



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

CENTRE  
NUMBER

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**SCIENCE**

**5126/03**

Paper 3 Chemistry

**October/November 2010**

**1 hour 15 minutes**

Candidates answer on the Question Paper

Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs, tables or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE ON ANY BARCODES.

**Section A**

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

**Section B**

Answer any **two** questions.

Write your answers on the lined paper provided and, if necessary, continue on separate answer paper.

A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use |  |
|--------------------|--|
| Section A          |  |
| Section B          |  |
|                    |  |
|                    |  |
| Total              |  |

This document consists of **13** printed pages and **3** lined pages.



**Section A**

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

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- 1** Choose one metallic element and one non-metallic element. Complete Table 1.1 with these two elements.

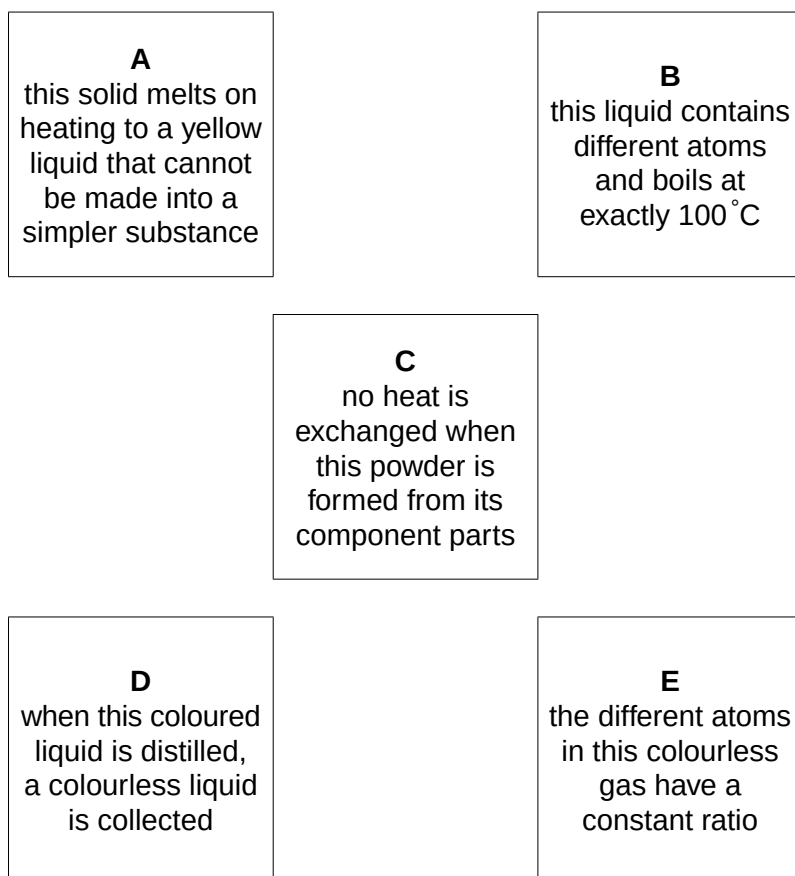
**Table 1.1**

|                      | name | chemical symbol | <b>one</b> physical property |
|----------------------|------|-----------------|------------------------------|
| metallic element     |      |                 |                              |
| non-metallic element |      |                 |                              |

[6]

- 2 The boxes in Fig. 2.1 contain descriptions of five different substances, **A**, **B**, **C**, **D** and **E**. Decide whether each substance should be classified as an element, compound or mixture. Show your decision by ticking (✓) the correct box for each substance in Fig. 2.2.

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**Fig. 2.1**

| substance | element | compound | mixture |
|-----------|---------|----------|---------|
| <b>A</b>  |         |          |         |
| <b>B</b>  |         |          |         |
| <b>C</b>  |         |          |         |
| <b>D</b>  |         |          |         |
| <b>E</b>  |         |          |         |

**Fig. 2.2**

[5]

- 3 Table 3.1 describes properties of two different solutions. Complete the table.

