



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
International General Certificate of Secondary Education

CANDIDATE  
NAME

CENTRE  
NUMBER

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**COMBINED SCIENCE**

**0653/31**

Paper 3 (Extended)

**October/November 2013**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**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 pencil for any diagrams or graphs.

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

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 24.

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.

This document consists of **22** printed pages and **2** blank pages.



- 1 Sodium chloride is obtained from underground deposits in the Earth's crust.

Low-sodium salt is a mixture containing both sodium chloride and potassium chloride.

- (a) (i) Explain why the Earth's crust contains the compound sodium chloride and not the uncombined elements, sodium and chlorine.

.....  
..... [1]

- (ii) State **one** difference between a compound, such as potassium chloride, and a mixture, such as low-sodium salt.

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

- (b) Table 1.1 contains the names and symbols of some positive and negative ions.

**Table 1.1**

| positive ions |                              | negative ions |                               |
|---------------|------------------------------|---------------|-------------------------------|
| name          | symbol                       | name          | symbol                        |
| potassium     | K <sup>+</sup>               | fluoride      | F <sup>-</sup>                |
| ammonium      | NH <sub>4</sub> <sup>+</sup> | oxide         | O <sup>2-</sup>               |
| calcium       | Ca <sup>2+</sup>             | nitride       | N <sup>3-</sup>               |
| aluminium     | Al <sup>3+</sup>             | sulfate       | SO <sub>4</sub> <sup>2-</sup> |

- (i) Use the information shown in Table 1.1 and the Periodic Table on page 24 to determine the ions that have an electron configuration of 2, 8, 8.

..... [1]

- (ii) Deduce the chemical formula of the compound calcium fluoride.

Show how you obtained your answer.

..... [2]

- (c) The element calcium is formed during the electrolysis of molten calcium chloride.

During this process, calcium ions are converted to calcium atoms on the surface of the cathode.

- (i) Explain why calcium atoms form on the cathode and **not** on the anode.

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

- (ii) Describe what happens at the surface of the cathode to convert calcium ions to calcium atoms.

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

- 2 Fig. 2.1 shows the inside of a refrigerator.

The temperature inside the freezing compartment is  $-20^{\circ}\text{C}$  and the temperature in the rest of the refrigerator is  $+5^{\circ}\text{C}$ .

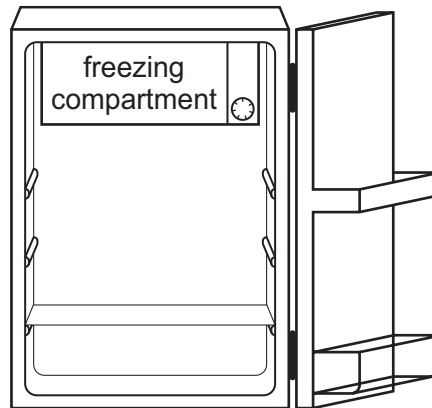


Fig. 2.1

- (a) (i) The air in the refrigerator is cooled by convection.

Draw **one** arrow on Fig. 2.1 to show the movement of the air cooled by the freezing compartment. [1]

- (ii) Explain this movement in terms of particles and density.

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

- (b) The volume of air in the refrigerator is  $0.15\text{ m}^3$ .

The density of air is  $1.26\text{ kg/m}^3$ .

Calculate the mass of air in the refrigerator.

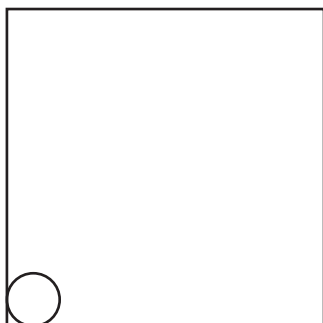
State the formula that you use, show your working and state the unit of your answer.

formula

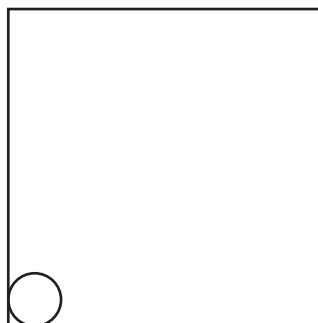
working

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

- (c) (i) Complete the diagrams to show the arrangement of water molecules in solid ice and in liquid water. One molecule has been drawn for you in each box. Each diagram should contain at least twelve water molecules.



solid ice



liquid water

[2]

- (ii) Each sentence describes either a solid, a liquid or a gas.

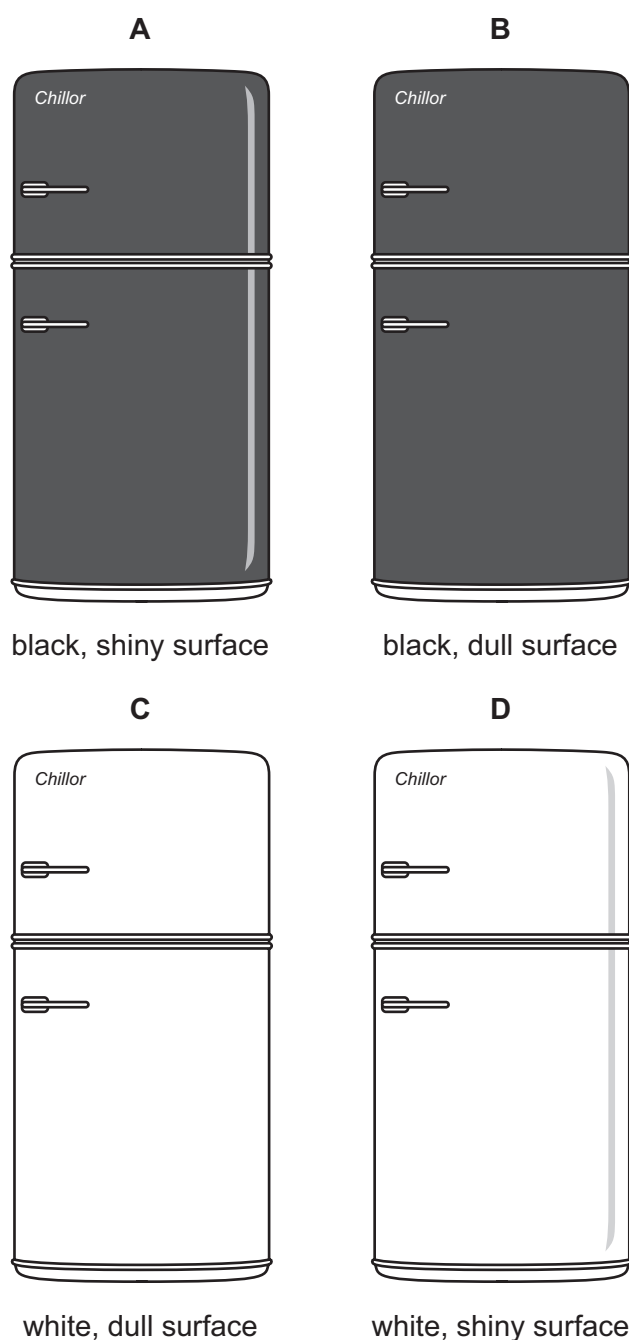
In the right hand column write the letter **S** for solid, **L** for liquid or **G** for gas to match the description.

| description                                       | <b>S, L or G</b> |
|---|------------------|
| It cannot flow.                                   |                  |
| It cannot transfer heat by convection.            |                  |
| It contains particles which are widely separated. |                  |
| It expands the most when heated.                  |                  |
| It fills a closed container.                      |                  |
| It has a fixed volume but not a fixed shape.      |                  |

[2]

- (d) A refrigerator can be warmed up by radiation energy absorbed by the outside surface of the refrigerator. Such absorption needs to be kept as low as possible.

