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91164

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Level 2 Chemistry, 2017

91164 Demonstrate understanding of bonding, structure, properties and energy changes

2.00 p.m. Thursday 16 November 2017
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

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

You should attempt ALL the questions in this booklet.

A periodic table is provided on the Resource Sheet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 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.

Merit

TOTAL 15

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QUESTION ONE

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(a) When solid calcium chloride, $CaCl_2(s)$, reacts with water, the temperature increases.

Circle the term that best describes this reaction.

endothermic **exothermic**

Give a reason for your choice.

Heat is given off into the environment. This means energy has been released. //

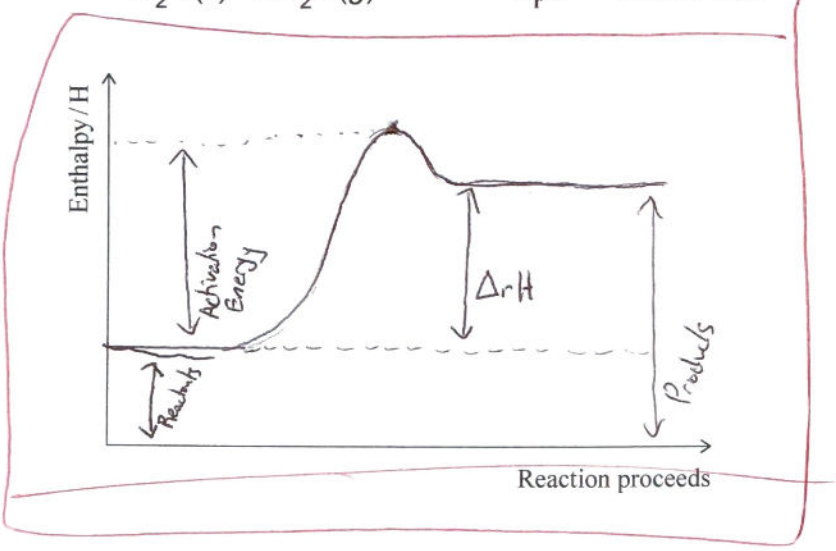
(b) When a person sweats, water is lost from the body by evaporation. This is an endothermic process. This evaporation speeds up when a person exercises.

(i) Explain why the evaporation of water in sweat from the body is endothermic, and why exercise increases this evaporation.

It is endothermic because it cools down the environment. Energy from the environment is used to change the state of the sweat from liquid to gas. When exercising, this process becomes quicker because the body temperature increases. This gives the sweat particals more energy to evaporate. //

(ii) Draw a labelled enthalpy diagram for the evaporation of water, $H_2O(\ell)$.

$H_2O(\ell) \rightarrow H_2O(g)$ $\Delta_r H^\circ = 40.7$ kJ mol^{-1}



(iii) Sodium chloride, NaCl, is another compound that is excreted from the body in sweat.

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Use your knowledge of structure and bonding to explain the dissolving process of sodium chloride, NaCl, in water.

Support your answer with a labelled diagram.

NaCl is an ionic compound consisting of positively charged Na cations and negatively charged anions. These ions are held together in a 3d lattice structure by strong electrostatic forces of attraction.

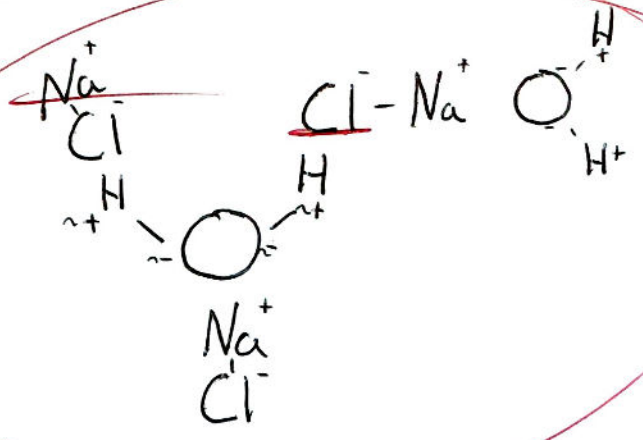
H_2O is a polar molecule. H_2O molecules are held together by weak intermolecular forces. The partially positive dipole of H_2O are the H particals while the partially negative are the O particals.

When NaCl is added to water, the force of attraction between water molecules is overcome by the attraction between water molecules and ions.

