Annual Examinations for Secondary Schools 2014

FORM 5 CHEMISTRY TIME: 1h 45min

Name: _________________________ Class: _______________

Useful Data: Atomic numbers and relative atomic masses are shown in the periodic table printed below. One mole of any gas occupies 22.4 dm³ at standard temperature and pressure. Faraday constant = 96500 C mol⁻¹ Q = It

PERIODIC TABLE

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

Key

- a: relative atomic mass
- b: symbol
- c: atomic number

Marks Grid [ For Examiner’s use only ]

<table>
<thead>
<tr>
<th>Question N°.</th>
<th>Section A</th>
<th>Section B</th>
<th>Theory Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Max Mark</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Actual Mark</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theory Paper: 85% Practical: 15% Final Score: 100%
SECTION A – Answer ALL questions. This section carries 60 marks.

1 This question is about carbon and its compounds. Match each of the following carbon-containing substances with the correct description. Each substance can only be used once.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon monoxide</td>
<td>a. Fine solid particles emitted in the smoky exhaust of engines in which the fuel is not burnt completely</td>
</tr>
<tr>
<td>calcium carbonate</td>
<td>b. A form of carbon that conducts electricity</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>c. Substance formed when carbon dioxide gas reacts with water</td>
</tr>
<tr>
<td>soot</td>
<td>d. An element that is found in group 4 of the periodic table</td>
</tr>
<tr>
<td>graphite</td>
<td>e. It is the main component of limestone</td>
</tr>
<tr>
<td>diamond</td>
<td>f. A form of carbon that is burnt in the blast furnace to obtain a high temperature</td>
</tr>
<tr>
<td>methane</td>
<td>g. Poisonous gas produced when fuels are burnt in a limited supply of air</td>
</tr>
<tr>
<td>coke</td>
<td>h. A form of carbon that is transparent and very hard</td>
</tr>
<tr>
<td>carbon</td>
<td>i. A gas produced from the complete combustion of fossil fuels</td>
</tr>
<tr>
<td></td>
<td>j. A gas which burns easily and is commonly used as a fuel</td>
</tr>
</tbody>
</table>

2 Use the periodic table on the first page of the exam paper to help you answer this question. Near each statement write the symbol of an element that corresponds to the description.

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A transition metal</td>
<td></td>
<td>f. A halogen</td>
<td></td>
</tr>
<tr>
<td>b. An alkali metal</td>
<td></td>
<td>g. An alkali earth metal</td>
<td></td>
</tr>
<tr>
<td>c. The element made of the smallest atoms</td>
<td></td>
<td>h. The most reactive metal in the third row (period 3)</td>
<td></td>
</tr>
<tr>
<td>d. An element that has 5 outer shell electrons</td>
<td></td>
<td>i. The most reactive non-metal in the third row (period 3)</td>
<td></td>
</tr>
<tr>
<td>e. A non-metal that has 6 outer shell electrons and 3 electron shells</td>
<td></td>
<td>j. The most unreactive element in the third row (period 3)</td>
<td></td>
</tr>
</tbody>
</table>
Jason decided to investigate the order of reactivity of 4 metals with dilute sulfuric acid. The acid he used had a molar concentration of 0.5 mol dm\(^{-3}\).

He tested the following metals:

- aluminium
- zinc
- iron
- magnesium

He noted that in all four test-tubes, bubbles of gas were formed, as shown in the picture below.

![Test tubes with gas bubbles](image)

### a.

(i) Using your knowledge of the activity series of metals, predict which metal corresponds to each test-tube reaction in the diagram.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Reaction A</th>
<th>Reaction B</th>
<th>Reaction C</th>
<th>Reaction D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Write a balanced chemical equation, including state symbols, to represent the reaction of magnesium with dilute sulfuric acid.

\[
\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2 \uparrow
\]

### b.

(i) Mention **two** ways of ensuring that the testing of all four metals with the acid is ‘fair’.

