



**Cambridge International Examinations**  
Cambridge International General Certificate of Secondary Education

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**CHEMISTRY**

**0620/32**

Paper 3 Theory (Core)

**February/March 2016**

**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 16.

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.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **15** printed pages and **1** blank page.



## 2

1 The diagram shows part of the Periodic Table.

| I  |  | II |    |  |    |  |    |  |  |    |    |    |    | III | IV | V  | VI | VII | VIII |
|----|--|----|----|--|----|--|----|--|--|----|----|----|----|-----|----|----|----|-----|------|
| Li |  |    |    |  |    |  |    |  |  |    |    |    | C  | N   | O  | F  | Ne |     |      |
|    |  |    |    |  |    |  |    |  |  |    |    | Al | Si |     |    | Cl | Ar |     |      |
|    |  |    | Ti |  | Cr |  | Fe |  |  | Cu | Zn |    | Ge |     | Br | Kr |    |     |      |
|    |  |    |    |  |    |  |    |  |  |    |    |    | Sn |     | I  | Xe |    |     |      |
|    |  |    |    |  |    |  |    |  |  |    |    |    | Pb |     |    |    |    |     |      |

Answer the following questions using only the elements in the diagram.

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

(a) Which element

(i) forms 78% of the air,

..... [1]

(ii) has an oxide which is a product of respiration,

..... [1]

(iii) is used to make food containers because of its resistance to corrosion,

..... [1]

(iv) forms an ion of type  $X^{3+}$ ,

..... [1]

(v) forms an ion whose aqueous solution forms a light blue precipitate on addition of a few drops of aqueous ammonia?

..... [1]

**3**

**(b)** Calcium is an element with several naturally-occurring isotopes.

**(i)** What is the meaning of the term *element*?

..... [1]

**(ii)** Two of the isotopes of calcium are



Complete the table to show the number of protons, neutrons and electrons in one atom of each of these isotopes.

|                     | ${}_{20}^{43}\text{Ca}$ | ${}_{20}^{48}\text{Ca}$ |
|---------------------|-------------------------|-------------------------|
| number of protons   |                         |                         |
| number of neutrons  |                         |                         |
| number of electrons |                         |                         |

[3]

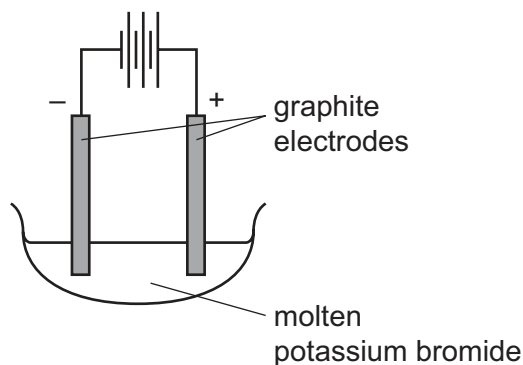
**(iii)** Determine the number of electrons in one calcium ion,  $\text{Ca}^{2+}$ .

..... [1]

[Total: 10]

4

- 2 Molten potassium bromide can be electrolysed using the apparatus shown.



- (a) Predict the products of this electrolysis at the  
positive electrode (anode), .....  
negative electrode (cathode). ..... [2]

- (b) (i) Explain why graphite electrodes are used in this electrolysis.  
..... [1]

- (ii) Give **one** other use of graphite.  
..... [1]

- (c) When chlorine is bubbled through an aqueous solution of potassium bromide, the solution turns red-brown in colour.

Which substance causes the red-brown colour?

..... [1]

- (d) Describe what you would observe when an aqueous solution of potassium bromide is added to an acidified aqueous solution of silver nitrate.

..... [1]

- (e) Silver nitrate decomposes when heated. One of the products is nitrogen dioxide.

State **one** adverse effect of nitrogen dioxide on health.

..... [1]

[Total: 7]

## 5

3 Many metals react with either cold water or steam.

(a) Describe the reaction of sodium with cold water, and iron with steam.