The partially negative O in H_2O are attracted to the positive Na cations while the partially positive H in H_2O are attracted to the negative Cl anions.

Therefore, NaCl dissolves in water.

Space for diagram



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(c) Thermite reactions occur when a metal oxide reacts with a metal powder.

The equations for two thermite reactions are given below:

Reaction 1: $Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$ $\quad \Delta_r H^\circ = -852 \text{ kJ mol}^{-1}$

Reaction 2: $3CuO(s) + 2Al(s) \rightarrow 3Cu(s) + Al_2O_3(s)$ $\quad \Delta_r H^\circ = -1520 \text{ kJ mol}^{-1}$

Use calculations to determine which metal oxide, iron(III) oxide, $Fe_2O_3(s)$, or copper(II) oxide, $CuO(s)$, will produce more heat energy when 50.0 g of each metal oxide is reacted with aluminium powder, $Al(s)$.

$M(Fe_2O_3) = 160 \text{ g mol}^{-1}$

$n(Fe_2O_3) = \frac{m}{M}$

$= \frac{50}{160}$

$= 0.3125 \text{ mol}$

$\Delta H = \frac{\Delta E}{n}$

$-852 = \frac{\Delta E}{0.3125}$

$= 266.25$

$= 266 \text{ KJ}$

$M(CuO) = 79.6 \text{ g mol}^{-1}$

$n(CuO) = \frac{m}{M}$

$= \frac{50}{79.6}$

$= 0.6281 \text{ mol}$

$\Delta H = \frac{1520}{3}$

$= 506.6 \text{ KJ mol}^{-1}$

$\Delta H = \frac{\Delta E}{n}$

$506.6 = \frac{\Delta E}{0.6281}$

$\Delta E = 318.2579564$

$= 318 \text{ KJ}$

∴ CuO will produce more heat energy when 50g is reacted.

CuO will produce 318 KJ while Fe_2O_3 will produce 266 KJ

M5

QUESTION TWO

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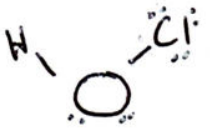
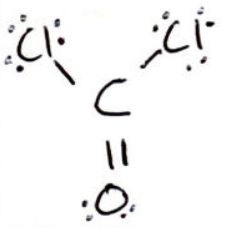
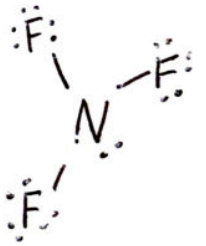
(a) (i) Draw the Lewis structure (electron dot diagram) for the following molecules, and name their shapes.

Molecule	HOCl	$COCl_2$	NF_3
Lewis structure			
Name of shape	Bent	Trigonal Planar	Trigonal pyramid
Approximate bond angle around the central atom	109.5°	120°	109.5°

(ii) Justify the shapes and bond angles of HOCl and $COCl_2$.

This gives it a tetrahedral arrangement.

HOCl has a total of 4 regions of electronegativity. These regions repel equally for maximum seperation to give a bond angle of 109.5°. There are 2 bonded regions and two non-bonded regions. This means that the shape of HOCl is bent.

$COCl_2$ has a total of 3 regions of electronegativity. These regions repel equally to give a bond angle of 120°. This gives it a trigonal planar arrangement. There are 3 bonded regions and no non-bonded regions. Therefore $COCl_2$ has a trigonal planar shape too.

(b) Three-dimensional diagrams for two molecules are shown below.

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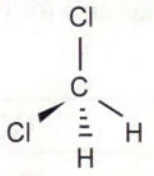
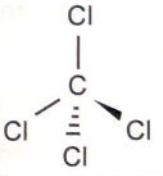
Molecule		
Name	Dichloromethane	Tetrachloromethane
Polarity of molecule	Polar	Non-polar

(i) In the boxes above, identify the polarity of each molecule, by writing either **polar** or **non-polar.**

(ii) Justify your choices.

CCl_2H_2 consists of 2 C-Cl bonds and 2 H-C bonds. Due to the electronegativity difference between particals, dipoles are formed. With the C-Cl bond, the partially negative dipole is the Cl, therefore the partially positive end is the C. With the C-H bonds, the partially negative dipole is the C, while the partially positive end is the H. Due to the unsymetrical nature of the molecule, Dichloromethane is polar because the dipoles cannot cancel out. Therefore it is polar.