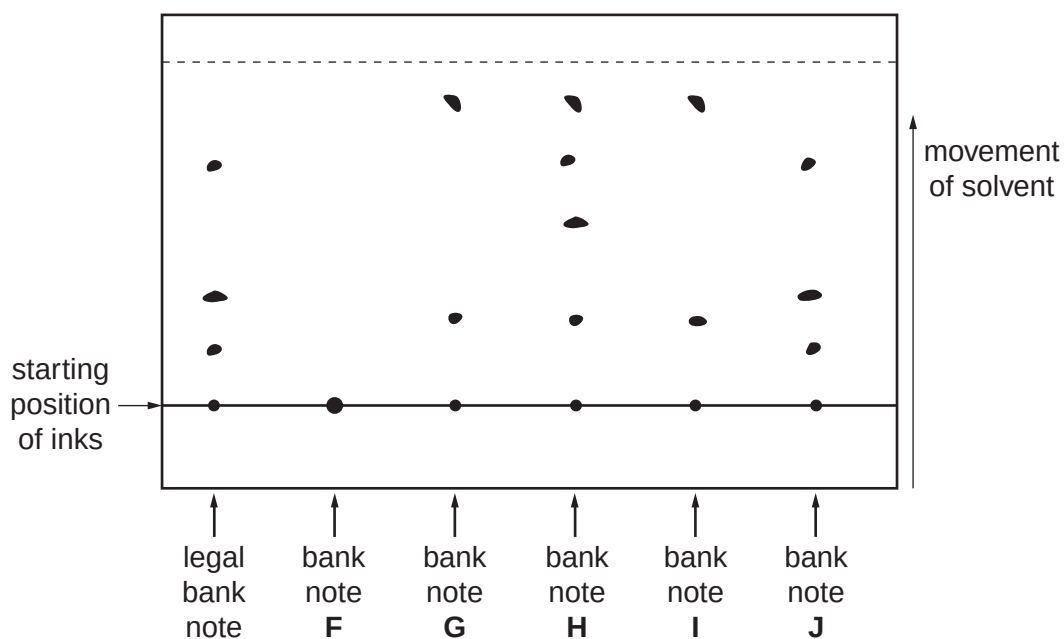
**Table 3.1**

| solution                 | colour when mixed with Universal Indicator solution | <b>one</b> product of the reaction with ammonium carbonate |
|--------------------------|-----------------------------------------------------|------------------------------------------------------------|
| hydrochloric acid        |                                                     |                                                            |
| aqueous sodium hydroxide |                                                     |                                                            |

[4]

- 4 Forensic scientists use paper chromatography to compare the inks from five different bank notes with the ink used to make legal bank notes.

The results are shown as a chromatogram in Fig. 4.1.



**Fig. 4.1**

- (a) Draw the apparatus that could be used to produce this chromatogram.

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[2]

- (b) Which of the bank notes **F**, **G**, **H**, **I** and **J**

- (i) is **not** a forgery,

.....

- (ii) are printed with identical inks,

.....

- (iii) is printed with ink containing four solvent-soluble dyes?

.....

[3]

- (c) Use your knowledge of bank notes to suggest why water would probably **not** be a suitable solvent to use for this chromatography.

.....

..... [1]

5 (a) An element has an atomic number of 9.

(i) Write the electronic structure of an atom of the element.

.....

(ii) Explain how the electronic structure shows that this is a non-metal.

.....

(iii) What is the charge on an ion of this element?

.....

[3]

(b) Table 5.1 gives the particles in the nuclei of five different atoms, **K**, **L**, **M**, **N** and **O**.

**Table 5.1**

| letter<br>(not chemical symbol) | <b>K</b>                | <b>L</b>                | <b>M</b>                | <b>N</b>                | <b>O</b>                |
|---------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| particles in each<br>nucleus    | 3 protons<br>3 neutrons | 4 protons<br>5 neutrons | 5 protons<br>5 neutrons | 5 protons<br>6 neutrons | 6 protons<br>7 neutrons |

Which letter or letters from **K**, **L**, **M**, **N** or **O** best represent

(i) the nucleus of an atom with an atomic number of six,

.....

(ii) the nucleus of an atom with a relative atomic mass of six,

.....

