Level 2 Chemistry, 2013

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

9.30 am Tuesday 19 November 2013
Credits: Five

<table>
<thead>
<tr>
<th>Achievement</th>
<th>Achievement with Merit</th>
<th>Achievement with Excellence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate understanding of bonding, structure, properties and energy changes.</td>
<td>Demonstrate in-depth understanding of bonding, structure, properties and energy changes.</td>
<td>Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.</td>
</tr>
</tbody>
</table>

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 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 2–12 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.
QUESTION ONE

(a) Draw the Lewis structure for each of the following molecules.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>CH₄</th>
<th>H₂O</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewis structure</td>
<td>:(\cdot) (\cdot) (\cdot)</td>
<td>:(\cdot) (\cdot) :</td>
<td>:(\cdot) :</td>
</tr>
</tbody>
</table>

(b) Boron and phosphorus both bond with three fluorine atoms to form BF₃ and PF₃. However, the molecules have different shapes and bond angles.

The following table shows the Lewis structures for the molecules BF₃ and PF₃.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>BF₃</th>
<th>PF₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewis structure</td>
<td>:(\cdot) (\cdot) (\cdot) :</td>
<td>:(\cdot) (\cdot) :</td>
</tr>
</tbody>
</table>

Explain why these molecules have different shapes and bond angles.

In your answer include:

- the shapes of BF₃ and PF₃
- factors that determine the shape of each molecule
- the approximate bond angle in BF₃ and PF₃
- justification of your chosen bond angles for each molecule.
The 3-dimensional diagram of NH$_3$ is shown below.

Circle the word that describes the **polarity** of the molecule NH$_3$.

- polar
- non-polar

Justify your choice.
(ii) Elements M and X form a compound MX$_2$. Atoms of element X have a higher electronegativity value than atoms of element M, therefore the M–X bonds are polar. Depending on what elements M and X are, molecules of the compound formed will be polar or non-polar.

State the most likely shape(s) of the molecule if it is:

**Polar:**

**Non-polar:**

Justify your answer and draw diagrams of the possible molecules with dipoles labelled. You do not need to identify what elements M and X are.
QUESTION TWO

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

<table>
<thead>
<tr>
<th>Substance</th>
<th>Type of substance</th>
<th>Type of particle</th>
<th>Attractive forces between particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(s) (graphite)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl₂(s) (chlorine)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CuCl₂(s) (copper chloride)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu(s) (copper)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (i) Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature.

In your answer, you should refer to the particles and the forces between the particles in both substances.
(ii) Using your knowledge of structure and bonding, explain why, although both graphite and copper are good conductors of electricity, copper is suitable for electrical wires, but graphite is not.
(c) Chlorine reacts with methane to form chloromethane and hydrogen chloride, as shown in the equation below.

\[ \text{CH}_4(g) + \text{Cl}_2(g) \rightarrow \text{CH}_3\text{Cl}(g) + \text{HCl}(g) \]

Use the following bond enthalpies to calculate \( \Delta H^\circ \) for this reaction.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond enthalpy /kJ mol(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>H–Cl</td>
<td>431</td>
</tr>
<tr>
<td>C–H</td>
<td>414</td>
</tr>
<tr>
<td>C–Cl</td>
<td>324</td>
</tr>
<tr>
<td>Cl–Cl</td>
<td>242</td>
</tr>
</tbody>
</table>
QUESTION THREE

(a) Dissolving ammonium nitrate in a beaker containing water can be represented by the following equation:

\[ \text{NH}_4\text{NO}_3(s) \rightarrow \text{NH}_4^+(aq) + \text{NO}_3^-(aq) \quad \Delta H^\circ = 25.1 \text{ kJ mol}^{-1} \]

Circle the term below that best describes this process.

exothermic

endothermic

Circle the description below that best describes what you would observe happening to the beaker during this process.

gets colder

stays the same

gets warmer

Explain your choices.

(b) Glucose is an important source of energy in our diet. The equation below shows the combustion of glucose to form carbon dioxide and water.

\[ \text{C}_6\text{H}_{12}\text{O}_6(s) + 6\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 6\text{H}_2\text{O}(l) \quad \Delta H^\circ = -2820 \text{ kJ mol}^{-1} \]

(i) Circle the term below that best describes this process.

exothermic

endothermic

Give a reason for your choice.
(ii) Females who are moderately active need 9800 kJ of energy per day.

Calculate the number of moles of glucose that would provide this daily energy requirement.

(c) (i) Many portable BBQ and camping gas canisters contain butane, $C_4H_{10}$. Butane is a gas at room temperature, and has a boiling point of $-0.5^\circ C$. The gas canisters contain both gas and liquid butane. As the gaseous butane is used, some of the liquid evaporates.

Circle the term below that best describes this process.

- exothermic
- endothermic

Give a reason for your choice, and use your knowledge of structure and bonding, and energy changes, to explain the changes occurring as the liquid evaporates.

(ii) The equation below shows the combustion of butane.

$$C_4H_{10}(g) + \frac{13}{2} O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$$

When 100 g of butane undergoes combustion, 4960 kJ of energy is released.

Calculate the enthalpy change when 1 mole of butane undergoes combustion.

$$M(C_4H_{10}) = 58.1 \text{ g mol}^{-1}.$$
(d) The iron oxides $\text{Fe}_3\text{O}_4$ and $\text{Fe}_2\text{O}_3$ react with aluminium as shown below.

$$3\text{Fe}_3\text{O}_4(s) + 8\text{Al}(s) \rightarrow 4\text{Al}_2\text{O}_3(s) + 9\text{Fe}(s) \quad \Delta H^\circ = -3348 \text{ kJ mol}^{-1}$$

$$\text{Fe}_2\text{O}_3(s) + 2\text{Al}(s) \rightarrow \text{Al}_2\text{O}_3(s) + 2\text{Fe}(s) \quad \Delta H^\circ = -851 \text{ kJ mol}^{-1}$$

Justify which iron oxide, $\text{Fe}_3\text{O}_4$ or $\text{Fe}_2\text{O}_3$, will produce more heat energy when 2.00 kg of iron is formed during the reaction with aluminium.

Your answer should include calculations of the heat energy produced for the given mass of iron formed.

$$M(\text{Fe}) = 55.9 \text{ g mol}^{-1}.$$