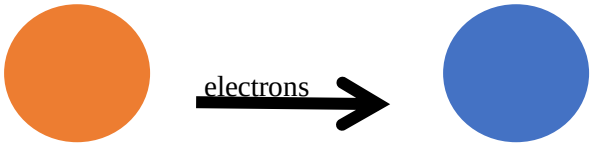
Subject Code	Chem 1	General Inorganic Chemistry
Module Code	2.0	Nomenclature of Inorganic Compounds
Lesson Code	2.6	Oxidation and Reduction Reactions Part I
Time Frame		30 minutes

Components	Tasks	TA[1] (min)	ATA[2] (min)
Target 	After working on this module, you are expected to: 1. Identify the oxidation number of chemical species. 2. Identify the oxidized and reduced substance in a given redox reaction 3. Apply redox reaction in real life	1	
Hook 	In the previous modules, we learned the different types of chemical reaction and how to balance this chemical reaction at the same time solve stoichiometric problems using the balanced chemical reactions. Before we start our next lesson let us first have a household scavenger hunt. In this activity let us find as many as we can the following items in your house without going out. Use the scavenger hunt checklist below as your guide. **Household Scavenger Hunt:** **Check the box if you have found this item inside the household** ☐ Rusty metal ☐ Hydrogen peroxide solution ☐ Indoor plant ☐ A battery ☐ Bleach ☐ A match ☐ A discolored apple core Do you know how rust is formed? Or how a battery can power up your mobile phone, your wall clock and your other gadgets at home? Or have you noticed a slice of apple that is left exposed to the air turn brown? What do you think is happening to this entire phenomenon? Have you seen a rusty metal? The brownish metallic deposit in the surface of the metal indicates that the metal was exposed to the external	5	

[1] Time allocation suggested by the teacher.
[2] Actual time allocation spent by the student (for information purposes only).

	environment for a slightly long period of time. This happens when iron reacts with oxygen and water in the atmosphere in a process that we call as Redox reaction.		
Ignite 	So, technically what is a redox reaction? A **redox reaction** or **Reduction-Oxidation reaction** is a reaction in which an electron is transferred from one reactant to another. This movement of electrons occurs from the reactant (or atom in the reactant) with less attraction for to electrons to the reactant (or atom) with more attraction to for electrons.  **Figure 1. Persons catching a ball. A simple analogy to Redox reactions** Redox reaction is just like playing a game of throwing and catching a ball by two people. The person who initially has the ball, throws (gives) the ball to the person who is supposed to receive the ball. The two processes involved in this game are giving and receiving the ball by the two players. The two process involved is giving and receiving a ball all in same game. In a redox reaction, two processes involve the giving and receiving of the electrons. These two processes are oxidation and reduction. **Oxidation reaction** or **oxidation** is a chemical process in which a substance loses an electron. In early definition oxidation is used mainly because substances that are frequent in losing electrons are substances containing oxygen. The substance, specifically the reactant that is oxidized in the process is called the **Reducing Agent.** On the other hand, a chemical process in which a substance gains an electron is called **Reduction reaction** or **Reduction.** The reactant that undergoes the process of reduction is called Oxidizing agent**.** For a better understanding of a redox reaction, we can ponder on the picture of an oilrig shown on Figure 2 and its relevance on the concept. Also, we can use the mnemonic "LEORA" or "GEROA" that is shown on the image below.  **Figure 2. A picture of an oilrig. This will be a visual mnemonics tool for understanding redox reaction where OIL (Oxidation is Loss) of electrons RIG (reduction is gain) of electrons**	20	



Loses an **E**lectron	**G**ain an **E**lectron
Undergoes the process of **O**xidation	Undergoes the process of **R**eduction
The substance is called **R**educing **A**gent	The substance is called **O**xidizing **A**gent

Figure 3. **Summarized mnemonic for understanding the concept of redox reaction.**

Now, we know the difference between reduction and oxidation reactions, we also need to understand that to identify redox reaction we need to see the changes in the number of electrons. To do that we need a "bookkeeping" scheme to track the changes of electrons in every atom. The **oxidation numbers** or **oxidation state** is a hypothetical way to designate a charge of an individual atom may it be in its ionic or elemental state or in a neutral compound or a polyatomic ion. To do this, shown in Table 1 are the rules on how to assign oxidation states.

Table 1 **RULES for ASSIGNING OXIDATION STATES (Number)**

Condition	Examples
1.) The oxidation state of an atom in a free element is 0.	O_2 , Fe , C All of them have 0 oxidation state
2.) The oxidation state of a monoatomic ion is equal to its charge	Mg^{+2} +2 ox no. F^- -1 ox no.

