Study of Chemical Bonding Misconception on Senior High School Students caused by Learning Strategy and Content in Textbook

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Abstract

Chemical bonding is very important concept for studying other chemistrytopics.However, most chemical bonding concepts are abstract, so it needs abstract or formal thinking ability. Most of the students have not reached the formal thinking ability yet making this topic is difficult to understand. This ledto students' misunderstandings. Such consistent misunderstandings can behave to misconceptions of learned concepts. Moreover, misconception can also be caused by learning strategy and content in textbook. For example, when teaching the ionic compounds, teachers draw ions with similar size. This drawing is also found in some textbooks. This makes students experienced misconceptions about the size of ionic radii. The results of the analysis show some misconceptions that can arise due to learning strategies and content in textbooks, namely: (1) The radius of sodium ion is greater than the radius of sodium atom and the radius of chlorine ion is smaller than the radius of chlorine atom ; (2) The radius of sodium ion is greater than chloride ion; (3) The ionic bond is a bond formed by electron transfer between metals and nonmetals; (4) Sodium atoms use electrons together with chlorine atoms to form molecules; (5) In the representation image of NaCl, the sodium ion is ionic bonded with one chloride ion, whereas with another chloride ion is an attractive force; (6) A covalent bond is a bond in which two atoms are bonded to each other by the use of electrons together and each atom satisfies the noble gas configuration; (7) Nonpolar molecules are formed only when atoms in their molecule have the same electronegativity; and (8) A metal bond is formed when one, two, or three electrons in the valence shell are donated to the lattice so that the noble gas configuration is satisfied.

Keywords: misconception, chemical bonding, learning strategy, textbook

Introduction

Chemical bonding is a very important concept for studying other chemical topics. This is because the concept in chemistry is a tiered concept from a simple to a higher level concept (Sastrawijaya, 1988). Nahum et al. (2010) argues that chemical bonding is one of the key concepts in chemistry and one of the most fundamental. Ozmen et al. (2004) argues that chemical bonds are the key material for studying molecular structure, and the structure is closely related to the physical and chemical properties of a compound. Therefore, a good understanding of the concept on the topic of chemistry is necessary in order to study other chemistry subjects students have no difficulty.

Concepts on the topic of Chemical bonds if categorized by Gagne opinion are largely in the defined category of concepts. According to Effendy (2002) the defined concept is derived from abstract objects. Therefore, the concepts of chemical bonding are largely abstract. Tan & Treagust (1999) argues that the abstract concept of chemical bonding is caused that the students can not see the atoms, the structure of the atom, and how the atoms react with other atoms.Therefore, to understand the chemical bonding material requires the ability of abstract or formal thinking. Most of the students have not yet reached the formal thinking ability so that the topic of chemical bonding is difficult to understand. This results in students having the potential to experience misunderstandings. Such consistent misunderstandings can lead to misconceptions of learned concepts. This opinion has also been expressed by Effendy (2002), Özmenet al. (2009), Pabuccu & Geban (2012), and Kumphaet al. (2014). Besides students have not yet reached formal thinking ability, misconception can also be caused by learning strategy and content contained in textbook. In this paper the study of misconception caused by instructional strategy and content contained in textbook on topic of ion radius size, ionic bond, The presence of ionic compounds and their crystal lattices, covalent bonds, polar molecules, and metal bonds.

Ion Radius Size

Teachers' ionic bonding studies usually use learning strategies by drawing circles on the whiteboard or the aid of a ball-and-stick (molymod) model that represents ionic bonds. However, most teachers do not care about the size of the circle or ball so the size of the radius of the ions looks the same. Coll & Taylor (2001) who reported that when teachers teach about ionic bonds, teachers draw ions of similar size. In addition, teachers typically use a ball-and-stick model to describe the three-dimensional shapes of ionic compounds Such as NaCl in which the size of the ball representing the Na^+ and Cl^- ions has a similar size. Coll & Taylor (2001) reported that the content in a text book that describes ions in ionic compounds of similar size. Modeling of ions in ionic compounds is what causes some misconception students about the size of ionic radius.

