A Guide to Intermolecular Force

Teaching Approach

In Grade 10 learners studied covalent bonding, ionic bonding and metallic bonding.

In Grade 11, learners will have already studied atomic combinations and molecular structure in more detail. By now they will be familiar with molecular geometry and how molecular shapes affect the polarity of a molecule.

Learners need to be able to identify whether a molecule is polar or non-polar. This means that they firstly need to be able to predict the polarity of the bonds but they also need to be able to work out the shape of the molecule in order to determine if the *molecule* is polar or not.

Learners also confuse intramolecular forces (bonds) with intermolecular forces, so lots of practice is needed to describe the forces present in any substance.

In this topic, learners will study:

- Intermolecular forces between covalent molecules
- Hydrogen bonds
- Intermolecular forces and ionic compounds
- Intermolecular forces and how they affect physical properties of compounds

Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next day's lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

1. **Intermolecular Forces: Revision**

   In this lesson we revise the covalent bonding, covalent molecules as well as the polar and non-polar covalent molecules concepts. The difference between intra-molecular forces and inter-molecular forces is also briefly discussed.

2. **Intermolecular Forces between Covalent Molecules**

   In this lesson, the intermolecular forces known as the Van der Waals forces involved with covalently bonded substances are studied. These include; London forces, dipole-induced dipole forces, dipole-dipole forces.

3. **Hydrogen Bonds**

   In this lesson, hydrogen bonds are studied. The lesson proceeds then to explain some of the physical properties of water that can be attributed to hydrogen bonds.

4. **Intermolecular Forces and Ionic Compounds**

   In this lesson, the intermolecular forces involving ionic compounds are studied. These include ion-dipole forces, ion-induced dipole forces.

5. **Intermolecular forces and Physical Properties**

   This lesson looks at the relationship between intermolecular properties and the physical properties of compounds.

6. **Practical Demonstrations of Intermolecular Forces**

   This lesson contains practical demonstrations of all the properties of substances related to their intermolecular forces that were discussed in the last lesson.

Resource Material

1. Intermolecular Forces: Revision	http://www.chemguide.co.uk/atoms/bonding/covalent.html	A description of the covalent bond and examples.
	http://users.stlcc.edu/gkrishnan/polar.html	The difference between polar and non-polar molecules, with examples.
2. Intermolecular Forces between Covalent Molecules	http://www.chemguide.co.uk/atoms/bonding/vdw.html	This page explains the origin of the two weaker forms of intermolecular attractions - van der Waals dispersion forces and dipole-dipole attractions.
	http://en.wikipedia.org/wiki/Van_der_Waals_force	A description of Van der Waals forces.
3. Hydrogen Bonds	http://www.chemguide.co.uk/atoms/bonding/hbond.html	Explains the origin of hydrogen bonding with a range of examples.
	http://www.elmhurst.edu/~chm/vchembook/161Ahydrogenbond.html	Explains the origin of hydrogen bonding with a range of examples.
4. Intermolecular Forces and Ionic Compounds	https://www.boundless.com/chemistry/liquids-and-solids/intermolecular-forces/ion-dipole-force/	Description of ion-dipole forces
	https://www.chem.unsw.edu.au/coursenotes/CHEM1/nonunipass/hainesIMF/iondipole.html	Description of ion-induced dipole forces
5. Intermolecular Forces and Physical Properties	http://www.chemguide.co.uk/atoms/structures/molecular.html	This page describes how the physical properties of substances with molecular structures varies with the type of intermolecular attractions - hydrogen bonding or van der Waals forces.
6. Practical Demonstrations of Intermolecular Forces	http://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/physprop.htm	A resource on intermolecular forces.
	http://maimelatct.files.wordpress.com/2014/02/physicalsciences-grade-11-term-1-1.pdf	Not only is this a wonderful set of notes and other resources for all of Grade 11 Term 1 (lesson plans) from Chipa Maimela, but it also provides a pointer to the kind of experiment to do for capillarity: *Investigate and explain the effects of intermolecular forces on evaporation, surface tension, solubility, boiling points and*

		capillarity. *Use the guidelines in Oxford Successful Physical Sciences Grade 11 p 95 and complete the five individual experiments in consecutive lessons.* *Learners can complete the write-up once all the experiments have been done.*
	http://www.bozemanscience.com/ap-chem-018-intermolecular-forces/	This video provides a good summary of intermolecular forces and their effects on the properties of substances. Capillarity, which is not covered in lesson 6, is also mentioned.
	https://www.youtube.com/watch?v=yw3KsRRbIf4	This short video gives a very clear view of capillarity, although it does not explain it or compare capillarity in different substances.
	http://www.tutorvista.com/content/physics/physics-iii/solids-and-fluids/capillarity.php	Some simple examples of how capillarity works in everyday examples like candle wicks and wet towels.

