**Cambridge Assessment International Education**
Cambridge International General Certificate of Secondary Education (9–1)

**CHEMISTRY** **0971/21**

Paper 2 Multiple Choice (Extended) **May/June 2019**

**45 minutes**

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 16.
Electronic calculators may be used.

This document consists of **16** printed pages.


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**1** Which statement explains why ammonia gas, $NH_3$, diffuses at a faster rate than hydrogen chloride gas, $HCl$?

**A** Ammonia expands to occupy all of the space available.

**B** Ammonia has a smaller relative molecular mass than hydrogen chloride.

**C** Ammonia is an alkali and hydrogen chloride is an acid.

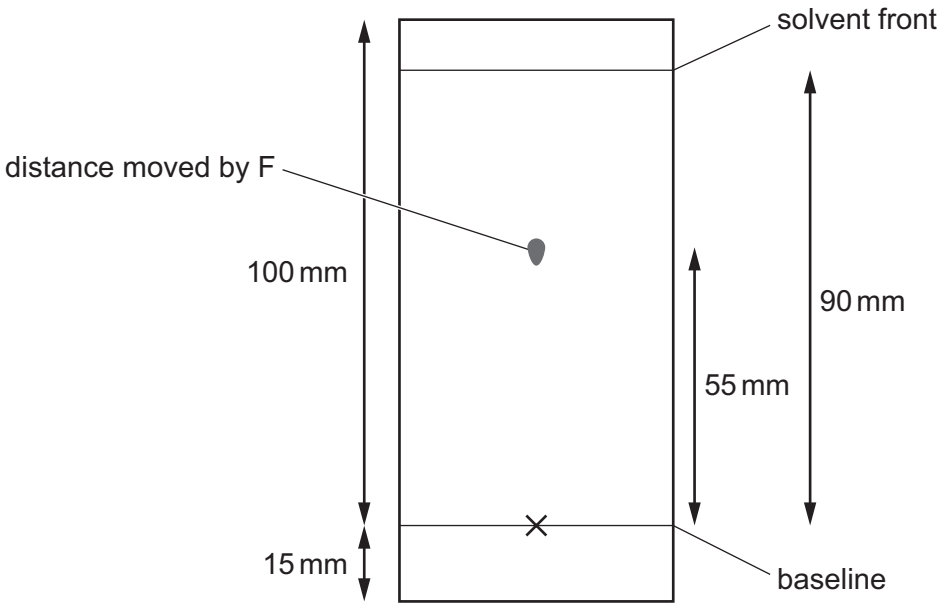
**D** Ammonia molecules diffuse in all directions at the same time.

**2** 2.00 g of powdered calcium carbonate is added to 50.0 $cm^3$ of hydrochloric acid.

Which apparatus is used to measure the calcium carbonate and the hydrochloric acid?

| | calcium carbonate | hydrochloric acid |
|---|---|---|
| **A** | balance | burette |
| **B** | balance | thermometer |
| **C** | pipette | burette |
| **D** | pipette | thermometer |

**3** The measurements from a chromatography experiment using substance F are shown. The diagram is not drawn to scale.




What is the $R_f$ value of F?

**A** 0.55 **B** 0.61 **C** 0.90 **D** 1.64

**4** Which statement about an atom of fluorine, $^{19}_{9}F$, is correct?

**A** It contains more protons than neutrons.

**B** It contains a total of 28 protons, neutrons and electrons.

**C** Its isotopes contain different numbers of protons.

**D** Its nucleus contains 9 neutrons.

**5** Which row describes the formation of single covalent bonds in methane?

| | | |
|---|---|---|
| **A** | atoms share a pair of electrons | both atoms gain a noble gas electronic structure |
| **B** | atoms share a pair of electrons | both atoms have the same number of electrons in their outer shell |
| **C** | electrons are transferred from one atom to another | both atoms gain a noble gas electronic structure |
| **D** | electrons are transferred from one atom to another | both atoms have the same number of electrons in their outer shell |

**6** Which statement describes the structure of an ionic compound?

**A** It is a giant lattice of oppositely charged ions.

**B** It is a giant lattice of positive ions in a ‘sea’ of electrons.

**C** It is a giant molecule of oppositely charged ions.

**D** It is a simple molecule of oppositely charged ions.

**7** Propane burns in oxygen.

$$C_3H_8 + xO_2 \rightarrow 3CO_2 + yH_2O$$

Which values of *x* and *y* balance the equation?

| | *x* | *y* |
|---|---|---|
| **A** | 5 | 4 |
| **B** | 7 | 4 |
| **C** | 10 | 8 |
| **D** | 13 | 8 |

**8** A tablet contains 0.080 g of ascorbic acid ($M_r$ = 176).

What is the concentration of ascorbic acid when one tablet is dissolved in 200 $cm^3$ of water?

