Bonding: the structure of compounds

Lesson plan and teacher's notes · Form 2 Chemistry · 1 period of 40 minutes

School	(write school name)	**Teacher**	(write name)
Date	(date)	**Class**	Form 2
Subject	Chemistry	**Enrolment**	Boys ___ Girls ___ Total ___
Time	40 minutes	**Topic**	Bonding: the structure of compounds

Learners explain what the structure of a compound means, describe simple molecules with the shapes of water, carbon dioxide and ammonia, describe giant structures (macromolecules and ionic lattices), and link structure to melting point, boiling point and conduction so they can classify a compound as simple or giant.

Specific outcomes

By the end of the lesson, learners should be able to:

1. Explain what the structure of a compound means
2. Describe simple molecules and name examples such as water, carbon dioxide and ammonia
3. Describe giant structures: macromolecules and ionic lattices
4. Link the structure of a compound to its melting point, boiling point and conduction, and classify a compound as simple or giant

Prior knowledge

- Atoms and the idea of ionic and covalent bonds
- Solids, liquids and gases
- Formulae of simple compounds such as H_2O and NaCl

Teaching and learning materials

- chalk and board
- plasticine or clay and sticks or matchsticks for models
- sugar or sand samples if available
- exercise books

References

Ministry of Education (CDC) Form 2 Chemistry syllabus and module; 25Schools learners' note: Bonding: the structure of compounds.

Lesson development

Stage and time	Teacher activities	Learner activities
Introduction 5 min	Ask why water flows, diamond is very hard and table salt forms tiny crystals although all are made from atoms. Write structure of a compound on the board.	Suggest reasons and copy the meaning of structure of a compound.
Development: simple molecules 10 min	Describe simple molecules held by weak intermolecular forces. Show H_2O as V-shaped, CO_2 as linear and NH_3 as pyramidal. Explain why little energy is needed to pull them apart.	Draw the three shapes and say why they have low melting and boiling points.
Development: giant structures 12 min	Describe macromolecules joined by covalent bonds (diamond, graphite, silicon dioxide) and ionic lattices (NaCl, MgO, CaF_2) held by strong electrostatic forces.	Make a table of simple molecules, macromolecules and ionic lattices with examples.
Development: classifying 10 min	Use the key question: what holds the particles together and how strong is it? Work the sodium chloride and carbon dioxide example.	Classify four compounds as simple or giant and give the reason.
Conclusion 3 min	Ask which of two compounds is more likely to be a gas at room temperature and why. Set the homework.	Answer and copy the homework.

Teacher's content notes

Read these before the lesson. They are what you need to know, not what to copy onto the board.

What the structure of a compound is

The structure of a compound is the arrangement of its atoms in space and the bonds that join them. Compounds form through chemical bonds such as ionic and covalent bonds, and these give each compound its own three-dimensional structure. The structure decides the properties of the compound, such as its melting point, its solubility and how it reacts. Compounds are classified into two groups: simple structures and giant structures.

Simple molecules

Simple molecules are separate, small molecules held to each other by weak intermolecular forces. Water (H_2O), carbon dioxide (CO_2) and ammonia (NH_3) are examples. Water is V-shaped, carbon dioxide is linear and ammonia is pyramidal. Because the forces between the molecules are weak, little energy is needed to pull them apart, so simple molecules have low melting points and low boiling points. They are usually liquids or gases at room temperature and normal pressure.

Giant structures

Giant structures are very large. There are two kinds in this topic. Macromolecules are large molecules in which the atoms are joined by covalent bonds. Diamond, graphite and

silicon dioxide are examples. The covalent bonds are strong, so a lot of energy is needed to break them. Macromolecules have high melting and boiling points, are usually solids at room temperature and are usually non-conductors, except graphite. Ionic lattices are large ionic structures such as sodium chloride (NaCl), magnesium oxide (MgO) and calcium fluoride (CaF_2), with ions held by strong electrostatic forces of attrac

Simple or giant

To decide whether a substance has a simple or a giant structure, ask what holds the particles together and how strong it is.

