HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

Month Year. Vol(No)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 761-771

Analysis of The Ionic Bond and Related Concept in High School Chemistry Textbooks in Pekanbaru

Ardiansyah* & Indah Fitriyani

Department of Chemistry Education, Faculty of Education and Teacher Training, State Islamic University of Sultan Syarif Kasim Riau, Jl. HR Soebrantas No. 155, Pekanbaru, Indonesia 28293

* Corresponding Author e-mail: ardiansyahm.pd@uin-suska.ac.id

Article History
Received: 30-07-2024
Revised: 17-08-2024
Published: 31-08-2024

Keywords: ionic bond; misconception; textbook

Abstract
Misconceptions about ionic bonding bond and related concept have been revealed by many studies. One source of student misconceptions is high school chemistry textbooks. This research aims to analyze the ionic bonding conceptions contained in Class X high school chemistry textbooks in the city of Pekanbaru. This research uses document analysis techniques. The research sample was 5 high school chemistry books for class X in Pekanbaru City. Misconception are grouped according to Hershey (2004), namely Oversimplifications, Overgeneralizations, Obsolete Concepts and Terms, Misidentifications, and Flawed Research. Most textbooks suffer from Overgeneralizations of the concepts of chemical stability, ionic bonds, and properties of ionic compound.

How to Cite: Ardiansyah, A., & Fitriyani, I. (2024). Analysis of The Ionic Bond and Related Concept in High School Chemistry Textbooks in Pekanbaru. Hydrogen: Jurnal Kependidikan Kimia, 12(4), 761-771. doi:https://doi.org/10.33394/hjkk.v12i4.12532

https://doi.org/10.33394/hjkk.v12i4.12532

INTRODUCTION

Misconceptions are conceptions that are not in line with experts' conceptions (Suyono & Sabtiawan, 2019) . Everyone can experience misconceptions, including lecturers, teachers and students (Suprapto, 2020). Misconceptions in students can hinder students in their learning (Soeharto et al., 2019) because students may not be able to learn the next concept if the initial concept is wrong (Ardiansyah et al., 2021). Therefore, student misconceptions must be prevented from the source and causal factors.

Misconceptions among students can be caused by several factors. Widiyatmoko & Shimizu (2018) said that there are 4 main factors that contribute to students' misconceptions, namely daily experience, language, teachers and textbooks. Meanwhile, according to Biswajit (2019) and Resbiantoro et al. (2022), the sources of misconceptions are the students themselves, teachers, language, teaching methods, traditional practices and beliefs, and books.

The books that students use in learning are called textbooks (Saputri & Widyaningrum, 2016). Textbooks are the main media in the learning process according to the applicable curriculum (Ulumudin et al., 2017). So, textbooks act as the main carrier of the curriculum in the learning process at school (Hadar, 2017). In addition, textbooks have an important role in constructing students' conceptual understanding (Widiyatmoko & Shimizu, 2018). However, textbooks can also be a source of students' misconceptions about the information they provide (Kaltakci-Gurel et al., 2016).

Textbook information that causes students' misconceptions is simplification of concepts, insufficient information, use of unfamiliar terms, confusing language, explanation errors, and use of symbols (Gudyanga, 2014). This can be prevented if the teacher first carries out a concept analysis in the textbook before teaching students in class. However, most teachers do not have sufficient time to obtain data about misconceptions (Bozkurt, 2019) and students' pre-concepts comprehensively (Habiddin & Page, 2019). Therefore, teachers must be assisted by other parties to provide data about misconceptions contained in textbooks.

Misconceptions in textbooks can hinder students in their learning. Zajkov et al., (2017) said that providing inaccurate information in textbooks can trigger student misconceptions, thereby preventing students from developing the knowledge and skills they should obtain. Misconceptions in textbooks can come from ambiguous sentences or inappropriate picture illustrations. Hanifah, (2021) found that image errors in textbooks were greater than text errors. This certainly makes it difficult for students to develop concepts correctly.