**A** $9.1 \times 10^{-5}$ mol / $dm^3$

**B** $4.5 \times 10^{-4}$ mol / $dm^3$

**C** $9.1 \times 10^{-2}$ mol / $dm^3$

**D** $2.3 \times 10^{-3}$ mol / $dm^3$

**9** Which statement about the electrolysis of copper(II) sulfate solution using carbon electrodes is correct?

**A** A colourless gas is produced at the anode.

**B** A colourless gas is produced at the cathode.

**C** The colour of the electrolyte remains the same.

**D** The mass of both electrodes remains constant.

**10** Aluminium metal is extracted from aluminium oxide by electrolysis.

Which ionic half-equation describes a reaction that occurs at the named electrode?

| | ionic half-equation | electrode |
|---|---|---|
| **A** | $2O^{2-} \rightarrow O_2 + 2e^-$ | anode |
| **B** | $Al^{3+} + 3e^- \rightarrow Al$ | anode |
| **C** | $2O^{2-} \rightarrow O_2 + 4e^-$ | cathode |
| **D** | $Al^{3+} + 3e^- \rightarrow Al$ | cathode |

**11** Which statement about the hydrogen fuel cell is **not** correct?

**A** Chemical energy is converted into electrical energy.

**B** Hydrogen is oxidised.

**C** The reaction that takes place is endothermic.

**D** Water is the only product.

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**12** Nitrogen reacts with hydrogen to produce ammonia.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

The reaction is exothermic. The bond energies are shown in the table.

| bond | bond energy in kJ / mol |
|---|---|
| N≡N | 945 |
| H–H | 436 |
| N–H | 390 |

What is the energy change for this reaction?

**A** –1473 kJ / mol

**B** –87 kJ / mol

**C** 87 kJ / mol

**D** 1473 kJ / mol

**13** Which change in reaction conditions increases both the collision rate and the proportion of molecules with sufficient energy to react?

**A** addition of a catalyst

**B** increasing the concentration of a reactant

**C** increasing the surface area of a reactant

**D** increasing the temperature of the reaction

**14** When blue-green crystals of nickel(II) sulfate are heated, water is produced and a yellow solid remains. When water is added to the yellow solid, the blue-green colour returns.

Which process describes these changes?

**A** combustion

**B** corrosion

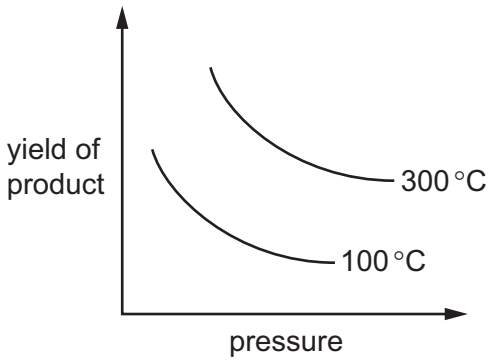
**C** neutralisation

**D** reversible reaction

**15** The graph shows how the yield of product in a reversible reaction changes as the temperature and pressure are changed.

All reactants and products are gases.

reactants $\rightleftharpoons$ products




Which row is correct for this reversible reaction?

| | side of reaction with fewer moles | forward reaction |
|---|---|---|
| **A** | reactant | exothermic |
| **B** | reactant | endothermic |
| **C** | product | endothermic |
| **D** | product | exothermic |

**16** Which changes represent oxidation?

1 $2I^- \rightarrow I_2 + 2e^-$

2 Cr(VI) $\rightarrow$ Cr(III)

3 Fe(II) $\rightarrow$ Fe(III)

**A** 1 and 2 **B** 1 and 3 **C** 1 only **D** 2 only

**17** Nitrogen(I) oxide, $N_2O$, nitrogen(II) oxide, NO, and carbon monoxide, CO, are all non-metal oxides.

They do not react with acids or bases.

Which statement is correct?

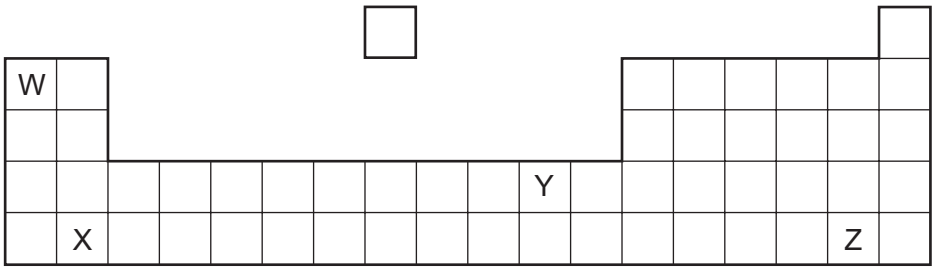
**A** They are acidic oxides.