- Ensure that each test-tube contains the same amount of acid.
- Ensure that the metals are of the same size and shape.

(ii) Explain why it would not be a good idea to use sodium metal for this type of experiment.

- Sodium reacts too vigorously with water and can cause an explosion.

(iii) Jason tested the gas produced with a burning splint and in each case, it burnt with a pop showing it is hydrogen. Write a balanced chemical equation to represent this reaction.

\[
\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{energy}
\]
4. Martina, a chemistry student, sets up the apparatus shown below in order to prepare a dry gas. **Dilute hydrochloric acid solution** is placed in the dropping funnel and **potassium sulfite powder** in the reaction flask. The tap of the dropping funnel is opened to allow the dilute hydrochloric acid to pour onto the potassium sulfite. The tap is immediately closed.

![Diagram of apparatus](image)

a. (i) Write the names corresponding to the diagram labels A, B, C and D:

A ___________________________  B ___________________________

C ___________________________  D ___________________________  [2]

(ii) Write a balanced chemical equation showing the reaction of dilute hydrochloric acid with potassium sulfite.

_______________________________________________________________________  [2]

(iii) Which gas is being prepared in this experiment?

_______________________________________________________________________  [1]

b. (i) Martina was going to use a gas syringe to collect the gas but unluckily, the only syringe available in her lab broke. On the diagram draw and label an alternative piece of equipment that can be used to collect the gas. Name the collecting technique used and explain why you chose it.

_______________________________________________________________________

_______________________________________________________________________  [4]

(ii) Explain the purpose of the liquid D shown in the diagram.

_______________________________________________________________________  [1]
Cracking is an important part of the crude oil refining process. Luke decided to try cracking on a small scale in the chemistry laboratory by using the apparatus shown below. He used the compound decane as the ‘long-chained hydrocarbon’ to be cracked.

a. (i) What is the role of aluminium oxide or broken porcelain in this experiment?

__________________________________________________________________________________ [1]

(ii) Explain why cracking is used in the oil industry.

__________________________________________________________________________________ [2]

b. The equation below represents the reaction that occurs when decane is cracked:

\[ C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4 \]

(i) Write the chemical name of the two products.

\[ C_8H_{18} \] __________________________________________________________________________ [2]

\[ C_2H_4 \] __________________________________________________________________________ [2]

(ii) Write A on the diagram above where you would expect \( C_2H_4 \) to be collected and write B where you would expect \( C_8H_{18} \) to be collected. [2]

c. (i) \( C_8H_{18} \) belongs to the family of compounds (homologous series) known as alkanes. To which series does \( C_2H_4 \) belong?

__________________________________________________________________________________ [1]

(ii) Draw the structures of \( C_2H_4 \) and \( C_8H_{18} \). [2]
Nicole investigated the rate of reaction of marble chips (calcium carbonate) with dilute nitric acid.

She reacted 1.0 g of marble chips with 100 cm$^3$ of 0.2 mol dm$^{-3}$ nitric acid solution in a conical flask as shown in the diagram to the right.

During the investigation, Nicole took readings of the mass of the flask and contents over a period of time.

She then plotted the results on the graph shown below.

---

a. (i) Write a balanced chemical equation to represent this reaction.

_______________________________________________________________________ [2]

(ii) Explain the purpose of the cotton wool in this experiment.

_______________________________________________________________________ [1]

...this question continues on the next page...
b. Use the graph on page 6 to find:

(i) The initial mass of the flask and contents. [1]

(ii) The time when the reaction stopped. [1]

(iii) The final mass of the flask and contents. [1]

c. (i) Calculate the change in mass of the flask and contents due to the reaction. [1]

(ii) Explain what caused the change in mass of the flask during this reaction. [1]

(iii) Explain which section of the graph (page 6) A, B or C represents the highest rate of the reaction. [1]

d. Nicole tried out the experiment a second time. This time she reacted 1.0 g of marble chips with 100 cm$^3$ of 0.4 mol dm$^{-3}$ nitric acid solution (instead of 0.2 mol dm$^{-3}$).