Analysis of textbook misconceptions has been carried out by experts. Hershey, (2004) groups misconceptions into 5 categories, namely Oversimplifications, Overgeneralizations, Obsolete Concepts and Terms Misidentifications, and Flawed Research (research that disabled). Agustina et al., (2016) have analyzed book misconceptions using the method from Hershey (2004). This method is commonly used in science books, such as physics, biology and chemistry. The quality of textbook presentation can be improved by considering common misconceptions that occur among students, providing clear and precise explanations, as well as illustrations that are correct according to the concept and risk management (Zajkov et al., 2017). Additionally, animations can be added to textbooks to strengthen the visualization of concepts for students (Chophel, 2022).

Chemistry is a science that includes concepts, calculations, and a combination of both (Prodjosantoso et al., 2019). Some of the concepts in chemistry are abstract, making it difficult for students to learn them and encouraging students to experience misconceptions (Ikenna, 2015), one of which is the concept of chemical bonds. The concept of chemical bonds acts as a bridge between concepts in chemistry (Hunter et al., 2022). Therefore, to study chemistry well, students must have the correct concept of chemical bonds.

In reality, students' misconceptions about chemical bonds are still often found. Students have misconceptions about lattice, intermolecular forces, electrical conductivity of graphite (Fahmi and Irhasyuarna, 2017), the process of forming ionic bonds and covalent bonds, intermolecular forces, bond polarity (Prodjosantoso et al., 2019), ionic bonds, covalent bonds, stability elements, and Lewis structures (Ardiansyah et al., 2021). However, analysis of misconceptions about chemistry textbooks used by students in Pekanbaru city as a learning resource has never been reported. In fact, knowing misconceptions in textbooks is one way to help teachers and students reconstruct concepts well.

METHOD

This research uses a qualitative research approach. The data collection technique used is document analysis technique. Document analysis techniques are systematic procedures for reviewing or analyzing documents in either digital or printed form. Textbook data was obtained by distributing questionnaires to 24 high school chemistry teachers. Next, 5 textbooks were selected to analyze misconceptions regarding ionic bonding material (Flick, 2014). The selection of this book is based on chemistry textbooks which are widely used by teachers in classroom learning and are available on the market.

The researcher is the main instrument in this research. The researcher acted as a data collector and analyzer of chemical bond misconceptions contained in class The main source of reference for misconceptions is a book about misconceptions in chemistry written by (Taber, 2002). Meanwhile, supporting sources for misconceptions are general chemistry books and scientific articles in accredited scientific journals.

Identification of conceptions about ionic bond and related concept in high school chemistry textbooks was carried out by comparing the book information with students' misconceptions about ionic bond and related concept in various national/international accredited scientific journals (Bozkurt, 2019). Apart from that, it is also compared with the actual concept in reference books or scientific articles (Novitasari et al., 2019). Furthermore, the conception categories as Correct Concept (CC) and misconceptions that were identified were grouped into 5 categories, namely Oversimplifications (OS), Overgeneralizations (OG), Obsolete Concepts and Terms (OC), Misidentifications (MI), and Flawed Research (FR) (Hershey, 2004). Then an analysis of the misconceptions found is carried out and provides better recommendations for presenting these concepts in textbooks. This research was carried out in 3 stages:

1. Selection of document samples
   A total of 5 chemistry textbooks were selected using a purposive sampling technique to analyze misconceptions. The textbooks analyzed are textbooks used by high school teachers in Pekanbaru City as references in learning and can be obtained easily in the market.
2. Identify data on students' ionic bond and related conception
   Data on students' ionic bond misconceptions were identified by studying literature in accredited national/international scientific journal articles. This was done to facilitate the identification of chemical bonding misconceptions in high school chemistry textbooks
3. Analysis of chemistry textbook conceptions.
   Conceptions analysis is carried out in several stages. First, researchers worked independently to analyze and group conceptions about ionic bond and related concept contained in textbooks. This analysis and grouping was carried out by comparing textbook information with students' misconceptions and actual concepts. The results of this analysis are stated in a checklist. Second, these results were consulted with 3 experts in the field of chemistry to get recommendations and feedback regarding the misconceptions found. Third, finalize textbook conceptions and misconception categories based on expert recommendations.