The four refrigerators shown in Fig. 2.2 are identical except for the outside surface.



**Fig. 2.2**

State which refrigerator is most effective at keeping the contents cool.

Explain your answer.

.....

.....

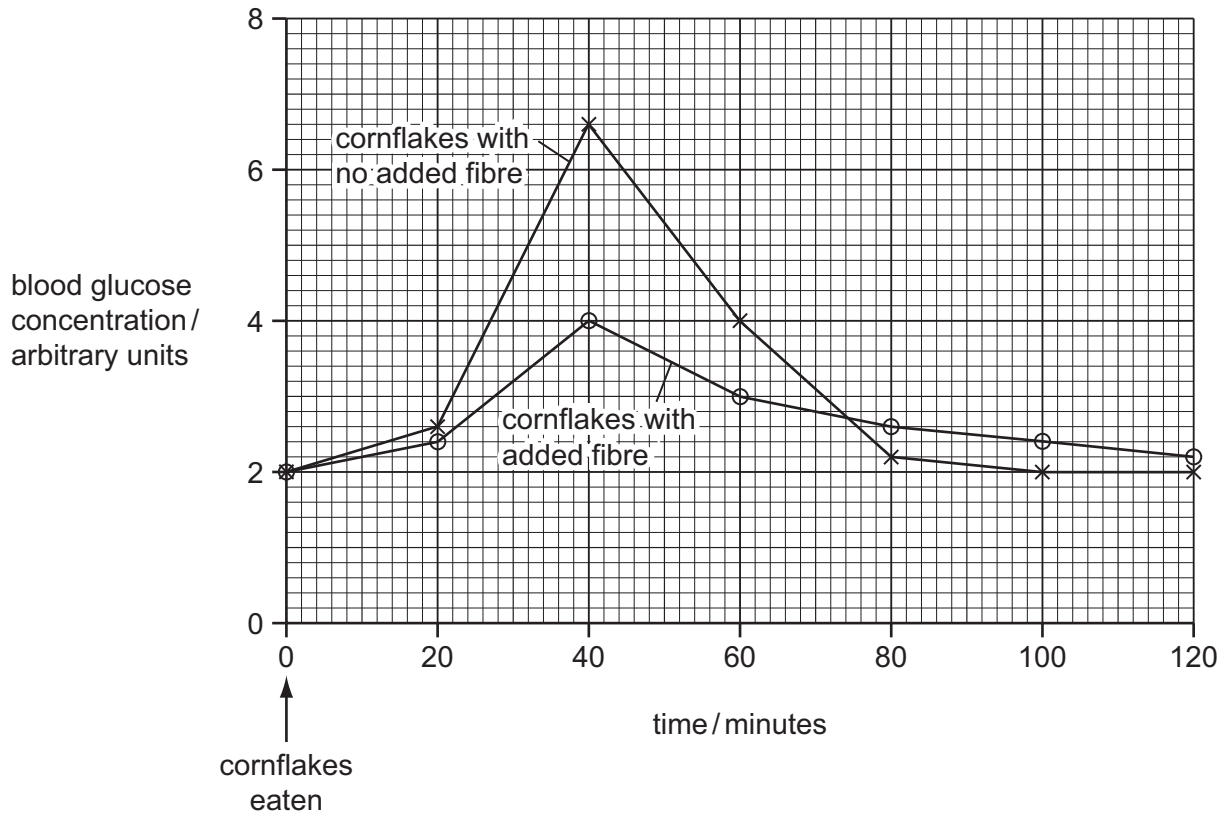
..... [2]

**Please turn over for Question 3.**

- 3 The concentration of glucose in the blood does not normally vary much.

Researchers investigated how adding fibre to foods affected the concentration of glucose in the blood after eating.

Fig. 3.1 shows the results that they obtained for two different types of cornflakes. Cornflakes contain a lot of starch.



**Fig. 3.1**

Use the information in Fig. 3.1 to help you to answer the following questions.

- (a) Describe how the blood glucose concentration changed after eating cornflakes with no added fibre.

.....

.....

.....

.....

..... [3]



(b) Suggest explanations for these changes in blood glucose concentration.

.....

.....

.....

.....

..... [3]

(c) (i) Describe how adding fibre to the cornflakes affected the changes in blood glucose concentration after eating.

.....

.....

.....

.....

..... [3]

(ii) Outline **one** other way in which fibre in the diet affects health.

.....

..... [1]

- 4 Fig. 4.1 shows the nucleus and **outer** electron shell of an atom of an element from the second period of the Periodic Table .