3.) The sum of the oxidation states of all atoms in:	
a.) A neutral molecule or compound is 0	H_2O 2(ox state of H) + (ox state of O) = 0
b.) An ion is equal to the charge of the ion.	SO_4^{2-} (ox state of S) + 4(ox state of O) = -2
4.) In their compounds, metals have a positive oxidation state.	
a.) Group 1A metals always have a +1 oxidation state	$NaCl$ (Na have an oxidation state of +1)
b.) Group 2A metals always have a +2 oxidation state	$MgCl_2$ (Mg have an oxidation state of +2)
5.) In their compounds, nonmetals are assigned oxidation states based on the hierarchy below the top always takes precedence over entries at the bottom.	
a.) Flourine has an oxidation state of (-1)	MgF_2 (F has an oxidation state of -1)
b.) Hydrogen has an oxidation state of (+1) if paired with non-metal, except boron	HCl (H has an oxidation state of +1)
c.) Hydrogen has an oxidation state of (-1) if paired with boron or metal.	CaH_2 (H has an oxidation state of -1)
d.) Oxygen in peroxides have an oxidation state of (-1)	H_2O_2 (O has an oxidation state of -1)
e.) Oxygen in all other compounds have an oxidation state of (-2)	H_2O (O has an oxidation state of -2)
f.) Group 7A elements in combination with metals, nonmetals (except O), and other halogens down the group have an oxidation state of (-1)	CCl_4 (Cl has an oxidation state of -1)

The rules for assigning the oxidation state should be prioritized based on the sequence, where in condition number 1 is prioritized over condition number 2 and so on, in a given redox reaction.

Let's try some exercises on how to assign oxidation states in some compounds using the rules mentioned.

Example 1 Assigning Oxidation States

Assign an oxidation state of each element in these compounds:
(a) nitrogen dioxide (c) chromate ion
(b) sulfuric acid (d) calcium chloride

Solutions:

(a) 3(a): The sum of the oxidation state of a neutral molecule is 0 5(e): Oxygen in all other compounds have an oxidation state (-2)	**NO_2** (N oxidation state) +2 (O oxidation state) = 0 (N oxidation state) + 2(-2) = 0 N oxidation state = + 4
(b) 3(a): The sum of the oxidation state of a neutral molecule is 0 5(c): Hydrogen has an oxidation state of (+1) if paired with non-metal 5(e): Oxygen in all other compounds have an oxidation state (-2)	**H_2SO_4** 2(H oxidation state) + (S oxidation state) + 4(O oxidation state) = 0 2(+1) + (S oxidation state) + 4(O oxidation state) = 0 2(+1) + (S oxidation state) + 4(-2) = 0 S oxidation state = +6
(c) 3(b): The sum of the oxidation state of all atoms in an ion is equal to the charge of the ion. 5(e): Oxygen in all other compounds have an oxidation state (-2)	**CrO_4^{2-}** (Cr oxidation state) + 4(O oxidation state) = -2 (Cr oxidation state) + 4(-2) = -2 Cr oxidation state = +2

(d) 3(a): The sum of the oxidation state of a neutral molecule is 0 4(b): Group 2A metals always have a +2 oxidation state	**$CaCl_2$** (Ca oxidation state) +2 (Cl oxidation state) = 0 2 + 2 (Cl Oxidation state) = 0 Cl oxidation state = -1

Now that we know how to determine the oxidation number or state of a certain element in a compound or ion, let us apply this concept to actual redox reactions.

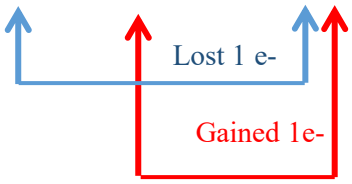
This time we will discuss how to identify a redox reaction and illustrate how the changes in oxidation number can prove the reaction is redox or not.

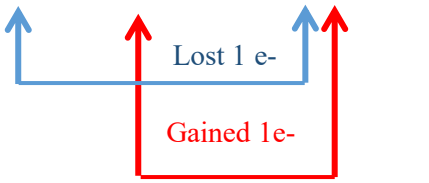
To illustrate whether a reaction is redox or not, let us try to have an example.

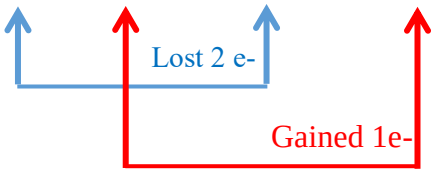
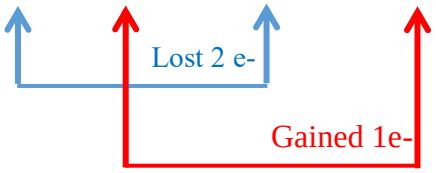
Example 2 — Identifying Redox Reactions

Identify whether this reactions is a redox reaction or not?