(iii) two nuclei from different isotopes of the same element?

.....

[3]

- 6 (a) Table 6.1 includes some organic reactions. Fill in the boxes. The first has been completed for you as an example.

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Table 6.1

|         | organic compounds       | types of reaction                                                                                                                     | products                                                                                                   |
|---------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| example | ethene                  | <div style="border: 1px solid black; padding: 2px; display: inline-block;"> <i>reduction</i><br/>           .....         </div><br>→ | ethane                                                                                                     |
| (i)     | ethene                  | polymerisation<br>→                                                                                                                   | <div style="border: 1px solid black; padding: 2px; display: inline-block;">           .....         </div> |
| (ii)    | ethanol                 | <div style="border: 1px solid black; padding: 2px; display: inline-block;">           .....         </div><br>→                       | ethanoic acid                                                                                              |
| (iii)   | ethanol + ethanoic acid | esterification<br>→                                                                                                                   | <div style="border: 1px solid black; padding: 2px; display: inline-block;">           .....         </div> |

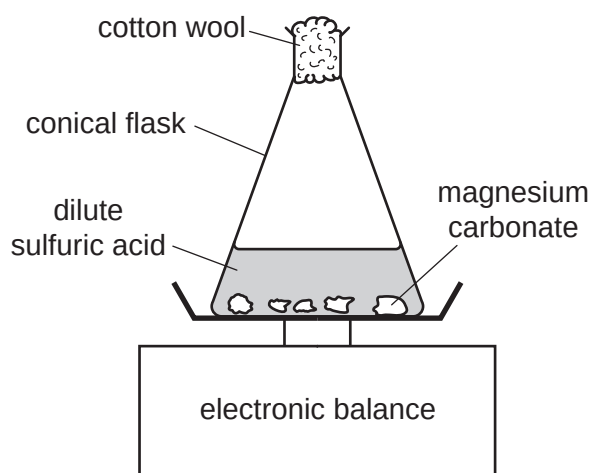
[3]

- (b) Ethene has a low boiling point and is a gas at room temperature. It consists of covalently bonded molecules. Explain why the boiling point of ethene is low.

.....  
 .....  
 ..... [2]

- 7 Magnesium carbonate and dilute sulfuric acid react to produce a gas. Data to determine the rate of this reaction are collected using the apparatus shown in Fig. 7.1.

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**Fig 7.1**

- (a) What is the purpose of the cotton wool in the mouth of the conical flask?

.....[1]



- (b) The reading on the electronic balance is taken every minute and used to plot the graph shown in Fig. 7.2.

