Chemistry/Additional Science
Unit C2: Discovering Chemistry

Higher Tier

Tuesday 10 June 2014 – Afternoon
Time: 1 hour

You must have:
Calculator, ruler

Instructions

● Use black ink or ball-point pen.
● Fill in the boxes at the top of this page with your name, centre number and candidate number.
● Answer all questions.
● Answer the questions in the spaces provided – there may be more space than you need.

Information

● The total mark for this paper is 60.
● The marks for each question are shown in brackets
  – use this as a guide as to how much time to spend on each question.
● Questions labelled with an asterisk (*) are ones where the quality of your written communication will be assessed
  – you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.

Advice

● Read each question carefully before you start to answer it.
● Keep an eye on the time.
● Try to answer every question.
● Check your answers if you have time at the end.
The Periodic Table of the Elements

The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

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Answer ALL questions

Some questions must be answered with a cross in a box ☑. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☑.

Particles and formulae

1  (a) Atoms contain protons, neutrons and electrons.

Complete the table to show the relative mass and relative charge of each particle and its position in an atom.

<table>
<thead>
<tr>
<th>relative mass</th>
<th>relative charge</th>
<th>position in atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>proton</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>neutron</td>
<td>1</td>
<td>in nucleus</td>
</tr>
<tr>
<td>electron</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Complete the sentence by putting a cross (✓) in the box next to your answer.

An atom of an element always contains

☐ A more protons than neutrons
☐ B equal numbers of protons and neutrons
☐ C more electrons than protons
☐ D equal numbers of protons and electrons

(c) The symbols for some atoms are given in the box

Ca Cl K N Ne O

From the box, choose the symbol of

(i) an atom in group 2 of the periodic table

(ii) an atom that readily forms an ion with a charge of 2−
(d) The formula of aluminium nitrate is $\text{Al(NO}_3\text{)}_3$

(i) State the total number of atoms in the formula $\text{Al(NO}_3\text{)}_3$

(ii) What is the most likely formula of aluminium nitride?

Put a cross (✗) in the box next to your answer.

- A  $\text{Al(NO}_3\text{)}_2$
- B  AlNO$_3$
- C  AlNO$_2$
- D  AlN

(Total for Question 1 = 8 marks)
Rates of reactions and energy changes

2 (a) Marble chips react with hydrochloric acid to produce carbon dioxide.
The equation for the reaction is
\[ \text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2 \]
Which one of these changes would decrease the rate of this reaction?
Put a cross (\(\square\)) in the box next to your answer.

\[ \square \text{A} \] use hydrochloric acid which is more dilute
\[ \square \text{B} \] use smaller sized marble chips
\[ \square \text{C} \] use marble chips which have a larger surface area
\[ \square \text{D} \] use a larger volume of the hydrochloric acid

(b) Explain why increasing the temperature of a reaction increases the rate of the reaction.
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

Which of these graphs shows the mass of the catalyst during the reaction?

Put a cross (✓) in the box next to your answer.

(1)
(ii) The decomposition of hydrogen peroxide, $\text{H}_2\text{O}_2$, produces oxygen and water.

Give the balanced equation for this reaction.

(2)

(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(Total for Question 2 = 8 marks)
Metals

3 There are many metallic elements in the periodic table.

(a) Which row of the table correctly shows two metals that are in group 1 and two metals that are transition metals?

Put a cross (X) in the box next to your answer.

<table>
<thead>
<tr>
<th>group 1</th>
<th>transition metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ A lithium and zinc</td>
<td>calcium and copper</td>
</tr>
<tr>
<td>□ B potassium and caesium</td>
<td>copper and iron</td>
</tr>
<tr>
<td>□ C sodium and potassium</td>
<td>copper and magnesium</td>
</tr>
<tr>
<td>□ D sodium and magnesium</td>
<td>manganese and nickel</td>
</tr>
</tbody>
</table>

(b) (i) Describe the structure of metals in terms of the particles present in their structures.

