Cambridge IGCSE

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

| | |
|---|---|
| CANDIDATE NAME | |
| CENTRE NUMBER | |
| CANDIDATE NUMBER | |

*2119876214*

**CHEMISTRY** **0620/31**

Paper 3 Theory (Core) **October/November 2018**

**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.

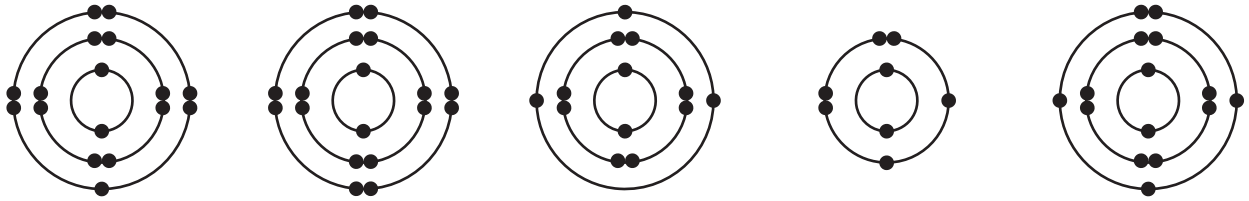
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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 **16** printed pages.

**1** **(a)** The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.

**A** **B** **C** **D** **E**



Answer the following questions about these structures.
Each structure may be used once, more than once or not at all.
State which structure, **A**, **B**, **C**, **D** or **E**, represents:

**(i)** an atom of a metallic element ..... [1]

**(ii)** an atom with a proton number of 13 ..... [1]

**(iii)** an atom of phosphorus ..... [1]

**(iv)** an atom with only **two** shells of electrons ..... [1]

**(v)** an atom which forms a stable ion with a single negative charge. ..... [1]

**(b)** Complete the table to show the number of electrons, neutrons and protons in the carbon atom and potassium ion shown.

| | number of electrons | number of neutrons | number of protons |
|---|---|---|---|
| $^{14}_{6}C$ | 6 | | |
| $^{40}_{19}K^{+}$ | | 21 | |

[3]

[Total: 8]

**2** **(a)** The table shows the ions present in a 1000 $cm^3$ sample of blood plasma.

| ion present | formula of ion | mass present in the 1000 $cm^3$ sample / g |
|---|---|---|
| sodium | $Na^+$ | 3.25 |
| potassium | $K^+$ | 0.16 |
| calcium | $Ca^{2+}$ | 0.10 |
| magnesium | $Mg^{2+}$ | 0.04 |
| chloride | $Cl^-$ | 3.65 |
| hydrogencarbonate | $HCO_3^-$ | 1.50 |
| phosphate | $PO_4^{3-}$ | 0.64 |
| sulfate | $SO_4^{2-}$ | 0.10 |

Answer these questions using only information from the table.

**(i)** Which positive ion is present in the lowest concentration?

..... [1]

**(ii)** Give the name of the compound formed from $K^+$ and $Cl^-$ ions.

..... [1]

**(iii)** Calculate the mass of potassium ions present in 200 $cm^3$ of this blood plasma.

mass of potassium ions = ..... g [1]

**(iv)** When the 1000 $cm^3$ sample of blood plasma is crystallised, several compounds are formed.

Suggest the name of the compound which forms the greatest mass of crystals.

..... [1]

**(b)** Describe a test for potassium ions.

test .....

result .....
[2]

**(c)** Blood plasma also contains proteins.
Proteins are present in food.

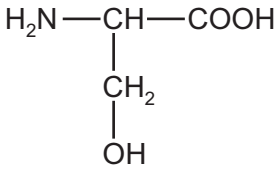
Which **one** of the following substances is also present in food?
Draw a circle around the correct answer.

**carbohydrate** **hematite** **poly(ethene)** **terylene**

[1]

