NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
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# Level 2 Chemistry, 2006

## 90308 Describe the nature of structure and bonding in different substances

Credits: Four
2.00 pm Monday 27 November 2006

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

A Periodic Table is provided on the RESOURCE SHEET in your Level 2 Chemistry package.

You should answer ALL the questions in this booklet.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–9 in the correct order and that none of these pages is blank.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

| Achievement Criteria | | |
|---|---|---|
| Achievement | Achievement with Merit | Achievement with Excellence |
| Describe the bonding in simple molecules and the nature of [illegible] of solids. ✓ | Link selected properties of simple molecules and different types of solids to their structure. | Discuss properties of substances in terms of structure and bonding. |
| Overall Level of Performance: A | | |

You are advised to spend 45 minutes answering the questions in this booklet.

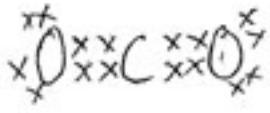
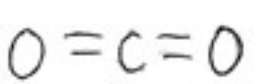
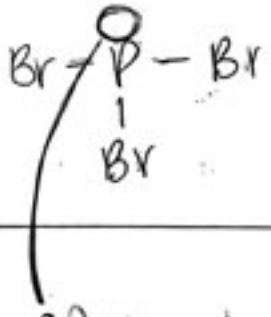
## QUESTION ONE

Complete the table below by:

(a) drawing a Lewis structure (electron dot diagram) for each molecule

(b) drawing a diagram to show the shape of the molecule

(c) naming the shape of the molecule.

| Formula of molecule | (a) Lewis structure | (b) Diagram of shape | (c) Name of shape |
|---|---|---|---|
| $SF_2$ |  |  | bent or v-shaped |
| $CO_2$ |  |  | linear |
| $PBr_3$ |  |  | trigonal pyramid |

M

*Did not need lone pair because seen in Lewis diagram and shape correct. However would have seen additional evidence

## QUESTION TWO

Assessor's use only

The following table contains oxides of elements from the third row of the Periodic Table. Complete the table below by:

(a) stating the type of particle found in each substance as an **atom**, **ion** or **molecule**

(b) specifying the attractive force that exists between the particles in the solid state of the substance.

| Solid | (a) Type of particle | (b) Attractive force between particles |
|---|---|---|
| sodium oxide | ion | strong anion and cation forces recognise opposit charges |
| sulfur trioxide | molecule | weak intermolecular forces |
| silicon dioxide | atom | strong covalent forces |
| aluminium oxide | ion | strong anion and cation forces |

M

although not stating ionic or electrostatic it was clear evidence of the difference

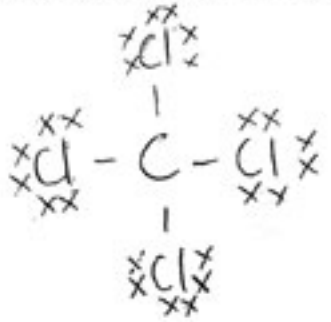
## QUESTION THREE

Assessor use only

Two ozone depleting substances are $CCl_4$ and $CH_2Cl_2$.

State whether the molecules are **polar** or **non-polar** and discuss the reasons for your choice. Include a Lewis structure of the molecules with your answer.

(a) $CCl_4$



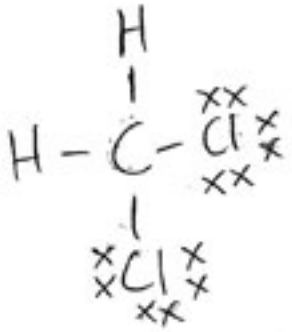
$CCl_4$ is a non-polar substance. It has four regions of equal electron amounts. It is a symmetrical molecule and the four dipole regions cancel each other out. Because it is an evenly symmetrical molecule and the dipoles cancel out, $CCl_4$ is a non-polar substance.

(no linking of why dipoles cancel & symmetry treated them as separate ideas.)

This answer needed recognition of tetrahedral shape, either in diagram or written answer. It needed reference to the electronegativity of the bonds before alluding to symmetry of the molecule.

It got achieved because the ~~the polarity of each molecule was~~ Lewis diagrams were correct but ~~not identified~~ this is the borderline example of achieved for this question.

(b) $CH_2Cl_2$



$CH_2Cl_2$ is a polar molecule. Although it has four electron regions and it could be seen as a symmetrical molecule, the dip~~o~~ole $CH_2Cl_2$ is also non-polar. It has four electron regions and can be symmetrical. The dipole's cancel each other out since there are two H regions and two Cl regions.

## QUESTION FOUR

Molecules of water ($H_2O$) and ozone ($O_3$) each contain 3 atoms and both the molecules are bent. However, the bond angle in $H_2O$ is significantly smaller than the bond angle in $O_3$.