(ii) Explain how metals conduct electricity.
(c) (i) Describe what you would see when a small piece of sodium is added to water. (2)

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(ii) Write the balanced equation for the reaction of sodium with water to form sodium hydroxide and hydrogen. (3)


(Total for Question 3 = 10 marks)
Salts and analysis

4 (a) Which of the following pairs of substances contains one substance that is soluble in water and one that is insoluble in water?  

Put a cross (✘) in the box next to your answer.  

☐ A aluminium nitrate and lead sulfate  
☐ B ammonium chloride and copper sulfate  
☐ C copper hydroxide and lead sulfate  
☐ D sodium hydroxide and potassium nitrate

(b) Barium chloride is an ionic compound and has a high melting point.  

Explain why barium chloride has a high melting point.  

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(c) Barium chloride solution is used to test for the presence of sulfate ions in a solution.  

When sulfate ions are present, insoluble barium sulfate is formed.  

(i) Describe the appearance of barium sulfate.  

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(ii) Complete the balanced equation for the reaction between barium chloride and potassium sulfate.  

\[ \text{BaCl}_2 + \text{K}_2\text{SO}_4 \rightarrow \]
(d) Compound X is a metal carbonate.

(i) A flame test was carried out on compound X.
A lilac flame was seen.

Complete the sentence by putting a cross (\[\square\]) in the box next to your answer.

The formula of the metal ion in compound X is

- A  Ca\(^{2+}\)
- B  Cu\(^{2+}\)
- C  K\(^+\)
- D  Na\(^+\)

(ii) Lead carbonate is an insoluble salt.

Describe how a pure, dry sample of solid lead carbonate can be obtained from sodium carbonate solution and lead nitrate solution.

(Total for Question 4 = 10 marks)
Chlorine and carbon

5 (a) Chlorine has an atomic number of 17. Chlorine-35 and chlorine-37 are two isotopes of chlorine.

(i) Complete the table to show the numbers of protons, neutrons and electrons in each of the isotopes.

(ii) A normal sample of chlorine contains only chlorine-35 and chlorine-37 atoms.

Explain why the relative atomic mass of chlorine is 35.5

(b) Tetrachloromethane is a simple molecular, covalent compound. The formula of its molecule is CCl₄.

There are four electrons in the outer shell of a carbon atom.
There are seven electrons in the outer shell of a chlorine atom.

Draw a dot and cross diagram to show the bonding in a molecule of tetrachloromethane, CCl₄.

Show outer shell electrons only.
*(c) The diagrams show the arrangements of carbon atoms in diamond and in graphite.

\[ \text{\textbullet} = \text{carbon atom} \]

strong bonds

diamond

graphite

strong bonds

Compare a use of diamond with a use of graphite, explaining each use in terms of the bonding and structure. In your answer you should use information from the diagrams.

(Total for Question 5 = 12 marks)
Group 7 elements

6 (a) A compound of iron and chlorine was formed by reacting 2.80 g of iron with 3.55 g of chlorine.

Calculate the empirical formula of the compound.
(relative atomic masses: Cl = 35.5, Fe = 56.0)

(b) Sodium reacts with chlorine to form sodium chloride.

$$2Na + Cl_2 \rightarrow 2NaCl$$

Calculate the maximum mass of sodium chloride that could be formed by reacting 9.20 g of sodium with excess chlorine.
(relative atomic masses: Na = 23.0, Cl = 35.5)
*(c) Chlorine, bromine and iodine are in group 7 of the periodic table.

The order of reactivity of these three elements can be shown by carrying out displacement experiments.

You are provided with
- potassium bromide solution
- potassium chloride solution
- potassium iodide solution
- bromine solution
- chlorine solution
- iodine solution

Describe how these solutions could be used to carry out experiments to show the order of reactivity of bromine, chlorine and iodine, explaining how the results would show the order of reactivity. You may use equations if you wish.