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CHEMISTRY **0620/31**

Paper 3 Theory (Core) **October/November 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages.

[Turn over

1 Fig. 1.1 shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII
							H										He
Li													C	N			Ne
	Mg											Al	Si		S	Cl	
K			Ti				Fe			Cu	Zn						
																I	

Fig. 1.1

Answer the following questions using only the symbols of the elements in Fig. 1.1.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(a) forms an ion which produces a red colour in a flame test

..... [1]

(b) is present in diamond

..... [1]

(c) forms an ion with a charge of 2–

..... [1]

(d) is extracted from bauxite

..... [1]

(e) is used in electrical wiring because of its good electrical conductivity and ductility.

..... [1]

[Total: 5]

2 The symbol for an atom of argon is shown.

$^{40}_{18}Ar$

(a) Complete Table 2.1 to show the number of protons and neutrons in one atom of $^{40}_{18}Ar$.

Table 2.1

number of protons	
number of neutrons	

[2]

(b) Argon is an unreactive monatomic element.

(i) Explain what is meant by the term monatomic.

..... [1]

(ii) Explain why argon is unreactive. Give your answer in terms of electronic configuration.

..... [1]

(c) At room temperature and pressure, argon is a gas.

A sample of argon is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of argon when:

- the temperature of the argon is increased
- the pressure of the argon is increased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of argon
temperature is increased	
pressure is increased	

[2]

[Total: 6]

3 **(a)** Table 3.1 shows the masses of ions, in mg, present in a 1000 cm^3 sample of river water.

Table 3.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of river water / mg
ammonium	NH_4^+	0.5
bromide	Br^-	0.2
calcium	Ca^{2+}	1.4
hydrogencarbonate	HCO_3^-	6.0
iodide	I^-	3.2
lithium	Li^+	4.3
nitrate	NO_3^-	9.5
phosphate	PO_4^{3-}	0.7
sodium	Na^+	8.3
sulfate		0.9

Answer these questions using the information from Table 3.1.

(i) Name the positive ion that has the highest concentration.

..... [1]

(ii) State the formula of the sulfate ion.

..... [1]

(iii) Describe a test to identify the presence of iodide ions, I^-, in a sample of water.

test .....

.....

observations .....

[2]

(iv) Calculate the mass of nitrate ions, NO_3^-, in 200 cm^3 of river water.

mass = ... mg [1]

(b) Give the formulae of **two** ions from Table 3.1 which can be combined with potassium ions to make an NPK fertiliser.

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

(c) Name **two** ions from Table 3.1 which lead to deoxygenation of water and damage to aquatic life.

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

(d) The diagram in Fig. 3.1 shows the apparatus used to separate pure water from the sample of river water.