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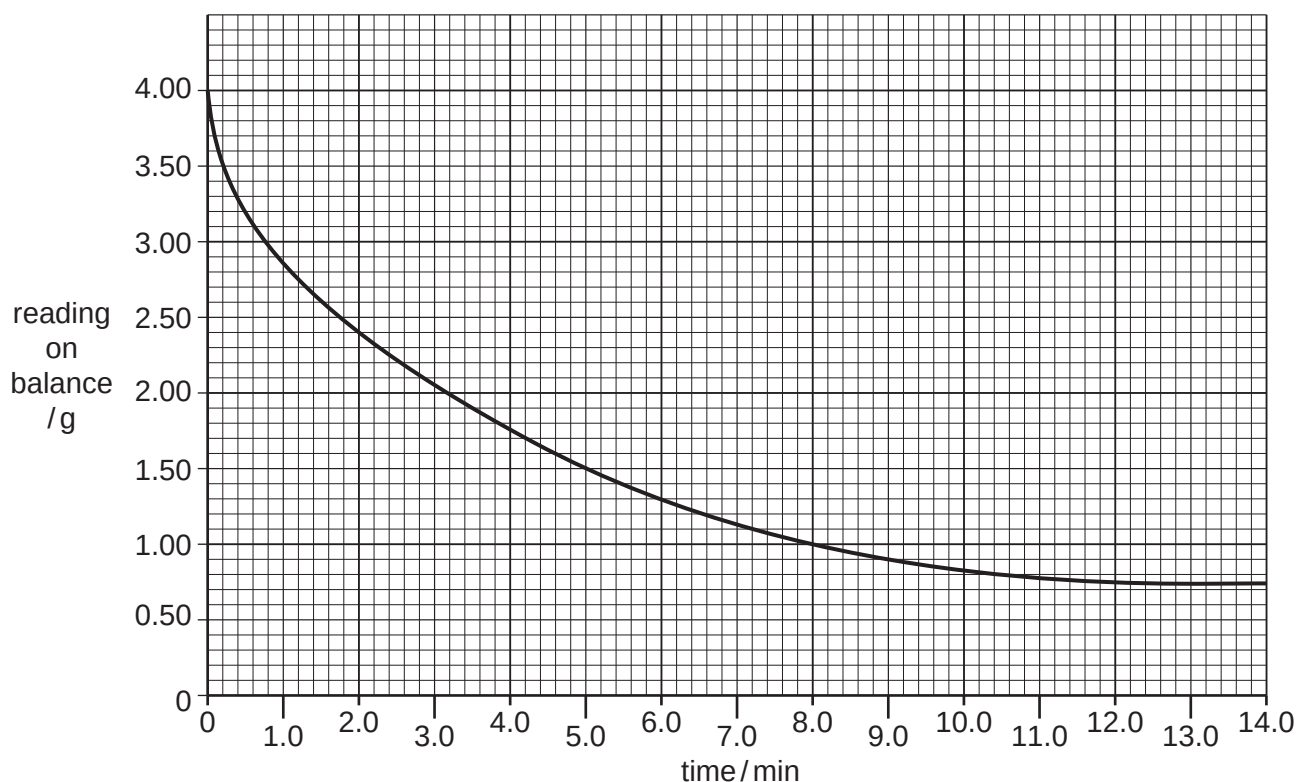


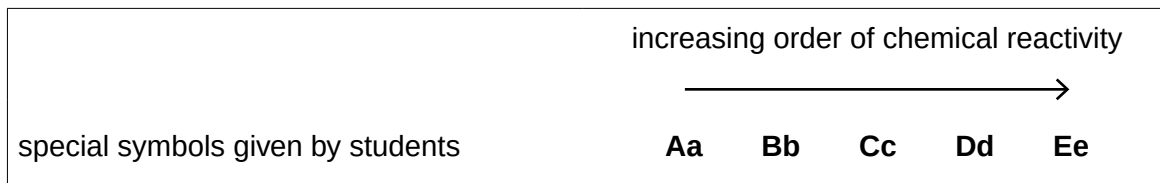
Fig. 7.2

- (i) Why does the reading on the electronic balance decrease over the first few minutes?
- .....
- (ii) What can you tell from the graph about the rate of this reaction during its first 14 minutes?
- .....
- .....
- (iii) Calculate from the graph the fall in mass over the first 8 minutes of the reaction.
- .....
- (iv) Calculate the average rate of reaction over the first 8 minutes in grams per minute.

..... g/min  
[5]

- 8 Students give their own special symbols to five **metallic** elements. All five metals are in the same group of the Periodic Table. The special symbols are shown in Fig. 8.1. The order of chemical reactivity of these metals is also shown.

For  
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Use



**Fig. 8.1**

The students know

1. the group of the Periodic Table in which these metals are placed,
2. that chlorine,  $Cl$ , combines with the metal they had given the special symbol **Aa**.

As a result they give the compound so formed the formula **AaCl**.

- (a) (i) In which group of the Periodic Table must all these elements be placed?

.....

- (ii) Choose from Fig. 8.1 the special symbol of the element which is most likely to be the first member of this group.

.....

- (iii) Write the formula for the compound formed between this element and oxygen.

.....

[3]

- (b) (i) Suggest the name of the element given the special symbol **Bb** by the students.

.....

- (ii) How would you expect this element to react with water?

.....

- (iii) Use the special symbol **Bb** to write a chemical equation for this reaction with water. State symbols are not required.

.....

[4]

## Section B

Answer any **two** questions.

Write your answers on the lined pages provided and, if necessary, continue on separate answer paper.

