SHREWSBURY SCHOOL

SIXTH FORM ENTRANCE EXAMINATION 2014

CHEMISTRY
(1 hour)

Instructions to candidates:

• Answer ALL TWENTY questions from SECTION A on the grid provided.
• Answer THREE questions ONLY from SECTION B in the spaces provided.
• Section A is worth 20 marks and Section B 30 marks. (50 marks in total).
• You may use a calculator.
• You are provided with a copy of the Periodic table at the end of Section B
Name: ...............................................................................

Sixth Form Assessment – Chemistry Answer Sheet

Answer all questions – circle the correct letter for each question below.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
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<td>5</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
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<td>6</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
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<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>9</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>11</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>12</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>15</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>16</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>17</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>18</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>19</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>
SECTION A

Answer ALL questions from SECTION A on the grid provided on page 22.

Question 1

An attempt was made to compress a gas and a solid using the apparatus shown.

Which substance would be compressed and what is the reason for this?

<table>
<thead>
<tr>
<th>substance</th>
<th>reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>gas</td>
</tr>
<tr>
<td>B</td>
<td>gas</td>
</tr>
<tr>
<td>C</td>
<td>solid</td>
</tr>
<tr>
<td>D</td>
<td>solid</td>
</tr>
</tbody>
</table>

A: gas particles are close together
B: gas particles are far apart
C: solid particles are close together
D: solid particles are far apart

Question 2

Which statements about a sodium atom, $^{23}_{11}$Na, are correct?

1. The number of protons and neutrons is the same.
2. The number of protons and electrons is the same.
3. The number of outer electrons is one.

A: 1, 2 and 3
B: 1 and 2 only
C: 1 and 3 only
D: 2 and 3 only
**Question 3**

Rubidium is in Group I of the Periodic Table and bromine is in Group VII.

Rubidium reacts with bromine to form an ionic compound.

Which row shows the electron change taking place for rubidium and the correct formula of the rubidium ion?

<table>
<thead>
<tr>
<th></th>
<th>electron change</th>
<th>formula of ion formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>electron gained</td>
<td>Rb⁺</td>
</tr>
<tr>
<td>B</td>
<td>electron gained</td>
<td>Rb⁻</td>
</tr>
<tr>
<td>C</td>
<td>electron lost</td>
<td>Rb⁺</td>
</tr>
<tr>
<td>D</td>
<td>electron lost</td>
<td>Rb⁻</td>
</tr>
</tbody>
</table>

**Question 4**

A solid mixture contains an ionic salt, X, and a covalent organic compound, Y.

Two students suggest methods of separating the mixture as shown.

**Method 1**

Shake with water

**Method 2**

Shake with ethanol

Which methods of separation are likely to work?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>C</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Question 5

The diagrams show the labels of four bottles.

Which label is **not** correct?

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td><strong>B</strong></td>
<td><strong>C</strong></td>
<td><strong>D</strong></td>
</tr>
<tr>
<td>Bromine ( \text{Br}_2 )</td>
<td>Iodine ( \text{I}_2 )</td>
<td>Potassium ( \text{K} )</td>
<td>Sodium ( \text{Na} )</td>
</tr>
</tbody>
</table>
Question 6

A student investigates the rate of reaction between zinc and an excess of sulfuric acid.

The graph shows the results of two experiments, X and Y.

![Graph showing volume of hydrogen vs. time]

Which change explains the difference between X and Y?

A  A catalyst is added in Y.
B  A lower temperature is used in Y.
C  Larger pieces of zinc are used in Y.
D  Less concentrated acid is used in Y.

The diagrams show the labels of four bottles.

Which label is not correct?

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromine</td>
<td>Iodine</td>
<td>Potassium</td>
<td>Sodium</td>
</tr>
<tr>
<td>Br₂</td>
<td>I₂</td>
<td>K</td>
<td>Na</td>
</tr>
</tbody>
</table>

Question 7

The nucleon number and proton number of the lithium atom are shown by the symbol $^{7}_3\text{Li}$.

What is the correct symbol for the lithium ion in lithium chloride?