**B** They are amphoteric oxides.

**C** They are basic oxides.

**D** They are neutral oxides.

**18** The positions of elements W, X, Y and Z in the Periodic Table are shown.




Which elements form basic oxides?

**A** W, X and Y **B** W and X only **C** Y only **D** Z only

**19** Ethanoic acid is a weak acid.

Hydrochloric acid is a strong acid.

Which statements are correct?

1 Ethanoic acid molecules are partially dissociated into ions.

2 1.0 mol / $dm^3$ ethanoic acid has a higher pH than 1.0 mol / $dm^3$ hydrochloric acid.

3 Ethanoic acid is always more dilute than hydrochloric acid.

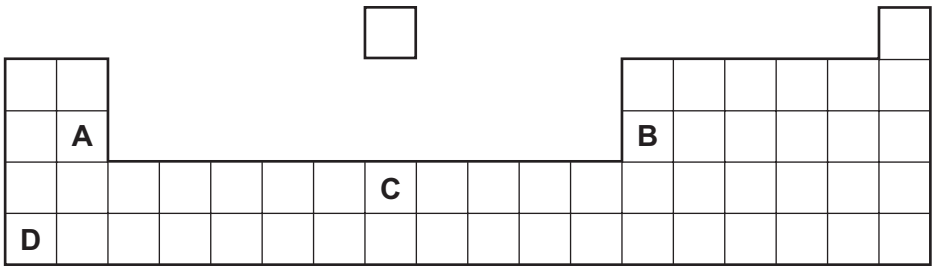
4 Ethanoic acid is a proton acceptor.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

**20** The properties of an element are shown.

| electrical conductivity | density | reaction with water |
|---|---|---|
| high | low | reacts violently with cold water |

Which element has these properties?



**21** Which statement about elements in Group I and Group VII of the Periodic Table is correct?

**A** Bromine reacts with potassium chloride to produce chlorine.

**B** Iodine is a monoatomic non-metal.

**C** Lithium has a higher melting point than potassium.

**D** Sodium is more reactive with water than potassium.

**22** Which statement about elements in Group VIII of the Periodic Table is correct?

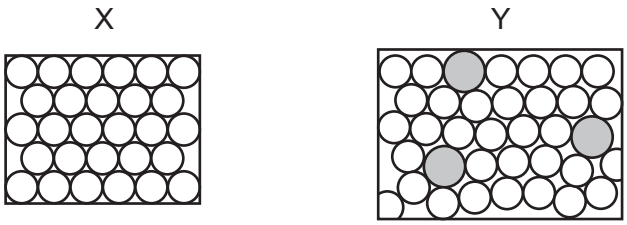
**A** They all have a full outer shell of electrons.

**B** They all react with Group I elements to form ionic compounds.

**C** They are all diatomic molecules.

**D** They are all liquids at room temperature.

**23** The diagrams show the structure of two substances used to make electrical conductors.




Which statement correctly describes X and Y?

**A** X is a pure metal and Y is a compound.

**B** X is a pure metal and Y is an alloy.

**C** X is a solid and Y is a liquid.

**D** X is harder and stronger than Y.

**24** Three metal compounds, P, Q and R, are heated using a Bunsen burner.

The results are shown.

P colourless gas produced, which relights a glowing splint

Q colourless gas produced, which turns limewater milky

R no reaction

Which row shows the identity of P, Q and R?

| | P | Q | R |
|---|---|---|---|
| **A** | magnesium carbonate | potassium carbonate | potassium nitrate |
| **B** | magnesium carbonate | potassium nitrate | potassium carbonate |
| **C** | potassium nitrate | magnesium carbonate | potassium carbonate |
| **D** | potassium nitrate | potassium carbonate | magnesium carbonate |

**25** Zinc is extracted from its ore, zinc blende, using two chemical reactions.

1 $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

2 $2ZnO + C \rightarrow 2Zn + CO_2$

Which substance is reduced in reactions 1 and 2?

| | reaction 1 | reaction 2 |
|---|---|---|
| **A** | $O_2$ | C |
| **B** | $O_2$ | ZnO |
| **C** | ZnS | C |
| **D** | ZnS | ZnO |

**26** Four metals, zinc, M, copper and magnesium, are reacted with aqueous solutions of their nitrates.

The results are shown.

| metal | magnesium nitrate | M nitrate | copper nitrate | zinc nitrate |
|---|---|---|---|---|
| magnesium | | ✓ | ✓ | ✓ |
| zinc | ✗ | ✓ | ✓ | |
| M | ✗ | | ✓ | ✗ |
| copper | ✗ | ✗ | | ✗ |

key
✓ = reacts
✗ = no reaction

What is the order of reactivity of these four metals starting with the most reactive?