RESULTS AND DISCUSSION

High School Chemistry Textbook

Based on the results of a survey of high school chemistry teachers with the help of a Google form which collected information about chemistry textbooks used by teachers as references in chemistry learning and the ease of getting access to books in the market, a total of 5 textbooks were selected for further analysis as shown in Table 1. These books act as representatives of high school chemistry textbooks on chemical bonding material in Pekanbaru city both in terms of text presentation and picture illustrations.

Table 1. High school chemistry textbook

Code	Authors	Title	Year	Publisher
TB1	Unggul Sudarmo	Kimia Untuk SMA/MA Kelas X Kelompok Peminatan MIPA	2013	Erlangga
TB2	Tine Maria Kuswati, Sri Rahayu Ningsih	Konsep dan Penerapan Kimia SMA/MA kelas X Kelompok Peminatan MIPA	2016	Bailmu
TB3	A. Haris Watoni,	Kimia untuk Siswa SMA/MA Kelas X	2016	Yrama Widya

	Dini Kurniawati, Meta Juniastri	Kelompok Peminatan MIPA		
TB4	Nana Sutresna, Dindin Sholehudin, Tati Herlina	Buku Siswa Aktif dan Kreatif Belajar Kimia Untuk SMA/MA Kelas X Peminatan MIPA	2016	Grafindo Media Pratama
TB 5	Nurhalimah Umiyati	Buku Siswa Kimia SMA/MA untuk Keas X Peminatan MIPA	2020	Media Tama

Conceptions of Ionic Bonding in Textbooks

The concepts contained in high school chemistry textbooks are discussed in 3 main groups, namely chemical stability, ionic bond, and properties of ionic compounds. Analysis of conceptions in each item is carried out thoroughly by focusing on concepts where students experience misconceptions based on the literature study that has been carried out. Furthermore, every misconception found will fall into 5 categories, namely Oversimplifications (OS), Overgeneralizations (OG), Obsolete Concepts and Terms (OC), Misidentifications (MI), and Flawed Research (FR) (Hershey, 2004).

Chemical Stability Conception

The results of the analysis of the conception of high school chemistry books about chemical stability are given in Table 2. All the chemistry books analyzed focused too much on fulfilling the octet or duplet rule in explaining why atoms bond, even though the octet rule has limitations in its application. The octet rule is useful in determining which ions are most likely to form, knowing the valence of elements, and predicting which simple compounds will form, but it does not show why the electronic configuration of noble gases is stable (Taber, 1995). Apart from that, the octet rule also cannot explain why molecules such as boron trifluoride (BF_3), phosphorus pentachloride (PCl_5), and sulfur hexafluoride (SF_6) are stable, even though they do not fulfill the octet rule (Gillespie & Silvi, 2002).

Table 2. Chemical stability conception in textbook

Source	Conception	Category
TB1, p.96	"To achieve a stable state like a noble gas, the atoms form an electron configuration like a noble gas"	**OG**
TB2, p.93	"…Elements other than noble gases can achieve stability by forming molecules. The electron configuration of each atom in the molecule it forms resembles a noble gas (octet, except for helium duplets)"	**OG**
TB3, p.141	"To achieve stability like noble gas elements, atoms other than noble gases must bond together" "The rule that states that stable atoms must have 8 valence electrons is called octet's law"	**OG**
TB4, p.56	"…atoms combine to achieve a more stable electron configuration. Maximum stability is achieved when the atom already has the same electron configuration (isoelectron) as the electron configuration of the noble gas"	**OG**
TB5; p.66	"An element will form stability with other elements by handing over electrons so that a stable chemical bond occurs. The electron configuration of an atom will be stable when its outermost electron is 2 (duplet) or 8 (octet)"	**OG**

Textbook statements regarding atomic stability and the octet rule as in Table 2 can cause students to experience misconceptions. This was discovered by Ardiansyah et al., (2021) that students thought that molecules would not form if one of the atoms was not an octet. Presenting chemical bonding material that focuses too much on the octet rule will cause students to be hampered in learning more complicated concepts (Taber, 2002). According to

Taber (1995), textbook statements stating that the purpose of chemically bonded atoms is to fulfill the octet or duplet rule will fail to explain why hydrogen gas ($H_{2(g)}$) and fluorine gas ($F_{2(g)}$) can react to produce acid fluoride gas ($HF_{(g)}$).

