

CANDIDATE  
NAME

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NUMBER

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**CHEMISTRY**

**0971/31**

Paper 3 Theory (Core)

**May/June 2019**

**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 an HB 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.

A copy of the Periodic Table is printed on page 20.

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

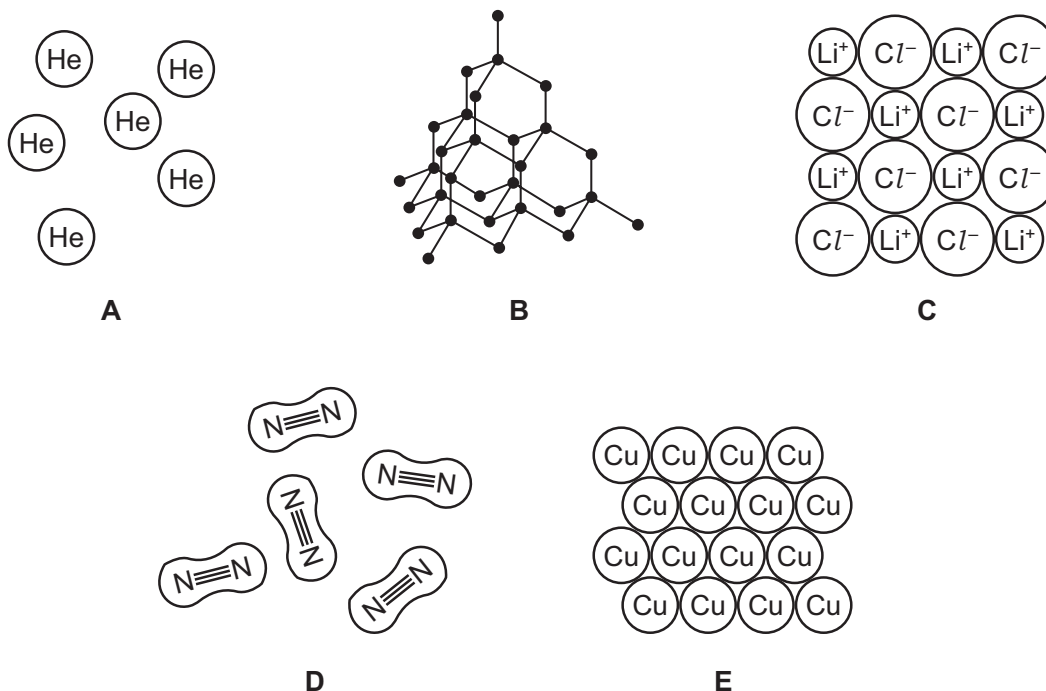
At the end of the examination, fasten all your work securely together.

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

This document consists of **18** printed pages and **2** blank pages.



1 The diagrams show part of the structures of five substances, **A**, **B**, **C**, **D** and **E**.



(a) Answer the following questions about these structures.

Each structure may be used once, more than once or not at all.

(i) Which **two** of these structures, **A**, **B**, **C**, **D** or **E**, are covalently bonded?

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

(ii) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is a diatomic molecule?

..... [1]

(iii) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is a compound?

..... [1]

(iv) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is very soluble in water?

..... [1]

(v) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is used in cutting tools?

..... [1]

(vi) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is used in electrical wiring?

..... [1]

(b) Substance **B** is an element.

What is meant by the term *element*?

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

[Total: 8]

2 This question is about iron and iron compounds.

(a) Name the main ore of iron.

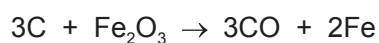
..... [1]

(b) In a blast furnace used for the extraction of iron, carbon reacts with oxygen from the air to form carbon monoxide.

Complete the chemical equation for this reaction.



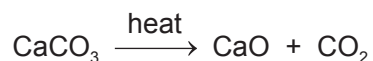
(c) In the hotter parts of the furnace, carbon reacts with the iron(III) oxide present in the iron ore.