CCl_4 consists of 4 C-Cl bonds. Due to the electronegativity difference of particals, a dipole is formed in each bond. The partially negative end of the dipole is the Cl, while the partially positive end is the C. However, due to the symetrical nature of CCl_4, no overall polarity is formed because the C-Cl dipoles cancel out. Therefore CCl_4 is non-polar.

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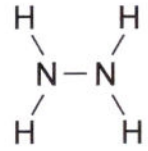
(c) Hydrazine, N_2H_4, is used as rocket fuel.

Use calculations to determine which of **Reaction 1** or **Reaction 2** releases more energy.

Reaction 1: $N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$

Reaction 2: $N_2H_4(g) + 2F_2(g) \rightarrow N_2(g) + 4HF(g)$

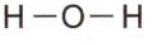
The structure of each chemical species is shown in the box below.

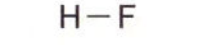

hydrazine


oxygen


fluorine


nitrogen


water


hydrogen fluoride

Use the average bond enthalpies given in the table below.

Bond	Average Bond enthalpy /kJ mol^{-1}	Bond	Average Bond enthalpy /kJ mol^{-1}
H–H	436	N–N	158
H–F	567	F–F	159
N–H	391	O=O	498
O–H	463	N≡N	945

Show your working and include appropriate units in your answer.

R1 = (158 + 4(391) + 498) − (945 + 2×2(463) = −557 kJ

R2 = (158 + 4(391) + 4(159)) − (945 + 4(567)) = −855 kJ

Reaction two releases more energy with 855 kJ while Reaction one only releases 557 kJ. //

o.

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QUESTION THREE

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(a) Complete the table below by stating the type of solid, the type of particle, and the type of bonding (attractive forces) between the particles in each solid.

Solid	Type of solid	Type of particle	Attractive forces between particles
Al(*s*) (aluminium)	Metal	Atom	Metallic forces.
$MgCl_2$(*s*) (magnesium chloride)	Ionic	Ion	strong electrostatic forces
S_8(*s*) (sulfur)	Molecular	molecule	weak intermolecular forces

(b) Circle the substance which has ~~the lowest~~ melting point.

Al(*s*) $MgCl_2(s)$ $S_8(s)$ ← This one

Justify your choice, referring to the attractive forces between the particles of ALL three substances.

The melting point of solids is determined by the strength of the forces that hold them together.
Al is a metal made up from fixed positive nucleis and free moving electrons. This causes strong metalic forces to hold the atoms together. Therefore it has a high melting point.
S_8 is a molecular substance made up from molecules. These molecules are held together by weak intermolecular forces of attraction. Therefore, not much energy is required to break the particals apart. Therefore it has a low melting point.
$MgCl_2$ is an ionic compound made up from ions. These ions are held tightly together with strong electrostatic forces of attraction in a 3d-lattice structure. Therefore, lots of energy is required to break the particals apart and it has a high melting point. //

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Question Three continues on the following page.

(c) Circle the substance which is malleable.

Al(s) $MgCl_2(s)$ $S_8(s)$

Justify your choice by referring to the structure and bonding of your chosen substance.

You may include a diagram or diagrams in your answer.

Metals such as Al are made up from atoms. This consists of fixed positive nuclei and negative free-moving electrons. The nuclei are surrounded by a "sea" of these electrons. This allows the forces of attraction between these particles (metallic) to be non-directional. It is very easy to move particles into shapes because of this. This is called malleability. Because it is non-directional forces holding particles together, moving the particles into shapes still allows them to stick together with equally as much force and not break apart.

Space for diagram

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Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

ASSESSOR'S USE ONLY

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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Subject:	Chemistry	Standard:	91164	Total score:	15

Q	Grade score	Annotation
1	M5	This candidate received a grade score of M5 as the response linked reaction processes to reaction progress, the attractions of water and NaCl, although without an accurate diagram, and correctly analysed the energy output of thermochemical calculations.
2	M5	This candidate received a grade score of M5 as the response linked electronegativity to bond polarity and bond enthalpies to one correct enthalpy change, although the unit was incorrect.
3	M5	This candidate received a grade score of M5 as the response linked two of the three attractive forces to the energy requirements of melting while also linking the malleability of aluminium to the non-directional nature of metallic bonding.