In this reaction, hydrogen gas fulfills the duplet rule and fluorine gas fulfills the duplet rule, but the two gases can still react to form the product, HF gas. According to Taber (2002), this reaction can be explained best if we consider the amount of energy required to break a bond and the energy released when a new bond is formed. Bonds are broken in hydrogen (requires 436 kJ mol^{-1}) and in fluorine (requires 158 kJ mol^{-1}), and are formed in hydrogen fluoride (562 kJ mol^{-1}), 2 moles of HF are produced for each mole of hydrogen and fluorine reacted. Therefore, an explanation can be given in terms of more stable products, since there are stronger bonds in these products. Or in other words the reaction occurs to minimize the energy of the system.

Presenting material on chemical bonds that focuses too much on fulfilling the octet without considering the energy of the system will encourage students to have misconceptions. Hanson (2018) found that students failed to understand that the ionization process is not a spontaneous process, but requires energy. If students are able to understand this well, then they will be able to judge which species are stable and which are not according to the given context. However, most students are unable to relate energy changes to ion formation and prefer the octet rule as the reason for stability.

Ionic Bonding Conception

Almost all chemistry books, except TB5 have given the correct definition of ionic bonding. The following is the definition of ionic bonds in TB2:

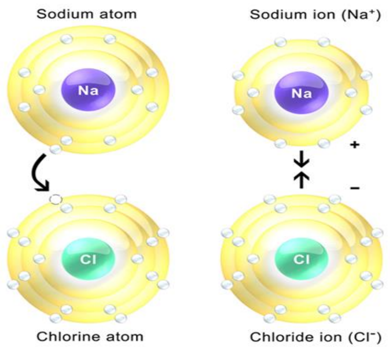
> *"**ikatan ion adalah ikatan yang terbentuk akibat gaya elektrostatik antara ion positif dan ion negatif**"*
>
> "Ionic bonds are bonds formed due to electrostatic forces between positive ions and negative ions"

This definition is a definition that is well accepted by chemists. Gillespie, (1997) states that electrostatic forces are the only important forces in chemistry and ionic bonds are the result of electrostatic attractions between two ions with different charges.

Ionic bonds as bonds that occur due to the process of handing over electrons are a misidentification in explaining ionic bonds as in TB5. The process of handing over electrons is not a type of bond, but a type of chemical reaction, namely a redox reaction. Ionic bonds can also occur without electron transfer, such as in neutralization and precipitation reactions (Taber, 2002). In the neutralization reaction between hydrochloric acid (HCl) and sodium hydroxide (NaOH) solutions, a solution can be formed with Na^+ and Cl^- ions present in the solution. If the solvent is evaporated by heating, this solution will form sodium chloride (NaCl) crystals with ionic bonds and this process occurs without electron transfer.

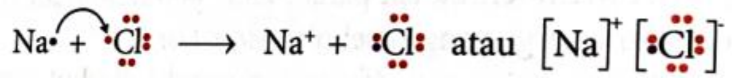
Table 3. Ionic bonding conception in textbook

Sub-concept	**Source**	**Conception**	**Category**
Ionic bonds definition	TB1, p.98 TB2, p.97 TB4, p.57	"*Ion bonding occurs due to the electrostatic attraction between positive and negative ions*"	**CC**
	TB3,	"*Ionic bonds are chemical bonds formed from the electrostatic*	**OG**

