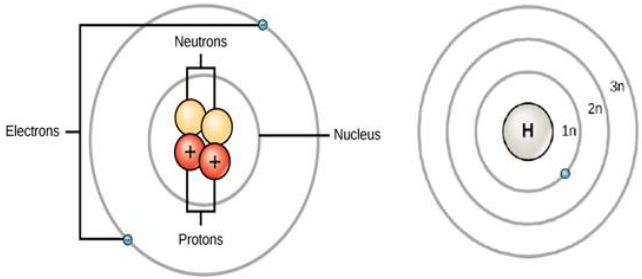
WEEK 5

UNIT 2. MOLECULAR COMPOSITION OF CELL	**Where? How long?**	***Explanations /Questions***
Introduction This unit serves to provide notion on the chemistry of life. How life is almost based on carbon compounds and exclusively based on chemical reactions taking place in watery or aqueous solution at cellular level. In addition, life processes are dominated and governed by polymeric molecules formed from simple molecules or monomers which join end to end to form macromolecules.	10 minutes	Where is this from?
Expectation To understand how living systems are assembled, we must first understand a little about atomic structure, about how atoms can be linked together by chemical bonds to make molecules, and about the ways in which these small molecules are joined together to make larger molecules, until finally we arrive at the structures of cells and then of organisms. The chapter will focus on molecules from which cells are made and examine their structures. ***Course outline*** Basic cell chemistry Carbohydrates Lipids Proteins Nucleic acids		
Learning outcomes		
At the end of this unit, you should be able to: • Explain the ways in which naturally occurring elements combine to create molecules, cells, tissues, organ systems, and organisms • Describe the structure of macromolecules.		

UNIT 2-1_BASIC CELL CHEMISTRY	**Where? How long?**	***Explanations /Questions***
Introduction Chemical compounds in the cell can be divided into two major groups: Organic and Inorganic compounds. Organic compounds are chemical compounds that contain the element carbon . The smallest particle of an element that still retains its distinctive chemical properties is an *atom*. The atoms in organic compounds are held together by covalent bonds, which form as a result of the sharing of two electrons between two atoms. Water is an inorganic compound which is composed of hydrogen and oxygen. It is an important compound in the cell. ***Expectation*** All biological processes follow the laws of physics and chemistry, so in order to understand how biological systems work, it is important to understand the underlying physics and chemistry. For many of you, this chapter will be a review of basic chemical components of the cell. ***Course outline*** Atoms Chemical bonds and molecules Water	10 minutes	Where is this from? Explain here what it is they are going to be learning and ***why*** they need to know about the basic cell chemistry Also what the expectations are in terms of time commitment, tutor support and so on.
Learning outcomes At the end of this unit, you should be able to • Define and describe an atom • State the elements in the cells • Differentiate the covalent and ionic bonding. • Describe the properties of water • Explain why water is a universal solvent • Discuss the role of buffers in acid-base balance		

ACTIVITY AHEAD OF LESSON :BASIC CHEMISTRY OF THE CELL		30 minutes	
Purpose:	All the cells in your organisms are composed of chemicals, and chemical reactions are involved in all of your body's activities . Cell chemistry explains how your cells produce energy and proteins, why you breathe and have blood and what sorts of foods and vitamins are important for nutrition. With a basic understanding of chemistry, you can understand why your organs function the way they do and how the systems of your body work together.		
Over to you:	Read following links then go to this website for animation atomic structure and Ionic vs covalent bonding. ***Be certain to note anything that you don't understand***		
Activity:	Do the pre-test quiz with the below animation.		

ATOMS All matter is made of atoms. Each atom is made of: • Neutrons (0 charge) • Protons (+ charge) • Electrons (- charge)  **Figure 2.1 the structure of an atom:** each atom has nucleus composed of positively charged protons and neutrons which are neutral and negatively charged electrons orbiting the nucleus at defined energy levels (n).by OpenStax, Nov 7, 2018 ,accessed February 14, 2019. https://cnx.org/contents/GFy_h8cu@11.6:vogY0C26@21/Atoms-Isotopes-Ions-and-Molecules-The-Building-Blocks.	10 minutes	Notes to tutor Before starting the lesson ask following questions to students: - What is the smallest part of matter? - What is an atom? - What are the three main parts of an atom? - Where are these parts located in an atom? - What does it mean if an atomic particle has an electrical charge?
CHEMICAL BONDS AND MOLECULES **Chemical bond** It is an attractive force existing between two atoms when their electrons interact. **Molecules** Molecules are two or more atoms joined in chemical bonds. Molecules can be formed by atoms of the same kind or different kind. When two or more molecules are joined, they form a compound. When an atom bonds to the other by transferring its electrons to the other, the resultant bond is **ionic bond** while when atoms share their electrons the formed bond is **covalent bond**.		Explain what is: **An ion:** an atom with a positive or negative charge due to loss or gain of electrons in its outer shell. *Examples:* Mg, Cl

Molecules are two or more atoms joined in chemical bonds.