- 9 (a) Briefly describe how lime (calcium oxide) is manufactured and give one of its uses. Include a chemical equation, with state symbols, in your description. [5]
- (b) Fig. 9.1 describes some of the reactions of calcium oxide.

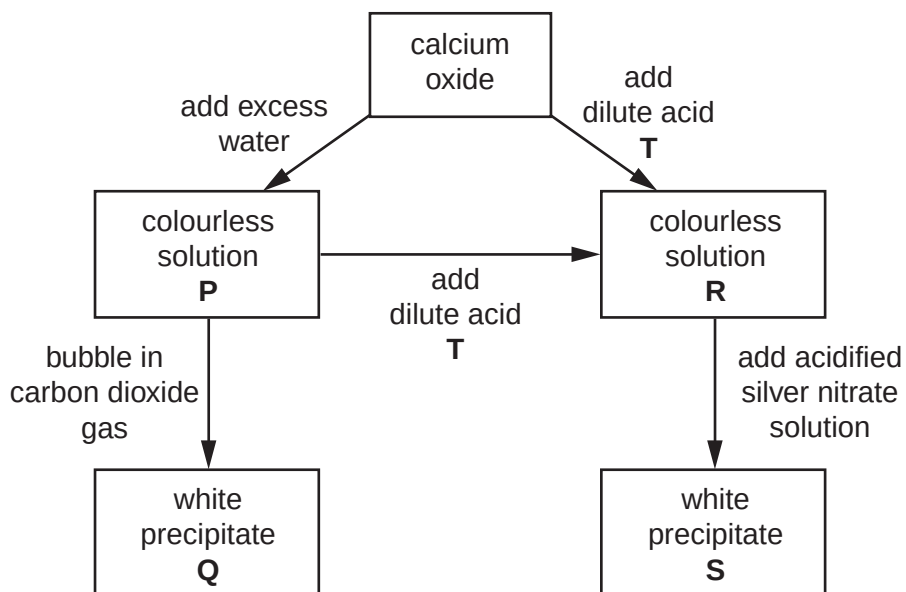


Fig. 9.1

Identify substances **P**, **Q**, **R**, **S** and **T**.

[5]

**10 (a)** Burning fossil fuels, such as coal, can produce sulfur dioxide and carbon monoxide. Explain how these two pollutant gases are formed and state their harmful effects. [6]

**(b)** A coal contains 2% by mass of sulfur. What mass and volume of sulfur dioxide are formed when 100 grams of this coal are burned completely in air?

[Relative atomic masses:  $A_r$ : O, 16; S, 32]

[The volume of one mole of any gas is  $24\text{ dm}^3$  at room temperature and pressure.] [4]

**11 (a)** Organic compounds form homologous series. Give the general characteristics of members of any homologous series. [3]

**(b) (i)** Draw the structure of an alkane with two carbon atoms in each molecule.

**(ii)** Calculate the percentage by mass of hydrogen in this alkane.

[Relative atomic masses:  $A_r$ : H, 1; C, 12]

**(iii)** What substances are formed when this alkane burns in excess air?

Write an equation for the reaction. State symbols are required.

[7]





[illegible]

[www.theallpapers.com](http://www.theallpapers.com)

