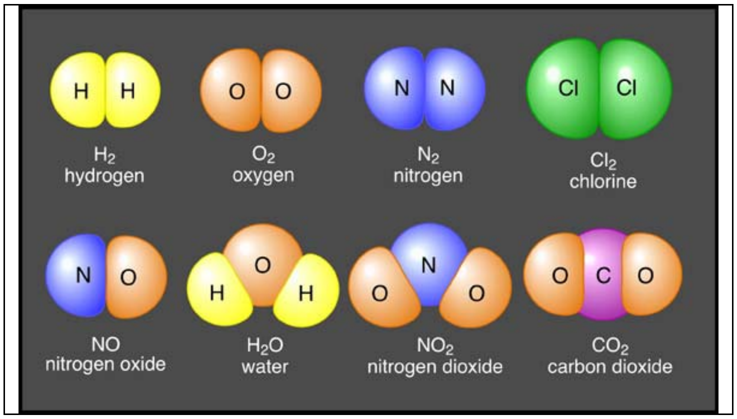
Examples: sugar ($C_{12}H_{22}O_{11(s)}$) acetylene, water

Properties of molecular compounds
- **Low melting point**
- **Low boiling point**
- **Good insulators**
- **Poor conductors**
- **Distinct crystal shape**

Of the 10 million compounds discovered so far, about 9 million are molecular compounds.

Writing Formulas For Molecular Compounds

It is similar to the way it is done in ionic compounds, except that no ions are present and the ion charge is not used in the formulas. This makes it difficult to predict how the non-metals will combine. The formulas do tell how many of each type of atom is present in the molecule.



Naming of Molecular Compounds

Rules:

1. The first element in the compound uses the element name (just like the ionic compounds do).
2. The second element has a suffix – **ide** – (like the ionic compounds).
3. When there is more than 1 atom in the formula, a prefix is used which tells how many atoms there are:

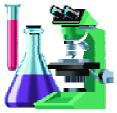
Number of Atoms	Prefix
1	**mono**
2	**di**
3	**tri**
4	**tetra**
5	**penta**

4. Exception to #3 above – when the first element has only 1 atom the prefix mono is not used.

Examples: **CO_2** carbon **di**oxide **CCl_4** carbon **tetra**chloride

Comparing Ionic And Molecular Compounds

Use a cover card to begin listing the comparison attributes for both the ionic and molecular compounds. This technique will be discussed in class.



Science in Action Textbook (pgs. 157-169)

Unit 2 Matter and Chemical Change

4.0 Substances undergo a chemical change when they interact to produce different substances.

4.1 Chemical Reactions (pgs. 157-161)

A **chemical reaction** takes place when two or more substances combine to form new substances. Different types of chemical reactions can occur, including ***combination***, ***decomposition***, ***displacement*** and ***exchange*** reactions. The substances at the beginning of the reaction are called **reactants**. The new materials produced by the reaction are called **products**. Chemical reactions can be written as **word equations** which gives the names of all the reactants (separated by a "plus' sign +) followed by an arrow which points to the names of all the products (separated by a 'plus' sign +)

Chemical Reaction Movies (So Cool!)

eg. (***iron + oxygen + water ---» rust***)

(***Iron plus oxygen plus water produces rust***)

A **chemical change** results from a chemical reaction. Evidence that a chemical change has occurred include:

- A change on colour
- The formation of an odour
- The formation of a solid or a gas (bubbles)
- The release or absorption of energy
  - A chemical change, which **releases** energy, is called **EXOTHERMIC**.
  - A chemical change, which **absorbs** energy, is called **ENDOTHERMIC**

Chemical Reactions Involving Oxygen

Combustion is a chemical reaction that occurs when oxygen reacts with a substance to form a new substance and gives off energy.

Identification Tests:

- *for* OXYGEN

Examples of Chemical Reactions

Light a wooden splint. Blow out the flame, allowing the splint to continue glowing. Hold the glowing splint in a small amount of the unknown gas. If the splint bursts into flame, then the gas being tested is oxygen.

- for HYDROGEN

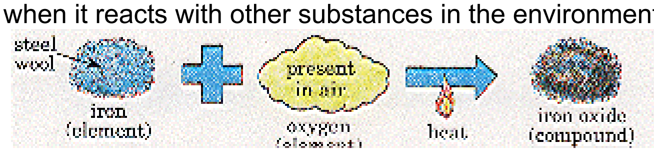
Light a wooden splint. Hold the glowing splint in a small amount of the unknown gas. If you hear a "**pop**", then the gas being tested is Hydrogen.

- for CARBON DIOXIDE

If you put a burning splint into Carbon Dioxide, the flame will go out and you will know the gas is not oxygen or hydrogen, but you will not know for sure that it is Carbon Dioxide. The test for Carbon Dioxide is not a combustion test, but rather uses a liquid called **limewater** (a clear colorless solution of calcium hydroxide, or slaked lime)Bubble the unknown gas through the limewater solution, or add a few drops of the limewater solution to the gas and swirl it around. If the limewater turns ***milky***, the gas is Carbon Dioxide

Corrosion is a slow chemical change that occurs when oxygen in the air reacts with a metal. Corrosion is a chemical reaction in which the metal is decomposed (eaten away), when it reacts with other substances in the environment.

The corrosion of iron is called '***rusting***'.



Many metals can corrode. The green roofs of the parliament buildings are an example of corrosion. The red-brown copper color is replaced with the green color because copper corrodes. Gold does not corrode. Solid solutions of metals (alloys) resist corrosion. Corrosion protection involves protecting the metal from contact with the environment and the factors that affect the reaction rate of this chemical reaction (e.g. painting the metal)

Cellular Respiration

Cellular Respiration is a chemical reaction that takes place in the cells in your body.

Animations of cellular respiration

4.2 Conservation of Mass in Chemical Reactions (pgs. 163-165)

Chemistry Tutorials

The Law of Conservation of Mass

In a chemical reaction, the total mass of the reactants,
is always equal to the total mass of the products.

This law ties in well with the atomic theory, which states that atoms are never created or destroyed. In a chemical reaction the atoms and molecules are simply rearranged.

Chemistry Dictionary

Law of Definite Composition

Law of Multiple Proportions

This law of conservation of mass however does not apply to nuclear reactions, because there Is some loss of mass: ***the mass is changed into energy***. This was first suggested by **Albert Einstein** in his famous equation:

$$E = MC^2$$

(**E** Is Energy, **M** is Mass, $\mathbf{C^2}$ is a large number)

A very tiny amount of mass is equal to a very large amount of energy

In an **open system** some of the mass seems to disappear, when it is in the form of a gas.

4.3 Factors Affecting the Rate of a Chemical Reaction (pgs. 166-169)

Reaction Rate

The speed of a chemical reaction is called the **reaction rate**.

- **Temperature** of the reactants affects the rate of all reactions (The higher the temperature the faster the reaction rate)
- **Surface Area** of the reactants affects the reaction rate (The more surface in contact, the faster the reaction rate)
- **Concentration** of the reactants affects the reaction rate. (The higher the concentration, the faster the reaction rate)
- **The presence of a Catalyst** affects the reaction rate (Catalysts are substances that help a reaction proceed faster).

Catalysts

Catalysts are not consumed in the reaction. Types of reactions involving catalysts can be found in living and non-living things. **Enzymes** help in the reactions in the body, which break down food. They also get rid of poison in the body. *Catalase* (an enzyme found in plant and animal cells) speeds up the breaking down of hydrogen peroxide into harmless oxygen and water.

Assess Your Learning **p. 171**

UNIT SUMMARY – p. 172

Unit Review **pgs. 175-177**