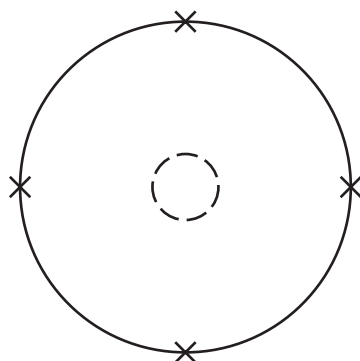


Fig. 4.1

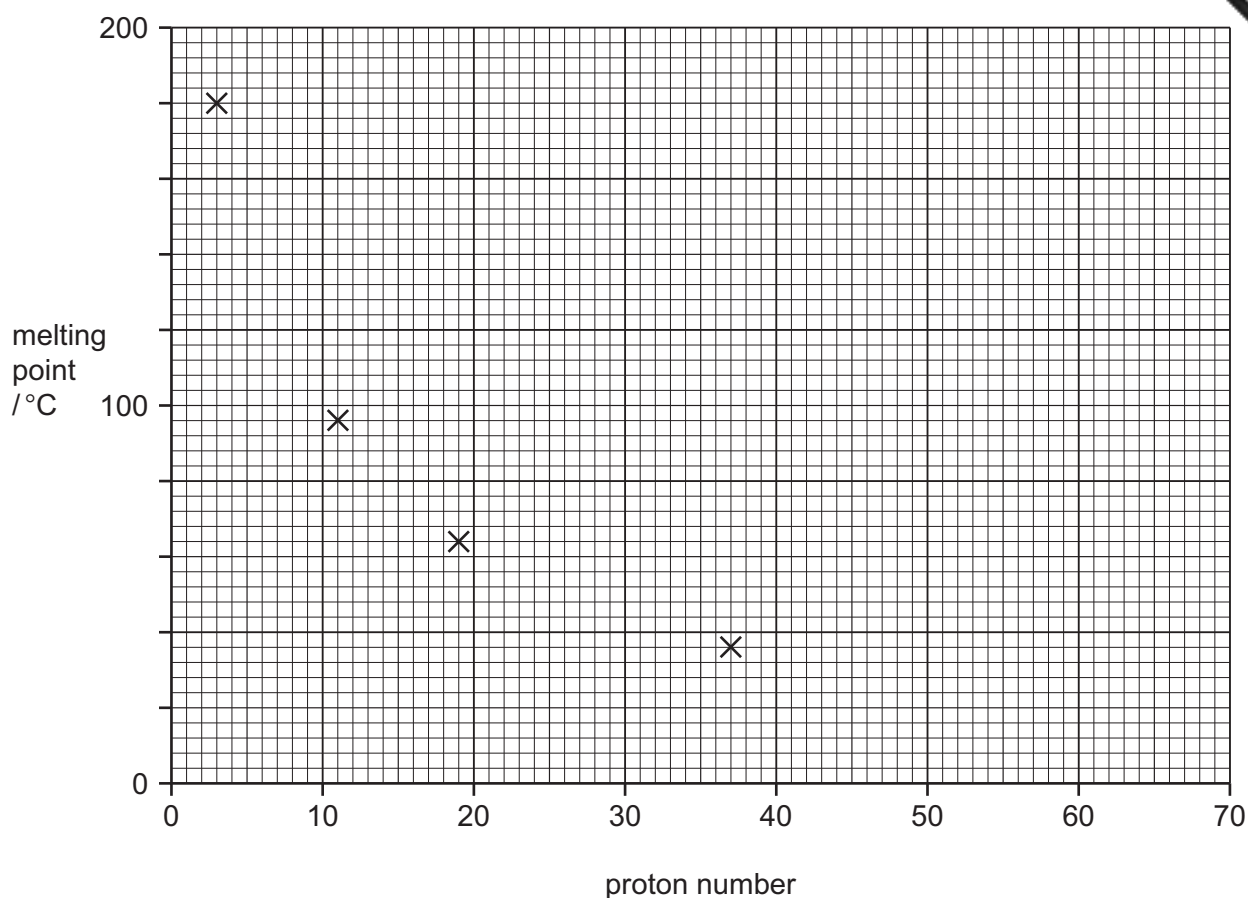
- (a) Deduce the name of the element and explain your answer briefly.

name of element .....

explanation .....

..... [2]

- (b) Fig. 4.2 shows the melting points of four metallic elements from the same group in the Periodic Table.



**Fig. 4.2**

- (i) State the number of the group that contains the elements whose melting points are shown in Fig. 4.2.

Explain your answer briefly.

group number .....

explanation .....

..... [2]

- (ii) Estimate the melting point of the next element in the same group of the Periodic Table.

Use the symbol **X** to mark your estimate on the grid in Fig. 4.2. [2]

- (c) Fig. 4.3 shows a cross section through a blast furnace which is used to extract iron from iron oxide.

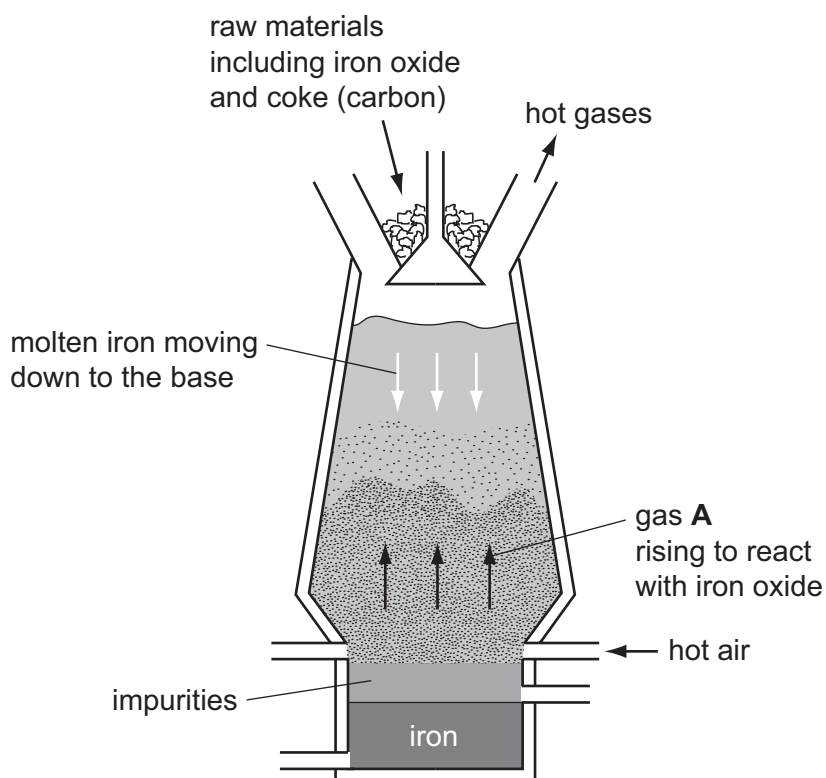


Fig. 4.3

- (i) Name gas **A** which reacts with iron oxide to produce iron.

..... [1]

- (ii) Name the type of chemical change that the iron oxide undergoes in (i).

Explain your answer briefly.

type of chemical reaction .....

explanation .....

.....

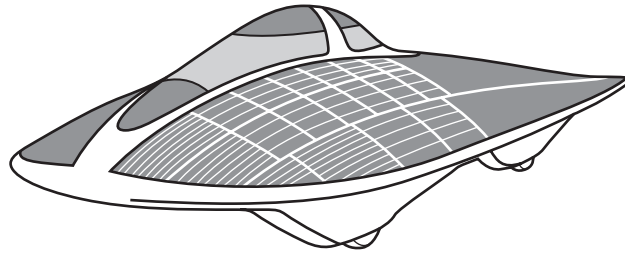
..... [2]

- (iii) State the **word** chemical equation for the reaction that occurs in (i).

..... [1]

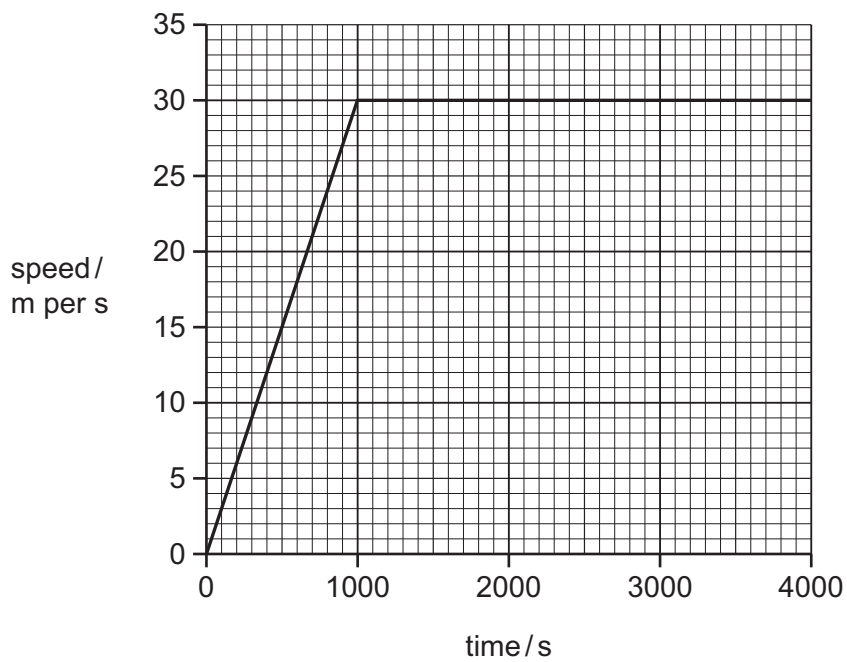
**Please turn over for Question 5.**

- 5 Fig. 5.1 shows a solar-powered vehicle.