In your answer describe

- the products formed,
- any observations that can be made.

.....

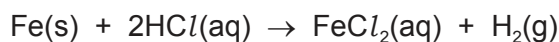
.....

.....

.....

..... [4]

(b) Iron reacts with hydrochloric acid.



Describe a practical method to investigate the rate of this reaction.  
You may draw a labelled diagram.

.....

.....

..... [3]

(c) The experiment in (b) was repeated using different sized pieces of iron.

All other conditions remained the same.

The sizes of the pieces of iron were

- large pieces,
- small pieces,
- iron powder.

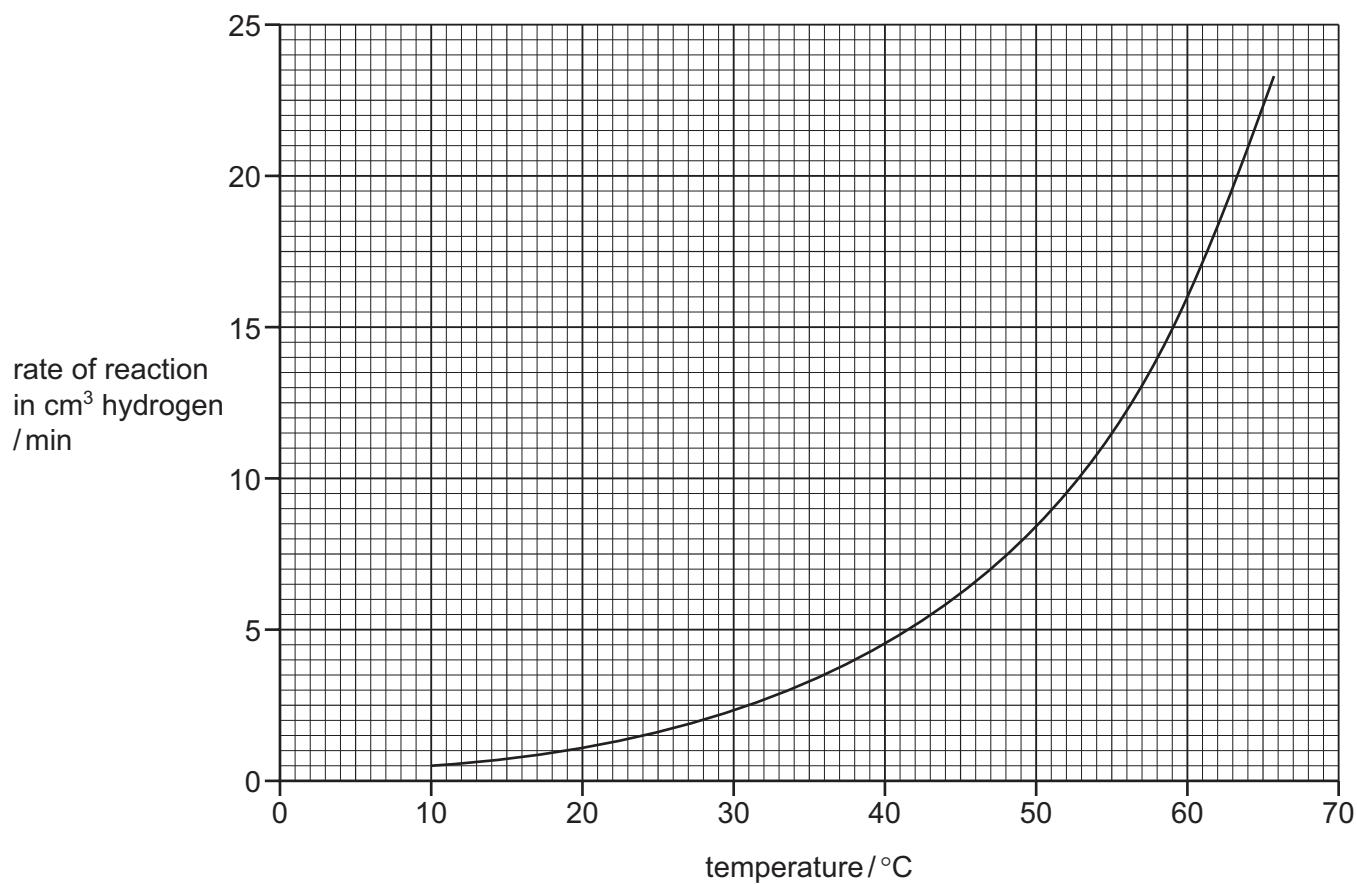
Complete the table below by writing the sizes of the pieces in the first column.

| sizes of the pieces of iron | rate of reaction in cm <sup>3</sup> hydrogen / min |
|-----------------------------|----------------------------------------------------|
|                             | 25                                                 |
|                             | 3                                                  |
|                             | 10                                                 |

[1]

6

- (d) The graph shows the effect of temperature on the rate of the reaction of hydrochloric acid with iron.



- (i) Describe the effect of temperature on the rate of this reaction.

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

- (ii) Determine the rate of reaction at 60 °C.

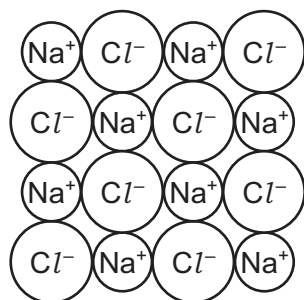
..... cm<sup>3</sup> hydrogen / min [1]

- (e) Describe how the concentration of hydrochloric acid affects the rate of its reaction with iron.

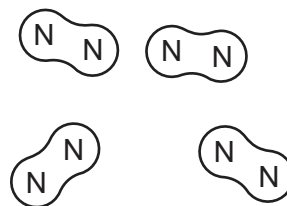
.....  
..... [1]

[Total: 12]

4 The structures of sodium chloride and nitrogen are shown below.



sodium chloride



nitrogen

(a) Describe the structure and bonding of these two substances and the differences in

- their volatility,
- their electrical conductivity.

.....

.....

.....

.....

.....

..... [5]

(b) Ammonia is manufactured by reacting nitrogen with hydrogen using a catalyst.

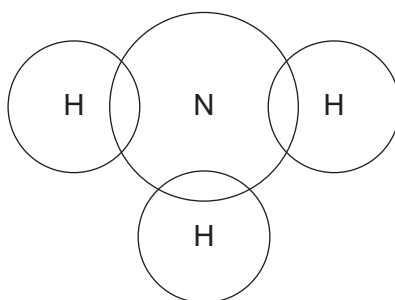
(i) What is the purpose of the catalyst?

..... [1]

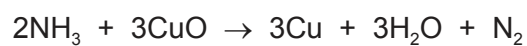
(ii) Complete the chemical equation for this reaction.



(iii) Complete the electronic structure of a molecule of ammonia.  
Show only the outer electrons.



[2]

**8****(iv)** Ammonia reacts with copper(II) oxide.

Which compound is reduced in this reaction?

Explain your answer.

.....

..... [2]

[Total: 12]

- 5 (a) The table shows some properties of cobalt, copper, magnesium and tin.

| metal     | relative heat conduction | density in g/cm <sup>3</sup> | melting point /°C | relative strength |
|-----------|--------------------------|------------------------------|-------------------|-------------------|
| cobalt    | 1.00                     | 8.90                         | 1495              | 55.0              |
| copper    | 3.85                     | 8.92                         | 1083              | 32.0              |
| magnesium | 1.50                     | 1.74                         | 649               | 1.5               |
| tin       | 0.64                     | 7.28                         | 232               | 1.0               |

Answer the questions using the information shown in the table.

- (i) Which metal is the best to use for the base of a pan for cooking food?  
Use information in the table to give reasons for your answer.

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

- (ii) Which **two** metals in the table are transition elements?  
Use information in the table to give reasons for your answer.