A $^{6}_2\text{Li}^-$  B $^{6}_3\text{Li}^+$  C $^{7}_3\text{Li}^+$  D $^{7}_3\text{Li}^-$
Question 8

The diagram represents ethene.

Which compound has chemical properties similar to those of ethene?

A  

B  

C  

D

Question 9

A gas jar of bromine vapour and a gas jar of air are set up as shown in diagram 1.

The glass slide is removed. Diagram 2 shows the appearance of the gas jars after one hour.

Which statement explains why the bromine and air mix together?

A  Bromine is denser than air.

B  Bromine is lighter than air.

C  Bromine molecules moved upwards and molecules in air moved downwards.

D  Molecules in bromine and air moved randomly.
Question 10

The diagram shows the structure of three particles, R, S and T.

![Diagram of particles R, S, T with electron, proton, neutron, and nucleus labels]

Which row describes these particles?

<table>
<thead>
<tr>
<th></th>
<th>ions</th>
<th>isotopes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>R</td>
<td>S and T</td>
</tr>
<tr>
<td>B</td>
<td>R and S</td>
<td>T</td>
</tr>
<tr>
<td>C</td>
<td>S</td>
<td>R and T</td>
</tr>
<tr>
<td>D</td>
<td>T</td>
<td>R and S</td>
</tr>
</tbody>
</table>

Question 11

The chemical formulae of two substances, W and X, are given.

\[
\begin{align*}
W & : \text{NaAl}_2\text{Si}_3\text{O}_8 \\
X & : \text{CaAl}_2\text{Si}_2\text{O}_8
\end{align*}
\]

Which statements are correct?

1. W and X contain the same amount of oxygen.
2. W contains three times as much silicon as X.
3. X contains twice as much aluminium as W.

A  1 and 2  B  1 and 3  C  2 and 3  D  1, 2 and 3
Question 12

The list gives the order of some metals (and hydrogen) in the reactivity series.

Metal X is also included:

Most reactive: K, Mg, Zn, (H), X

Least reactive: Cu

Which row correctly shows the properties of metal X?

<table>
<thead>
<tr>
<th></th>
<th>reacts with dilute acids</th>
<th>oxide reduced by carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>C</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>D</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Question 13

Which are properties of an acid?

1. Reacts with ammonium sulfate to form ammonia
2. Turns red litmus blue

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>C</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>D</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Question 14

Which diagram does not show the outer shell electrons in the molecule correctly?

A  

\[
\text{H} - \text{H} 
\]

B  

\[
\text{H} - \text{Cl} 
\]

C  

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

D  

\[
\begin{array}{c}
\text{Cl} \\
\text{H} \\
\text{C} \\
\text{Cl} \\
\text{Cl} \\
\end{array}
\]

Question 15

The apparatus shown can be used to measure the rate of some chemical reactions.

![Gas syringe and reaction mixture diagram]

For which two reactions would this apparatus be suitable?

reaction 1 \[ \text{AgNO}_3(aq) + \text{HCl}(aq) \rightarrow \text{AgCl}(s) + \text{HNO}_3(aq) \]

reaction 2 \[ 2\text{H}_2\text{O}_2(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{O}_2(g) \]

reaction 3 \[ \text{MgO}(s) + 2\text{HCl}(aq) \rightarrow \text{MgCl}_2(aq) + \text{H}_2\text{O}(l) \]

reaction 4 \[ \text{ZnCO}_3(s) + 2\text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \]

A  1 and 2  B  1 and 3  C  2 and 4  D  3 and 4
Question 16

Which structure is incorrect?

A
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{H} \\
\end{array}
\]

B
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{O} \\
\text{H} \\
\end{array}
\]

C
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{H} \\
\end{array}
\]

D
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{O} \\
\text{H} \\
\end{array}
\]

Question 17

To grow rose plants, a fertiliser containing nitrogen, phosphorus and potassium is often used.

For the best rose flowers, the fertiliser should contain a high proportion of potassium.

Which fertiliser is best for producing rose flowers?