1. $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
2. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
3. $HBr(aq) + KOH(aq) \rightarrow KBr(aq) + H_2O(l)$

1.) a.) Determine the oxidation state of every element	Oxidation states: 0 0 +1-1 $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ To determine whether the reaction is redox we need to see whether there are changes in the electrons in every element. To do that we need to assign the oxidation states of every element using the oxidation rules.
b.) Determine which atom gained or lost an electron. **Note:** To determine the which substance	Oxidation states: 0 0 +1-1 $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$  In this reaction sodium (Na) lost 1 electron. This means that sodium has undergone the

	has undergone the process of oxidation or reduction use the mnemonics OILRIG or "LEORA" and "GEROA"	process of **Oxidation.** On the other hand, chlorine (Cl) gained 1 electron. This means that chlorine has undergone the process of **Reduction.** Since, two elements in the reactant have changed their oxidation state, in the reactant side to the product side this means that this reaction is a redox reaction.		
	c.) Determine the reducing agent and oxidizing agent. **Note:** To determine the which substance is the oxidizing or reducing agent we use the mnemonics "LEORA" and "GEROA"	Oxidation states: 0 0 +1-1 $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$  Since Na (s) has undergone the process of **oxidation** this means that Na is a **reducing agent**. On the other hand, Cl_2 (g) has undergone the process of **reduction** this means that it is an **Oxidizing agent.**		
	2.) a.) Determine the oxidation state of every element	Oxidation States: 0 +1-1 +2-1 0 $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$		

	b.) Determine which atom gained or lost an electron. **Note:** To determine the which substance has undergone the process of oxidation or reduction use the mnemonics OILRIG or "LEORA" and "GEROA"	Oxidation States: 0 +1-1 +2-1 0 $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$  In this reaction magnesium (Mg) lost 2 electrons. This means that magnesium has undergone the process of **Oxidation.** On the other hand, hydrogen (H) gained 1 electron. This means that hydrogen has undergone the process of **Reduction.** Since, two elements in the reactant have changed their oxidation state, in the reactant side to the product side this means that this reaction is a redox reaction.		
	c.) Determine the reducing agent and oxidizing agent. **Note:** To determine the which substance is the oxidizing or reducing agent we use the mnemonics "LEORA" and "GEROA"	Oxidation States: 0 +1-1 +2-1 0 $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$  Since Mg (s) has undergone the process of **oxidation** this means that Mg is a **reducing agent**. On the other hand, HCl (aq) contains the hydrogen that has undergone the process of **reduction** this means that it is a **Oxidizing agent.**		
	3.) a) Determine the oxidation state of every element	Oxidation States +1 -1 +1-2+1 +1-1 +1-2 $HBr(aq) + KOH(aq) \rightarrow KBr(aq) + H_2O(l)$ To determine whether the reaction is redox we need to see whether there are changes in the electrons in every element. To do that we need to assign the oxidation states of every element using the oxidation rules.		

	Since all elements still have the same oxidation number from the reactant and product then. This reaction is not a Redox reaction.

Let us go back to some of the items in our scavenger hunt. Just like any substances that are part of the scavenger hunt, a battery operates because of redox reactions. A simple dry cell battery, a battery found in your wall clock or your TV remote has this equation.

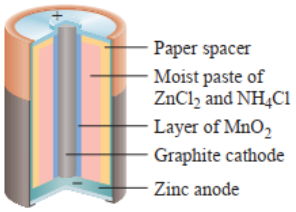


Figure 4. A structure of a typical dry cell battery.

$$Zn\ (s) + 2NH_4^+(aq) + MnO_2\ (s) \rightarrow Zn^{+2}(aq) + 2NH_3(aq) + H_2O\ (l) + Mn_2O_3\ (s)$$

The reaction is redox because zinc (Zn) in its elemental form becomes and ionic zinc with +2 charge making Zn loose 2 e-. Thus, zinc has undergone the process of oxidation. While manganese (Mn) in MnO_2 gained 1 electron to form Mn_2O_3. Thus manganese undergoes the process of reduction. You will learn more about redox reaction and its application on batteries when you go to the topic in Electrochemistry in Chemistry 2

Figure 5. A typical indoor plant (Chinese Evergreen).

Another thing in your household that utilizes redox reaction is your indoor plants. Plants utilize redox reaction through the process of photosynthesis.

