

Ionic bonding

Target level

This probe may be used with students in the 14–16 age range who have studied chemical bonding, or with post-16 chemistry students.

Topic

Ionic bonding.

Rationale

This probe is designed to elicit alternative conceptions about ionic bonding that have been found to be commonplace among students. In particular, the probe explores the extent to which students see ionic bonding in sodium chloride as a molecular phenomena, with discrete NaCl ion pairs which are internally ionically bonded, but attracted to each other by weaker forces. These ideas are discussed in Chapter 8 of the Teachers' notes.

The probe presented here is an edited version of the draft which was piloted, and which was considered to be too long. When the probe was tried out in schools and colleges it was considered 'excellent'. Teachers reported that it led to 'interesting results' and 'lively debate' which brought out many misconceptions. It was considered to help clarify points and to provoke students into asking questions and thinking about the topic. It was considered by students to be 'useful', 'good for revision' and 'interesting' - and some even found it enjoyable!

Instructions

It is worth reiterating to the students that the diagram shows just a small part of a slice through the lattice structure - and that the real structure is three-dimensional.

A blank answer sheet is provided offering the options 'true', 'false' and 'do not know' for each item. An alternative version of the answer sheet only includes the 'true' and 'false' options as some teachers prefer not to allow a 'do not know' option.

Resources

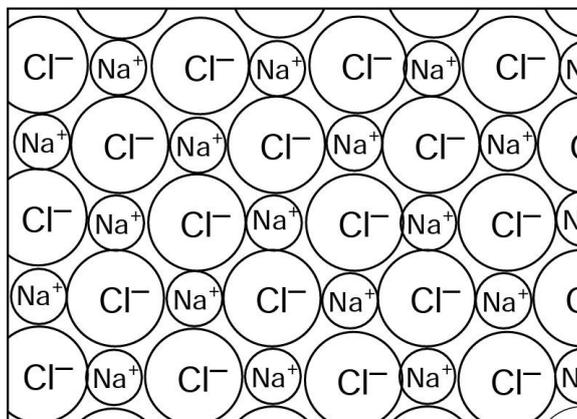
- _ Student worksheets
- Ionic bonding - true or false?
- True or false? - response sheets (two versions)
- Ionic bonding – answers

Feedback for students

A suggested feedback sheet is provided for students (**Ionic bonding – answers**) and teachers may wish to issue this after students have tackled the probe.

Ionic bonding – answers

Below you will find listed the 20 statements you were asked to think about. Following each is a brief comment suggesting whether or not the statement is true, and why.

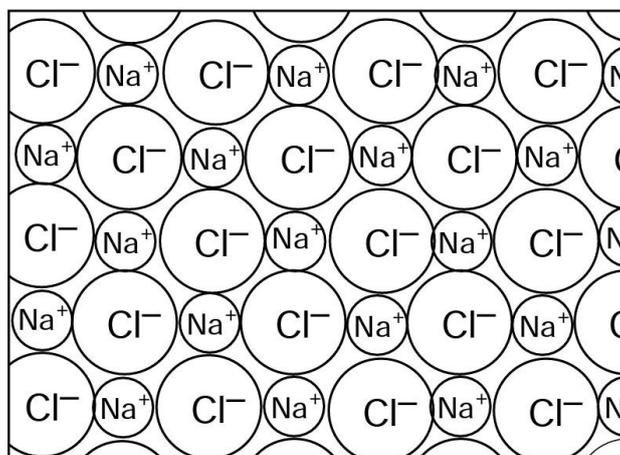


1. A positive ion will be attracted to any negative ion. **TRUE:** any positively charged object will be attracted to any negatively charged object. It does not matter how the objects acquired the charge, the attraction only depends on the amount of charge, and the distance between the two charged objects.
2. A sodium ion is only bonded to the chloride ion it donated its electron to. **FALSE:** each positive sodium ion is bonded to each of the neighbouring negative chloride counterions. It is irrelevant how the ions came to be charged.
3. A sodium atom can only form one ionic bond, because it only has one electron in its outer shell to donate. **FALSE:** a sodium ion can strongly bond to as many chloride ions as can effectively pack around it in the regular crystal lattice. In NaCl there will be six chloride ions strongly bonded to each sodium ion.
4. The reason a bond is formed between chloride ions and sodium ions is because an electron has been transferred between them. **FALSE:** The reason a bond is formed between chloride ions and sodium ions is because they have opposite electrostatic charges - negative and positive.
5. In the diagram a chloride ion is attracted to one sodium ion by a bond and is attracted to up to three other sodium ions just by forces. **FALSE:** In the diagram each chloride ion is attracted to up to four sodium ions by a bond that is an electrostatic force. (There would also be a fifth sodium ion above the chlorine ion and one more below - but these are not shown in the diagram.)
6. In the diagram each molecule of sodium chloride contains one sodium ion and one chloride ion. **FALSE:** there are no molecules in sodium chloride, just ions. A molecule comprises a group of atoms strongly bound together, and only weakly bonded (if at all) to other molecules. In sodium chloride each ion is strongly bonded to each of its six nearest neighbours.
7. An ionic bond is the attraction between a positive ion and a negative ion. **TRUE.**
8. A positive ion can be bonded to any neighbouring negative ion, if it is close enough. **TRUE.** The bond is just the attraction between the oppositely charged ions. If the ions are close together this force will be a strong bond.
9. A negative ion will be attracted to any positive ion. **TRUE:** any negatively charged object will be attracted to any positively charged object. It does not matter how the