Misconceptions about ionic radius are found in Coll & Taylor's (2001) study which reported that students assume the radius of sodium ions is greater than the radius of chloride ions. Coll & Taylor (2001) argues, this shows that students are still confused in determining the size of ionic radii compared to their atomic size in the elemental periodic system. The identified misconception is that the students assume that the radius of the sodium ion is greater than the radius of the sodium atom and the radius of the chloride ion is less than that of the chlorine atomic radius (Coll & Taylor, 2001). The student reasoned that the increasing number of electrons in the valence shell showed similarity with the increasing number of protons on the periodic table. Students assume that with increasing electrons the tensile force between the nucleus and the electrons in the outermost shell is greater. Effendy (2016a) argues that the Na^+ ion size is smaller than the size of Na atoms because the nucleus of the electrons in Na^+ ion is stronger than that of Na . The size of Cl^- ion ions is greater than the size of Cl atoms because the nuclei's tensile strength of the electrons in the Cl^- ion ion is weaker than that of Cl.

Ionic Bonding

Most teachers teach ionic bonding begins with the electron transfer process on the formation of NaCl compounds in the gas phase. It is also found in some content in textbooks that describes ionic bonding begins with the transfer electron process of forming NaCl compounds in the gas phase. Like the following reaction.

$$Na(g) + Cl\ (g) \rightarrow NaCl(g) \quad (1)$$

Tan & Treagust (1999), Effendy (2016b) argues that the teacher described the illustration of ionic bonds with images of sodium atoms to chlorine atoms forming sodium ions and chloride ions as Figure 1. Then the teacher explains sodium ions and powerful electrostatic tooth chloride ions. Effendy (2016b) argues that ionic-related topics beginning with the above explanation can lead to misconceptions. One of the misconceptions that can arise is that students assume ionic bonds are bonds that are formed through the transfer of electrons from metals and non-metals (Effendy, 2016b and Taber, 1998).

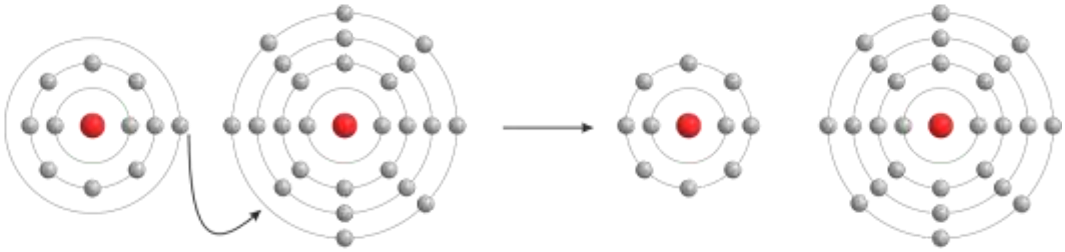


Fig. 2. Electron Transfer from Sodium Atom to Chlorine Atom

Taber (1998) argues, if the definition of ionic bonds is an electron transfer, then it is a wrong/misconception. Taber (2002) states that the student's opinion regarding electron transfer is that the process of forming the ionic bond is only a small part of the process of forming the NaCl compound. In fact, the NaCl compound can be formed through a neutralization process followed by water evaporation. For example the reaction between NaOH and HCl.

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l) \quad (2)$$

If the reaction product of equation 2 is heated the water will evaporate and NaCl crystals form. It shows that the ionic bonds present in the NaCl compound are not the result of electron transfer, but the electrostatic attraction between the cation and the anion.

The Existence of the Ionic Compound and Its Crystal Lattice

Misconceptions about the existence of ionic compounds (NaCl) as molecules are found in different countries. Some researchers have found that students have misconceptions about the presence of ionic compounds (NaCl) as molecules such as Tan & Treagust (1999), Pabucu & Geban (2012), Kumpha et al. (2014), and Vrabec & Proks (2016). Tan & Treagust (1999) and Tan et al. (2001) argues that these misconceptions are found in many countries most likely due to teaching strategies or content in textbooks.Tan et al. (2001) argues that the cause of the misconception of crystal structure is one of them when students are taught by teachers using three dimensional models of ball and stick. Students assume that six sticks connecting one ball to another represent a bond. Where the bond represents the covalent bonds that form the NaCl compound and the ionic bonds that bind the molecules into solids. In addition, the content in the text book also does not explain in detail related image representation of NaCl crystal lattice structure. As in Effendy (2016a) explains that the line on the NaCl crystal representation is not a symbol of covalent bonding. The lines are illustrated to facilitate the identification of the lattice forms of ionic compounds and the geometry formed by ions with other ions having opposite charges around them at the same distance.