	p.150	*force between positive ions and negative ions to form solid ionic compounds*”	
	TB5; p.70	“Bonds that occur due to the electron transfer between one atom and another are called ion bonds”	**MI**
formation of ionic bonding	TB1, p.98 TB2, p.98 TB3, p.150 TB4, p.57 TB5; p.70	“NaCl is formed from Na atoms and Cl atoms.… The 11Na atom, which has an electron configuration of 2 8 1, tends to release one valence electron to form a Na+ cation (2 8). The 17Cl atom configured 2 8 7, tends to accept one electron so that it forms the Cl- anion (2 8 8)” (TB4, p.57)	**OS**
	TB4, p.57 TB5; p.70	“Ion bonds are formed between atoms that easily release electrons (metal atoms) and other atoms that easily accept electrons (non-metallic atoms)” (TB4, p.57)	**OG**
Ionic bonding modeling	TB1, p.98 TB2, p.98 TB3, p.150 TB4, p.57	Almost all books (except TB5) describe ionic bonding formation with an electron transfer diagram from 1 Na atom to 1 Cl atom as follows:  Source:(https://commons.wikimedia.org/wiki/File:Ionic_Bonds.png)	**OS**
Ionic compound formula	TB1, p.99 TB3, p.161 TB4, p.57	“Crystals in sodium chloride (NaCl), for example, are composed of sodium ions and chloride ions in balanced amounts. Each Na+ ion is surrounded by 6 Cl- ions and vice versa, each Cl- ion is surrounded by 6 Na+ ions connected”	**CC**
	TB2, p.98 TB5; p.71	“….each Na+ ion and Cl- ion bind to form a 'molecule' of NaCl compound”	**CC**

The explanation of the process of forming ionic bonds is also overgeneralized in several chemistry textbooks, such as in TB4 and TB5, which state that ionic bonds are formed on metal and non-metal atoms as given in Table 3. Ionic bonds do not occur in all bonds between metal and non-metal atoms. For example, beryllium hloride ($BeCl_2$) which consists of metal and non-metal atoms but has covalent bonds (Suyono & Sabtiawan, 2019) (Ardiansyah et al., 2021) . An explanation like this will encourage misconceptions among students in explaining the process of forming ionic bonds that ionic bonds occur in metal and non-metal atoms through the transfer of electrons (Prodjosantoso et al., 2019) (Temel & Özcan, 2016).

Overgeneralization also occurs in all books in explaining or modeling the process of forming ionic bonds in the formation of NaCl. NaCl is described as being formed from a single Na atom and a single isolated Cl atom. Na gives 1 electron to Cl to form Na^+ and Cl^- which form ionic bonds through electrostatic forces. The following is a simple process found in TB2:



The textbook also explains that the Na atom spontaneously releases its electrons to form the Na^+ cation. In fact, the Na atom needs energy from outside to release its valence electrons to form the Na^+ cation. In addition, if NaCl is made from Na and Cl, then Na exists in the form of Na metal and Cl exists in the form of Cl_2 molecules, not in the form of single Na and Cl atoms (Taber, 2002). Modeling the formation of NaCl from Na and Cl atoms will lead students to the misconception that NaCl exists as separate molecules or pairs of Na^+ and Cl^- ions (Pazinato et al., 2021).

All textbooks explain the formulas of formed ionic compounds well. Some textbooks (TB1, TB3, TB4) explain in detail how the bond between Na^+ and Cl^- in a 3-dimensional structure where each Na^+ cation is surrounded by 6 Cl^- anion, and vice versa where each Cl^- is surrounded by 6 Na^+. However, other textbooks (TB2, TB5) only describe the 3-dimensional structure of NaCl, but do not explain explicitly how the amounts of Na^+ and Cl^- in this structure. This causes students to experience misconceptions because they assume that the Na^+ cation will bond only with 1 Cl^- anion (Taber, 2002).

Properties of Ionic Compounds

Almost all books explain the properties of ionic compounds well as shown in Table 4. TB 1 and TB 2 explain the properties of ionic compounds in terms of boiling point and electrical conductivity. Ionic compounds are able to conduct electricity in the form of melts and solutions, whereas in solid form they are not. Ionic compounds also have high melting and boiling points. TB 3 and TB 5 overgeneralize the nature of ionic compounds which states that all ionic compounds are solid at room temperature. In reality, not all ionic compounds are solid at room temperature, but some are liquid known as room-temperature ionic liquids (RTIL) (Benedetto, 2017).