<table>
<thead>
<tr>
<th>fertiliser</th>
<th>proportion by mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>A</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>29</td>
</tr>
<tr>
<td>D</td>
<td>29</td>
</tr>
</tbody>
</table>
Question 18
In an oil refinery, petroleum is separated into useful fractions.
The diagram shows some of these fractions.

What are fractions X, Y and Z?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>fuel oil</td>
<td>bitumen</td>
<td>paraffin (kerosene)</td>
</tr>
<tr>
<td>B</td>
<td>fuel oil</td>
<td>paraffin (kerosene)</td>
<td>bitumen</td>
</tr>
<tr>
<td>C</td>
<td>paraffin (kerosene)</td>
<td>bitumen</td>
<td>fuel oil</td>
</tr>
<tr>
<td>D</td>
<td>paraffin (kerosene)</td>
<td>fuel oil</td>
<td>bitumen</td>
</tr>
</tbody>
</table>

Question 19
The table shows the structure of different atoms and ions.

<table>
<thead>
<tr>
<th>particle</th>
<th>proton number</th>
<th>nucleon number</th>
<th>number of protons</th>
<th>number of neutrons</th>
<th>number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td>12</td>
<td>24</td>
<td>12</td>
<td>W</td>
<td>12</td>
</tr>
<tr>
<td>Mg$^{2+}$</td>
<td>X</td>
<td>24</td>
<td>12</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>F</td>
<td>9</td>
<td>19</td>
<td>9</td>
<td>Y</td>
<td>9</td>
</tr>
<tr>
<td>F$^-$</td>
<td>9</td>
<td>19</td>
<td>9</td>
<td>10</td>
<td>Z</td>
</tr>
</tbody>
</table>

What are the values of W, X, Y and Z?

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>12</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>12</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Question 20

The structures of three compounds are shown.

Why do these substances all belong to the same homologous series?

A  They all contain an even number of carbon atoms.
B  They all contain the same functional group.
C  They are all hydrocarbons.
D  They are all saturated.
SECTION B

Answer THREE of the following FOUR questions

Question 1
This question is about metals and their properties. All metals have a giant metallic structure and have many important uses.

a) Describe what is meant by metallic bonding.

b) Why are metals good conductors of electricity?

c)(i) Rhodium, platinum and palladium are metals that are present in catalytic converters to reduce the toxicity of emissions from car engines. These metals act as catalysts. Explain how catalysts speed up the rate of reactions.

(ii) The metals in c(i) catalyse the reaction of carbon monoxide with nitrogen monoxide (NO) to produce harmless gases, nitrogen and carbon dioxide. Write an equation for this reaction.
d) The reactivity of a metal is a measure of its ability to form positive ions. When excess copper was added to aqueous silver nitrate the following reaction takes place.

\[
\text{Cu (s) + AgNO}_3 \text{ (aq) } \rightarrow \text{CuSO}_4 \text{ (aq) } + \text{Ag (s)}
\]

(i) State two observations that will be seen in this reaction.

1. 
2. 

[2]

(ii) What type of reaction is taking place in the equation above?

…………………………………………………………………………………………………… [1]

e) A chemist investigated the reaction of copper with nitrogen. He predicted that two possible products were likely copper(I) nitride and copper(II) nitride.

State the formulae of these two nitrides.

<table>
<thead>
<tr>
<th>compound</th>
<th>ions</th>
<th>formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper(I) nitride</td>
<td>(\text{Cu}^+) and (\text{N}_3^-)</td>
<td></td>
</tr>
<tr>
<td>copper(II) nitride</td>
<td>(\text{Cu}^{2+}) and (\text{N}_3^-)</td>
<td></td>
</tr>
</tbody>
</table>

[1]
Question 2
This question is about organic chemistry, which is the chemistry of carbon containing compounds.

a) Alkenes are a group of unsaturated hydrocarbons that have the general formula of C$_n$H$_{2n}$.
(i) State what is meant by the term unsaturated.

_________________________________________________________________________________________________________

_________________________________________________________________________________________________________

[1]

(ii) Name and draw the structure of the alkene with three carbon atoms.

name ______________________________________________________________________________________________________

[2]

b) Alkenes can be obtained from alkanes. This process involves a long hydrocarbon alkane being broken down into a smaller alkane and an alkene.