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

- (iii) Which metal in the table is most likely to be used in an alloy for aircraft bodies?  
Use information in the table to give reasons for your answer.

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

- (b) Some observations about the reactions of the four metals with hydrochloric acid are shown in the table.

| metal     | observations                       |
|-----------|------------------------------------|
| cobalt    | Bubbles formed very slowly.        |
| copper    | No bubbles formed.                 |
| magnesium | Many bubbles formed very rapidly.  |
| tin       | A steady stream of bubbles formed. |

Use the information in the table to put these metals in order of their reactivity with hydrochloric acid.

least reactive  $\longrightarrow$  most reactive

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

[2]

10

- (c) Crystals of hydrated cobalt(II) sulfate,  $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$ , can be made by reacting dilute sulfuric acid with insoluble cobalt carbonate.

Describe how you could prepare a pure dry sample of cobalt(II) sulfate crystals from dilute sulfuric acid and cobalt(II) carbonate.

.....

.....

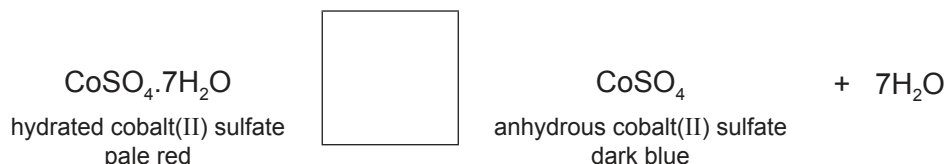
.....

.....

..... [4]

- (d) When heated, hydrated cobalt(II) sulfate forms an anhydrous salt in a reversible reaction.

- (i) Complete the equation for this reaction by inserting the sign for a reversible reaction in the box.



[1]

- (ii) Suggest how you could use this reaction to test for the presence of water.

.....

..... [2]

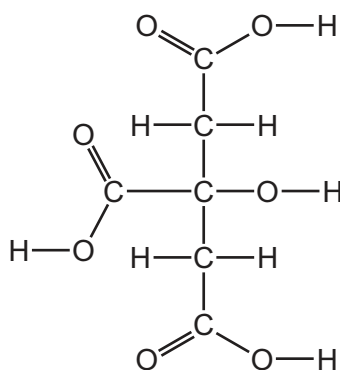
[Total: 15]

6 Citric acid is found in lemon juice. Citric acid shows typical acidic properties.

(a) Describe how you could determine the pH of a solution of lemon juice using Universal Indicator.

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

(b) The structure of citric acid is shown below.



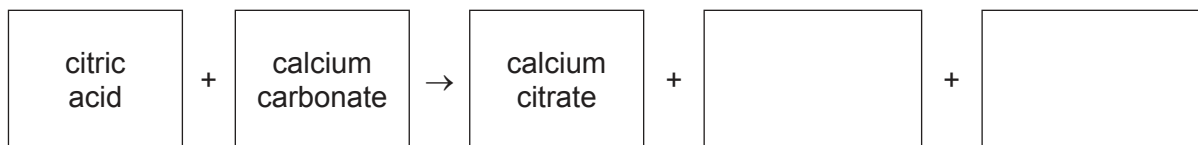
(i) On the diagram, draw a ring around a carboxylic acid functional group. [1]

(ii) State the name of **one** other carboxylic acid.

..... [1]

(c) Calcium citrate can be prepared by neutralising aqueous citric acid with excess calcium carbonate.

(i) Complete the word equation for this reaction.



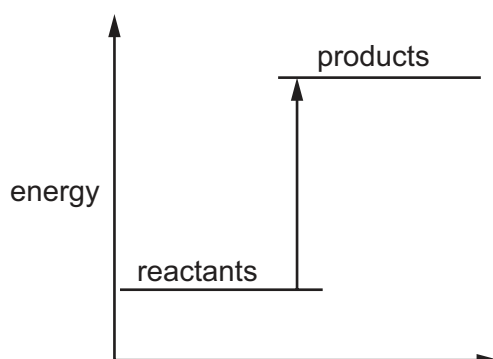
[2]

(ii) Suggest how you could separate the excess calcium carbonate from the rest of the solution.