- objects acquired the charge, the attraction only depends on the amount of charge, and the distance between the two charged objects.
10. It is not possible to know where the ionic bonds are, unless you know which chloride ions accepted electrons from which sodium ions. **FALSE:** as the bonding is just the attraction between ions, there will be a bond between any adjacent oppositely charged ions.
 11. A chloride ion is only bonded to the sodium ion it accepted an electron from. **FALSE:** each negative chloride ion is bonded to each of the neighbouring positive sodium counter-ions. It is irrelevant how the ions came to be charged.
 12. A chlorine atom can only form one strong ionic bond, because it can only accept one more electron into its outer shell. **FALSE:** a chloride ion can strongly bond to as many sodium ions as can effectively pack around it in the regular crystal lattice. In NaCl there will be six sodium ions strongly bonded to each chloride ion.
 13. There is a bond between the ions in each molecule, but no bonds between the molecules. **FALSE:** there are no molecules in sodium chloride, but a continuous network of bonds throughout the lattice.
 14. A negative ion can only be attracted to one positive ion. **FALSE:** there is no limit to the number of positive ions that a negative ion can be attracted to (although there is a limit to how many can cluster around it).
 15. The reason a bond is formed between chloride ions and sodium ions is because they have opposite charges. **TRUE:** the opposite charges attract them together, and this force of attraction is the ionic bond.
 16. In the diagram a sodium ion is attracted to one chloride ion by a bond and is attracted to three other chloride ions just by forces. **FALSE:** In the diagram each sodium ion is attracted to up to four chloride ions by a bond that is an electrostatic force. (There would also be a fifth chloride ion above the sodium ion and one more (a sixth) below - but these are not shown in the diagram.)
 17. A positive ion can only be attracted to one negative ion. **FALSE:** there is no limit to the number of positive ions that a negative ion can be attracted to (although there is a limit to how many can cluster around it).
 18. An ionic bond is when one atom donates an electron to another atom, so that they both have full outer shells. **FALSE:** an ionic bond is the electrostatic force which holds two oppositely charged ions together. The ions could have become charged by electron transfer, but usually the ions were charged long before they came into contact. The bond is no stronger in the few cases where an electron has transferred between two atoms to give the ions that have become bonded.
 19. A negative ion can be bonded to any neighbouring positive ion, if it is close enough. **TRUE.** The bond is just the attraction between the oppositely charged ions. If the ions are close together this force will be a strong bond.
 20. There are no molecules shown in the diagram. **TRUE:** A molecule comprises a group atoms strongly bound together, and only weakly bonded (if at all) to other molecules. In sodium chloride each ion is strongly bonded to each of its six nearest neighbours.

Ionic bonding – true or false?

The statements below refer to the diagram of the structure of sodium chloride. The diagram shows part of a slice through the three dimensional crystal structure.



Please read each statement carefully, and decide whether it is correct or not.

1. A positive ion will be attracted to any negative ion.
2. A sodium ion is only bonded to the chloride ion it donated its electron to.
3. A sodium atom can only form one ionic bond, because it only has one electron in its outer shell to donate.
4. The reason a bond is formed between chloride ions and sodium ions is because an electron has been transferred between them.
5. In the diagram a chloride ion is attracted to one sodium ion by a bond and is attracted to other sodium ions just by forces.
6. In the diagram each molecule of sodium chloride contains one sodium ion and one chloride ion.
7. An ionic bond is the attraction between a positive ion and a negative ion.
8. A positive ion can be bonded to any neighbouring negative ions, if it is close enough.
9. A negative ion can be attracted to any positive ion.
10. It is not possible to point to where the ionic bonds are, unless you know which chloride ions accepted electrons from which sodium ions.
11. A chloride ion is only bonded to the sodium ion it accepted an electron from.
12. A chlorine atom can only form one ionic bond, because it can only accept one more electron into its outer shell.
13. There is a bond between the ions in each molecule, but no bonds between the molecules.
14. A negative ion can only be attracted to one positive ion.
15. The reason a bond is formed between chloride ions and sodium ions is because they have opposite charges.
16. In the diagram a sodium ion is attracted to one chloride ion by a bond and is attracted to other chloride ions just by forces.
17. A positive ion can only be attracted to one negative ion.
18. An ionic bond is when one atom donates an electron to another atom, so that they both have full outer shells.
19. A negative ion can be bonded to any neighbouring positive ions if it is close enough.
20. There are no molecules shown in the diagram.

True or false? – response sheet

1.	True	False	1.
2.	True	False	2.
3.	True	False	3.
4.	True	False	4.
5.	True	False	5.
6.	True	False	6.
7.	True	False	7.
8.	True	False	8.
9.	True	False	9.
10.	True	False	10.
11.	True	False	11.
12.	True	False	12.
13.	True	False	13.
14.	True	False	14.
15.	True	False	15.
16.	True	False	16.
17.	True	False	17.
18.	True	False	18.
19.	True	False	19.
20.	True	False	20.

True or false? – response sheet

1.	True	Do not know	False	1.
2.	True	Do not know	False	2.
3.	True	Do not know	False	3.
4.	True	Do not know	False	4.
5.	True	Do not know	False	5.
6.	True	Do not know	False	6.
7.	True	Do not know	False	7.
8.	True	Do not know	False	8.
9.	True	Do not know	False	9.
10.	True	Do not know	False	10.
11.	True	Do not know	False	11.
12.	True	Do not know	False	12.
13.	True	Do not know	False	13.
14.	True	Do not know	False	14.
15.	True	Do not know	False	15.
16.	True	Do not know	False	16.
17.	True	Do not know	False	17.
18.	True	Do not know	False	18.
19.	True	Do not know	False	19.
20.	True	Do not know	False	20.