Burts and Smith (1987) argues that students' misconceptions regarding the existence of ionic compounds can lead to a misconceptions of the crystal lattice structure. One of the apparent student misconceptions reported by Tan & Treagust (1999), Pabucu & Geban (2012), Kumpha et al. (2014), and Vrabec & Proks (2016) ie, students assume that sodium atoms use electrons together with chlorine atoms to form molecules. Then, the molecules are ionic bound to form a NaCl solid. Another misconception was found by Taber (2002) who reported that when students presented images of NaCl representation as in Figure 2, students assumed that sodium ions bind ionic with one chloride ion, whereas with other chloride ions is a force. In the case of Effendy (2016a) Sodium ions are surrounded by six chloride ions closest to octahedral geometry while chloride ions are surrounded by six sodium ions closest to octahedral geometries such as Fig. 3.

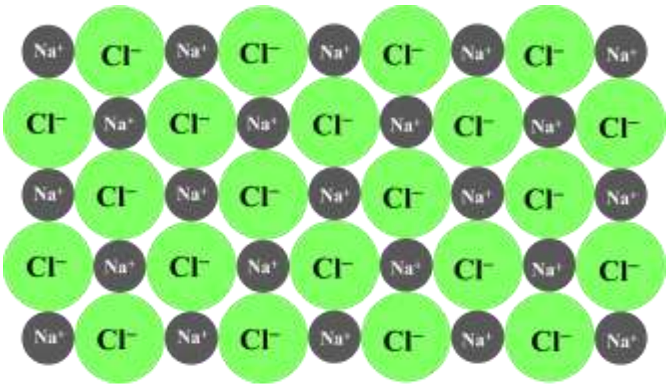
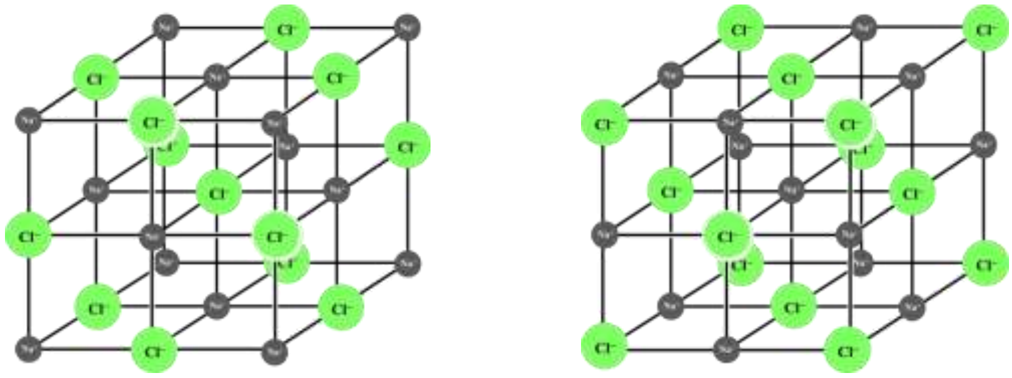


Fig. 2. 2-Dimensional Representation of NaCl Crystal Lattice Structure



(a) (b)

Fig. 3. NaCl Centered Crystallized Lattice (a) Na + ions as Origin and (b) Clones of origin

Covalent Bonding

Taber (1998) reports that students assume covalent bonds are bonds in which two atoms are bonded to each other through the use of electrons together and each atom satisfies the noble gas configuration. Based on the student's assumption, students have a sense of the use of electrons together-covalent bonds 'Forces' that hold the atoms in the molecule, not the electrostatic attraction between the electrons and the involved nuclei. Another case, Boo (2000) reported that the letters used together are called covalent bonds. Tan et al. (2001) argues that students' understanding is appropriate for textbooks as follows:

"A covalent bond is the use of a pair of shared electrons in a molecule,"

"One pair of shared electrons is a single covalent bond,"

"Two pairs of shared electrons are covalent double bonds," and

"Three pairs of shared electrons are triple covalent bonds."