..... [1]

12

- (d) The energy level diagram for the reaction of citric acid with sodium hydrogen carbonate is shown below.

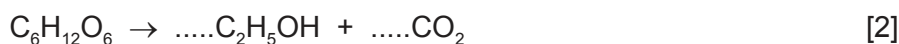


Is this reaction exothermic or endothermic?  
Give a reason for your answer.

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

- (e) Both citric acid and ethanol can be manufactured by fermentation.

- (i) Complete the chemical equation for the fermentation of glucose to form ethanol.



- (ii) State **two** conditions needed for fermentation.

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

- (iii) Complete the table below and calculate the relative molecular mass of glucose.

| type of atom | number of atoms | relative atomic mass |                    |
|--------------|-----------------|----------------------|--------------------|
| carbon       | 6               | 12                   | $6 \times 12 = 72$ |
| hydrogen     |                 |                      |                    |
| oxygen       |                 |                      |                    |

relative molecular mass = ..... [2]

[Total: 14]

7 Rhenium is a metal.

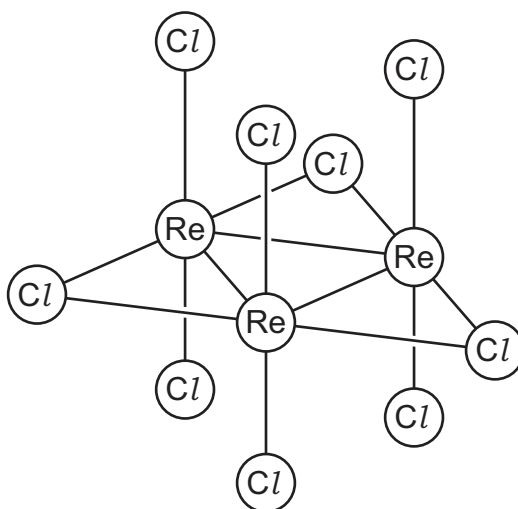
(a) Describe **three** physical properties of rhenium.

.....

.....

..... [3]

(b) The structure of a rhenium chloride molecule is shown.



Determine the simplest formula for this chloride of rhenium.

..... [1]

(c) Rhenium oxide is a yellow solid which undergoes sublimation at a low temperature.

What is the meaning of the term *sublimation*?

..... [1]

(d) Rhenium oxide reacts with water to form perrhenic acid.  
Perrhenic acid is strongly acidic.

(i) Which **one** of the following pH values represents an acidic solution?  
Draw a ring around the correct answer.

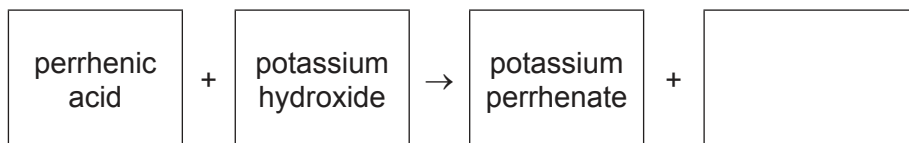
pH 2      pH 7      pH 9      pH 14

[1]

14

- (ii) Perrhenic acid reacts with potassium hydroxide.

Complete the word equation for this reaction.



[1]

- (iii) Which **one** of the following compounds will react with perrhenic acid?  
Tick **one** box.

|                     |                          |
|---------------------|--------------------------|
| ethane              | <input type="checkbox"/> |
| hydrochloric acid   | <input type="checkbox"/> |
| potassium carbonate | <input type="checkbox"/> |
| sodium chloride     | <input type="checkbox"/> |

[1]

- (e) Potassium perrhenate has a similar formula to potassium manganate(VII).  
Potassium manganate(VII) decomposes to give off oxygen.

Describe a test for oxygen.

test .....

result .....

[2]

[Total: 10]

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The Periodic Table of Elements

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

lanthanoids

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

actinoids

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