Sketch on the same graph on page 6 the curve you would expect her to obtain.

(Assume that the cotton wool weighed exactly like the one in the first experiment.) [1]
Arizona wildfire tragedy: 19 firefighters lose their lives

On the hot afternoon of 30 June 2013, a group of firefighters made their way to the dry area around Yarnell Hill in the Granite Mountains (USA).

Their mission was to put out what seemed a small fire that had been triggered by lightning. Some of the trees and shrubs had caught fire. They could see the smoke where combustion was taking place. But the wind suddenly blew up and the fire roared to life and became very dangerous.

The firefighters were trapped, so they prepared their personal shelters, capsule-like devices designed to deflect heat and trap breathable air.

Some of the men made it into their shelters but because of the large amounts of toxic carbon monoxide and thick smoke containing soot, they did not make it.

19 out of the 20 firefighters lost their lives.

Use the underlined words in bold to help you answer some of the questions below.

a. (i) Name 2 things that acted as a fuel for this wildfire. [2]
(ii) What gas, present in air, is necessary for wood to burn? [1]
(iii) Wood does not start burning on its own. What natural cause started the reaction? [1]
(iv) What made the fire burn more fiercely? Use your knowledge of chemistry to explain why. [3]
(v) Name two weather conditions that would increase the chance for a forest fire to start. [2]
(vi) Find another word in the newspaper article above that means ‘burning’. [1]
(vii) The firefighters’ shelters were designed to trap ‘breathable air’. Name two dangerous substances that are produced when wood (fuel) burns in a limited supply of air. [2]

b. (i) The hydrocarbon propane is a fossil fuel. Copy and complete the equation shown below. Include balancing and state symbols.

\[ _{-}C_3H_8(g) + O_2(g) \rightarrow _{-}CO_2 + \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ (l) \text{ or } (g) \] [3]

(ii) The two main products of the complete burning of fossil fuels are responsible for the World’s increased Greenhouse Effect. Name these two products. [2]

(iii) Draw a simple labelled diagram to explain the Earth’s Greenhouse Effect. [3]
Some clothes cannot be washed in water because they would change shape or shrink. Therefore they are taken for **dry-cleaning**. Dry-cleaning is also used to remove dirt and greasy stains that water and detergents cannot. 

Chemists can ‘design’ dry-cleaning solvents so that they have exactly the properties needed.

‘*I should have taken my t-shirt for dry-cleaning instead of washing it at home!*’

---

**a.** In dry-cleaning, special **solvents** (liquids) that dissolve grease are used instead of water.

(i) Once the clothes are removed from a dry-cleaning machine, they are ‘wet’ with the solvent. The solvent is then dried. **What process is happening when the solvent is drying?**

(ii) **List two ways of making the solvent dry faster.**

---

**b.** When choosing a solvent for dry-cleaning, chemists look at the following **properties**:

- Whether it is flammable (catches fire easily) or not
- If it is poisonous or not
- Its boiling point:
  - If it is too high it will prove costly to recycle
  - If it is too low it will evaporate in the machine causing problems

The manager of a dry-cleaning business has asked you to give her some advice on which solvent to use for a dry-cleaning machine. The table below gives you some important properties of five solvents:

<table>
<thead>
<tr>
<th>Solvent</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to dissolve grease</td>
<td>excellent</td>
<td>very good</td>
<td>very good</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Does it burn (flammable)?</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Is its vapour poisonous?</td>
<td>slightly</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>What is its boiling point?</td>
<td>127 ºC</td>
<td>400 ºC</td>
<td>130 ºC</td>
<td>120 ºC</td>
<td>45 ºC</td>
</tr>
</tbody>
</table>

Decide which one of the five solvents would make the best choice for use in dry-cleaning and explain your reasons for making that choice.

*...this question continues on the next page...*
A dry-cleaning solvent that has **dissolved** impurities in it can be made pure again using the apparatus shown above.