**A** copper → zinc → M → magnesium

**B** copper → M → zinc → magnesium

**C** magnesium → M → zinc → copper

**D** magnesium → zinc → M → copper

**27** Why is aluminium used to make containers for storing food?

**A** It conducts electricity.

**B** It has a high melting point.

**C** It is resistant to corrosion.

**D** It is strong.

**28** Water can be treated by filtration then chlorination.

Which uses do **not** need water of this quality?

1 water for cooling in industry

2 water for washing clothes

3 water for drinking

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**29** Oxides of nitrogen are formed in car engines and are a source of air pollution.

To decrease this pollution, catalytic converters are fitted to car exhausts.

What happens to the oxides of nitrogen in the catalytic converter?

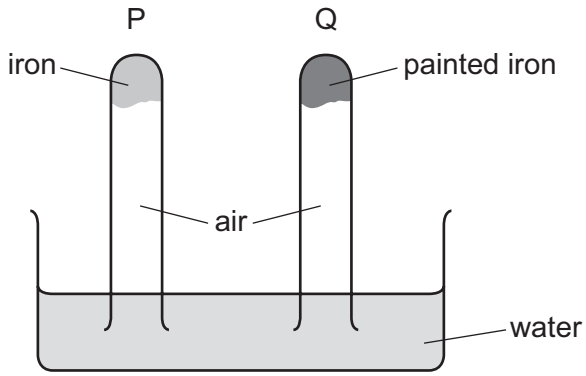
**A** combustion

**B** cracking

**C** oxidation

**D** reduction

**30** The diagram shows an experiment to investigate how paint affects the rusting of iron.




What happens to the water level in tubes P and Q?

| | tube P | tube Q |
|---|---|---|
| **A** | falls | rises |
| **B** | no change | rises |
| **C** | rises | falls |
| **D** | rises | no change |

**31** Ammonia is manufactured by the Haber Process.

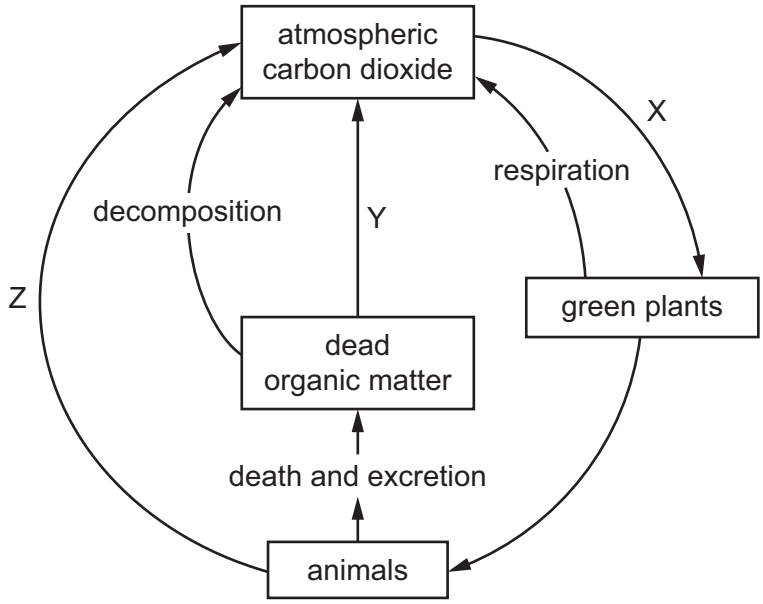
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

Which conditions maximise the yield of ammonia?

| | pressure | temperature |
|---|---|---|
| **A** | high | high |
| **B** | high | low |
| **C** | low | high |
| **D** | low | low |

**32** The carbon cycle is shown.




Which row describes processes X, Y and Z?

| | X | Y | Z |
|---|---|---|---|
| **A** | respiration | combustion | photosynthesis |
| **B** | respiration | photosynthesis | combustion |
| **C** | photosynthesis | combustion | respiration |
| **D** | photosynthesis | respiration | combustion |

