SECTION B

THIS QUESTION SHOULD BE ANSWERED IN THE SEPARATE ANSWER BOOK PROVIDED. Complete all the details on the front of the answer book.

You should aim to spend no more than 35 minutes on this section. This time recommendation includes reading time.

Read straight through the passage on pages 26 and 27 on **ARGON IN THE SPOTLIGHT**, and then more carefully, in order to answer the following questions.

5. (a) Give a chemical reason for the derivation of the name "argon".

(1)

(b) (i) Who was responsible for the discovery of argon?

(1)

(ii) Which investigation led to the discovery of argon?

(1)

(c) Why is air compressed slowly in the liquefaction process?

(1)

(d) Why is nitrogen not suitable for a gas in electric light bulbs?

(1)

(e) Suggest the product of the reaction of oxygen and carbon in steel making.

(1)

(f) Explain why argon is so unreactive in terms of its electronic structure.

(1)

(g) **Describe how argon is manufactured from air**, in not more than 100 words.

(8)

You are NOT asked to summarise the whole passage, nor to include equations in your summary.

At the end of your summary state the number of words you have used.

Credit will be given for answers written in good English, using complete sentences and using technical words correctly and chemical names rather than formulae. Avoid copying long sections from the original text. Numbers count as one word, as do standard abbreviations, units and hyphenated words. Any title you give your passage does not count in your word total.

There are penalties for the use of words in excess of 100.

TOTAL 15 Marks

[*Turn over*

ARGON IN THE SPOTLIGHT

It may seem surprising that uses exist for a colourless, odourless, totally unreactive gas like argon. Being denser than air, it cannot be used to lift balloons as its fellow Group member helium can, yet more argon is used than all the other members of the Noble gas group put together. How was it discovered? Why are unreactive substances of interest to chemists? Of what possible use can it be?

1994 was the centenary of the discovery of argon by Sir William Ramsay. Ramsay discovered argon whilst investigating apparent differences in the density of nitrogen made in different ways.

The name argon was chosen because of its chemical unreactivity. The word is derived from the Greek *argos* meaning lazy or easy.

Like the noble metals they were named after, the noble gases exist uncombined in nature, but thinly spread out. Physical rather than chemical processes are needed to separate them from their surroundings. The noble gases are obtained by fractional distillation of liquefied air.

Filtered air is compressed in five or six stages. The effect of each compression is to heat up the gas mixture. To minimise this, the air is compressed slowly. The air is then allowed to expand rapidly to give a maximum cooling effect and the process of compression followed by expansion is carried out repeatedly until the air is liquefied.

Between the second and third stages, carbon dioxide is removed by passing the air through aqueous sodium hydroxide. Residual moisture is removed by passage through silica gel or activated alumina.

After the compression stages, dry carbon dioxide-free air is fractionally distilled. This separates liquid oxygen from nitrogen. As nitrogen has a lower boiling point (77 K) than oxygen (90 K), nitrogen boils first and leaves the top of the distillation column as a gas. Oxygen collects at the bottom of the column as a liquid. Because the boiling point of argon is nearer the boiling point of oxygen, argon is mainly found in the liquid oxygen fraction. This fraction is passed to another distillation column where 80-90 % pure argon is produced. Residual oxygen is removed by reaction with hydrogen. This reaction produces water, so the resulting gas is then dried to leave pure argon.

Most of the uses of argon arise because it is the most abundant, hence the cheapest, noble gas. Its very unreactivity is an advantage. Many electric light bulbs are filled with argon, as this enables them to run at higher temperatures, where there is a more efficient transformation of electrical energy to light energy. Although nitrogen is much cheaper and unreactive at normal temperatures, it combines with the hot filaments to form nitrides, which would not conduct electricity.

The steel industry is the largest single user of argon. The gas is used as an inert stir gas to ensure homogeneity as oxygen is blown through the molten metal to adjust the carbon content.

So lazy, unreactive argon really can be useful in different ways, and it has also helped chemists to understand chemical bonding.

(523 words)

Adapted from "Argon- in the spotlight" by Gordon Woods, *Chemistry Review*, May 1995.

DO NOT FORGET TO ANSWER PARTS (a), (b), (c), (d), (e), (f) AND (g) IN THE SEPARATE ANSWER BOOK PROVIDED.

At the end of the examination check that all the details at the front of the answer book are correct and tie it loosely to this question paper.

END

SECTION B

5. (a) 'Argon' comes from the Greek word for lazy or easy and denotes **unreactivity.** **(1 mark)**
ACCEPT inert **.**

(b) (i) Ramsay. **(1 mark)**

(ii) Investigation of the differences in the **density** of **nitrogen made in different** ways. **(1 mark)**

(c) To **minimise heating**. **(1 mark)**

(d) At high temperature nitrogen would react with hot metal filaments to form **nitrides** which **do not conduct electricity**. **(1 mark)**

(e) Carbon reacts with oxygen to form **carbon dioxide**. **(1 mark)**

(f) Argon has a **stable** (filled) outer shell of electrons. **(1 mark)**

(g) Examiners will need to consider each answer for (i) key points and (ii) style and use of English. Candidates should have recorded their word total at the end of their answer, and this should be checked.

up to 105 words: no penalty
106 - 115 words: -1
116 - 125 words: -2
126 - 135 words: -3

and at a rate of -1 penalty for every 5 words excess thereafter, up to a maximum penalty equal to the number of key points included by the answer.

Note that words appearing in the title to the summary do not count in the word total. Normally hyphenated words, numbers and chemical formulae count as one word. The question does not ask for equations in the summary, but if included they should be counted in the word total.

CO_2 – 2 words
NaOH (aq) – 2 words
80-90% – 4 words
70K – 2 words
if units given – 1 word
5/6 ≡ 3 words

1. Air is liquefied/cooled by a series of **slow compressions** and **rapid expansions**..... **(1)**

2. to **minimise heating** during **compression** and maximise cooling during expansion. **(1)**

3. **Carbon dioxide** is removed by passing the air through aqueous **sodium hydroxide**. **Moisture** is removed by passing through **silica gel** or **activated alumina**. **(1)**

(1)

4. (Liquid) **air** is **fractionally distilled**. **(1)**

5. **Oxygen** (fraction) is (re)**distilled** to produce **argon**. **(1)**

6. **Residual oxygen** is removed by **reaction with hydrogen**..... **(1)**

7. ....to **form water** which is **removed** by **drying**.

Marking for key points

One mark should be awarded for every key point clearly identified in an answer, up to a maximum of 6 marks. A tick should be made in the script at which the examiner decided to award each mark eg ✓. The total marks for key points should be placed in the body of the script at the end of the answer, out of 6.

To gain the mark for a key point the wording used by the candidate must make clear the essential chemistry of the point.

Quality of Written Communication (2)
This should be impression marked on a scale 2 - 1 - 0.
Candidates are expected to:
- show clarity of expression;
- construct and present coherent argument;
- demonstrate effective use of grammar, punctuation and spelling.

The answer should read fluently, with links between key points. **(2 marks)**

SECTION B, TOTAL 15 Marks

END