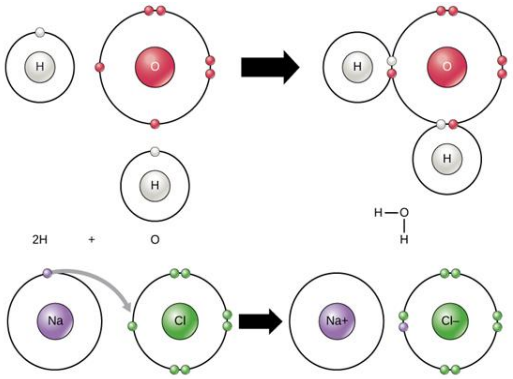


Figure 2.2 types of bonds: ionic bond is formed between sodium (Na) and chlorine (Cl) where Na donate electron to chlorine to form crystals of $Na^{+}Cl^{-}$. Covalent bond is formed by sharing of a pair of electrons. The bond formed between hydrogen and water results into water molecule. by OpenStax, Nov 7, 2018 ,accessed February 14, 2019. https://cnx.org/contents/GFy_h8cu@11.6:vogY0C26@21/Atoms-Isotopes-Ions-and-Molecules-The-Building-Blocks.

Covalent bond

The example of covalent bond is shown in the combination of hydrogen (H) and carbon (C). When bonding atoms have the same or closer electronegativity, the covalent bond formed is called **nonpolar covalent bond**. If they are different and have high difference in electronegativity, the formed bond is **polar covalent bond** as there will be a creation of partial charges on bonding atoms.

Polar covalent bond

An example of polar covalent bond is observed when oxygen (O) combines with hydrogen to form water molecules. Water consists of an oxygen atom bound to two hydrogen atoms by two single covalent bonds. The resulting molecule is stable: it satisfies the octet rule, has no unpaired electrons, and carries no net electrical charge.

10 minutes

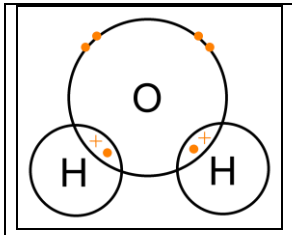
Notes to tutor

Explain : electronegativity: A measure of an atom's ability to pull electrons from another atom

Simple way to define polar and non-polar bound:
polar bond is a covalent bond that has an unequal sharing of electrons while a non-polar has an equal sharing of electrons.

IN CLASS ACTIVITY: COVALENT AND IONIC BOND		20 minutes	
Purpose:	This is to show common differences between covalent and ionic compounds.		
Over to you:	Go to the internet and search characteristic of covalent an ionic bond		
Activity:	Using a table show similarities between covalent and ionic bonds. Give two examples of molecules linked by each type of bond.		

ACTIVITY AHEAD OF LESSON :WATER		30 minutes	
Purpose:	Water is one of the more abundant molecules and the one most critical to life on Earth. Approximately 60–70 % of our organisms is made up of water. Without it, life as we know it simply would not exist. In this topic we look at the special chemistry of the water molecule. Water's chemistry gives it the properties that make water so important – both to living things and to shaping earth's natural environments. To understand the unique chemistry of water, we will first investigate types of covalent bonds. Activities in this unit are designed to compare the physical properties of polar, slightly polar, and nonpolar liquids.		
Over to you:	Read following links for the book Molecular Biology of the Cell by Albert B. (4th) . ***Be certain to note anything that you don't understand***		
Activity:	Answer these questions: Explain why water is considered a polar molecule. Explain how water is a solvent. What helps water molecules absorb heat without causing a great change in temperature? ***Bring you answers in class for discussion.***		

WATER		Note to tutor
The majority of cellular content and even all living organisms are made of water where it occupies almost 70% of the total weight. Water is very important in that all processes of life occur in aqueous environment. Not only in life processes water is needed but also in our everyday activity such as cooking, cleaning and drinking. **PROPERTIES OF WATER** Water is liquid at room temperature, it is solid below 0^0C and it is in gaseous state at high temperature. It is a polar solvent, it solvates a large number of polar organic and inorganic molecules due to its ability to form hydrogen bond between its own molecules and also with a varied number of molecules. Its cohesive and adhesive properties render it suitable for transporting soluble nutrients in living organisms. All biochemical reaction occur in water. - **Water polarity** Water is composed of polar molecules: the hydrogen and oxygen within water molecules (H_2O) form polar covalent bonds. Oxygene is highly electronegative. H- bond are donor and acceptor. Polar substances dissolves in water= hydrophilic Non-polar molecules (eg : oils and fats) do not dissolve in water= hydrophobic. **Amphipathic molecules** have both hydrophilic and hydrophobic properties.  **Figure 2.3: Diagram of water**. By Benjah-bmm27.May 15, 2007. Accessed February 22, 2019. https://commons.wikimedia.org/wiki/File:Water-2D-dot-cross.png. - **High Specific Heat** Water can absorb or release large amounts of heat energy with little temp change. E.g. Water stabilizes temp. in cells and ecosystems - **High heat of Vaporization** Many H-bonds must be broken before water can evaporate. - **Cohesion and Adhesion** Water molecules stick to each other held by H-bond by the cohesion property while water molecules stick to unlike surfaces such as glass or plastic due to H-bonds between water and other polar compounds by the adhesion property.	20 minutes	**Make sure that students understand following definitions:** cohesion condensation evaporation calorie solution solvent surface tension