**Fig. 5.1**

- (a) Fig. 5.2 shows a speed/time graph for the vehicle for the first hour of a journey.



**Fig. 5.2**

- (i) Calculate the distance travelled during 4000 s.

Show your working and state the unit of your answer.

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

- (ii) Calculate the acceleration of the vehicle during the first 1000s.

Show your working.

..... m/s<sup>2</sup> [2]

- (b) Fig. 5.3 shows the energy flow diagram for the solar-powered vehicle.

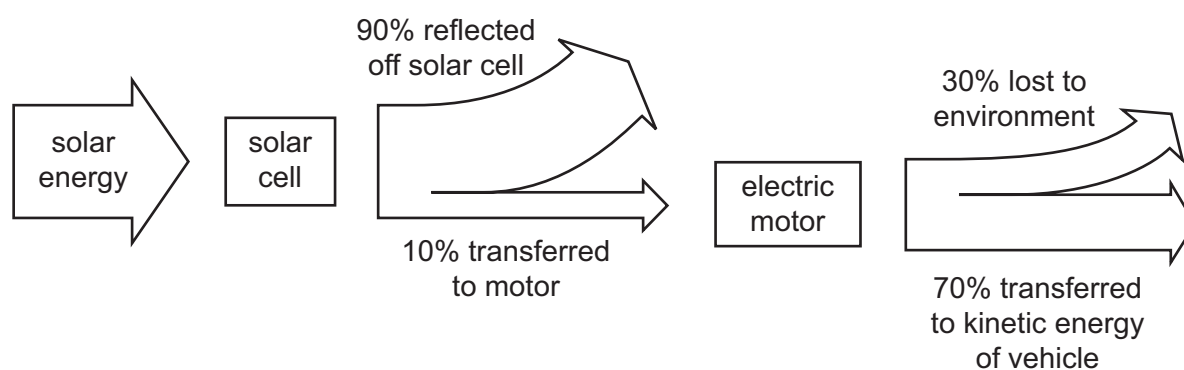


Fig. 5.3

- (i) State the efficiency of the **solar cell**.

..... % [1]

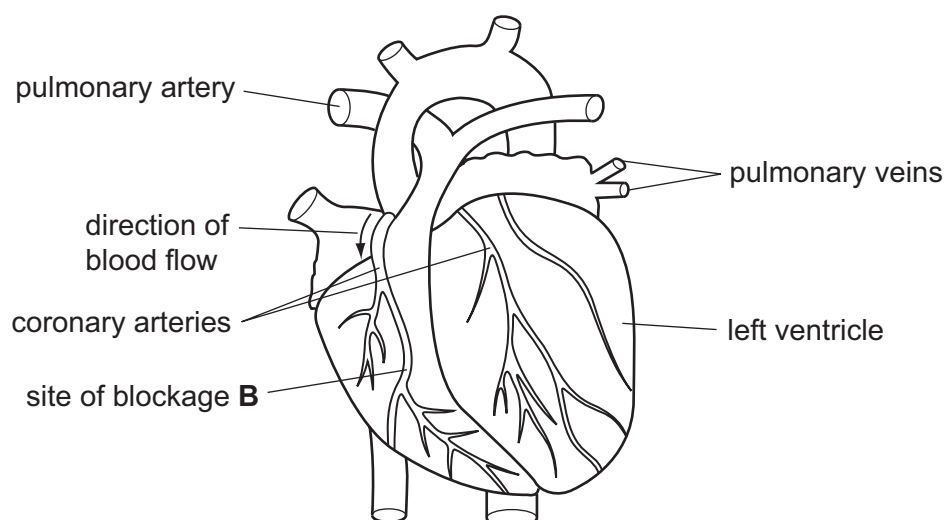
- (ii) During part of the journey, the solar cell receives 1 000 000 joules of solar energy.

Calculate the number of joules transferred as kinetic energy to the **vehicle**.

Show your working.

..... J [2]

- 6 Fig. 6.1 shows an external view of the heart and the blood vessels that are connected



**Fig. 6.1**

- (a)** The muscles in the walls of the ventricles contract and relax rhythmically.
- (i)** Describe how contraction of the muscles in the wall of the left ventricle affects the blood inside the ventricle.
- .....
- .....
- ..... [2]
- (ii)** Describe how contraction of the muscles in the wall of the left ventricle affects the valve between the left atrium and the left ventricle.
- ..... [1]
- (b)** The coronary arteries supply the muscles of the heart with oxygen and nutrients.
- (i)** Explain why these muscles require a constant supply of oxygen.
- .....
- .....
- ..... [2]



- (ii) A blockage occurs in the coronary artery at site **B**.

On Fig. 6.1, shade the area of the heart wall that will be affected by this blockage.

[1]

- (iii) List **three** lifestyle factors that **increase** the chance that a blockage will develop in a coronary artery.

1 .....

2 .....

3 ..... [3]

7 Ethene,  $C_2H_4$ , is an unsaturated hydrocarbon.

(a) Fig. 7.1 shows structures of the molecules involved when ethene reacts with bromine.

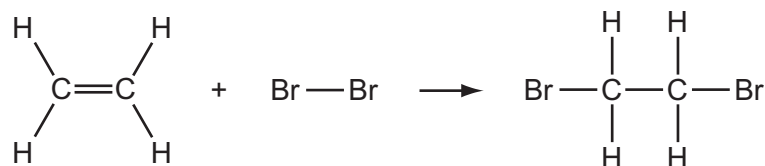


Fig. 7.1

(i) Describe the colour change that is observed when ethene reacts with bromine.

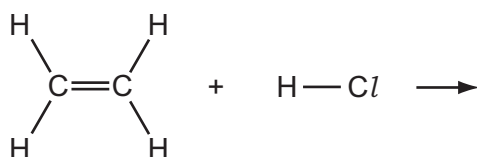
from ..... to ..... [1]

(ii) Name the type of chemical reaction shown in Fig. 7.1.

..... [1]

(iii) The reaction between ethene and hydrogen chloride,  $HCl(g)$ , is similar to the reaction shown in Fig. 7.1.

Complete the equation below to suggest the structure of the molecule that is produced.



[2]

(b) Methane,  $CH_4$ , reacts with steam in the presence of a catalyst to produce carbon monoxide,  $CO$ , and hydrogen gas.

Construct a balanced symbol chemical equation for this reaction.