**33** Which row shows the conditions used in the Contact process?

| | temperature / °C | pressure / atm | catalyst |
|---|---|---|---|
| **A** | 25 | 2 | iron |
| **B** | 25 | 200 | iron |
| **C** | 450 | 2 | vanadium(V) oxide |
| **D** | 450 | 200 | vanadium(V) oxide |

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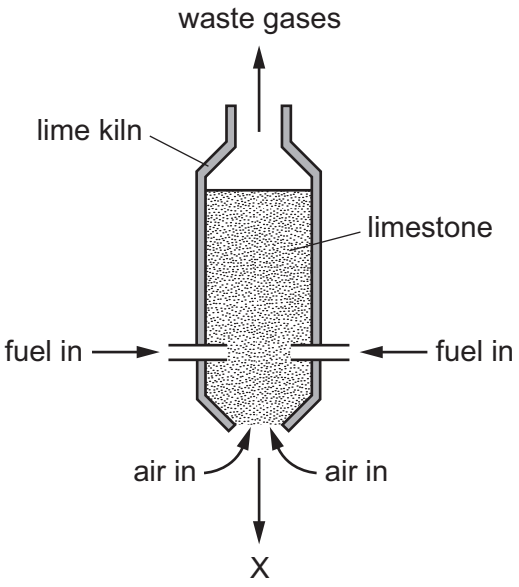
**34** The diagram represents a lime kiln used to heat limestone to a very high temperature.




What leaves the kiln at X?

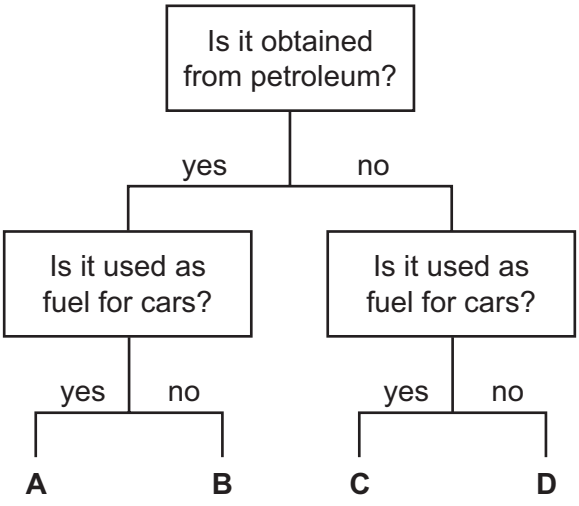
**A** calcium carbonate

**B** calcium hydroxide

**C** calcium oxide

**D** calcium sulfate

**35** Which fuel could be gasoline?



**36** Why is ethanol a member of the homologous series of alcohols but propane is **not**?

**A** Ethanol has two carbon atoms per molecule but propane has three.

**B** Ethanol can be made from ethene but propane is obtained from petroleum.

**C** Ethanol is a liquid but propane is a gas.

**D** Ethanol contains the same functional group as other alcohols but propane does not.

**37** Chlorine reacts with methane.

Which statements are correct?

1 The reaction takes place in the dark.

2 The reaction of chlorine with methane forms chloromethane.

3 Chloromethane reacts with chlorine to produce dichloromethane.

4 The reaction of chlorine with methane is an addition reaction.

**A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 3 and 4

**38** Which statements about aqueous ethanoic acid are correct?

1 Ethanoic acid contains the functional group –COOH.

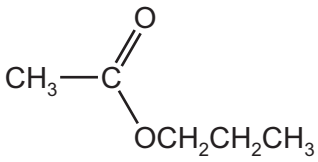
2 Ethanoic acid reacts with carbonates to produce hydrogen.

3 Ethanoic acid turns Universal Indicator paper blue.

4 Ethanoic acid has a pH lower than pH 7.

**A** 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 4

**39** The structure of an ester is shown.




What is the name of the ester?

**A** ethyl propanoate

**B** methyl propanoate

**C** propyl ethanoate

**D** propyl methanoate

**40** The structure of a polymer is shown.

Which type of polymer is shown and by which process is it formed?

| | type of polymer | formed by |
|---|---|---|
| **A** | carbohydrate | addition polymerisation |
| **B** | carbohydrate | condensation polymerisation |
| **C** | polyester | addition polymerisation |
| **D** | polyester | condensation polymerisation |

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## The Periodic Table of Elements

**Key**

| atomic number |
|---|
| **atomic symbol** |
| name |
| relative atomic mass |

| Group | I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1<br>H<br>hydrogen<br>1 | | | | | | | | | | | 2<br>He<br>helium<br>4 |
| | 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 |
| actinoids | 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>– |

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

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