Taber (1998, 2002) argues that the misconception of covalent bonds is due to students' assumptions about the formation of chemical bonds based on how the octet rule can be met. Such student understanding can be due to the fact that teacher learning emphasizes that the formation of covalent bond in a compound must meet the octet rule. In fact, according to Effendy (2016b) not all covalent compounds meet the octet rules in the formation of covalent bonds. In addition, the students' assumption that octet rules are met in order to achieve stability is a false assumption. In fact, according to Effendy (2016b) the determination of the

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stability of a covalent compound is determined based on formal payload. Therefore, when teaching the covalent bond teachers should emphasize that the stability of the covalent compound is due to its formal charge. Where, the formal charge of a stable compound is zero.

Polar Molecule

Peterson & Treagust (1989) and Ozmenet al. (2009) reported that students assume that nonpolar molecules are formed only if their molecular atoms have similar electronegativity. If you look at misconceptions that arise, it shows that teachers have actually used the concept of electronegativity to teach molecular polytheism. However, the teacher teaches the less precise molecular polytheism topic where nonpolar molecules belong not only to molecules consisting only of atoms that have similar electronegativity. Effendy (2017) explains that nonpolar molecules can be composed of the same or composed atoms of different atoms and have dipole moments equal to zero.

Peterson & Treagust (1989) and Ozmenet al. (2009) argue that the misconception of students who assume that nonpolar molecules consist of atoms having similar electronegativity arises because students do not use molecular and bonded forms as a contribution to determine the polarity of a molecule. Ozmen et al. (2009) reported that some students think that CO_2 is a nonpolar molecule because the polarity of two bonds C=O neutralizes each other. However, other students think that H_2O is a nonpolar molecule like CO_2 because there are two atoms attached to the central atom are the same and have the same electronegativity. Therefore, in order for students to understand correctly, the concept of dipole moment to determine the polarity of a molecule needs to be taught.

Metal Bonding

Effendy (2016b) states that there are three theories about metal iktan, namely the theory of free electrons, the theory of valence bonds, and molecular orbital theory. However, for high school students the theory is taught only the theory of free electrons. In some studies found students who have misconceptions related to the formation of metal bonds based on the theory of free electrons. Taber (1998) reports that students assume metal bonds are formed when one, two, or three electrons in the valence shell are donated to the lattice so that the noble gas configuration is fulfilled. That is because students conceptualize electrons as something that is distributed or transferred in such a way that the atoms take turns Full outer shell or meet the noble gas configuration. Effendy (2016b) argues that metal bonds are the forces of attraction between metal cations with negatively charged electron clouds formed from valence electrons from metal atoms.

When viewed based on the definition of true metal bonding based on the theory of free electrons. Students tend to use the concept of octet rules to define metal bonds. In addition to metal bonding, the concept of octet rule is also often used by students to define covalent bonds and ionic bonds. This suggests that teachers tend to membelajarkan chemical bonds using octet rules. Whereas Taber (1998) suggests that teachers emphasize that chemical bonds are the forces of attraction between the atomic nucleus and the involved electrons. Where, in metal bonds the nuclei of metal atoms attract the cloud of electrons around metal ions. According to Effendy (2016c) the presence of electron clouds serves as a hoard between existing metal ions so that the repulsion between these ions becomes minimal.

Conclusion

The results of the analysis show some misconceptions that can arise due to learning strategies and content in textbooks among others, namely: (1) The radius of sodium ion is greater than the radius of sodium atom and the radius of chlorine ion is smaller than the radius of chlorine atom ; (2) The radius of the sodium ion is greater than chloride ion; (3) The ionic bond is a bond formed by the electron transfer between metals and non-metals; (4) Sodium atoms use electrons together with chlorine atoms to form molecules; (5) In the representation image of NaCl, the sodium ion is ionic bonded with one chloride ion, whereas with another chloride ion is an attractive force; (6) A covalent bond is a bond in which two atoms are bonded to each other by the use of electrons together and each atom satisfies the noble gas configuration; (7) Nonpolar molecules are formed only when atoms in their molecule have the same electronegativity; and (8) A metal bond is formed when one, two, or three electrons in the valence shell are donated to the lattice so that the noble gas configuration is satisfied.

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