Questions to ask during the lesson

Question	Expected answer
A learner asks why diamond is very hard while water flows easily. (a) Say what the structure of a compound is. (b) Say what the two groups of structures are. (c) Say what the structure decides.	(a) The arrangement of its atoms in space and the bonds that join them. (b) Simple structures and giant structures. (c) Its properties, such as melting point, solubility and how it reacts.
A class studies water, carbon dioxide and ammonia. (a) Say what kind of structure they have. (b) Say what holds the molecules to their neighbours. (c) Say why they have low melting and boiling points.	(a) Simple molecules. (b) Weak intermolecular forces. (c) Little energy is needed to pull the molecules apart.
A learner studies diamond, graphite and silicon dioxide. (a) Name the kind of giant structure. (b) Say what joins the atoms. (c) Say why they have high melting points.	(a) Macromolecules. (b) Covalent bonds. (c) The bonds are strong, so a lot of energy is needed to break them.
A learner reads that sodium chloride, magnesium oxide and calcium fluoride are all the same kind of structure. (a) Name the kind. (b) Say what holds the ions together. (c) Give the formula of calcium fluoride.	(a) Ionic lattices. (b) Strong electrostatic forces of attraction. (c) CaF_2.

Worked examples for the board

Example 1: which is a gas?

Sodium chloride has a giant structure but carbon dioxide has a simple structure. Which is more likely to be a gas at room temperature? Carbon dioxide is a simple molecule. Its molecules are held by weak intermolecular forces. Little energy is needed to separate them, so the melting and boiling points are low. So carbon dioxide is the one that is a gas at room temperature.

Example 2: classifying diamond

Diamond has atoms joined by strong covalent bonds, so it is a macromolecule, a giant structure. A lot of energy is needed to break the bonds, so it has a high melting point and is a solid at room temperature.

Example 3: classifying ammonia

Ammonia is NH_3. It is a small separate molecule held to its neighbours by weak intermolecular forces, so it is a simple molecule with a pyramidal shape and low melting and boiling points.

Board plan

Write the title. Left: meaning of structure of a compound. Centre: the table comparing simple molecules, macromolecules and ionic lattices. Right: the key question for classifying and the sodium chloride and carbon dioxide example.

Type	Held together by	Melting and boiling points	Examples
Simple molecule	Weak intermolecular forces between molecules	Low	H_2O, CO_2, NH_3
Macromolecule	Strong covalent bonds between atoms	High	Diamond, graphite, silicon dioxide
Ionic lattice	Strong electrostatic forces between ions	High	NaCl, MgO, CaF_2

Simple and giant structures compared

Mistakes to expect

Learners often think	Put it right
Simple molecules have low melting points because the bonds inside each molecule are weak.	The forces between the molecules are weak, so little energy is needed to pull them apart. That is why melting and boiling points are low.
All giant structures conduct.	Macromolecules are usually non-conductors, except graphite.
Water, carbon dioxide and ammonia all have the same shape.	Water is V-shaped, carbon dioxide is linear and ammonia is pyramidal.
A compound has the same properties whatever its structure.	The structure decides the properties, such as melting point, solubility and how it reacts, so describing the structure helps to predict the behaviour.

Differentiation

Learners who struggle

Give learners a card with the three types and one example of each, and the key question. Build the shapes of H_2O, CO_2 and NH_3 with plasticine and sticks before they draw them.

Learners who finish early

Ask learners who finish early to choose three compounds from a list, classify each as simple or giant, and predict whether each is a solid, liquid or gas at room temperature, giving a reason.

Hearing or visual impairment

For learners with visual impairment, let them feel the models of V-shaped, linear and pyramidal molecules and describe each aloud. For learners with hearing impairment, write each term and each shape on the board and point to the model when explaining.

No projector, no printing

Use plasticine or clay balls and sticks or grass stems for the shapes, and draw the structures on the board. Samples of salt and sugar from the kitchen can be looked at in their tiny crystals.

If time is short

Teach simple molecules and macromolecules with the shapes of H_2O, CO_2 and NH_3. Leave ionic lattices and classifying for the next lesson.