Table 4. Properties of ionic compound conception in textbook

Sub-concept	Source	Conception	Category
Properties of ionic compound	TB1, p.100	"...In a liquid and solution state, it can conduct electricity because the ions are free to move. In a solid state, ionic compounds cannot conduct electricity because their ions cannot move"	**CC**
	TB2, p.97	"The ion bonds are so strong that the boiling and melting points of ion compounds are relatively high. … Ionic compounds when dissolved in water will decompose into ions, therefore the solution can conduct electricity"	**CC**
	TB3,p.162	"At room temperature, ionic compounds are solid that are brittle and easily break down because cations and anions are close to each other"	OG
	TB4	"The properties of ionic compounds is not explained explicitly"	
	TB5; p.71	"At room temperature, all ionic compounds are solids."	OG

Recommendations for Presenting Ionic Bonds Concept in Textbooks

Bergqvist et al., (2013) suggest avoiding the introduction of ionic bonds as an electron transfer process. The formation of ionic bonds from reactants is shown in the form of molecules or lattice structures and is not focused on atoms as seen in Figure 1. Apart from that, ionic bonds also need to be explained through the formation of ionic compounds from precipitation reactions or evaporation of salt solutions which do not involve an electron transfer process. Finally, they also propose to present a visual mode and explanation of the ionic lattice showing the electrostatic forces between ions in all directions. Textbooks can also add animated videos of ion formation to prevent student misconceptions (Chophel, 2022).

Taber, (1997) suggest to presenting ionic bonding as electrostatic framework compared to molecular framework (common misconceptions that occur in ionic bonds). The electrostatic framework emphasizes that ion structures do not contain discrete molecules, but only ions with different charges arranged in a 3-dimensional structure with certain coordination numbers. Meanwhile, the molecular framework focuses more on the process of handing over electrons and ion pairs are considered to act as molecules.

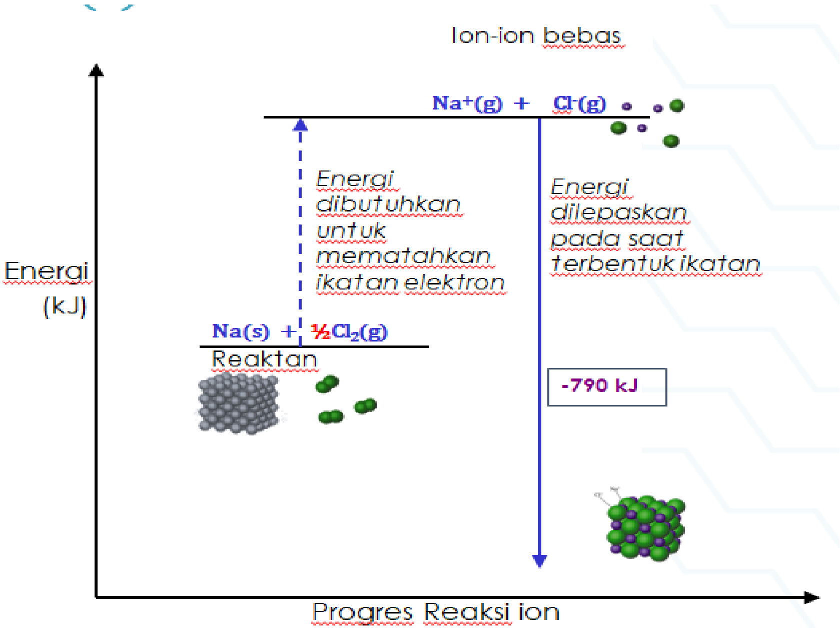


Figure 1. Recommendation of formation of ionic compounds

CONCLUSION

The types of textbook misconceptions found in the concept of ionic bonds are overgeneralization, oversimplification, and misidentification. Overgeneralization occurs in the concept of atomic stability, the definition of ionic bonds, and the process of ion formation. Oversimplification occurs in the explanation and illustration of the formation of ionic bonds. Meanwhile, misidentification only occurs in the definition of ionic bonds.

RECOMMENDATIONS

It is necessary to carry out research on the analysis of covalent bonds and metallic bonds in high school chemistry textbooks so that a comprehensive understanding of the concept of chemical bonds is obtained. High school chemistry textbooks experience misconceptions in presenting chemical bonding material. The most common misconceptions are oversimplification and overgeneralization regarding the formation of ionic bonds and the properties of ionic bonds. The presentation of chemical bonding material should focus on the energy stability of the bonded atoms using an electrostatic framework approach.