# DATA SHEET

## The Periodic Table of the Elements

| Group                                                  |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    |                                                                             |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
|--------------------------------------------------------|------------------------------------|-------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|------------------------------------|-----------------------------------|-----------------------------------|------------------------------------|-----------------------------------------------------------------------------|-------------------------------------|------------------------------------|-------------------------------------|----------------------------------|--|--|-----------------------------------|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|--------------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|----------------------------------------|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|-----------------------------------|--|--|--|--|--|--|----------------------------------------|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|----------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|---------------------------------------|--|--|--|--|--|--|---------------------------------------|--|--|--|--|--|--|------------------------------------|--|--|--|--|--|--|----------------------------------------|--|--|--|--|--|--|-------------------------------------|--|--|--|--|--|--|---------------------------------------|--|--|--|--|--|--|
| I                                                      | II                                 |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   | III                                | IV                                                                          | V                                   | VI                                 | VII                                 | 0                                |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 7<br><b>Li</b><br>Lithium<br>3                         | 9<br><b>Be</b><br>Beryllium<br>4   | 1<br><b>H</b><br>Hydrogen<br>1      |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   | 11<br><b>B</b><br>Boron<br>5       | 12<br><b>C</b><br>Carbon<br>6                                               | 14<br><b>N</b><br>Nitrogen<br>7     | 16<br><b>O</b><br>Oxygen<br>8      | 19<br><b>F</b><br>Fluorine<br>9     | 20<br><b>Ne</b><br>Neon<br>10    |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
|                                                        |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    |                                                                             |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 23<br><b>Na</b><br>Sodium<br>11                        | 24<br><b>Mg</b><br>Magnesium<br>12 |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   | 27<br><b>Al</b><br>Aluminium<br>13 | 28<br><b>Si</b><br>Silicon<br>14                                            | 31<br><b>P</b><br>Phosphorus<br>15  | 32<br><b>S</b><br>Sulfur<br>16     | 35.5<br><b>Cl</b><br>Chlorine<br>17 | 40<br><b>Ar</b><br>Argon<br>18   |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 39<br><b>K</b><br>Potassium<br>19                      | 40<br><b>Ca</b><br>Calcium<br>20   | 45<br><b>Sc</b><br>Scandium<br>21   | 48<br><b>Ti</b><br>Titanium<br>22  | 51<br><b>V</b><br>Vanadium<br>23   | 52<br><b>Cr</b><br>Chromium<br>24   | 55<br><b>Mn</b><br>Manganese<br>25  | 56<br><b>Fe</b><br>Iron<br>26     | 59<br><b>Co</b><br>Cobalt<br>27     | 59<br><b>Ni</b><br>Nickel<br>28    | 64<br><b>Cu</b><br>Copper<br>29   | 65<br><b>Zn</b><br>Zinc<br>30     | 70<br><b>Ga</b><br>Gallium<br>31   | 73<br><b>Ge</b><br>Germanium<br>32                                          | 75<br><b>As</b><br>Arsenic<br>33    | 79<br><b>Se</b><br>Selenium<br>34  | 80<br><b>Br</b><br>Bromine<br>35    | 84<br><b>Kr</b><br>Krypton<br>36 |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 85<br><b>Rb</b><br>Rubidium<br>37                      | 88<br><b>Sr</b><br>Strontium<br>38 | 89<br><b>Y</b><br>Yttrium<br>39     | 91<br><b>Zr</b><br>Zirconium<br>40 | 93<br><b>Nb</b><br>Niobium<br>41   | 96<br><b>Mo</b><br>Molybdenum<br>42 | 101<br><b>Ru</b><br>Ruthenium<br>44 | 103<br><b>Rh</b><br>Rhodium<br>45 | 106<br><b>Pd</b><br>Palladium<br>46 | 108<br><b>Ag</b><br>Silver<br>47   | 112<br><b>Cd</b><br>Cadmium<br>48 | 115<br><b>In</b><br>Indium<br>49  | 119<br><b>Sn</b><br>Tin<br>50      | 122<br><b>Sb</b><br>Antimony<br>51                                          | 127<br><b>Te</b><br>Tellurium<br>52 | 127<br><b>I</b><br>Iodine<br>53    | 131<br><b>Xe</b><br>Xenon<br>54     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 