Task

Question 1

State whether the following covalent molecules are polar or non-polar:

1.1 BI_3
1.2 H_2O
1.3 NH_3
1.4 CH_4
1.5 CO_2

Question 2

Which of the following compounds will experience London forces between their molecules?

H_2O; Cl_2, Ar; PH_3; BF_3; HCl; CH_4

Question 3

Methanol, CH_3OH, is found in methylated spirits and can be used as a fuel. Methanol is found as a liquid at room temperature. The methanol molecule is not much larger than the methane molecule, CH_4. However, methane is a gas at room temperature. Explain why this is so.

Question 4

Explain why an iceberg floats on the surface of the water and does not sink.

Question 5

Arrange the following substances in order of increasing boiling point:

H_2O; CO; H_2

Question 6

Why does sodium chloride (NaCl) dissolves easily in water but hardly at all in carbon tetrachloride (CCl_4)?

Question 7

Which of the following pairs of substances:

HCl and CO; NaCl and CCl_4; KBr and H_2S; CCl_4 and Br_2

7.1 Interact with one another via ion-dipole forces?
7.2 Interact with one another via dipole-dipole forces?
7.3 Interact with one another via ion-induced dipole forces?
7.4 Interact with one another via induced dipole-induced dipole forces?

Question 8

Which substance would you expect to have a higher boiling point out of N_2 and Br_2? Explain.

Question 9

If you had a sample of solid bromine ($Br_2(s)$) and you dropped it into some liquid bromine ($Br_2(l)$), would it float or sink? Explain.

Question 10

Which substance will have the higher boiling point, NO or Ne? Explain.

Question 11

Metallic joints in the road such as that shown in this diagram are often seen on roads and bridges. Explain what their purpose is.

Task Answers

Question 1

1.1 Non-polar
1.2 Polar
1.3 Polar
1.4 Non-polar
1.5 Non-polar

Question 2

Cl_2, Ar, CH_4

Question 3

Methanol is polar and will experience dipole-dipole intermolecular forces. Methanol is non-polar and will experience weak London forces between the molecules. Dipole-dipole forces are stronger than London forces. As a result more energy is required to break apart the molecules of methanol. Therefore methanol has a higher boiling point than methane.

Question 4

The lattice of water molecules occupies a greater volume when in the solid phase than in the liquid phase. This is as a result of the hydrogen bonding within the water molecules, combined with the non-linear shape of the water molecules. Thus, water is less dense in the solid phase than in the liquid phase, so ice floats on water.

Question 5

H_2 (Van der Waals; London forces) ; CO (Van der Waals; dipole-dipole forces) ; H_2O (Hydrogen bonds)

Question 6

NaCl dissolves in water because NaCl is ionic and dissociates into 'polar' Na^+ and Cl^- ions when dissolved in water. Water is polar and so NaCl will dissolve because of ion-dipole forces. However, CCl_4 is non-polar, so NaCl cannot dissolve in it.

Question 7

7.1 KBr and H_2S
7.2 HCl and CO
7.3 NaCl and CCl_4
7.4 CCl_4 and Br_2

Question 8

Br_2. molecules are larger, therefore stronger intermolecular forces, therefore higher boiling point.

Question 9

It would sink. Molecules in a solid are packed closer together than in a liquid and are therefore more dense, so will sink when placed in the liquid.

Question 10

NO. NO molecules are polar whilst atoms of Ne are non-polar. Therefore intermolecular forces are stronger in NO than in Ne. Molecules of NO are more difficult to break apart, therefore boiling point will be higher.

Question 11

As the temperature of the road increases, the molecules in the tar will expand. The joint is there in the road to allow for this expansion, otherwise the road may crack or get bumps in it.

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Mindset Learn Executive Head	Dylan Busa
Content Manager Classroom Resources	Jenny Lamont
Content Coordinator Classroom Resources	Helen Robertson
Content Administrator	Agness Munthali
Content Developer	Candace Rennie
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	Liz Harris

Produced for Mindset Learn by Traffic

Facilities Coordinator	Cezanne Scheepers
Production Manager	Belinda Renney
Director	Alriette Gibbs
Editor	Belinda Renney
Presenter	Banji Longwe
Studio Crew	Abram Tjale
	James Tselapedi
	Wilson Mthembu
Graphics	Kieron Clarke

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