Using Lewis structures, discuss the reasons for the difference in **bond angles** of these two molecules.

Correct ozone L.D & - this was not a common answer.

Molecules of water have four electron regions. Two of these are hydrogens and two are pairs of unbonded electrons. The two pairs of unbonded electrons repel the two hydrogen regions as far away as possible. This causes it to be a bent molecule with small bond angles.

many students tried to discuss repulsion of lone pairs of electrons but failed to address the basic concepts involved in use of molecular geometry

The centre O atom in $O_3$, has three electron regions around it. Although the pair of unbonded electrons repels the other O atoms as far away as possible, because it only has one pair of unbonded electrons the bond angles are bigger than $H_2O$. Since $H_2O$ has two pairs of unbonded electrons, it repels the hydrogen atoms away further, causing smaller bond angles compared with $O_3$.

This answer needed to identify the bond angles and shapes caused by electron arrangement around the central atom (for both molecules) eg tetrahedral arrangement for water implying 109° but only 2 bonded regions thus it is a bent shape.

## QUESTION FIVE

The **physical properties** of some crystalline solids are stated below. For each example, explain why the substance has the property stated by relating the **property** to the **structure and bonding** within the solid.

(a) Solid sodium chloride does not conduct electricity. However, if it is melted, sodium chloride will conduct electricity.

Sodium chloride is an ionic substance. This means it has strong ionic bonds between anions and cations holding it together. In the solid state these bonds are rigid in a 3D ~~lattice~~ lattice. However in the molten or liquid state electrons become delocalised and are able to flow throughout the 3D network. If electrons are free flowing through Sodium Chloride, they can carry a charge which means they can conduct electricity. //

good start. identified the substance bonding involved

This was where many students did not demonstrate understanding the charged particle had to be identified as an ion.

(b) Potassium chloride will not dissolve in non-polar solvents, but will dissolve in water.

Potassium Chloride is a polar substance. This is because it is unsymmetrical and its dipoles do not cancel out. Because "Like dissolves like", meaning polar dissolves polar, Potassium Chloride will readily dissolve in polar water. This is why it will not dissolve in non-polar solvents. Water is polar and because Potassium chloride has the same polarity, it will dissolve in water. //

This was a common answer. Students have learned "like dissolves like" but when confronted with an ionic substance dissolving, they could not "let go" of polar solute and polar solvent, ~~so~~ thereby wrongly identifying KCl as polar in order to make their "like dissolves like" statement fit.

(c) Copper is easily shaped to form wires.

Assessor's use only

Copper is a metal substance. All metals have metallic strong bonding. However metals have free flowing, delocalised electrons in their network. This is why they can conduct electricity and why they are ductile. Meaning they can be made into wires. Because of the non-directional electrons in Copper's network, it is mouldable and ductile. // The student has attempted to identify that there is a non directional force but the language + jargon is still not clear enough evidence to ~~not~~ demonstate evidence

a good answer would include a description of the metallic bonding involving the atoms in a 3D lattice attracted to the nuclei of neighbouring atoms

## QUESTION SIX

The following table shows the melting and boiling points of chlorides of some elements of the third row of the Periodic Table.

| | sodium chloride $NaCl$ | magnesium chloride $MgCl_2$ | phosphorus trichloride $PCl_3$ | sulfur dichloride $SCl_2$ |
|---|---|---|---|---|
| **melting point/°C** | 801 | 712 | –91 | –80 |
| **boiling point/°C** | 1465 | 1418 | 74 | 59 |

(a) Describe the **trend** in melting and boiling points of chlorides across the third row of the periodic table by referring to the data in the table above.

This answer would have been N - however the trend was included in the answer to (b)

The two ionic substances have high boiling and melting points. When a metal is added to chloride it has high melting and boiling points.

(b) Discuss reasons for the differences in melting and boiling points of all FOUR chlorides, shown in the table above, by referring to the **particles** and **forces between the particles** in the solids.

This was a borderline example

$NaCl$ and $MgCl_2$ have high melting and boiling points. These are both ionic substances. Both $NaCl$ and $MgCl_2$ contain strong ionic bonds which are hard to break. The high melting and boiling points are due to the fact that the substances need lots of energy to breake their solid bonds. //

Both $PCl_3$ and $SCl_2$ do not have these strong bonds. They are molecular and only contain weak intermolecular forces. This is why it shows a low melting point and boiling point. The bonds (in) $PCl_3$ and $SCl_2$ are weak and easy to break. Because of this, the melting and boiling points are low ~~because~~ as the bonds don't need much energy to be broken. //

needed to identify strong covalent bonds.

This did not indicate clearly that the weak intermolecular forces were BETWEEN different molecules

Trend is in discussion.

A