**(d)** Compound **S** is one of the monomer units used to make proteins. Its structure is shown.

compound **S**



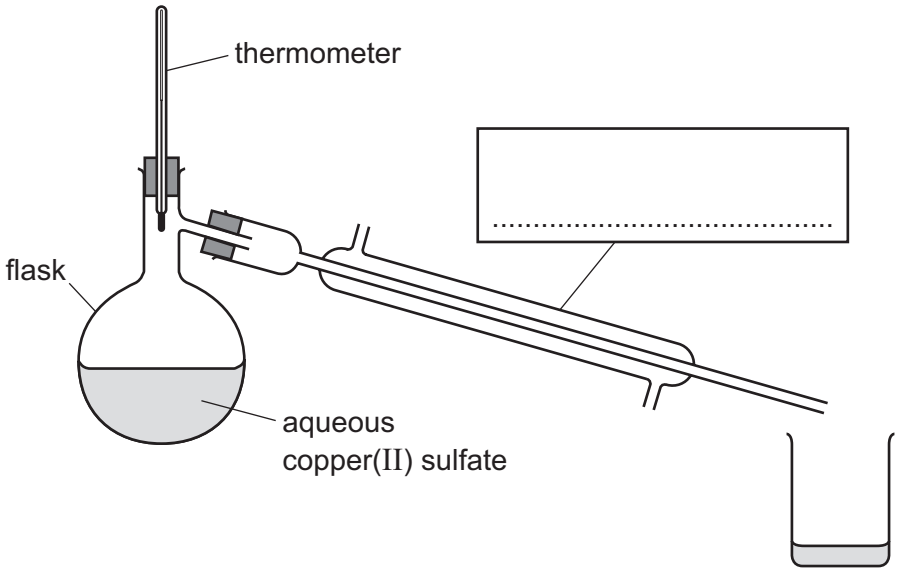
**(i)** On the structure, draw a circle around the alcohol functional group. [1]

**(ii)** Deduce the molecular formula of compound **S** showing the number of carbon, hydrogen, oxygen and nitrogen atoms.

..... [1]

[Total: 9]

**3** **(a)** The apparatus used for distillation is shown.




**(i)** Complete the box to name the apparatus. [1]

**(ii)** Describe and explain how the water is separated from the aqueous copper(II) sulfate by distillation.

.....

.....

.....

.....

..... [3]

**(b)** A sample of solid hydrated copper(II) sulfate is heated gently in a test-tube.

$$\underset{\substack{\text{hydrated}\\\text{copper(II) sulfate}}}{CuSO_4.5H_2O} \rightleftharpoons CuSO_4 + 5H_2O$$

Solid hydrated copper(II) sulfate is blue.

Describe **two** observations when the sample of solid hydrated copper(II) sulfate is heated gently in a test-tube.

1 .....

2 .....

[2]

**(c)** Copper(II) sulfate can be prepared by heating an excess of copper(II) oxide with dilute sulfuric acid.

**(i)** Complete the chemical equation for this reaction.

$$CuO + H_2SO_4 \rightarrow CuSO_4 + .....$$

[1]

**(ii)** What method is used to separate the excess copper(II) oxide from the solution?

..... [1]

**(d)** Copper(II) oxide can be reduced by hydrogen.

$$CuO + H_2 \rightarrow Cu + H_2O$$

How does this equation show that copper(II) oxide is reduced?

.....

..... [1]

**(e)** The chemical equation for the reaction of copper with concentrated nitric acid is shown.

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

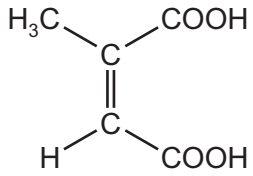
Complete the word equation for this reaction.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| copper | + | nitric acid | → | ..... ..... | + | ..... ..... | + | ..... |

[2]

[Total: 11]

**4** **(a)** The structure of citraconic acid is shown.




Citraconic acid is an unsaturated compound.

**(i)** What feature of the structure of citraconic acid shows that it is unsaturated?

..... [1]

**(ii)** Describe a test for an unsaturated compound.

test .....

result .....
[2]

**(b)** Ethanoic acid has a carboxylic acid functional group.

Draw the structure of the carboxylic acid functional group. Show all of the atoms and all of the bonds.

[1]