(i) Name the laboratory technique that can be used to obtain the pure solvent from the impure solution. [1]

(ii) Write a label corresponding to each of the letters (A-H) in the diagram above. [8]

(iii) Explain the process that is happening in the apparatus labelled E. [2]

9 A laboratory analyst working in a Pharmaceutical Company was given 4 reagent bottles each containing a white substance.

The labels, which had fallen off the bottles, were marked:

- **Magnesium sulfate** (*Epsom salts*)
- **Magnesium hydroxide** (*Magnesia*)
- **Magnesium chloride** (*Oral magnesium supplement*)
- **Magnesium bromide** (*Tranquilliser medicine*)

The analyst’s job was to identify which substance was stored in each bottle.

...this question continues on the next page...
a. Write the chemical formulae of each of the four substances:

(i) Magnesium sulfate
(ii) Magnesium hydroxide
(iii) Magnesium chloride
(iv) Magnesium bromide

b. The analyst carried out two simple tests on each substance.

1. He observed the appearance of the solid in each bottle.
2. He checked whether each solid was soluble in water or not.

Below are his results:

<table>
<thead>
<tr>
<th>Observations</th>
<th>Appearance</th>
<th>Solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A</td>
<td>white crystals</td>
<td>Dissolves in water to form a colourless solution</td>
</tr>
<tr>
<td>Substance B</td>
<td>white crystals</td>
<td>Dissolves in water to form a colourless solution</td>
</tr>
<tr>
<td>Substance C</td>
<td>white crystals</td>
<td>Dissolves in water to form a colourless solution</td>
</tr>
<tr>
<td>Substance D</td>
<td>white powder</td>
<td>Does not dissolve in water</td>
</tr>
</tbody>
</table>

The analyst then checked a data book showing the solubility of the magnesium compounds shown on the labels that had fallen off the bottles.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnesium sulfate</td>
<td>soluble</td>
</tr>
<tr>
<td>magnesium hydroxide</td>
<td>insoluble</td>
</tr>
<tr>
<td>magnesium chloride</td>
<td>soluble</td>
</tr>
<tr>
<td>magnesium bromide</td>
<td>soluble</td>
</tr>
</tbody>
</table>

(i) By using the information on the table of Solubility of magnesium salts, identify which of the four substances is found in bottle D. Explain your reasoning. [2]

(ii) Substance D can be classified as a base. What is a base? [1]

(iii) Name one substance that would react with substance D to produce a salt and water. [1]

...this question continues on the next page...
To discover which substances were stored in bottles A, B and C, the analyst then performed a series of chemical tests.

He first dissolved all three substances in water and then added drops of NaOH solution to the solutions of A, B and C.

All 3 solutions gave the same result shown in the picture.

(i) Explain why all three solutions, A, B and C, gave the same result when sodium hydroxide solution was added to them (a white precipitate insoluble in excess NaOH).

(ii) Copy and complete the following ionic equation:

\[
\text{____X}^{2+} + \text{____OH}^{-} \rightarrow \text{____} \text{_____}
\]

Make sure you balance the equation (X\(^{2+}\) represents the cation in each substance).

The analyst then performed a second test on the solutions of substances A, B and C. To each of the solutions he added a few drops of acidified silver nitrate solution. The results were:

A – no change observed
B – white precipitate formed
C – pale yellow precipitate formed

From these results identify substances A, B and C, by writing the chemical name or formula of each. Explain how you arrived at each answer.

e. The analyst wanted to confirm the identity of substance A by performing another test. He added some acidified barium (II) chloride solution to a solution of A.

(i) What change would you expect to see during this reaction? Remember to describe how solution A appeared before and after being added \(\text{BaCl}_2\) solution.

(ii) Copy and complete the equation below:

\[
\text{BaCl}_2(\text{aq}) + \text{_______(aq)} \rightarrow \text{BaSO}_4 + \text{MgCl}_2(\text{aq})
\]

Balance the equation and include any missing state symbols.