..... [3]

- 8 (a) Fig. 8.1 shows a circuit which could be used for the lights on a car. When each headlight bulb is fully lit, 6 A passes through it. When each sidelight is fully lit, 2 A passes through it.

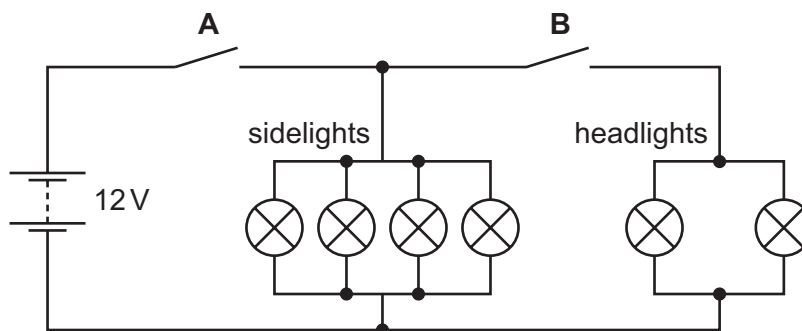


Fig. 8.1

Calculate the total current flowing from the battery when

switch **A** is closed and switch **B** is open,

.....

switches **A** and **B** are both closed.

..... [1]

- (b) Each sidelight has a resistance of  $24\ \Omega$ .

Calculate the combined resistance of the four sidelights connected in parallel in this circuit.

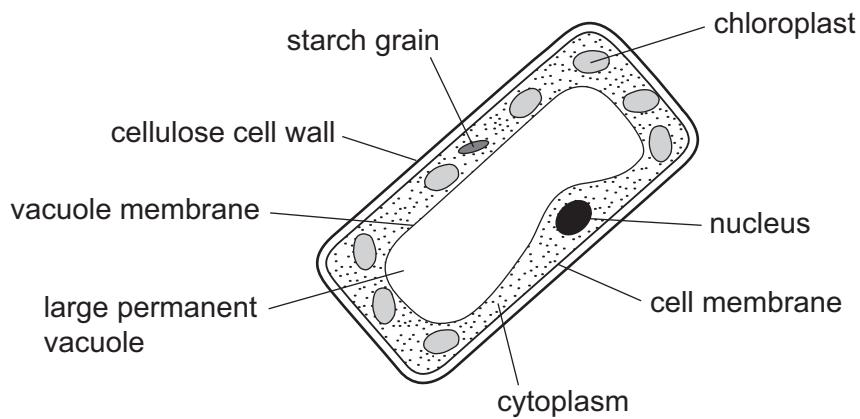
State the formula that you use and show your working.

formula

working

.....  $\Omega$  [3]

- 9 (a) Fig. 9.1 shows a plant cell.



**Fig. 9.1**

- (i) Name the tissue in the leaf in which this type of cell is found.

..... [1]

- (ii) Explain how this cell is adapted to carry out photosynthesis.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

- (b) About one tenth of the Earth's surface is covered by forests in which much photosynthesis takes place.

Explain how extensive deforestation could lead to an increase in the rate of global warming.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

10 (a) Fig. 10.1 represents the electromagnetic spectrum.

|            |        |             |               |           |            |             |
|------------|--------|-------------|---------------|-----------|------------|-------------|
| gamma rays | X-rays | ultraviolet | visible light | infra red | microwaves | radio waves |
|------------|--------|-------------|---------------|-----------|------------|-------------|

Fig. 10.1

Name the type of electromagnetic wave that is used

(i) to send a signal to a TV from a remote control,

..... [1]

(ii) to send satellite TV information.

..... [1]

(b) Gamma rays travel at a speed of  $3 \times 10^8$  m/s.

State the speed at which X-rays travel. .... [1]

(c) Fig. 10.2 represents a wave.

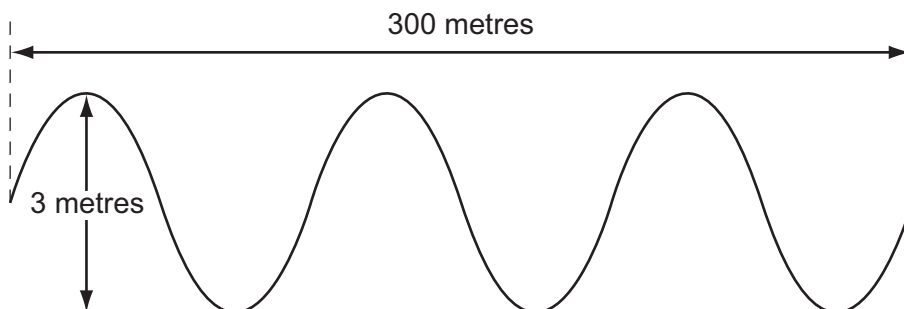


Fig. 10.2

Use Fig. 10.2 to find the

wavelength of the wave, ..... m

amplitude of the wave. .... m

[2]