Evaluation

Question or task	A correct answer shows
A learner is told that water, carbon dioxide and ammonia are simple molecules and that each has a shape. (a) Give the shape of water. (b) Give the shape of carbon dioxide. (c) Give the shape of ammonia.	(a) V-shaped, also called bent. (b) Linear, the atoms lie in a straight line. (c) Pyramidal.
A teacher says sodium chloride has a giant structure but carbon dioxide has a simple structure and asks which is more likely to be a gas at room temperature. (a) Name the substance. (b) Say what holds its molecules together. (c) Explain why it is a gas.	(a) Carbon dioxide. (b) Weak intermolecular forces. (c) Little energy is needed to separate the molecules, so melting and boiling points are low.
A learner studies diamond, graphite and sodium chloride. (a) Say which two are macromolecules. (b) Say what kind of structure sodium chloride has. (c) Say which of the macromolecules conducts.	(a) Diamond and graphite. (b) An ionic lattice, with ions held by strong electrostatic forces. (c) Graphite.

Homework

A learner is given four substances: water, silicon dioxide, magnesium oxide and ammonia. (a) Classify each as simple or giant. (b) Say which two are likely to be liquids or gases at room temperature and why. (c) Say what holds the particles together in magnesium oxide.

Extra practice with answers

Question	Answer

1. A learner is asked to describe the shape of three molecules in a test. (a) Give the shape of H_2O. (b) Give the shape of CO_2. (c) Give the shape of NH_3.	(a) V-shaped. (b) Linear. (c) Pyramidal.
2. A learner has to classify silicon dioxide, graphite and ammonia. (a) Say which two are macromolecules. (b) Say which is a simple molecule. (c) Say which macromolecule conducts.	(a) Silicon dioxide and graphite. (b) Ammonia. (c) Graphite.
3. A learner compares a simple molecule with an ionic lattice. (a) Say what holds the simple molecules together. (b) Say what holds an ionic lattice together. (c) Say which needs more energy to melt.	(a) Weak intermolecular forces. (b) Strong electrostatic forces between ions. (c) The ionic lattice.
4. A substance melts at a very low temperature and is a gas at room temperature. (a) Say which kind of structure it probably has. (b) Give a reason. (c) Name one example from the note.	(a) A simple molecule. (b) Weak forces between molecules need little energy to pull apart. (c) For example carbon dioxide or ammonia.
5. A learner says magnesium oxide is a simple molecule because it is a compound. (a) Say what is wrong. (b) Say what kind of structure it has. (c) Say how it is held together.	(a) It is a giant structure. (b) An ionic lattice. (c) By strong electrostatic forces of attraction between ions.

Answers to the learners' check-yourself questions

1. What is meant by the structure of a compound?
   The arrangement of the atoms and the bonds between them in three dimensions.
2. State the shape of a water molecule and of a carbon dioxide molecule.
   Water is V-shaped (bent); carbon dioxide is linear.
3. Name two examples of macromolecules.
   Any two of diamond, graphite and silicon dioxide.
4. Why do simple molecules have low boiling points?
   The forces between the molecules are weak, so little energy is needed to separate them.
5. Name one ionic lattice and the force that holds it together.
   Sodium chloride (or MgO or CaF_2), held by strong electrostatic forces of attraction.
6. A pupil at a school in Luangwa is given two white substances. Substance A melts at a low temperature and is a gas when heated slightly. Substance B does not melt in a hot flame. (a) Which one is more likely to have a simple structure? (b) Which one is more likely to be a giant structure? (c) Explain
   (a) Substance A. (b) Substance B. (c) A has weak forces between its molecules, so little energy separates them. B has strong bonds or forces throughout, so a lot of energy is needed to break them.
7. A teacher shows a class a pencil lead (graphite), a diamond ring and a glass of water. (a) Say which of the three is a simple molecule. (b) Say which two are macromolecules.

(c) Explain why diamond and graphite are both solids at room temperature even though water is a liquid.

(a) Water. (b) Diamond and graphite. (c) The atoms in diamond and graphite are joined by strong covalent bonds, so a lot of energy is needed to break them and they stay solid. The molecules of water are held only by weak intermolecular forces, so water is a liquid.

Teacher's reflection

What went well:

What I will change next time:

Learners who need follow-up: