# Chemistry
## Paper 1
### Foundation Tier

**Thursday 17 May 2018 – Morning**
**Time: 1 hour 45 minutes**

**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.
- Calculators may be used.
- Any diagrams may NOT be accurately drawn, unless otherwise indicated.
- You must **show all your working out** with your answer clearly identified at the end of your solution.

### Information
- The total mark for this paper is 100
- The marks for each question are shown in brackets
  - use this as a guide as to how much time to spend on each question.
- In questions marked with an asterisk (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.
- A periodic table is printed on the back cover of this paper.

### Advice
- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
1. Figure 1 shows the dot and cross diagram for a molecule of ammonia.

![Diagram of ammonia molecule]

(a) (i) What do the dots and crosses represent in the diagram? (1)
- A electrons
- B neutrons
- C protons
- D nuclei

(ii) Give the formula for the molecule of ammonia. (1)

(b) (i) Ammonia can be manufactured by the Haber process.

The word equation for the reaction is

\[ \text{nitrogen} + \text{hydrogen} \rightarrow \text{ammonia} \]

State the meaning of the \( \rightarrow \) symbol. (1)
(ii) In the Haber process, the percentage yield of ammonia at equilibrium changes with temperature.

Figure 2 shows how the percentage yield of ammonia at equilibrium changes with temperature.

![Graph showing the percentage yield of ammonia at equilibrium against temperature.]

**Figure 2**

State what happens to the percentage yield of ammonia at equilibrium as the temperature increases.

(1)

(iii) Use the graph to find the percentage yield of ammonia at equilibrium at 450°C.

(1)

percentage yield of ammonia at equilibrium = ..............................................
(c) Ammonia reacts with nitric acid to form ammonium nitrate.

(i) Complete the word equation for this reaction.

\[ \text{......................................................} + \text{......................................................} \rightarrow \text{...........................................................................................................................................} \]

(ii) An ammonium ion has the formula \( \text{NH}_4^+ \).

A nitrate ion has the formula \( \text{NO}_3^- \).

Which of the following is the formula for ammonium nitrate?

□ A \( (\text{NH})_4\text{NO}_3 \)

□ B \( (\text{NH}_4\text{NO})_3 \)

□ C \( \text{NH}_4\text{NO}_3 \)

□ D \( (\text{NHNO})_{12} \)

(iii) Explain why farmers spread ammonium nitrate on their fields.
2 (a) A titration of sodium hydroxide solution with hydrochloric acid can be carried out as follows

1. a pipette is used to measure 25.00 cm$^3$ of sodium hydroxide solution into a conical flask
2. a few drops of indicator are added to the sodium hydroxide solution
3. the burette is filled with hydrochloric acid
4. the hydrochloric acid is added to the sodium hydroxide solution until the indicator changes colour.

(i) Describe how the pipette should be used to measure exactly 25.00 cm$^3$ of sodium hydroxide solution into the conical flask. (2)

(ii) The burette is first washed with water. It is then rinsed with some of the acid before it is filled with the acid to begin the titration.

Explain why the burette is rinsed with the acid. (2)
(b) Universal indicator solution is not a suitable indicator for an acid-alkali titration.

(i) Give the name of an indicator that is suitable for use in the titration of sodium hydroxide solution with hydrochloric acid.

(1)

(ii) Universal indicator goes through a series of gradual colour changes as the pH changes in a solution.

Give a reason why universal indicator is not a suitable indicator to use in an acid-alkali titration.

(1)

(c) Figure 3 shows some titration results obtained from an experiment in which an alkali is titrated with an acid.

<table>
<thead>
<tr>
<th>titration</th>
<th>rough</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>final burette reading in cm$^3$</td>
<td>25.75</td>
<td>49.35</td>
<td>23.70</td>
</tr>
<tr>
<td>initial burette reading in cm$^3$</td>
<td>0.00</td>
<td>25.75</td>
<td>0.00</td>
</tr>
<tr>
<td>volume of acid used in cm$^3$</td>
<td>25.75</td>
<td>23.60</td>
<td>23.70</td>
</tr>
</tbody>
</table>

**Figure 3**

Calculate the accurate volume of acid reacting with the alkali.

(2)

accurate volume of acid reacting ...................................... cm$^3$

(Total for Question 2 = 8 marks)
3 (a) Atoms contain electrons, neutrons and protons.

(i) Draw one line to link each particle to its correct relative charge.

<table>
<thead>
<tr>
<th>particle</th>
<th>relative charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>electron</td>
<td>+1</td>
</tr>
<tr>
<td>neutron</td>
<td>0</td>
</tr>
<tr>
<td>proton</td>
<td>-1</td>
</tr>
</tbody>
</table>

(ii) Which of the following is the relative mass of a proton?

- A 0
- B $\frac{1}{1837}$
- C 1
- D -1

(b) Argon is in group 0 of the periodic table.

Identify, using the periodic table on the back cover of this paper, which of these elements is in the same period as argon.

- A bromine
- B iron
- C magnesium
- D xenon
(c) Figure 4 shows the atomic number and mass number of two isotopes of argon.

<table>
<thead>
<tr>
<th>isotope</th>
<th>atomic number</th>
<th>mass number</th>
</tr>
</thead>
<tbody>
<tr>
<td>argon-38</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>argon-40</td>
<td>18</td>
<td>40</td>
</tr>
</tbody>
</table>

**Figure 4**

Describe the structure of an atom of argon-38 and of an atom of argon-40.

(Total for Question 3 = 7 marks)
4 (a) The molecular formula of butene is $C_4H_8$.

Which of the following is the empirical formula of butene?  

- A CH  
- B CH$_2$  
- C $C_4H_8$  
- D $(CH_2)_4$  

(b) Calculate the relative formula mass of butene, $C_4H_8$.

(relative atomic masses: H = 1, C = 12)  

(c) When burnt completely in air, butene forms carbon dioxide and water.

(i) Balance the equation for this reaction by putting numbers in the spaces provided.

$$C_4H_8 + 6O_2 \rightarrow \text{ __________ CO}_2 + \text{ __________ H}_2O$$  

(ii) Describe the test to show that a gas is carbon dioxide.
(d) Substance X is a gas at room temperature. It is a simple molecular, covalent substance. Which row of the table shows the properties that substance X is most likely to have? (1)

<table>
<thead>
<tr>
<th>boiling point in °C</th>
<th>relative solubility in water</th>
</tr>
</thead>
</table>
| □ A  
-6                  | low                          |
| □ B  
600                 | high                         |
| □ C  
-6                  | high                         |
| □ D  
600                 | low                          |

(e) Diamond has a giant covalent structure. State one property of diamond that is the result of its giant covalent structure. (1)

(Total for Question 4 = 9 marks)
Two compounds of barium are barium sulfide and barium chloride.

(a) The hazard symbol shown in Figure 5 is on bottles containing barium metal.

(b) Give the names of the elements combined in barium sulfide.

(c) Barium chloride is toxic.

   Explain one safety precaution that should be taken when using barium chloride.
(d) (i) A beaker of barium chloride solution and a beaker of dilute sulfuric acid were placed on a balance, as shown in Figure 6.

![Figure 6](image)

The total mass reading on the balance was 25.7 g.

The dilute sulfuric acid was poured into the barium chloride solution and the beaker replaced on the balance, as shown in Figure 7.

![Figure 7](image)

The mixture formed contained a white precipitate.

State the total mass reading on the balance after the reaction.

(1) 

(ii) Give the name of the white precipitate formed by the reaction of barium chloride solution with dilute sulfuric acid.

(1)
(e) Solid sodium chloride is dissolved in water. The sodium chloride solution is electrolysed in the apparatus shown in Figure 8.

Figure 8

6V d.c. supply

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>glass beaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium chloride solution</td>
</tr>
</tbody>
</table>

(i) State why sodium chloride solution, rather than solid sodium chloride, must be used in this experiment.

(1)

(ii) The formulae of the ions present in the sodium chloride solution are

\[ \text{Na}^+ \quad \text{Cl}^- \quad \text{H}^+ \quad \text{OH}^- \]

Circle the ions that would be attracted to the anode.

(1)

(iii) Molten lead bromide can be electrolysed to form molten lead and bromine gas.

Explain how a student could modify the apparatus shown in Figure 8 to carry out this electrolysis.

(2)

(Total for Question 5 = 10 marks)
An ink is a mixture of coloured substances dissolved in water.

(a) Which method is used to separate the coloured substances in the ink?

- A chromatography
- B crystallisation
- C filtration
- D fractional distillation

(b) The apparatus shown in Figure 9 can be used to separate water from ink.

(i) Cold water flows through the condenser.

On Figure 9 use arrows to show where the water should flow in and where it should flow out.
(ii) Explain why a condenser is used.

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

(iii) The flask was heated with a Bunsen burner.

Give the name of an alternative piece of apparatus that could be used to heat the flask.

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

(c) The particles in the ink in the flask can be shown as in Figure 10.

![Diagram of particles in ink](image)

**Figure 10**

In the boxes below, draw the arrangement of particles that would be expected at A and B shown in Figure 9.

- particles at A
- particles at B
(d) Changes of state between the three states of matter are shown in Figure 11.

![Diagram showing changes of state between SOLID, LIQUID, and GAS]

The changes shown are physical changes.

Explain why these changes are called physical changes rather than chemical changes. (2)

(Total for Question 6 = 9 marks)
7 *(a) Pure metals are often converted into more useful alloys. For example, aluminium is converted into an alloy used in aircraft, iron is converted into an alloy used in cutlery and gold alloys are used in jewellery. These processes of alloying change the structures of the metals.

Some properties of pure aluminium, iron and gold are shown in Figure 12.

<table>
<thead>
<tr>
<th>density in g cm(^{-3})</th>
<th>malleability</th>
<th>relative strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminium</td>
<td>2.70</td>
<td>easy to bend</td>
</tr>
<tr>
<td>iron</td>
<td>7.75</td>
<td>easy to bend</td>
</tr>
<tr>
<td>gold</td>
<td>19.3</td>
<td>easy to bend</td>
</tr>
</tbody>
</table>

**Figure 12**

Explain how alloying changes these pure metals to make the alloys more suitable for the given uses.

(6)
(b) Iron objects can corrode when exposed to the atmosphere.

(i) Corrosion involves the oxidation of iron.

State what is meant by oxidation. 

(ii) Painting iron objects prevents corrosion.

Explain why painting iron objects prevents corrosion.

(iii) Corrosion of iron objects can be prevented by painting them or by electroplating them.

State one other way of preventing the corrosion of iron objects.
(c) The apparatus shown in Figure 13 was used to electroplate a spoon with nickel.

![Diagram of electroplating setup with nickel anode, electrolyte, and spoon as cathode.]

(i) State to what the anode and cathode have to be connected in order to carry out the electroplating.

(1)

(ii) Predict the name of a substance that could be dissolved in water to form the electrolyte for this electroplating.

(1)

(Total for Question 7 = 12 marks)
8  (a) State two characteristic properties of metals.

property 1 ..................................................................................................................................

property 2 ..................................................................................................................................

(b) Acids are used to make salts.

Give the name of the acid used to make chlorides.

(c) Salts of metals can be prepared by reacting the metal with an acid to produce the salt and hydrogen.

(i) Describe the test to show that the gas is hydrogen.

(ii) Nickel is a metal.

Explain how the structure of a nickel atom, Ni, changes when it forms a nickel ion, Ni^{2+}.
(d) A nickel sulfate solution is made by dissolving 23.5 g of nickel sulfate to make 250 cm³ of solution.

Calculate the concentration of the solution in g dm⁻³. (2)

\[
\text{concentration} = \frac{\text{mass of nickel sulfate}}{\text{volume of solution}} = \frac{23.5 \text{ g}}{0.25 \text{ dm}^3} = 94 \text{ g dm}^{-3}
\]

(e) Excess solid nickel carbonate is added to dilute sulfuric acid in a beaker.

\[
\text{nickel carbonate} + \text{sulfuric acid} \rightarrow \text{nickel sulfate} + \text{carbon dioxide} + \text{water}
\]

Nickel sulfate is formed in solution.

Describe how a sample of pure, dry nickel sulfate crystals can be obtained from the mixture of nickel sulfate solution and excess solid nickel carbonate in the beaker. (3)

(Total for Question 8 = 12 marks)
Most metals are extracted from ores found in the Earth’s crust.

The method used to extract a metal from its ore is linked to the reactivity of the metal.

Part of the reactivity series is shown in Figure 14.

```
calcium                         most reactive
aluminium
zinc
iron
copper

Figure 14
```

(a) Iron ore contains iron oxide.

Iron is extracted from iron oxide by heating the oxide with carbon.

```
iron oxide + carbon \rightarrow iron + carbon dioxide
```

(i) In this reaction

☐ A carbon is reduced
☐ B iron oxide is neutralised
☐ C iron oxide is reduced
☐ D iron is oxidised
(ii) The formula of the iron oxide is Fe₂O₃.

Calculate the maximum mass of iron that can be obtained from 240 tonnes of iron oxide, Fe₂O₃.

(relative atomic masses: O = 16, Fe = 56)

\[
\text{mass of iron} = \text{........................................... tonnes}
\]

(b) Aluminium cannot be extracted by heating its oxide with carbon. Aluminium has to be extracted from its oxide by electrolysis.

Explain why.

\[
\text{...........................................}
\]

(c) Predict the method that will have to be used to extract calcium from its ore.

\[
\text{...........................................}
\]
*(d) Aluminium is extracted from its ore by electrolysis. Iron is extracted from its ore by heating with carbon. Both metals can also be obtained by recycling.

Explain the advantages of recycling aluminium and iron rather than extracting them from their ores.
10 (a) Hydrogen burns in air at a temperature well above 100°C to form water.

(i) The boiling points of hydrogen and water are shown in Figure 15.

<table>
<thead>
<tr>
<th>boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen  -253</td>
</tr>
<tr>
<td>water  100</td>
</tr>
</tbody>
</table>

**Figure 15**

Use this information to add the missing state symbols to the equation for the reaction taking place as the hydrogen burns.

\[
2 \text{H}_2(\text{\underline{\text{_____}}}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{\underline{\text{_____}}})
\]

(ii) The atom economy for the reaction in (i) is 100%.

State how the equation shows that the atom economy is 100%.

(b) Lead can be obtained by heating its oxide with carbon. The balanced equation for the reaction is

\[
2 \text{PbO} + \text{C} \rightarrow 2\text{Pb} + \text{CO}_2
\]

Calculate the atom economy for the production of lead in this reaction.

(relative atomic masses: C = 12, O = 16, Pb = 207
relative formula masses: PbO = 223, CO₂ = 44)

Give your answer to two significant figures.

atom economy = ...................................................... %
(c) (i) In an experiment to produce lead, 7.67 g of lead are obtained. The theoretical yield of lead for the experiment is 11.80 g.

Calculate the percentage yield of lead in this experiment.

\[ \text{percentage yield} = \frac{7.67 \, \text{g}}{11.80 \, \text{g}} \times 100\% \]

(ii) In most reactions, the percentage yield of any product is less than 100%.

Give two reasons why the percentage yield is less than 100%.

\begin{align*}
\text{reason 1} & \quad \text{...} \\
\text{reason 2} & \quad \text{...}
\end{align*}

(Total for Question 10 = 11 marks)
The periodic table of the elements

* The elements with atomic numbers from 58 to 71 are omitted from this part of the periodic table.

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