(i) Suggest the name of this process.

_____________________________________________________________________________________________________

[1]

(ii) State the reaction conditions for this process.

_____________________________________________________________________________________________________

[2]

c) Cycloalkanes have the same general formula as alkenes.

(i) Cyclopentane, C$_5$H$_{10}$, can be prepared from pentane. A small molecule by-product is also formed in this reaction. Construct the equation for this reaction.

_____________________________________________________________________________________________________

[1]
(ii) Draw the structural formula of cyclopentane, \( \text{C}_5\text{H}_{10} \).

(iii) In the presence of ultraviolet light, cyclopentane, \( \text{C}_5\text{H}_{10} \), undergoes a reaction with bromine to form dibromopentane, \( \text{C}_5\text{H}_{10}\text{Br}_2 \), as the only product.

Draw a structure for this product, \( \text{C}_5\text{H}_{10}\text{Br}_2 \).

(iv) Suggest the name of this type of reaction.

______________________________

Total: 10
Question 3
This question is about chemical bonding. The table shows some information about some compounds.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Type of structure</th>
<th>Melting point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO (calcium oxide)</td>
<td>Giant</td>
<td>2900</td>
</tr>
<tr>
<td>H₂O (water)</td>
<td>Molecular</td>
<td>0</td>
</tr>
<tr>
<td>NaNH₂ (sodium amide)</td>
<td>Giant</td>
<td>210</td>
</tr>
<tr>
<td>NH₃ (ammonia)</td>
<td>Molecular</td>
<td>-78</td>
</tr>
</tbody>
</table>

a) The structure of a water molecule compound can be represented like this:

![Water molecule diagram]

The atoms are held together by covalent bonds. Define the term covalent bonding.

________________________________________________________________________________________[1]

b) Ammonia, NH₃, is also a covalent molecule.

Draw the dot and cross diagram to show the arrangement of electrons in a molecule of NH₃. You need only show electrons in outer shells.

________________________________________________________________________________________[2]

c) Sodium amide can be prepared by the reaction of sodium with liquid ammonia. Hydrogen is a by-product in this reaction.

(i) Construct an equation for this reaction.

________________________________________________________________________________________[2]

(ii) Suggest a possible observation in this reaction.

________________________________________________________________________________________[1]
(d) Sodium amide is a base.

(i) Define the term base.

(ii) The reaction of sodium amide with hydrochloric acid is similar to that of sodium hydroxide with hydrochloric acid.

Predict the two products of the reaction of sodium amide with hydrochloric acid.

1. ____________________________

2. ____________________________ [2]

(iii) Calcium oxide is also a base.

Draw the ‘dot-and-cross’ diagram for the oxide ion. Include the charge for the ion.

[1]

Total: 10
Question 4

A student carried out an experiment to investigate the speed of reaction between 50 cm$^3$ of dilute hydrochloric acid and excess zinc powder using the apparatus shown below.

The reaction was carried out at a room temperature of 25 °C.

<table>
<thead>
<tr>
<th>Time/ minutes</th>
<th>Volume of hydrogen collected/ cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
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<tr>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>6</td>
<td>56</td>
</tr>
</tbody>
</table>
a) Plot the results on the grid below and draw a smooth line graph. Circle any anomalous point.

b) Sketch, on the grid, the graph you would expect if the experiment was repeated

(i) At 60 °C,

(ii) using excess lumps of zinc
c) Beach sand is a mixture of sand and broken shells (calcium carbonate). Calcium carbonate reacts with dilute hydrochloric acid to form a solution of calcium chloride.

Plan an investigation to find out the percentage of shell material in a given sample of beach sand.

Your answer should include a stepwise method and any apparatus used and measurements taken.

[5]

Total: 10
DATA SHEET
The Periodic Table of the Elements

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</table>

*58-71 Lanthanoid series
†90-103 Actinoid series

Key

- a = relative atomic mass
- x = atomic symbol
- b = proton (atomic) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).