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + O_2$$

Photosynthesis reaction, as shown in the reaction above, happens when carbon dioxide (CO_2) from the atmosphere and water (H_2O) that was absorbed by the plants combines to form glucose ($C_6H_{12}O_6$) and oxygen (O_2) gas. This redox reaction happens because carbon from the carbon dioxide gains 4 electrons to form glucose, while oxygen from either carbon dioxide or water loses 2 electrons from both reactants.

As a challenge, can you find out what other Redox reactions can be attributed to the other items in the scavenger hunt?

Navigate 	Work on the following exercises to find out if you understood the lesson. Question 1 and 2 will not be graded so take that as your practice. For the last question, answer that in ½ sheet of paper and send it to my email. 1.) From the types of chemical reaction that you have learned, which of them is also a redox reaction? 2.) Determine the oxidation number (state) of every element of the following substance. (a) potassium bromate (b) sulfur trioxide (c) oxalate ion (d) perchloric acid 3.) For the following reactions determine: • the oxidation number of the every element • whether the reaction is redox • the substance that underwent oxidation and reduction • the substance that is that is the reducing agent and oxidizing agent. A.) $H_2(g) + O_2(g) \rightarrow H_2O(g)$ B.) $CaCO_3(s) \rightarrow CaO(s) + CO_2\ (g)$ C.) $HI(aq) + Ba(OH)_2(aq) \rightarrow H_2O(l) + BaI_2(aq)$	4	
Knot 	Here are some of the significant key ideas that you should remember about redox reaction. ▪ Redox reaction is a reaction wherein an electron is transferred from one reactant to another. The process of transferring electrons from a reactant with less attraction to a reactant with more attraction to an electron. ▪ Redox reaction is limited to the process of both reduction and oxidation. Reduction is the process where the substance gains an electron; the substance is then called as oxidizing agent. Oxidation on the other hand, is the process where the substance losses an electron; the substance is then called as reducing agents. ▪ In redox reaction there is a simultaneous giving and receiving of electrons. Meaning redox reactions are always paired. None is existent from one another. ▪ To determine whether a reaction is redox we need to determine first the oxidation number of every element, followed by determining the number of electron lost and gained. ▪ To easily determine whether the reaction is oxidation or reduction or which substance is a reducing or oxidizing agent, we can use the mnemonics (OIL RIG) or (LEORA and GEROA)	2	

References

Brown T., LEMay, H., Murphy, C & Woodward, P. (2012).*Chemistry: The Central Science 12th Edition*.USA: Pearson Education Inc.

Chang, Raymond (2008), *General Chemistry: The Essential Concepts 5th Edition*. New York: McGraw-Hill Companies.

J. Albarico (PSHS-CBRZ). (undated). THINK Framework. Based on Science Links by E.G. Ramos and N. Apolinario, Quezon City. Rex Bookstore.

Silberberg, Martin (2006), *Chemistry: The Molecular Nature of Matter and Change 4th Edition.* New York: McGraw-Hill Companies.

Tro, Nivaldo (2017), *Chemistry: A Molecular Approach 4th Edition,* USA: Pearson Education Inc.

Picture sources:

Council for the Curriculum Examinations. (n.d.). Developing Fundamental Movement Skills: Focus Catch. 29 Clarendon Road, Clarendon Dock, Belfast.

PikPng, (n.d.). Oil Platform Drilling Rig Petroleum Oil Well Augers – Offshore Oilrig Clipart – PNG Download. Retrieved from https://www.pikpng.com/pngvi/ihmJRTb_oil-platform-drilling-rig-petroleum-oil-well-augers-offshore-oil-rig-clipart/

Chang, Raymond (2008), *General Chemistry: The Essential Concepts 5th Edition*. New York: McGraw-Hill Companies.

Picard Caroline, Springen Karen, and Valeris Monique (2019). 30+ Gourgeous Indoor Plants That are Almost Impossilbe to Kill. Retrieved from https://www.goodhousekeeping.com/home/gardening/advice/g1285/hard-to-kill-plants/

Prepared by: DEXTER VILE J. LAURDEN	Reviewed by: PRINCESS ANN DIGNENENG
Position: Special Science Teacher II	Position: Special Science Teacher II
Campus: CALABARZONRC	Campus: CLC

Answers to Navigate part:

1.) combination/synthesis reaction, combustion reaction, single displacement reactions are some of the possible answers

2.)

a.) $KBrO_3$

Oxidation nos: K = +1, Br = +5, O= (-2)

b.) SO_3

Oxidation nos: S=+6, O= (-2)

c.) $C_2O_4^{2-}$

Oxidation nos: C = +3, O= (-2)

d.) $HClO_4$

Oxidation nos: H = +1, Cl = +7, O = (-2)