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SUPPLEMENTARY MATERIAL TO

Remediation of chemistry teachers' misconceptions about covalent bonding using cognitive conflict interviews: A case study

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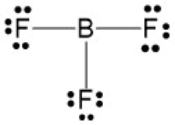
AN EXAMPLE OF COGNITIVE CONFLICT INTERVIEW

The misconception: An atom forms a bond to fulfill an octet or duplet structure

	Step	Cognitive conflict interview
1.	Identifying the pre-conception	Exploring and confirming respondent's misconceptions by using questions, for example: In a molecule, atoms form bonds. Why do these atoms form bonds one and another?
2.	Creating cognitive conflicts by providing the experimental facts, anomalies, and contradictions.	• Indicating atom(s) that in their compounds do not obey the octet or duplet rules, for example: • The Lewis structure of BF_3 is as follows:  Does the B atom in BF_3 molecule obey the octet or duplet rules? • Showing that the energy level of a molecule in a gaseous state is lower than the energy level of its constituent atoms in the same state, for example: The energy level of 1 mole of CH_4 molecules gas is 1652 kJ lower than the energy level of 1 mole of C atoms and 4 moles of H atoms in the gaseous state.

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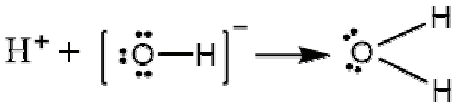
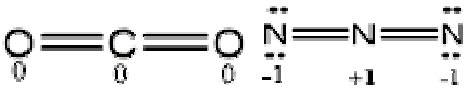
Step	Cognitive conflict interview
3. Stimulating the equilibration process using the relevant questions	Asking guided questions to assist a respondent in realizing their misconceptions and overcoming those misconceptions, for example: • Consider the Lewis structure of BF_3. Does the B atom in the BF_3 molecule have an octet or duplet configuration? • Do atoms form bonds to obey the octet or duplet rule? • Which has higher stability, 1 C atom and 4 H atoms in the gaseous phase or one CH_4 molecule in the same phase? • Which has a lower energy level, 1 mole of C atoms and 4 moles of H atoms in the gaseous phase or 1 mole of CH_4 molecules in the same phase? • What is the relationship between the energy level of matter and its stability?
4. Confirming the scientific concept	Asking a question to confirm the respondent's understanding, for example: If so, why does an atom bond with the other(s)?

THE CONCEPTUAL UNDERSTANDING TEST OF COVALENT BONDING

Indicator	Problem	Item
Explaining the purpose of atoms forming bonds	An H atom and a Cl atom bond to form the HCl molecule, as shown in the following equation:  Why do these atoms bond? *Answer* : …	1
Determining the type(s) of bond in a molecule	What is the type of the bond formed in question number 1? *Answer* : … *Reason* : …	2
Determining the types of atoms that can form covalent bonds	Consider the following compounds formed through the covalent bonding: CH_4, PCl_5, $BeCl_2$, $B(CH_3)_3$, and CO_2. Based on these examples, what types of atoms form covalent bonds? *Answer* : … *Reason* : …	3
Distinguishing between a covalent bonding and a coordinate covalent bonding	H_2O compounds can be formed in the reaction between H^+ and OH^- ions as follows:  How many kinds of O-H bonds are there in the water molecule produced by the above reaction? Mention! *Answer* : … *Reason* : …	4
Estimating the polarity of a covalent bonding in a molecule	Predict the polarity of the covalent bonds in molecules of CCl_4, PCl_3, PBr_5, F_2, H_2, and SeF_6! *Answer* : … *Reason* : …	5
Ordering the degree of polarity of the covalent bonds in the molecules	Order the polarity of the covalent bonds of HF, HCl, and HBr molecules from the largest to the smallest! *Answer* : … *Reason* : …	6

Indicator	Problem	Item
Describing the Lewis structure of a molecule	Write down the Lewis structures of SF_2 and SF_4? *Answer* : …	7
	What is the formal charge of the atoms in question number 7? *Answer* : …	8
	Write down the Lewis structures of NO_2^- and NO_2 along with the formal charge of each atom! *Answer* : …	9
	Why is the formal charge on the atom N of one of the species in the problem No.9 not equal to zero? *Answer* : …	10
Determining the stability of a molecule or polyatomic ion based on their formal charge	Both carbon dioxide, CO_2, and azide ion, N_3^-, species have the same number of electrons, which is 22 electrons. The Lewis structure of both species is as follows:  What is the stability of both species based on their formal charge? *Answer* : … *Reason* : …	11
Distinguishing between atoms that must obey the octet rule and those that do not need to obey the octet rule in the molecule	What atoms can have eight electrons or less in their valence shell, when acting as the central atom? Give an example! *Answer* : …	12
	What atoms tend to obey the octet rule when acting as the central atom? Give an example! *Answer* : …	13
	In which period atoms tend to have a formal charge of zero or can have more than eight electrons in their valence shell when acting as the central atom? Give an example! *Answer* : …	14
Ordering the covalent bonding lengths of several molecules	Draw the Lewis structure of ethane, ethene, and ethyne! *Answer* : …	15
	What is the bond order between the C atoms in ethane, ethene, and ethyne! *Answer* : … *Reason* : …	16
	Order the length of the covalent bonds between the C atoms in ethane, ethene, and ethyne molecules from the longest to the shortest! *Answer* : … *Reason* : …	17
	Order the length of the covalent bonds in the HF, HCl, and HBr molecules from the longest to the shortest! *Answer* : … *Reason* : …	18