**(c)** Complete the definition of a homologous series using words from the list.

**chemical compounds elements functional hydrocarbons physical**

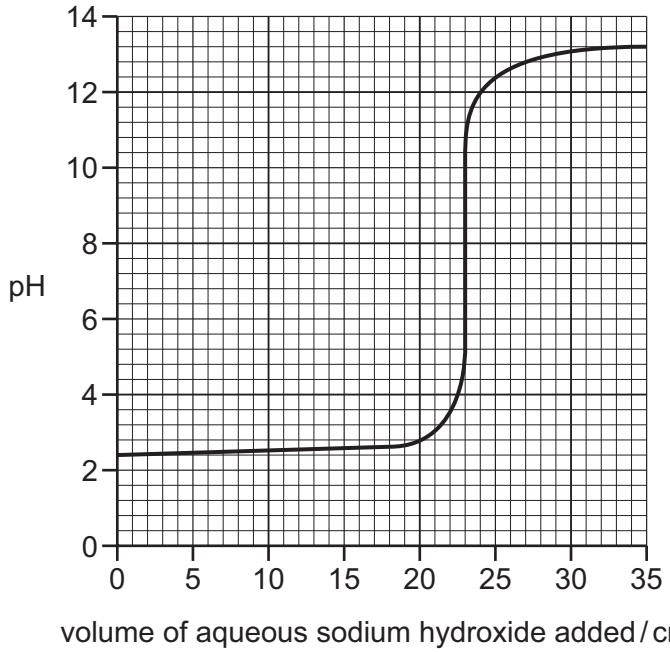
A homologous series is a family of similar ..... with similar .....

properties due to the presence of the same ..... group. [3]



**[Turn over**

**(d)** The graph shows how the pH of a dilute acid in a conical flask changes as aqueous sodium hydroxide is added to it.




**(i)** Describe how the pH changes as the aqueous sodium hydroxide is added.

.....

.....

..... [2]

**(ii)** What is the pH of the dilute acid before the aqueous sodium hydroxide is added?

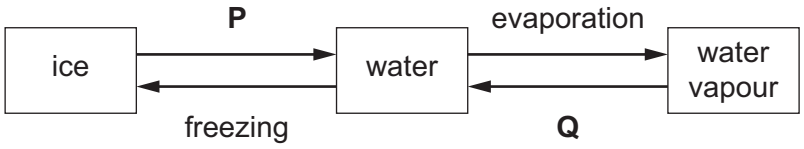
..... [1]

**(iii)** What volume of aqueous sodium hydroxide has been added when the pH reaches pH 7?

..... [1]

[Total: 11]

**5** **(a)** Some of the changes of state of water are shown.




**(i)** Give the names of the changes of state represented by **P** and **Q**.

**P** .....

**Q** .....
[2]

**(ii)** Use the kinetic particle model to describe the separation **and** motion of the particles in water when it is:

- a liquid

.....

.....

- a vapour

.....

.....
[4]

**(b)** When lithium reacts with water, hydrogen is produced and the solution formed is alkaline.

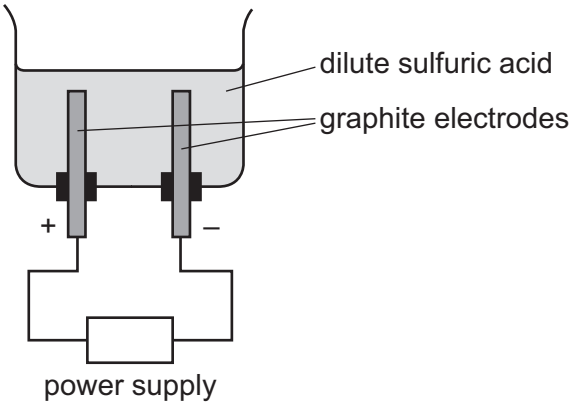
**(i)** Balance the chemical equation for this reaction.

$$.....Li + .....H_2O \rightarrow 2LiOH + H_2$$
[2]

**(ii)** Give the name of the product which causes the solution to be alkaline.

..... [1]

**(c)** Dilute sulfuric acid can be electrolysed using the apparatus shown.




**(i)** State the products of this electrolysis at:

the positive electrode (anode) .....

the negative electrode (cathode). .....
[2]

**(ii)** What observation is made at the electrodes?

..... [1]

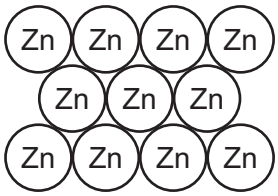
**(iii)** Suggest **one** reason why graphite is used for the electrodes rather than magnesium.