How does this equation show that carbon is oxidised?

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

(d) Limestone is added to the blast furnace. The limestone is converted into calcium oxide and carbon dioxide. The reaction is endothermic.



(i) What type of chemical reaction is this?

..... [1]

(ii) What type of oxide is calcium oxide?  
 Give a reason for your answer.

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

(e) Iron is a metal.

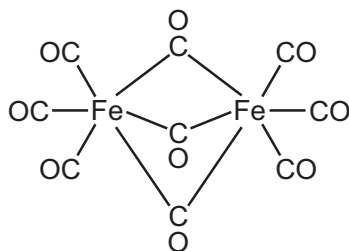
Give **three** physical properties that are characteristic of metals.

1 .....

2 .....

3 ..... [3]

(f) The structure of a compound of iron is shown.



Deduce the molecular formula of this compound to show the number of iron, carbon and oxygen atoms.

..... [1]

[Total: 11]

3 (a) The table shows the percentage by mass of the elements on Earth and in the Universe.

| element        | percentage by mass on Earth | percentage by mass in the Universe |
|----------------|-----------------------------|------------------------------------|
| helium         | 0.0                         | 21.0                               |
| hydrogen       | 0.1                         | 76.0                               |
| iron           | 35.0                        | 1.0                                |
| magnesium      | 14.0                        | 0.1                                |
| oxygen         | 29.0                        | 0.8                                |
| silicon        | 14.0                        | 0.1                                |
| sulfur         | 2.9                         | 0.1                                |
| other elements |                             | 0.9                                |
| total          | 100.0                       | 100.0                              |

Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of other elements present on Earth.

..... % [1]

(ii) Which non-metallic element is present on Earth in the greatest percentage by mass?

..... [1]

(iii) Give **two** major differences in the percentage by mass of the elements on Earth and in the Universe.

1 .....

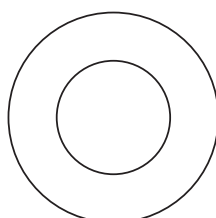
.....

2 .....

.....

[2]

(b) Complete the diagram to show the electron arrangement in an oxygen atom.



[1]

(c) Helium, neon and argon are noble gases.

(i) Explain, in terms of the electronic structure, why neon is unreactive.

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

(ii) State **one** use of argon.

..... [1]

[Total: 7]

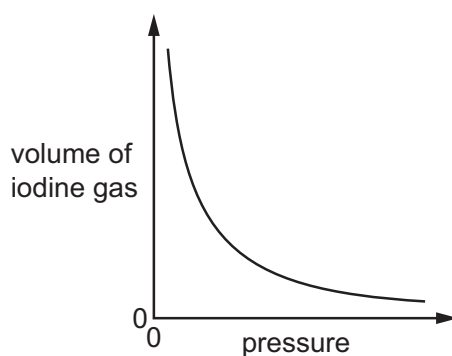
4 This question is about iodine and compounds of iodine.

(a) Use the kinetic particle model to describe the separation between the molecules and the type of motion of the molecules in:

- solid iodine .....
- .....
- iodine gas. ....
- .....

[4]

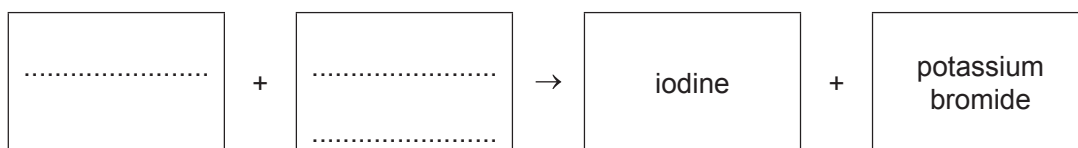
(b) The graph shows how the volume of iodine gas changes with pressure. The temperature is kept constant.



Describe how the volume of iodine gas changes with pressure.

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

(c) (i) Complete the word equation to show the halogen and halide compound which react to form the products iodine and potassium bromide.



[2]

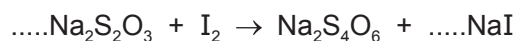
(ii) Explain, in terms of the reactivity of the halogens, why aqueous iodine does **not** react with aqueous potassium chloride.

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



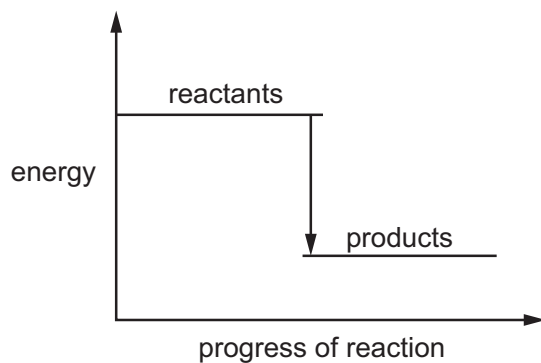
(d) Iodine reacts with aqueous sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

(i) Balance the chemical equation for this reaction.



[2]

(ii) The energy level diagram for this reaction is shown.



Explain how this diagram shows that the reaction is exothermic.

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

(e) Describe a test for iodide ions.

test .....

observations .....

[2]

(f) Molten sodium iodide is electrolysed.

Predict the product at the positive electrode.

..... [1]

[Total: 14]

5 Coal gas is made by heating coal in the absence of air. The list shows the main gases present in coal gas.

- carbon dioxide
- carbon monoxide
- ethene
- hydrogen
- methane
- nitrogen

(a) (i) Which **one** of these gases is an alkane?

..... [1]

(ii) Draw the structure of a molecule of ethene. Show all of the atoms and all of the bonds.

[1]

(iii) Describe how aqueous bromine can be used to tell the difference between methane and ethene.

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

(b) Ethene molecules react with each other to form poly(ethene).

(i) What is the name given to this type of chemical reaction?

..... [1]

(ii) Which **one** of the following words describes the ethene molecules in this reaction?  
Draw a circle around the correct answer.

**elements**      **mixtures**      **monomers**      **polymers**

[1]

(iii) Poly(ethene) is a non-biodegradable plastic.

What is meant by the term *non-biodegradable*?

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

(iv) Describe **one** pollution problem caused by non-biodegradable plastics.

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

(c) Ethanol can be made from ethene and one other reactant.

• Name the other reactant.

.....

• State the conditions needed to make ethanol from ethene.

.....

.....

[3]

[Total: 11]

6 This question is about copper and copper compounds.

(a) Describe how you could prepare a pure sample of crystals of hydrated copper(II) sulfate using dilute sulfuric acid and an excess of copper(II) oxide.

.....

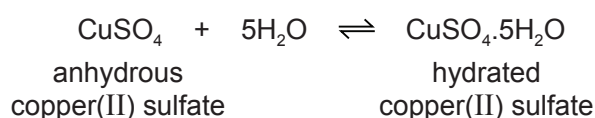
.....

.....

.....

..... [3]

(b) Anhydrous copper(II) sulfate is used to test for water.



(i) What is meant by the symbol  $\rightleftharpoons$ ?

..... [1]

(ii) How can hydrated copper(II) sulfate be changed into anhydrous copper(II) sulfate?

..... [1]

(c) Complete the table to calculate the relative formula mass of anhydrous copper(II) sulfate,  $\text{CuSO}_4$ .

Use your Periodic Table to help you.

| type of atom | number of atoms | relative atomic mass |                    |
|--------------|-----------------|----------------------|--------------------|
| copper       | 1               | 64                   | $1 \times 64 = 64$ |
| sulfur       |                 |                      |                    |
| oxygen       |                 |                      |                    |

relative formula mass = ..... [2]

- (d) Complete the table to show the number of electrons, protons and neutrons in the sulfur atom and copper ion shown.

|                              | number of electrons | number of neutrons | number of protons |
|------------------------------|---------------------|--------------------|-------------------|
| ${}^{34}_{16}\text{S}$       |                     |                    |                   |
| ${}^{63}_{29}\text{Cu}^{2+}$ |                     |                    | 29                |

[4]

- (e) Alloys of copper are used to make coins.

- (i) What is meant by the term *alloy*?

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

- (ii) Suggest why an alloy of copper is used to make coins instead of using pure copper.

..... [1]

[Total: 13]

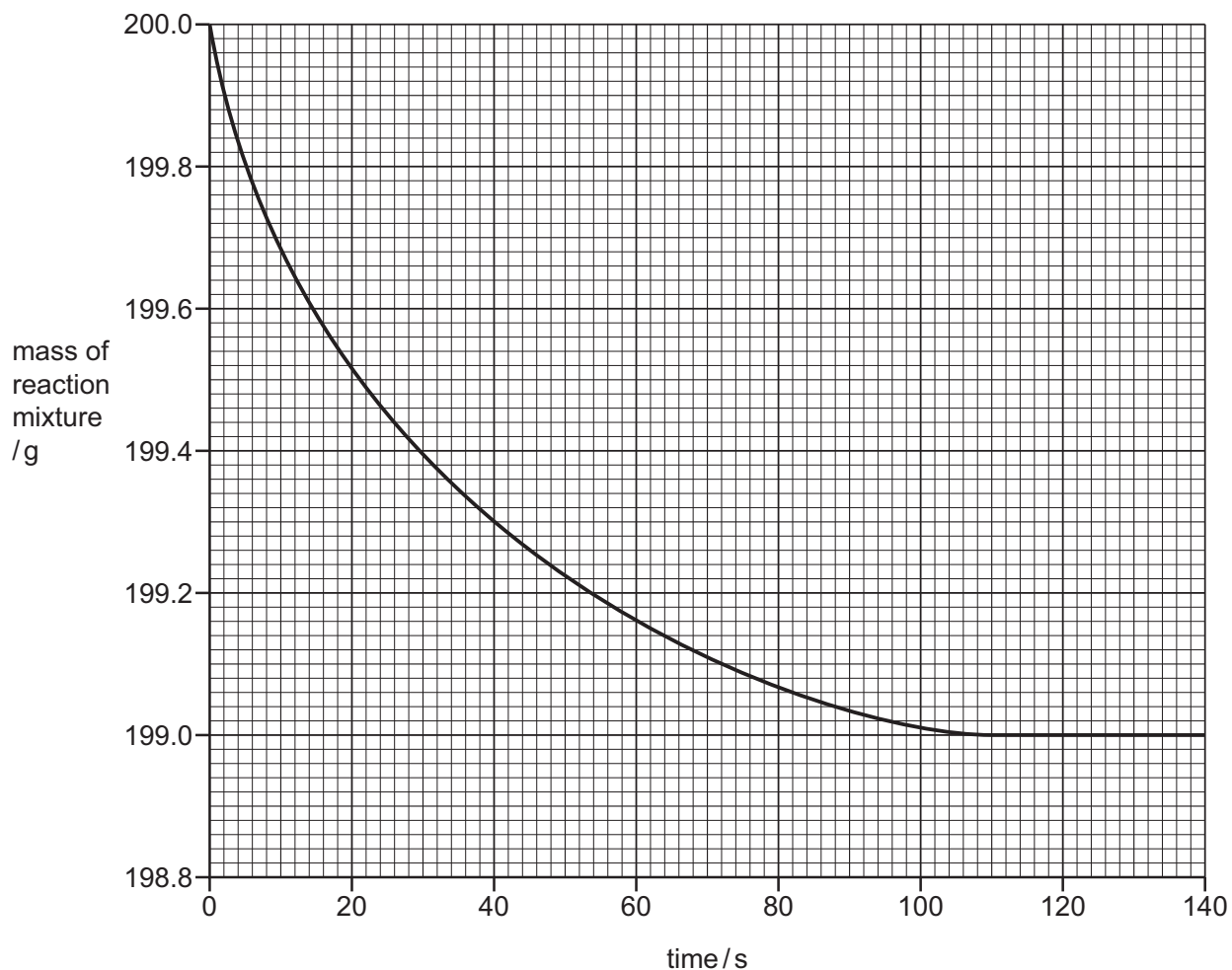
- 7 A student investigates the rate of reaction of small pieces of calcium carbonate with an excess of hydrochloric acid of concentration  $1 \text{ mol/dm}^3$ .



- (a) Name the salt formed when calcium carbonate reacts with hydrochloric acid.

..... [1]

- (b) The graph shows how the mass of the reaction mixture changes with time.



- (i) State why the reaction mixture decreases in mass.

..... [1]

- (ii) Calculate the loss in mass during the first 40 seconds of the experiment.

..... g [1]

- (iii) The experiment is repeated using hydrochloric acid of concentration  $2 \text{ mol/dm}^3$ . All other conditions are kept the same.

Draw a line **on the grid** for the experiment using hydrochloric acid of concentration  $2 \text{ mol/dm}^3$ . [2]

- (iv) In the experiment, when  $2.00 \text{ g}$  of calcium carbonate is used, the loss in mass of the reaction mixture is  $0.88 \text{ g}$ . All other conditions are kept the same.

Calculate the loss in mass when  $0.50 \text{ g}$  of calcium carbonate is used.

loss in mass = ..... g [1]

- (v) The experiment is repeated using the same mass of different sized pieces of calcium carbonate. All other conditions are kept the same.

The sizes of the pieces of calcium carbonate are:

- powder
- small pieces
- large pieces.

Complete the table by writing the sizes of the pieces of calcium carbonate in the first column.

| size of pieces of calcium carbonate | initial rate of loss in mass in g/s |
|-------------------------------------|-------------------------------------|
|                                     | 0.005                               |
|                                     | 0.030                               |
|                                     | 0.100                               |

[1]

[Total: 7]

8 (a) Sulfur dioxide is a pollutant in the air.

(i) State **one** source of sulfur dioxide in the air.

..... [1]

(ii) Sulfur dioxide is oxidised to sulfur trioxide in the air.  
Oxides of nitrogen act as catalysts for this reaction.

What is meant by the term *catalyst*?

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

(iii) Sulfur trioxide dissolves in rainwater to form acid rain.

Which **one** of the following pH values could be the pH of acid rain?  
Draw a circle around the correct answer.

pH 4      pH 7      pH 9      pH 13

[1]

(iv) State **one** adverse effect of acid rain on buildings.

..... [1]

(b) Sulfur dioxide melts at  $-73^{\circ}\text{C}$  and boils at  $-10^{\circ}\text{C}$ .

What is the physical state of sulfur dioxide at  $-20^{\circ}\text{C}$ ?  
Explain your answer.

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



(c) Excess sulfuric acid reacts with ammonia to make a salt which can be used as a fertiliser.

State the name of the salt formed when excess sulfuric acid reacts with ammonia.

..... [1]

(d) The table shows some observations about the reactivity of four metals with dilute sulfuric acid.

| metal     | reaction with sulfuric acid       |
|-----------|-----------------------------------|
| iron      | a slow stream of bubbles is seen  |
| magnesium | a rapid stream of bubbles is seen |
| nickel    | a few bubbles slowly form         |
| tungsten  | no bubbles are seen               |

Use the information in the table to put the four metals in order of their reactivity.  
Put the least reactive metal first.

least reactive  $\longrightarrow$  most reactive

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

[2]

[Total: 9]



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## The Periodic Table of Elements

| Group                             |                                    |  |  |                                    |                                     |                                     |                                     |                                     |                                       |                                      |                                      |                                    |                                      |                                    |                                     |                                  |                                  |
|-----------------------------------|------------------------------------|--|--|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|--------------------------------------|------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| I                                 | II                                 | III  |  |                                    |                                     |                                     |                                     |                                     |                                       |                                      |                                      | IV                                 | V                                    | VI                                 | VII                                 | VIII                             |                                  |
| 3<br><b>Li</b><br>lithium<br>7    | 4<br><b>Be</b><br>beryllium<br>9   | <div style="border: 1px solid black; padding: 5px; text-align: center;"> <b>Key</b><br/>           atomic number<br/>           atomic symbol<br/>           name<br/>           relative atomic mass         </div> |  |                                    |                                     |                                     |                                     |                                     |                                       |                                      |                                      | 5<br><b>B</b><br>boron<br>11       | 6<br><b>C</b><br>carbon<br>12        | 7<br><b>N</b><br>nitrogen<br>14    | 8<br><b>O</b><br>oxygen<br>16       | 9<br><b>F</b><br>fluorine<br>19  | 10<br><b>Ne</b><br>neon<br>20    |
| 11<br><b>Na</b><br>sodium<br>23   | 12<br><b>Mg</b><br>magnesium<br>24 | 13<br><b>Al</b><br>aluminium<br>27   | 14<br><b>Si</b><br>silicon<br>28       | 15<br><b>P</b><br>phosphorus<br>31 | 16<br><b>S</b><br>sulfur<br>32      | 17<br><b>Cl</b><br>chlorine<br>35.5 | 18<br><b>Ar</b><br>argon<br>40      |                                     |                                       |                                      |                                      |                                    |                                      |                                    |                                     |                                  |                                  |
| 19<br><b>K</b><br>potassium<br>39 | 20<br><b>Ca</b><br>calcium<br>40   | 21<br><b>Sc</b><br>scandium<br>45  | 22<br><b>Ti</b><br>titanium<br>48      | 23<br><b>V</b><br>vanadium<br>51   | 24<br><b>Cr</b><br>chromium<br>52   | 25<br><b>Mn</b><br>manganese<br>55  | 26<br><b>Fe</b><br>iron<br>56       | 27<br><b>Co</b><br>cobalt<br>59     | 28<br><b>Ni</b><br>nickel<br>59       | 29<br><b>Cu</b><br>copper<br>64      | 30<br><b>Zn</b><br>zinc<br>65        | 31<br><b>Ga</b><br>gallium<br>70   | 32<br><b>Ge</b><br>germanium<br>73   | 33<br><b>As</b><br>arsenic<br>75   | 34<br><b>Se</b><br>selenium<br>79   | 35<br><b>Br</b><br>bromine<br>80 | 36<br><b>Kr</b><br>krypton<br>84 |
| 37<br><b>Rb</b><br>rubidium<br>85 | 38<br><b>Sr</b><br>strontium<br>88 | 39<br><b>Y</b><br>yttrium<br>89  | 40<br><b>Zr</b><br>zirconium<br>91     | 41<br><b>Nb</b><br>niobium<br>93   | 42<br><b>Mo</b><br>molybdenum<br>96 | 43<br><b>Tc</b><br>technetium<br>—  | 44<br><b>Ru</b><br>ruthenium<br>101 | 45<br><b>Rh</b><br>rhodium<br>103   | 46<br><b>Pd</b><br>palladium<br>106   | 47<br><b>Ag</b><br>silver<br>108     | 48<br><b>Cd</b><br>cadmium<br>112    | 49<br><b>In</b><br>indium<br>115   | 50<br><b>Sn</b><br>tin<br>119        | 51<br><b>Sb</b><br>antimony<br>122 | 52<br><b>Te</b><br>tellurium<br>128 | 53<br><b>I</b><br>iodine<br>127  | 54<br><b>Xe</b><br>xenon<br>131  |
| 55<br><b>Cs</b><br>caesium<br>133 | 56<br><b>Ba</b><br>barium<br>137   | 57–71<br>lanthanoids   | 72<br><b>Hf</b><br>hafnium<br>178      | 73<br><b>Ta</b><br>tantalum<br>181 | 74<br><b>W</b><br>tungsten<br>184   | 75<br><b>Re</b><br>rhenium<br>186   | 76<br><b>Os</b><br>osmium<br>190    | 77<br><b>Ir</b><br>iridium<br>192   | 78<br><b>Pt</b><br>platinum<br>195    | 79<br><b>Au</b><br>gold<br>197       | 80<br><b>Hg</b><br>mercury<br>201    | 81<br><b>Tl</b><br>thallium<br>204 | 82<br><b>Pb</b><br>lead<br>207       | 83<br><b>Bi</b><br>bismuth<br>209  | 84<br><b>Po</b><br>polonium<br>—    | 85<br><b>At</b><br>astatine<br>— | 86<br><b>Rn</b><br>radon<br>—    |
| 87<br><b>Fr</b><br>francium<br>—  | 88<br><b>Ra</b><br>radium<br>—     | 89–103<br>actinoids  | 104<br><b>Rf</b><br>rutherfordium<br>— | 105<br><b>Db</b><br>dubnium<br>—   | 106<br><b>Sg</b><br>seaborgium<br>— | 107<br><b>Bh</b><br>bohrium<br>—    | 108<br><b>Hs</b><br>hassium<br>—    | 109<br><b>Mt</b><br>meitnerium<br>— | 110<br><b>Ds</b><br>darmstadtium<br>— | 111<br><b>Rg</b><br>roentgenium<br>— | 112<br><b>Cn</b><br>copernicium<br>— | 114<br><b>Fl</b><br>flerovium<br>— | 116<br><b>Lv</b><br>livermorium<br>— |                                    |                                     |                                  |                                  |

|             |                                     |                                   |  |                                     |                                    |                                    |                                    |                                      |                                   |                                      |                                     |                                  |                                      |                                     |                                     |
|-------------|-------------------------------------|-----------------------------------|--|-------------------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|-----------------------------------|--------------------------------------|-------------------------------------|----------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| lanthanoids | 57<br><b>La</b><br>lanthanum<br>139 | 58<br><b>Ce</b><br>cerium<br>140  | 59<br><b>Pr</b><br>praseodymium<br>141 | 60<br><b>Nd</b><br>neodymium<br>144 | 61<br><b>Pm</b><br>promethium<br>— | 62<br><b>Sm</b><br>samarium<br>150 | 63<br><b>Eu</b><br>europium<br>152 | 64<br><b>Gd</b><br>gadolinium<br>157 | 65<br><b>Tb</b><br>terbium<br>159 | 66<br><b>Dy</b><br>dysprosium<br>163 | 67<br><b>Ho</b><br>holmium<br>165   | 68<br><b>Er</b><br>erbium<br>167 | 69<br><b>Tm</b><br>thulium<br>169    | 70<br><b>Yb</b><br>ytterbium<br>173 | 71<br><b>Lu</b><br>lutetium<br>175  |
| actinoids   | 89<br><b>Ac</b><br>actinium<br>—    | 90<br><b>Th</b><br>thorium<br>232 | 91<br><b>Pa</b><br>protactinium<br>231 | 92<br><b>U</b><br>uranium<br>238    | 93<br><b>Np</b><br>neptunium<br>—  | 94<br><b>Pu</b><br>plutonium<br>—  | 95<br><b>Am</b><br>americium<br>—  | 96<br><b>Cm</b><br>curium<br>—       | 97<br><b>Bk</b><br>berkelium<br>— | 98<br><b>Cf</b><br>californium<br>—  | 99<br><b>Es</b><br>einsteinium<br>— | 100<br><b>Fm</b><br>fermium<br>— | 101<br><b>Md</b><br>mendelevium<br>— | 102<br><b>No</b><br>nobelium<br>—   | 103<br><b>Lr</b><br>lawrencium<br>— |

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