Checkpoint Task: Bonding and Structure

Student Activity

Introduction

In your study of Bonding and Structure at A Level, you will be building a lot on ideas that you have already covered previously. Because bonding is a complex subject that is often simplified at GCSE, many learners can have unclear ideas or misconceptions about the topic. This activity will encourage you to explore what you already understand about chemical bonding, and to identify those areas that you still struggle with or require refinement at A Level.

Task

Here are twenty statements about chemical bonding. Decide whether the statement is always true (unbreakable rule) or usually true (rule of thumb). For the statements that you think are not always true, try to think up some exceptions to the rule. You could use an equation or example element or compound to illustrate the 'exception to the rule'. Feel free to consult textbooks or other resources to help you with this.

See next page.

A. The atoms of Group 2 elements have two electrons in their outer shell.	B. Noble gases do not form any types of bonds because they have full outer shells.
C. Ionic substances have higher melting points than covalent substances.	D. Oppositely charged ions attract.
E. Delocalised electrons are more stable than electrons in fixed atomic orbitals.	F. Energy is released when ionic bonds form.
G. In an ionic compound, ions are combined in proportions which balance out the electrical charges.	H. Energy is needed to break covalent bonds.
I. Energy is required to form positive ions from atoms.	J. Energy is released when negative ions are formed from atoms.

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K. Bonding within compounds is either ionic or covalent.	L. Electrons shared between atoms (in molecular orbitals) are more stable than electrons in atomic orbitals.
M. Electrons that are closer to the nucleus experience less shielding and are more strongly attracted than electrons further away.	N. A covalent bond is formed from a shared pair of electrons; one electron comes from each atom within the bond.
O. Compounds are more stable than elements.	P. Elements always react to form ions with noble gas electron configurations.
Q. Ionic compounds are formed when metals react with non-metals.	R. Covalent compounds are formed when non-metals react with other non-metals.
S. Hydrogen atoms form ions by losing one electron and becoming H^+.	T. Within a covalent compound, all elements except hydrogen have eight electrons in their outer shells.

Answers

Unbreakable Rule Statements

A. The atoms of Group 2 elements have two electrons in their outer shell.

> This is not a guideline but relates to the position of elements in the periodic table. As learners are introduced to more complex ideas at A Level (such as s,p,d,f notation) they can grow doubtful of earlier, simpler ideas in case they turn out to now be 'wrong'.

D. Oppositely charged ions attract.

> This is of course always true, but the statement is included for the same reasons as the one above.

E. Delocalised electrons are more stable than electrons in fixed atomic orbitals.

> Learners have probably only met delocalised electrons in metals and graphite at this stage, but this will become important in organic chemistry later in the course.

F. Energy is released when ionic bonds form.

> Always true: if separating ions means overcoming electrostatic attractions and an input of energy, the reverse must be true when ions come together to form a lattice.

G. In an ionic compound, ions are combined in proportions which balance out the electrical charges.

> Always true: ionic compounds cannot have a charge overall, but this tests learners' understanding of the term 'compound' as they will have come across molecular ions.

H. Energy is needed to break covalent bonds.

> Always true, because an electrostatic attraction is being overcome.

I. Energy is required to form positive ions from atoms.

> Always true, for the same reasons as above.

L. Electrons shared between atoms (in molecular orbitals) are more stable than electrons in atomic orbitals.

> Always true but the wording may confuse students. This is linked to the idea in I – if energy is needed to pull apart the atoms in a covalent molecule, the electrons within the bonding orbital must be more energetically stable.

M. Electrons that are closer to the nucleus experience less shielding and are more strongly attracted than electrons further away.

Always true; again because of the electrostatic attractions involved.

Rule of Thumb Statements

B. Noble gases do not form any types of bonds because they have full outer shells.

Exception: Noble gases further down the group, such as xenon, do react with very reactive elements such as fluorine as they are able to accommodate more than eight electrons in their outer shell.

C. Ionic substances have higher melting points than covalent substances.

Exception: This is usually true but not the case for giant covalent structures such as diamond, graphite and silicon dioxide.

J. Energy is released when negative ions are formed from atoms.

Exception: Energy is usually released when anions with a single negative charge form. However, adding an electron to a negatively charged ion is always very endothermic and so formation of 2– or 3– ions is usually endothermic. In addition to this, the first electron affinity of some elements such as nitrogen, beryllium and noble gases are also endothermic.

K. Bonding within compounds is either ionic or covalent.

Exception: Once again, the existence of molecular ions means this is only a rule of thumb – many common substances contain both covalent and ionic bonding. Additionally there are covalent molecules which readily dissociate in solution to form ions.

N. Exception: dative covalent bonds are formed when one atom donates a pair of electrons to an electron-deficient species.

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O. Compounds are more stable than elements.

Exception: The formation of some compounds requires the breaking of very strong covalent bonds – as a result, these compounds are generally less stable than the elements. Oxides of nitrogen are a good example of this; ethane and hydrogen iodide also have a positive enthalpy of formation.

P. Elements always react to form ions with noble gas electron configurations.

> Exception: Transition metals generally do not form ions with noble gas configurations as this would require the removal of a large number of electrons.

Q. Ionic compounds are formed when metals react with non-metals.

> Exception: Aluminium forms several covalent compounds. Ionic compounds can also be formed from the combination of ammonium ions with non-metal anions, and organic acids and amines can form ionic salts.

R. Covalent compounds are formed when non-metals react with other non-metals.

> Exception: Aluminium and beryllium form several covalent compounds. Ionic compounds can also be formed from the combination of ammonium ions with non-metal anions.

S. Hydrogen atoms form ions by losing one electron and becoming H^+.

> Exception: In metal hydrides, hydrogen atoms gain an electron to form H^- ions.

T. Within a covalent compound, all elements except hydrogen have eight electrons in their outer shells.

> Exception: Group 13 elements can only share three electrons and so have six electrons in their outer shells. Elements in Period 3 or below can have more than eight (PF_5, SF_6)

AS and A LEVEL

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