Bonding, shape and intermolecular forces

AQA 7404 and 7405 · AS and A level

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Bonding in three substances

Name the bonding in solid sodium fluoride, in a fluorine molecule and in solid sodium. Describe the attraction involved in each.

2. Formation of ammonium

Ammonia reacts with H^+ to form NH_4^+. State the direction of the arrow used to represent the new bond. Give the shape and approximate H-N-H bond angle of the ion.

3. Methane, ammonia and water

Rank the bond angles in CH_4, NH_3 and H_2O from largest to smallest. Give approximate angles and explain the trend.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-bonding-shapes-intermolecular-forces

Bonding, shape and intermolecular forces

AQA 7404 and 7405 · AS and A level

4. Carbon dioxide and water

Which of CO_2 and H_2O has a permanent molecular dipole? Explain your answer by comparing their bonds and shapes.

5. Electrical conductivity

Explain why solid magnesium conducts electricity. Magnesium chloride conducts when molten. Predict whether it conducts when solid and identify what carries charge in the molten salt.

6. Two forms of carbon

Graphite conducts electricity along its layers. Pure diamond does not conduct. Explain these observations using the way carbon atoms are bonded in each structure.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-bonding-shapes-intermolecular-forces

Bonding, shape and intermolecular forces

AQA 7404 and 7405 · AS and A level

7. Two compounds of formula C_2H_6O

Ethanol has structural formula CH_3CH_2OH. Methoxymethane is CH_3OCH_3. Predict which compound has the higher boiling point and explain your choice.

8. Two isomers of C_5H_{12}

Pentane, $CH_3CH_2CH_2CH_2CH_3$, and 2,2-dimethylpropane, $C(CH_3)_4$, have the same molecular formula. Predict which has the higher boiling point. Explain how the shapes affect the intermolecular forces.

9. Extra challenge · One bond is replaced

In a model of gaseous PCl_5, phosphorus forms five bonds and has no lone pair. Draw its shape. Give the smallest bond angle and show which bonds make that angle.

A second model replaces just one axial P-Cl bond with a P-F bond. Keep the original bond directions and treat the P-F bond dipole as larger. Predict whether each molecule has a permanent dipole. Explain using the directions of the bond dipoles.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-bonding-shapes-intermolecular-forces

Worked answers

Bonding, shape and intermolecular forces · AQA 7404 and 7405 · AS and A level

1. Bonding in three substances

NaF has ionic bonding between oppositely charged ions. F_2 has covalent bonding, the attraction between the shared pair and both nuclei. Sodium has metallic bonding, the attraction between positive ions and delocalised electrons.

2. Formation of ammonium

Draw the dative bond arrow from N in NH_3, which supplies its lone pair, towards H^+.

There are four bonding pairs and no lone pair around N in NH_4^+. The ion is tetrahedral, with bond angles of about 109.5°.

3. Methane, ammonia and water

CH_4 (109.5°) > NH_3 (107°) > H_2O (104.5°). Their central atoms have zero, one and two lone pairs respectively.

Lone pairs repel bonding pairs more strongly than bonding pairs repel each other, reducing the bond angles.

4. Carbon dioxide and water

Oxygen is more electronegative, so each bond dipole points towards oxygen. CO_2 is linear and its equal dipoles point in opposite directions, so they cancel.

H_2O is bent because of two lone pairs on oxygen. Its two bond dipoles do not cancel.

5. Electrical conductivity

Solid Mg has mobile delocalised electrons. In solid $MgCl_2$, the ions are held at fixed positions in a lattice.

When $MgCl_2$ melts, its ions are mobile and can carry charge.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-bonding-shapes-intermolecular-forces

Worked answers

Bonding, shape and intermolecular forces · AQA 7404 and 7405 · AS and A level

6. Two forms of carbon

Each carbon in graphite forms three covalent bonds and contributes an electron to a delocalised system. These electrons can move along the layers.

Each carbon in diamond forms four covalent bonds. There are no mobile charge carriers.

7. Two compounds of formula C_2H_6O

Ethanol has the higher boiling point. Its O-H groups can form hydrogen bonds to oxygen lone pairs on neighbouring molecules.

Methoxymethane has no O-H bond. Its molecules cannot hydrogen-bond to one another. More energy is needed to separate the ethanol molecules.

8. Two isomers of C_5H_{12}

Pentane is less compact, so neighbouring molecules can make more contact. With stronger London forces, more energy is needed to separate pentane molecules.

The covalent bonds within both molecules remain intact when they boil.

9. Extra challenge · One bond is replaced

Five bonding pairs adopt a trigonal bipyramidal arrangement. Draw three equatorial bonds in a plane with 120° between them, and two axial bonds perpendicular to the plane. The smallest angle is 90°, between an axial and an equatorial bond.

In PCl_5 the two equal axial dipoles cancel, and the three equal equatorial dipoles cancel. In the model of PCl_4F the equatorial dipoles still cancel, but the two opposite axial dipoles are unequal. There is a resultant dipole towards F.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-bonding-shapes-intermolecular-forces