ACKNOWLEDGEMENTS

This work has been funded by State University Operational Assistance (BOPTN) State Islamic University of Sultan Syarif Kasim Riau Number 177/Un.04/PPK.2/TL.00/03/2023.

BIBLIOGRAPHY

Agustina, R., Sipahutar, H., & Harahap, F. (2016). Analisis Miskonsepsi Pada Buku Ajar Biologi SMA Kelas XII. *Jurnal Pendidikan Biologi*, *5*(2), 113–118. https://doi.org/10.24114/jpb.v5i2.4307

Ardiansyah, Jahro, I. S., & Darmana, A. (2021). Identification of High School Students ' Misconceptions on Chemical Bonding With Three Tier Test. *Jurnal Pendidikan Dan Pembelajaran Kimia*, *10*(3), 171–179. https://doi.org/10.23960/jppk.

Benedetto, A. (2017). Room-temperature ionic liquids meet bio-membranes: the state-of-the-art. *Biophysical Reviews*, *9*(4), 309–320. https://doi.org/10.1007/s12551-017-0279-1

Bergqvist, A., Drechsler, M., De Jong, O., & Rundgren, S. N. C. (2013). Representations of chemical bonding models in school textbooks-help or hindrance for understanding? *Chemistry Education Research and Practice*, *14*(4), 589–606. https://doi.org/10.1039/c3rp20159g

Biswajit, B. (2019). Misconceptions in Shape of Molecule: Evidence from 9th grade science students. *Educational Research and Reviews*, *14*(12), 410–418. https://doi.org/10.5897/err2019.3755

Bozkurt, F. (2019). Evaluation of geography textbooks in terms of misconceptions about climate topic. *Review of International Geographical Education Online*, *9*(1), 149–170. https://doi.org/10.33403/rigeo.573480

Chophel, Y. (2022). Remediating misconceptions related to particulate nature of matter using video animation: An action research. *International Research Journal of Science*, *2*(1), 65–77. https://doi.org/10.5281/zenodo.6496773

Fahmi and Irhasyuarna, Y. (2017). The Misconceptions of Senior High School Students in Banjarmasin on Chemical Bonding. *Journal of Education and Practice*, *8*(17), 32–39. http://www.iiste.org/Journals/index.php/JEP/article/view/37464

Flick, U. (2014). *An Introduction To Qualitative Research*. Sage Publication.

Gillespie, R. J. (1997). The Great Ideas of Chemistry. *Journal of Chemical Education*, *74*(7), 862. https://doi.org/10.1021/ed074p862

Gillespie, R. J., & Silvi, B. (2002). The octet rule and hypervalence: Two misunderstood concepts. *Coordination Chemistry Reviews*, *233–234*, 53–62. https://doi.org/10.1016/S0010-8545(02)00102-9

Gudyanga, E. (2014). Pedagogics of Chemical Bonding in Chemistry; Perspectives and Potential for Progress: The Case of Zimbabwe Secondary Education. *International Journal of Secondary Education*, *2*(1), 11. https://doi.org/10.11648/j.ijsedu.20140201.13

Habiddin, & Page, E. M. (2019). Development and validation of a four-tier diagnostic instrument for chemical kinetics (FTDICK). *Indonesian Journal of Chemistry*, *19*(3), 720–736. https://doi.org/10.22146/ijc.39218

Hadar, L. L. (2017). Opportunities to learn: Mathematics textbooks and students' achievements. *Studies in Educational Evaluation*, *55*(August), 153–166. https://doi.org/10.1016/j.stueduc.2017.10.002

Hanifah, M. (2021). Meta Analisis Miskonsepsi Buku Teks Biologi SMA Kelas XI. *Jurnal Biologi Dan Pembelajarannya (JB&P)*, *8*(1), 32–39. https://doi.org/10.29407/jbp.v8i1.15735

Hanson, R. (2018). Teacher Trainees' Interpretations of Chemical Stability and Chemical Reactivity. *International Journal for Cross-Disciplinary Subjects in Education*, *9*(4), 3906–3916. https://doi.org/10.20533/ijcdse.2042.6364.2018.0474

Hershey, D. R. (2004). Avoid Misconceptions When Teaching about Plants. *Website Http://Www. Actionbioscience. Org/Education/Hershey. Html*, 1–10.