..... [1]

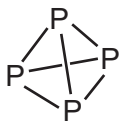
[Total: 13]

**6** **(a)** The diagrams show the structures of four substances, **R**, **S**, **T** and **U**.

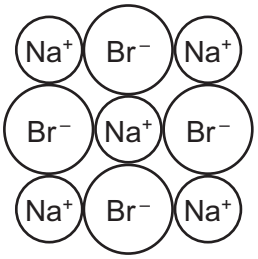
**R**



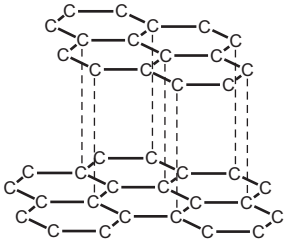

**S**




**T**




**U**



**(i)** Which **two** of these substances, **R**, **S**, **T** or **U**, are covalently bonded?

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

**(ii)** Which **two** of these substances, **R**, **S**, **T** or **U**, conduct electricity when solid?

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

**(iii)** Which substance, **R**, **S**, **T** or **U**, has the lowest melting point? ..... [1]

**(iv)** Which **one** of these substances, **R**, **S**, **T** or **U**, is soluble in water? ..... [1]

**(b)** Phosphorus burns in oxygen to form phosphorus(V) oxide.

**(i)** Balance the chemical equation for this reaction.

$$P_4 + 5O_2 \rightarrow .....P_2O_5$$ [1]

**(ii)** Is phosphorus(V) oxide an acidic oxide or a basic oxide?
Give a reason for your answer.

.....

..... [1]

**(c)** Phosphate ions are present in many fertilisers.

**(i)** Which **one** of the following ions is also present in many fertilisers?
Draw a circle around the correct answer.

$Ba^{2+}$ $Cu^{2+}$ $F^-$ $NO_3^-$ [1]

**(ii)** Why do farmers put fertilisers on their fields?

.....

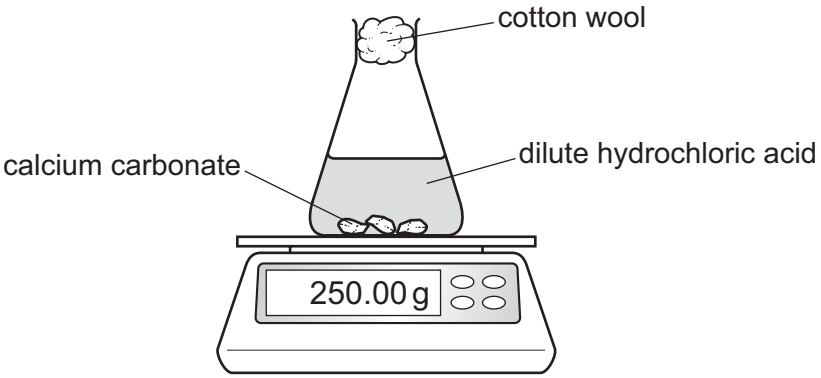
..... [1]

[Total: 10]

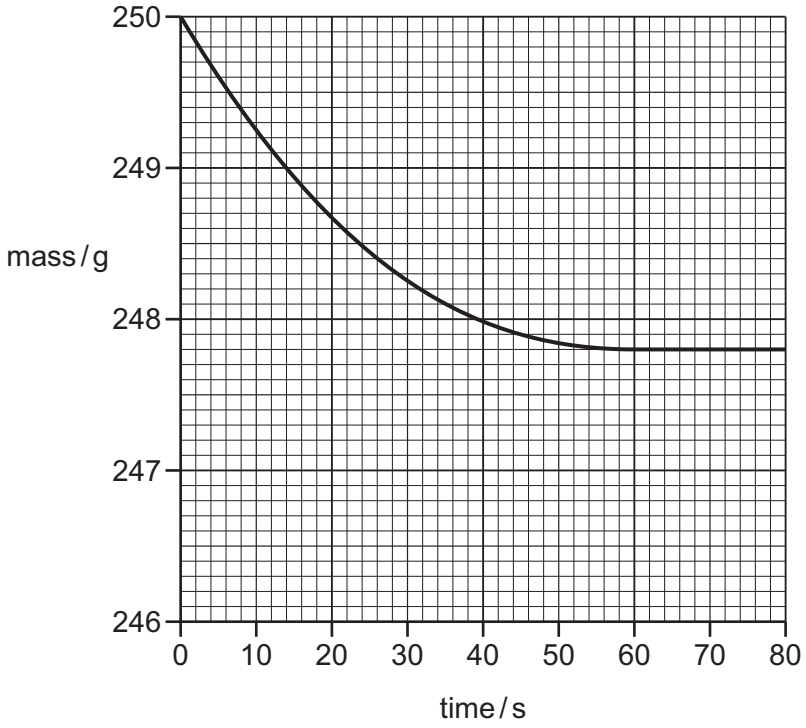
**7** **(a)** A student investigates the reaction of calcium carbonate with dilute hydrochloric acid.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

The student measures the mass of the reaction mixture at 10 second intervals using the apparatus shown.