**DATA SHEET**  
**The Periodic Table of the Elements**

| Group                             |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    |  |                                     |                                     |                                  |  |  |  |  |
|-----------------------------------|------------------------------------|-------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|----------------------------------|-----------------------------------|------------------------------------|------------------------------------|--|-------------------------------------|-------------------------------------|----------------------------------|--|--|--|--|
| I                                 | II                                 |                                     |                                    |                                    |                                     |                                     |                                     |                                   | III                                 | IV                               | V                                 | VI                                 | VII                                | 0  |                                     |                                     |                                  |  |  |  |  |
|                                   |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   | 1<br><b>H</b><br>Hydrogen<br>1     |                                    |  |                                     |                                     |                                  |  |  |  |  |
| 7<br><b>Li</b><br>Lithium<br>3    | 9<br><b>Be</b><br>Beryllium<br>4   |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   | 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 | 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       | 128<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        | 210<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  |  |  |  |  |
| 87<br><b>Fr</b><br>Francium       | 88<br><b>Ra</b><br>Radium          | 89<br><b>Ac</b><br>Actinium         |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    |  |                                     |                                     |                                  |  |  |  |  |
| 58-71 Lanthanoid series           |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 175<br><b>Lu</b><br>Lutetium<br>71       |                                     |                                     |                                  |  |  |  |  |
| 90-103 Actinoid series            |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 169<br><b>Tm</b><br>Thulium<br>69        |                                     |                                     |                                  | 173<br><b>Yb</b><br>Ytterbium<br>70      |  |  |  |
| Key                               |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 167<br><b>Er</b><br>Erbium<br>68         |                                     |                                     |                                  | 165<br><b>Ho</b><br>Holmium<br>67        |  |  |  |
| a = relative atomic mass          |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 162<br><b>Dy</b><br>Dysprosium<br>66     |                                     |                                     |                                  | 160<br><b>No</b><br>Nobelium<br>102      |  |  |  |
| X = atomic symbol                 |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 159<br><b>Tb</b><br>Terbium<br>65        |                                     |                                     |                                  | 157<br><b>Gd</b><br>Gadolinium<br>64     |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 152<br><b>Eu</b><br>Europium<br>63       |                                     |                                     |                                  | 150<br><b>Sm</b><br>Samarium<br>62       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 144<br><b>Nd</b><br>Neodymium<br>60      |                                     |                                     |                                  | 141<br><b>Pr</b><br>Praseodymium<br>59   |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 140<br><b>Ce</b><br>Cerium<br>58         |                                     |                                     |                                  | 138<br><b>La</b><br>Lanthanum<br>57      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 137<br><b>Ba</b><br>Barium<br>56         |                                     |                                     |                                  | 135<br><b>Xe</b><br>Xenon<br>54          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 131<br><b>Xe</b><br>Xenon<br>54          |                                     |                                     |                                  | 129<br><b>I</b><br>Iodine<br>53          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 127<br><b>I</b><br>Iodine<br>53          |                                     |                                     |                                  | 125<br><b>At</b><br>Astatine<br>85       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 123<br><b>Bi</b><br>Bismuth<br>83        |                                     |                                     |                                  | 121<br><b>Pb</b><br>Lead<br>82           |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 120<br><b>Pb</b><br>Lead<br>82           |                                     |                                     |                                  | 118<br><b>Ar</b><br>Argon<br>18          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 117<br><b>Cl</b><br>Chlorine<br>17       |                                     |                                     |                                  | 115<br><b>As</b><br>Arsenic<br>33        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 114<br><b>Sn</b><br>Tin<br>50            |                                     |                                     |                                  | 112<br><b>Cd</b><br>Cadmium<br>48        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 110<br><b>Ag</b><br>Silver<br>47         |                                     |                                     |                                  | 108<br><b>Ag</b><br>Silver<br>47         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 106<br><b>Pd</b><br>Palladium<br>46      |                                     |                                     |                                  | 104<br><b>Ru</b><br>Ruthenium<br>44      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 102<br><b>Rh</b><br>Rhodium<br>45        |                                     |                                     |                                  | 100<br><b>Ru</b><br>Ruthenium<br>44      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 98<br><b>Cf</b><br>Californium<br>98     |                                     |                                     |                                  | 96<br><b>Cm</b><br>Curium<br>96          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 94<br><b>Pu</b><br>Plutonium<br>94       |                                     |                                     |                                  | 92<br><b>U</b><br>Uranium<br>92          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 90<br><b>Th</b><br>Thorium<br>90         |                                     |                                     |                                  | 88<br><b>Ra</b><br>Radium<br>88          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 86<br><b>Rn</b><br>Radon<br>86           |                                     |                                     |                                  | 84<br><b>Po</b><br>Polonium<br>84        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 82<br><b>Pb</b><br>Lead<br>82            |                                     |                                     |                                  | 80<br><b>Hg</b><br>Mercury<br>80         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 79<br><b>Au</b><br>Gold<br>79            |                                     |                                     |                                  | 77<br><b>Ir</b><br>Iridium<br>77         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 76<br><b>Os</b><br>Osmium<br>76          |                                     |                                     |                                  | 74<br><b>W</b><br>Tungsten<br>74         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 73<br><b>Ta</b><br>Tantalum<br>73        |                                     |                                     |                                  | 71<br><b>Yb</b><br>Ytterbium<br>70       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 70<br><b>Yb</b><br>Ytterbium<br>70       |                                     |                                     |                                  | 68<br><b>Er</b><br>Erbium<br>68          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 67<br><b>Ho</b><br>Holmium<br>67         |                                     |                                     |                                  | 65<br><b>Tb</b><br>Terbium<br>65         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 66<br><b>Dy</b><br>Dysprosium<br>66      |                                     |                                     |                                  | 64<br><b>Gd</b><br>Gadolinium<br>64      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 63<br><b>Eu</b><br>Europium<br>63        |                                     |                                     |                                  | 61<br><b>Pm</b><br>Promethium<br>61      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 62<br><b>Sm</b><br>Samarium<br>62        |                                     |                                     |                                  | 60<br><b>Nd</b><br>Neodymium<br>60       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 61<br><b>Pm</b><br>Promethium<br>61      |                                     |                                     |                                  | 59<br><b>Pr</b><br>Praseodymium<br>59    |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 58<br><b>Ce</b><br>Cerium<br>58          |                                     |                                     |                                  | 56<br><b>Ba</b><br>Barium<br>56          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 57<br><b>La</b><br>Lanthanum<br>57       |                                     |                                     |                                  | 55<br><b>Cs</b><br>Caesium<br>55         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 54<br><b>Xe</b><br>Xenon<br>54           |                                     |                                     |                                  | 52<br><b>Te</b><br>Tellurium<br>52       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 51<br><b>Sb</b><br>Antimony<br>51        |                                     |                                     |                                  | 49<br><b>In</b><br>Indium<br>49          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 48<br><b>Cd</b><br>Cadmium<br>48         |                                     |                                     |                                  | 46<br><b>Pd</b><br>Palladium<br>46       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 47<br><b>Ag</b><br>Silver<br>47          |                                     |                                     |                                  | 45<br><b>Rh</b><br>Rhodium<br>45         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 44<br><b>Ru</b><br>Ruthenium<br>44       |                                     |                                     |                                  | 42<br><b>Mo</b><br>Molybdenum<br>42      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 43<br><b>Tc</b><br>Technetium<br>43      |                                     |                                     |                                  | 41<br><b>Nb</b><br>Niobium<br>41         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 40<br><b>Zr</b><br>Zirconium<br>40       |                                     |                                     |                                  | 38<br><b>Sr</b><br>Strontium<br>38       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 39<br><b>Y</b><br>Yttrium<br>39          |                                     |                                     |                                  | 