133<br><b>Cs</b><br>Caesium<br>55                      | 137<br><b>Ba</b><br>Barium<br>56   | 139<br><b>La</b><br>Lanthanum<br>57 | 178<br><b>Hf</b><br>Hafnium<br>72  | 181<br><b>Ta</b><br>Tantalum<br>73 | 184<br><b>W</b><br>Tungsten<br>74   | 186<br><b>Re</b><br>Rhenium<br>75   | 190<br><b>Os</b><br>Osmium<br>76  | 192<br><b>Ir</b><br>Iridium<br>77   | 195<br><b>Pt</b><br>Platinum<br>78 | 197<br><b>Au</b><br>Gold<br>79    | 201<br><b>Hg</b><br>Mercury<br>80 | 204<br><b>Tl</b><br>Thallium<br>81 | 207<br><b>Pb</b><br>Lead<br>82                                              | 209<br><b>Bi</b><br>Bismuth<br>83   | 209<br><b>Po</b><br>Polonium<br>84 | 210<br><b>At</b><br>Astatine<br>85  | 222<br><b>Rn</b><br>Radon<br>86  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 223<br><b>Fr</b><br>Francium<br>87                     | 226<br><b>Ra</b><br>Radium<br>88   | 227<br><b>Ac</b><br>Actinium<br>89  |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    |                                                                             |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| * 58–71 Lanthanoid series<br>† 90–103 Actinoid series  |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    |                                                                             |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| <div><div>a</div><div><b>X</b></div><div>b</div></div> |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    | a = relative atomic mass<br>X = atomic symbol<br>b = atomic (proton) number |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| Key                                                    |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    |                                                                             |                                     |                                    |                                     |                                  |  |  |                                   |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                      |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                   |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                  |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                       |  |  |  |  |  |  |                                    |  |  |  |  |  |  |                                        |  |  |  |  |  |  |                                     |  |  |  |  |  |  |                                       |  |  |  |  |  |  |
| 175<br><b>Lu</b><br>Lutetium<br>71                     |                                    |                                     |                                    |                                    |                                     |                                     |                                   |                                     |                                    |                                   |                                   |                                    | 173<br><b>Yb</b><br>Ytterbium<br>70                                         |                                     |                                    |                                     |                                  |  |  | 169<br><b>Tm</b><br>Thulium<br>69 |  |  |  |  |  |  | 167<br><b>Er</b><br>Erbium<br>68 |  |  |  |  |  |  | 165<br><b>Ho</b><br>Holmium<br>67 |  |  |  |  |  |  | 162<br><b>Dy</b><br>Dysprosium<br>66 |  |  |  |  |  |  | 159<br><b>Tb</b><br>Terbium<br>65 |  |  |  |  |  |  | 157<br><b>Gd</b><br>Gadolinium<br>64 |  |  |  |  |  |  | 152<br><b>Eu</b><br>Europium<br>63 |  |  |  |  |  |  | 150<br><b>Sm</b><br>Samarium<br>62 |  |  |  |  |  |  | 147<br><b>Pm</b><br>Promethium<br>61 |  |  |  |  |  |  | 144<br><b>Nd</b><br>Neodymium<br>60 |  |  |  |  |  |  | 141<br><b>Pr</b><br>Praseodymium<br>59 |  |  |  |  |  |  | 140<br><b>Ce</b><br>Cerium<br>58 |  |  |  |  |  |  | 232<br><b>Th</b><br>Thorium<br>90 |  |  |  |  |  |  | 231<br><b>Pa</b><br>Protactinium<br>91 |  |  |  |  |  |  | 238<br><b>U</b><br>Uranium<br>92 |  |  |  |  |  |  | 237<br><b>Np</b><br>Neptunium<br>93 |  |  |  |  |  |  | 244<br><b>Pu</b><br>Plutonium<br>94 |  |  |  |  |  |  | 243<br><b>Am</b><br>Americium<br>95 |  |  |  |  |  |  | 247<br><b>Cm</b><br>Curium<br>96 |  |  |  |  |  |  | 247<br><b>Bk</b><br>Berkelium<br>97 |  |  |  |  |  |  | 251<br><b>Cf</b><br>Californium<br>98 |  |  |  |  |  |  | 252<br><b>Es</b><br>Einsteinium<br>99 |  |  |  |  |  |  | 257<br><b>Fm</b><br>Fermium<br>100 |  |  |  |  |  |  | 258<br><b>Md</b><br>Mendelevium<br>101 |  |  |  |  |  |  | 259<br><b>No</b><br>Nobelium<br>102 |  |  |  |  |  |  | 260<br><b>Lr</b><br>Lawrencium<br>103 |  |  |  |  |  |  |

Key 
 a  
**X**  
 b
 
 a = relative atomic mass  
 X = atomic symbol  
 b = atomic (proton) number

The volume of one mole of any gas is 24dm<sup>3</sup> at room temperature and pressure (r.t.p.).