IONIZATION OF WATER The pure water can dissociate in equal number of Hydrogen ion (H^+) and hydroxide ions (OH^-) creating equilibrium. $$H_20 + H_20 \rightleftharpoons H_3O^+ + OH^-$$ $$H_20 \rightleftharpoons H^+ + OH^-$$ As for any other reversible reaction, the equilibrium constant for water dissociation can be calculated as follows: $$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]}$$ The concentration of H_2O in pure water at 25^0c is equal to 55.5mol/L. Replacing this value in the above equation we get : $$(55.5\ M) x\ (K_{eq}) = [H^+][OH^-]$$ Where (55.5 M)x (K_{eq}) represents the **ion product of water (KW)** at 25^0C As the $K_w = [H^+][OH^-]$ and K_{eq} of pure water at 25^0c is $1.8x10^{-16}$M we can replace K_{eq} its value and get $$[H^+][OH^-] = (55.5\ M) x\ 1.8x10^{-16} M$$ $$[H^+][OH^-] = 1x10^{-14}\ M^2$$ Thus the product $[H^+][OH^-]$ in aqueous solutions at 25^0 C is always equals to $1x10^{14}M^2$. The hydrogen potential written as pH is calculated as the negative of the base 10 logarithm of the concentration of H^+ $$pH = -\log [H^+]$$ The concentration of H^+ in pure water is $1x10^{-7}$. Thus the pH of pure water is $$pH = -\log 1x10^{-7}$$ $$pH = 7$$ Remember $[H^+][OH^-] = 1x10^{-14}\ M^2$ therefore $[OH^-] = (1x10^{-14}\ M^2) : (1x10^{-7}M)$, say $1x10^{-7}$M. When there are exactly equal concentrations of H^+ and OH^- , as in pure water, the solution is said to be at **neutral pH.** The pH scale varies from 0 to 14; any solution with pH falling between 0- 6.9 is said to be acidic while one with pH above 7 to 14 is said to be basic. **At pH 7 the solution is neutral.**	20 minutes	Provide this link to students for more clarification

ACIDS, BASES AND BUFFERS Any substance that can release hydrogen ions (H+) in a solution is an **acid** while substance releasing hydroxide ions (OH–) or any other negatively charged ions is a **base.** Mineral acids such hydrochloric, sulfuric and nitric acids are highly soluble in water because when they are dissolved into water, they are completely ionized and are said to be **strong acids**. It is the same to the bases such as KOH and NaOH, they are also completely dissociated and are called **strong bases**. **Weak acids** and **weak bases** are partially dissociated when dissolved in water leading to the equilibrium between non dissociated part and dissociated part. Let use an example of weak acid **HA;** when dissolved in water it is partially dissociated according to the following reaction: $$HA^- \rightleftharpoons H^+ + A^-$$ From the reaction above, **HA** is a proton donor (weak acid) while A^- is a proton acceptor (eak base). Proton donor and its corresponding proton acceptor make up a **conjugate acid-base pair.** Aqueous systems that tend to resist changes in pH when small amounts of acid (H+) or base (OH-) are added are known as **buffers**. Buffers are physiologically important in keeping the pH of the body carefully maintained in the narrow range required for survival. The phosphate and bicarbonate systems represent examples of biological buffers. $$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$ $$H_2CO_3^- \rightleftharpoons H^+ + HCO_3^-$$	20 minutes	

IN CLASS ACTIVITY: ACID AND BASE PROBLEMS		30 minutes	
Purpose:	Measurement of pH has great meaning in biochemistry because it affects the structure and activity of biological macromolecules; for example, the catalytic activity of enzymes is strongly dependent on pH. The pH of blood and urine are commonly measured in clinical setting to diagnose and monitor some diseases such as diabetes. When the pH of an individual is below the normal pH the condition is called acidosis the opposite is alkalosis. With This problem set will allow you to get knowledge about water, pH, pKa and buffer capacity.		
Over to you:	Follow this link and do related problem set.		
Activity:	The MCQ have answers with brief explanation. Incorrect answers are kinked to tutorial to help solve the problem.		

Commented [TN1]: Where are MCQ??

Anticipated time required for Unit 2_1 activities :

Theory : 2h all activities + 2h self-learning