37<br><b>Rb</b><br>Rubidium<br>37        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 36<br><b>Kr</b><br>Krypton<br>36         |                                     |                                     |                                  | 34<br><b>Se</b><br>Selenium<br>34        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 33<br><b>As</b><br>Arsenic<br>33         |                                     |                                     |                                  | 31<br><b>Ga</b><br>Gallium<br>31         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 32<br><b>S</b><br>Sulfur<br>16           |                                     |                                     |                                  | 30<br><b>Zn</b><br>Zinc<br>30            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 31<br><b>P</b><br>Phosphorus<br>15       |                                     |                                     |                                  | 29<br><b>Cu</b><br>Copper<br>29          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 15<br><b>P</b><br>Phosphorus<br>15       |                                     |                                     |                                  | 14<br><b>Si</b><br>Silicon<br>14         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 16<br><b>S</b><br>Sulfur<br>16           |                                     |                                     |                                  | 13<br><b>Al</b><br>Aluminium<br>13       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 17<br><b>Cl</b><br>Chlorine<br>17        |                                     |                                     |                                  | 12<br><b>C</b><br>Carbon<br>6            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 18<br><b>Ar</b><br>Argon<br>18           |                                     |                                     |                                  | 11<br><b>B</b><br>Boron<br>5             |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 19<br><b>F</b><br>Fluorine<br>9          |                                     |                                     |                                  | 10<br><b>Ne</b><br>Neon<br>10            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 20<br><b>Ne</b><br>Neon<br>10            |                                     |                                     |                                  | 9<br><b>O</b><br>Oxygen<br>8             |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 21<br><b>Na</b><br>Sodium<br>11          |                                     |                                     |                                  | 19<br><b>K</b><br>Potassium<br>19        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 22<br><b>Mg</b><br>Magnesium<br>12       |                                     |                                     |                                  | 20<br><b>Ca</b><br>Calcium<br>20         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 23<br><b>Na</b><br>Sodium<br>11          |                                     |                                     |                                  | 19<br><b>K</b><br>Potassium<br>19        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 24<br><b>Mg</b><br>Magnesium<br>12       |                                     |                                     |                                  | 20<br><b>Ca</b><br>Calcium<br>20         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 25<br><b>Al</b><br>Aluminium<br>13       |                                     |                                     |                                  | 21<br><b>Sc</b><br>Scandium<br>21        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 26<br><b>Fe</b><br>Iron<br>26            |                                     |                                     |                                  | 22<br><b>Ti</b><br>Titanium<br>22        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 27<br><b>Co</b><br>Cobalt<br>27          |                                     |                                     |                                  | 23<br><b>V</b><br>Vanadium<br>23         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 28<br><b>Ni</b><br>Nickel<br>28          |                                     |                                     |                                  | 24<br><b>Cr</b><br>Chromium<br>24        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 29<br><b>Cu</b><br>Copper<br>29          |                                     |                                     |                                  | 25<br><b>Mn</b><br>Manganese<br>25       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 30<br><b>Zn</b><br>Zinc<br>30            |                                     |                                     |                                  | 26<br><b>Fe</b><br>Iron<br>26            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 31<br><b>Ga</b><br>Gallium<br>31         |                                     |                                     |                                  | 27<br><b>Co</b><br>Cobalt<br>27          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 32<br><b>Ge</b><br>Germanium<br>32       |                                     |                                     |                                  | 28<br><b>Ni</b><br>Nickel<br>28          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 33<br><b>As</b><br>Arsenic<br>33         |                                     |                                     |                                  | 29<br><b>Cu</b><br>Copper<br>29          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 34<br><b>Se</b><br>Selenium<br>34        |                                     |                                     |                                  | 30<br><b>Zn</b><br>Zinc<br>30            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 35<br><b>Br</b><br>Bromine<br>35         |                                     |                                     |                                  | 31<br><b>Ga</b><br>Gallium<br>31         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 36<br><b>Kr</b><br>Krypton<br>36         |                                     |                                     |                                  | 32<br><b>Ge</b><br>Germanium<br>32       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 37<br><b>Rb</b><br>Rubidium<br>37        |                                     |                                     |                                  | 33<br><b>As</b><br>Arsenic<br>33         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 38<br><b>Sr</b><br>Strontium<br>38       |                                     |                                     |                                  | 34<br><b>Se</b><br>Selenium<br>34        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 39<br><b>Y</b><br>Yttrium<br>39          |                                     |                                     |                                  | 35<br><b>Br</b><br>Bromine<br>35         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 40<br><b>Zr</b><br>Zirconium<br>40       |                                     |                                     |                                  | 36<br><b>Kr</b><br>Krypton<br>36         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 41<br><b>Nb</b><br>Niobium<br>41         |                                     |                                     |                                  | 37<br><b>Rb</b><br>Rubidium<br>37        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 42<br><b>Mo</b><br>Molybdenum<br>42      |                                     |                                     |                                  | 38<br><b>Sr</b><br>Strontium<br>38       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 43<br><b>Tc</b><br>Technetium<br>43      |                                     |                                     |                                  | 39<br><b>Y</b><br>Yttrium<br>39          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 44<br><b>Ru</b><br>Ruthenium<br>44       |                                     |                                     |                                  | 40<br><b>Zr</b><br>Zirconium<br>40       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 45<br><b>Rh</b><br>Rhodium<br>45         |                                     |                                     |                                  | 41<br><b>Nb</b><br>Niobium<br>41         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 46<br><b>Pd</b><br>Palladium<br>46       |                                     |                                     |                                  | 42<br><b>Mo</b><br>Molybdenum<br>42      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 47<br><b>Ag</b><br>Silver<br>47          |                                     |                                     |                                  | 43<br><b>Tc</b><br>Technetium<br>43      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 48<br><b>Cd</b><br>Cadmium<br>48         |                                     |                                     |                                  | 44<br><b>Ru</b><br>Ruthenium<br>44       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 49<br><b>In</b><br>Indium<br>49          |                                     |                                     |                                  | 45<br><b>Rh</b><br>Rhodium<br>45         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 50<br><b>Sn</b><br>Tin<br>50             |                                     |                                     |                                  | 46<br><b>Pd</b><br>Palladium<br>46       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 51<br><b>Sb</b><br>Antimony<br>51        |                                     |                                     |                                  | 47<br><b>Ag</b><br>Silver<br>47          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 52<br><b>Te</b><br>Tellurium<br>52       |                                     |                                     |                                  | 48<br><b>Cd</b><br>Cadmium<br>48         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 53<br><b>I</b><br>Iodine<br>53           |                                     |                                     |                                  | 49<br><b>In</b><br>Indium<br>49          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 54<br><b>Xe</b><br>Xenon<br>54           |                                     |                                     |                                  | 50<br><b>Sn</b><br>Tin<br>50             |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 55<br><b>Cs</b><br>Caesium<br>55         |                                     |                                     |                                  | 51<br><b>Sb</b><br>Antimony<br>51        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 56<br><b>Ba</b><br>Barium<br>56          |                                     |                                     |                                  | 52<br><b>Te</b><br>Tellurium<br>52       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 57<br><b>La</b><br>Lanthanum<br>57       |                                     |                                     |                                  | 53<br><b>I</b><br>Iodine<br>53           |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 58<br><b>Ce</b><br>Cerium<br>58          |                                     |                                     |                                  | 54<br><b>Xe</b><br>Xenon<br>54           |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 59<br><b>Pr</b><br>Praseodymium<br>59    |                                     |                                     |                                  | 55<br><b>Cs</b><br>Caesium<br>55         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 60<br><b>Nd</b><br>Neodymium<br>60       |                                     |                                     |                                  | 56<br><b>Ba</b><br>Barium<br>56          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 61<br><b>Pm</b><br>Promethium<br>61      |                                     |                                     |                                  | 57<br><b>La</b><br>Lanthanum<br>57       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 62<br><b>Sm</b><br>Samarium<br>62        |                                     |                                     |                                  | 58<br><b>Ce</b><br>Cerium<br>58          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 63<br><b>Eu</b><br>Europium<br>63        |                                     |                                     |                                  | 59<br><b>Pr</b><br>Praseodymium<br>59    |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 64<br><b>Gd</b><br>Gadolinium<br>64      |                                     |                                     |                                  | 60<br><b>Nd</b><br>Neodymium<br>60       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 65<br><b>Tb</b><br>Terbium<br>65         |                                     |                                     |                                  | 61<br><b>Pm</b><br>Promethium<br>61      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 66<br><b>Dy</b><br>Dysprosium<br>66      |                                     |                                     |                                  | 62<br><b>Sm</b><br>Samarium<br>62        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 67<br><b>Ho</b><br>Holmium<br>67         |                                     |                                     |                                  | 63<br><b>Eu</b><br>Europium<br>63        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 68<br><b>Er</b><br>Erbium<br>68          |                                     |                                     |                                  | 64<br><b>Gd</b><br>Gadolinium<br>64      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 69<br><b>Tm</b><br>Thulium<br>69         |                                     |                                     |                                  | 65<br><b>Tb</b><br>Terbium<br>65         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 70<br><b>Yb</b><br>Ytterbium<br>70       |                                     |                                     |                                  | 66<br><b>Dy</b><br>Dysprosium<br>66      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 71<br><b>Lu</b><br>Lutetium<br>71        |                                     |                                     |                                  | 67<br><b>Ho</b><br>Holmium<br>67         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 72<br><b>Hf</b><br>Hafnium<br>72         |                                     |                                     |                                  | 68<br><b>Er</b><br>Erbium<br>68          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 73<br><b>Yb</b><br>Ytterbium<br>70       |                                     |                                     |                                  | 69<br><b>Tm</b><br>Thulium<br>69         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 74<br><b>W</b><br>Tungsten<br>74         |                                     |                                     |                                  | 70<br><b>Yb</b><br>Ytterbium<br>70       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 75<br><b>Re</b><br>Rhenium<br>75         |                                     |                                     |                                  | 71<br><b>Lu</b><br>Lutetium<br>71        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 76<br><b>Os</b><br>Osmium<br>76          |                                     |                                     |                                  | 72<br><b>Hf</b><br>Hafnium<br>72         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 77<br><b>Ir</b><br>Iridium<br>77         |                                     |                                     |                                  | 73<br><b>Ta</b><br>Tantalum<br>73        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 78<br><b>Pt</b><br>Platinum<br>78        |                                     |                                     |                                  | 74<br><b>W</b><br>Tungsten<br>74         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 79<br><b>Au</b><br>Gold<br>79            |                                     |                                     |                                  | 75<br><b>Re</b><br>Rhenium<br>75         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 80<br><b>Hg</b><br>Mercury<br>80         |                                     |                                     |                                  | 76<br><b>Os</b><br>Osmium<br>76          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 81<br><b>Tl</b><br>Thallium<br>81        |                                     |                                     |                                  | 77<br><b>Ir</b><br>Iridium<br>77         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 82<br><b>Pb</b><br>Lead<br>82            |                                     |                                     |                                  | 78<br><b>Pt</b><br>Platinum<br>78        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 83<br><b>Bi</b><br>Bismuth<br>83         |                                     |                                     |                                  | 79<br><b>Au</b><br>Gold<br>79            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 84<br><b>Po</b><br>Polonium<br>84        |                                     |                                     |                                  | 80<br><b>Hg</b><br>Mercury<br>80         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 85<br><b>At</b><br>Astatine<br>85        |                                     |                                     |                                  | 81<br><b>Tl</b><br>Thallium<br>81        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 86<br><b>Rn</b><br>Radon<br>86           |                                     |                                     |                                  | 82<br><b>Pb</b><br>Lead<br>82            |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 87<br><b>Fr</b><br>Francium<br>87        |                                     |                                     |                                  | 83<br><b>Bi</b><br>Bismuth<br>83         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 88<br><b>Ra</b><br>Radium<br>88          |                                     |                                     |                                  | 84<br><b>Po</b><br>Polonium<br>84        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 89<br><b>Ac</b><br>Actinium<br>89        |                                     |                                     |                                  | 85<br><b>At</b><br>Astatine<br>85        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 90<br><b>Th</b><br>Thorium<br>90         |                                     |                                     |                                  | 86<br><b>Rn</b><br>Radon<br>86           |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 91<br><b>Pa</b><br>Protactinium<br>91    |                                     |                                     |                                  | 87<br><b>Fr</b><br>Francium<br>87        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 92<br><b>U</b><br>Uranium<br>92          |                                     |                                     |                                  | 88<br><b>Ra</b><br>Radium<br>88          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 93<br><b>Np</b><br>Neptunium<br>93       |                                     |                                     |                                  | 89<br><b>Ac</b><br>Actinium<br>89        |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 94<br><b>Pu</b><br>Plutonium<br>94       |                                     |                                     |                                  | 90<br><b>Th</b><br>Thorium<br>90         |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 95<br><b>Am</b><br>Americium<br>95       |                                     |                                     |                                  | 91<br><b>Pa</b><br>Protactinium<br>91    |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 96<br><b>Cm</b><br>Curium<br>96          |                                     |                                     |                                  | 92<br><b>U</b><br>Uranium<br>92          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 97<br><b>Bk</b><br>Berkelium<br>97       |                                     |                                     |                                  | 93<br><b>Np</b><br>Neptunium<br>93       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 98<br><b>Cf</b><br>Californium<br>98     |                                     |                                     |                                  | 94<br><b>Pu</b><br>Plutonium<br>94       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 99<br><b>Es</b><br>Einsteinium<br>99     |                                     |                                     |                                  | 95<br><b>Am</b><br>Americium<br>95       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 100<br><b>Fm</b><br>Fermium<br>100       |                                     |                                     |                                  | 96<br><b>Cm</b><br>Curium<br>96          |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 101<br><b>Md</b><br>Mendelevium<br>101   |                                     |                                     |                                  | 97<br><b>Bk</b><br>Berkelium<br>97       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 102<br><b>No</b><br>Nobelium<br>102      |                                     |                                     |                                  | 98<br><b>Cf</b><br>Californium<br>98     |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 103<br><b>Lr</b><br>Lawrencium<br>103    |                                     |                                     |                                  | 99<br><b>Es</b><br>Einsteinium<br>99     |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 104<br><b>Rf</b><br>Rutherfordium<br>104 |                                     |                                     |                                  | 100<br><b>Fm</b><br>Fermium<br>100       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 105<br><b>Db</b><br>Dubnium<br>105       |                                     |                                     |                                  | 101<br><b>Md</b><br>Mendelevium<br>101   |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 106<br><b>Sg</b><br>Seaborgium<br>106    |                                     |                                     |                                  | 102<br><b>No</b><br>Nobelium<br>102      |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 107<br><b>Bh</b><br>Bohrium<br>107       |                                     |                                     |                                  | 103<br><b>Lr</b><br>Lawrencium<br>103    |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 108<br><b>Hs</b><br>Hassium<br>108       |                                     |                                     |                                  | 104<br><b>Rf</b><br>Rutherfordium<br>104 |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 109<br><b>Mt</b><br>Meitnerium<br>109    |                                     |                                     |                                  | 105<br><b>Db</b><br>Dubnium<br>105       |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 110<br><b>Ds</b><br>Darmstadtium<br>110  |                                     |                                     |                                  | 106<br><b>Sg</b><br>Seaborgium<br>106    |  |  |  |
| b = proton (atomic) number        |                                    |                                     |                                    |                                    |                                     |                                     |                                     |                                   |                                     |                                  |                                   |                                    |                                    | 111<br><b>Rg</b><br>Roentgenium<br>111   |                                     |                                     |                                  | 107                                      |  |  |  |

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

Key

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

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