Hunter, K. H., Rodriguez, J. M. G., & Becker, N. M. (2022). A Review of Research on the Teaching and Learning of Chemical Bonding. *Journal of Chemical Education*, *99*(7), 2451–2464. https://doi.org/10.1021/acs.jchemed.2c00034

Ikenna, I. A. (2015). Remedying students' misconceptions in learning of chemical bonding and spontaneity through intervention discussion learning model (IDLM). *International Journal of Educational and Pedagogical Sciences*, *8*(10), 3251–3254.

Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C. (2016). Identifying pre-service physics teachers' misconceptions and conceptual difficulties about geometrical optics. *European Journal of Physics*, *37*(4), 1–30. https://doi.org/10.1088/0143-0807/37/4/045705

Novitasari, C., Ramli, M., & Karyanto, P. (2019). Content analysis of misconceptions on bacteria in the biology textbook of high school. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022076

Pazinato, M. S., Bernardi, F. M., Miranda, A. C. G., & Braibante, M. E. F. (2021). Epistemological Profile of Chemical Bonding: Evaluation of Knowledge Construction in High School. *Journal of Chemical Education*, *98*(2), 307–318. https://doi.org/10.1021/acs.jchemed.0c00353

Prodjosantoso, A. K., Hertina, A. M., & Irwanto. (2019). The misconception diagnosis on ionic and covalent bonds concepts with three tier diagnostic test. *International Journal of Instruction*, *12*(1), 1477–1488. https://doi.org/10.29333/iji.2019.12194a

Saputri, D. A. F., & Widyaningrum, T. (2016). Misconceptions Analysis On The Virus Chapter. *Biology Textbooks For High School Students Grade X. International Journal of Active Learning*, *1*(1), 1. http://aseanjournals.com

Soeharto, Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 247–266. https://doi.org/10.15294/jpii.v8i2.18649

Suprapto, N. (2020). Do We Experience Misconceptions?: An Ontological Review of Misconceptions in Science. *Studies in Philosophy of Science and Education*, *1*(2), 50–55. https://doi.org/10.46627/sipose.v1i2.24

Suyono, & Sabtiawan, W. B. (2019). Reducing the misconception burdens of students with balance visual-verbal learning style through the conceptual change strategy assisted by student worksheet. *Journal of Science Education*, *20*(2), 85–98.

Taber, K. S. (1995). The Octet Rule. *Chemistry LibreTexts*, *September*, 1–28.

https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Electronic_Structure_of_Atoms_and_Molecules/Electronic_Configurations/The_Octet_Rule#:~:text=The octet rule

Taber, K. S. (1997). Students Understanding of Ionic Bonding: Molecular versus electrostatic framework? *School Science Review*, *78*, 85–95.

Taber, K. S. (2002). *Chemical misconceptions - prevention, diagnosis and cure: theoretical background* (Vol. 1). Royal Society of Chemistry. www.rsc.org/learn-chemistry/resource/.../pdf

Temel, S., & Özcan, Ö. (2016). The Analysis of Prospective Chemistry Teachers' Cognitive Structure: The Subject of Covalent and Ionic Bonding. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(8), 1953–1969. https://doi.org/10.12973/eurasia.2016.1273a

Ulumudin, I., Mahdiansyah, & Suwardi Joko, B. (2017). *Kelengkapan dan Kelayakan Buku Teks Kurikulum 2013*. Kemendikbud. https://litbang.kemdikbud.go.id

Widiyatmoko, A., & Shimizu, K. (2018). Literature Review of Factors Contributing to Students' Misconceptions in Light and Optical Instruments. *International Journal of Environmental & Science Education*, *13*(10), 853–863. http://www.ijese.com

Zajkov, O., Gegovska-Zajkova, S., & Mitrevski, B. (2017). Textbook-Caused Misconceptions, Inconsistencies, and Experimental Safety Risks of a Grade 8 Physics Textbook. *International Journal of Science and Mathematics Education*, *15*(5), 837–852. https://doi.org/10.1007/s10763-016-9715-0