The graph shows the results when 5.0 g of calcium carbonate is added to an **excess** of dilute hydrochloric acid.




**(i)** Suggest why the reaction mixture decreases in mass as the reaction proceeds.

..... [1]

**(ii)** Calculate the loss of mass in grams when the reaction is complete.

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

**(iii)** The experiment is repeated using dilute hydrochloric acid of **twice** the concentration. All other conditions are kept the same.

**On the grid**, draw a graph to show how the mass changes with time using dilute hydrochloric acid of **twice** the concentration. [2]

**(iv)** The original experiment is repeated at three different temperatures.
All other conditions are kept the same.
The three temperatures are 20 °C, 30 °C and 40 °C.

Complete the table by writing the temperatures in the first column.

| temperature in °C | initial rate of reaction in g / s |
|---|---|
| | 0.16 |
| | 0.64 |
| | 0.32 |

[1]

**(b)** Complete the sentences about the use of calcium carbonate in the extraction of iron using words from the list.

**bauxite** **dioxide** **hematite** **monoxide** **silicon** **slag**

The main ore of iron is called ..... . The main impurity in the iron ore is silicon(IV) oxide.

Calcium carbonate added to the blast furnace decomposes to form calcium oxide and carbon ..... . The calcium oxide reacts with the silicon(IV) oxide to form ..... .

[3]

[Total: 8]

**8** Glass can be made by heating a mixture of sand, sodium carbonate and limestone (calcium carbonate).

**(a) (i)** Calculate the relative formula mass of sodium carbonate, $Na_2CO_3$.
Show all your working.
Use your Periodic Table to help you.

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

**(ii)** Sodium carbonate can be manufactured by the reaction between limestone and sodium chloride. The reaction is endothermic.

What is meant by the term *endothermic*?

..... [1]

**(iii)** During this glass-making process, limestone decomposes into lime (calcium oxide).
Lime is used to treat acidic soils.

What type of chemical reaction occurs when lime reacts with acidic soils?
Draw a circle around the correct answer.

**addition** **neutralisation** **oxidation** **reduction**

[1]

**(b)** Charcoal (carbon) can be burned in an excess of clean, dry air to provide the heat needed to make glass.

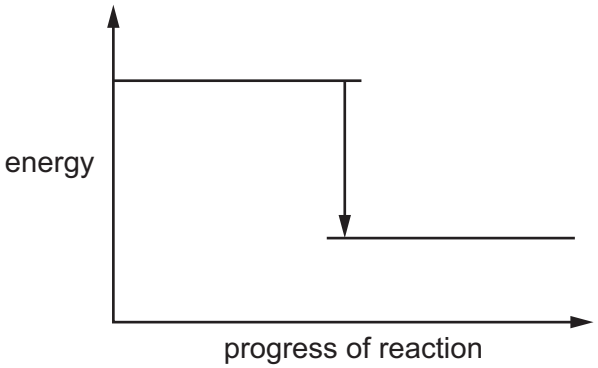
**(i)** Which gas is 21% of clean, dry air?

..... [1]

**(ii)** Write a word equation for carbon burning in an excess of air.

..... [1]

**(iii)** Complete the energy level diagram for this reaction by adding these **two** words:
- reactants
- product




[1]

**(c)** Argon is also present in clean, dry air.

**(i)** Give **one** use of argon.

..... [1]

**(ii)** Which **two** of the following statements about argon are correct?
Tick **two** boxes.

| | |
|---|---|
| Argon is unreactive. | ☐ |
| Argon is diatomic. | ☐ |
| Argon is monatomic. | ☐ |
| Argon forms ionic compounds. | ☐ |
| Argon is a greenhouse gas. | ☐ |

[2]

[Total: 10]

## The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
| | | | | | | | 1 H hydrogen 1 | | | | | | | | | | 2 He helium 4 |
| 3 Li lithium 7 | 4 Be beryllium 9 | | | | | | | | | | | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | | | | | | | | | | | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 |
| 19 K potassium 39 | 20 Ca calcium 40 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium – | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89–103 actinoids | 104 Rf rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | | 114 Fl flerovium – | | 116 Lv livermorium – | | |

**Key**

atomic number
atomic symbol
name
relative atomic mass

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

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).