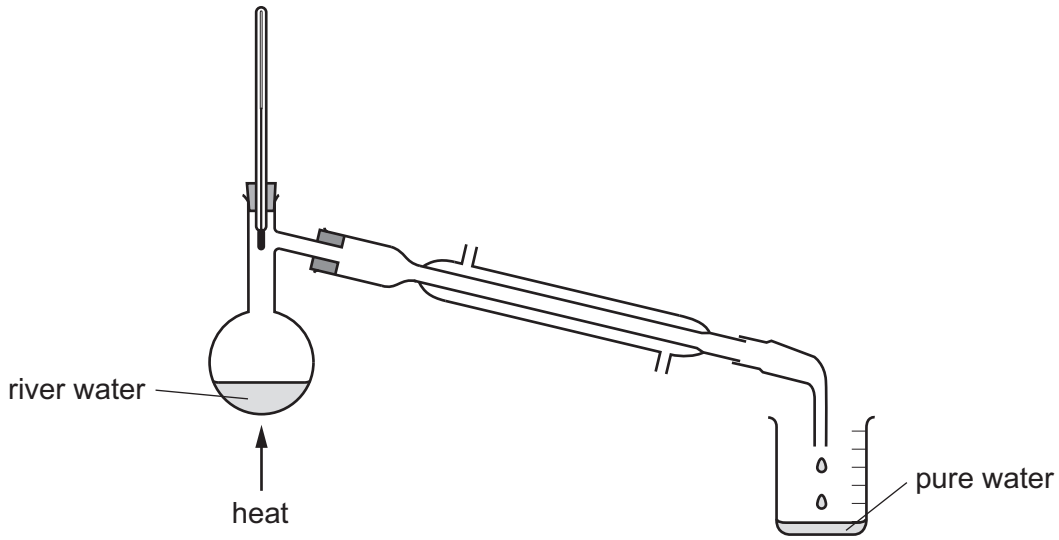


Fig. 3.1

Name the separation method shown in Fig. 3.1.

..... [1]

[Total: 9]

4 **(a)** Molecules of compound **C** are produced by some plants.

Fig. 4.1 shows the displayed formula of a molecule of compound **C**.

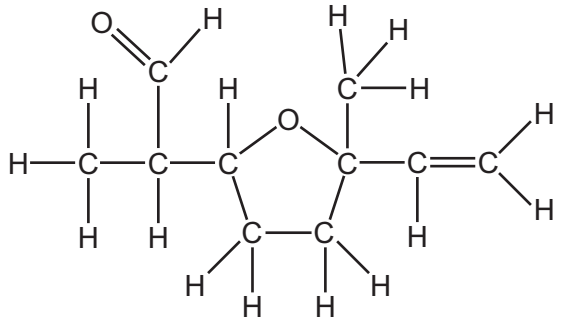


Fig. 4.1

Deduce the molecular formula of compound **C** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

(b) On Fig. 4.1, draw a circle around the part of the molecule which shows that the molecule is unsaturated. [1]

(c) A different molecule found in plants has the molecular formula $C_{11}H_{14}O_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_{11}H_{14}O_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	11	12	11 × 12 = 132
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(d) Petroleum is a mixture of hydrocarbons which can be separated into groups of compounds called fractions.

Explain what is meant by the term hydrocarbon.

.....

..... [1]

(e) Fig. 4.2 shows the names of some of the fractions obtained from petroleum using a fractionating column.

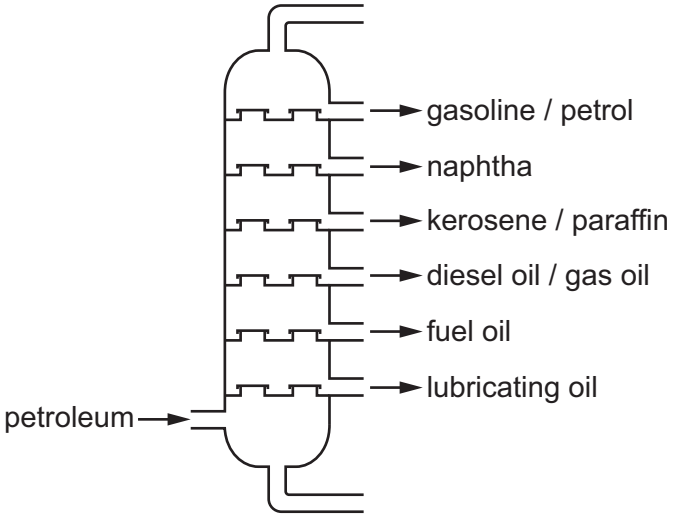


Fig. 4.2

Using only the fractions shown in Fig. 4.2, name the fraction which contains compounds that:

(i) have the lowest boiling point

..... [1]

(ii) have the highest viscosity

..... [1]

(iii) are used for jet fuel.

..... [1]

(f) Table 4.2 shows some properties of compounds found in the naphtha fraction.

Table 4.2

name	molecular formula	melting point / °C	boiling point / °C
heptane		–90	98
octane	C_8H_{18}		125
nonane	C_9H_{20}	–54	150
decane	$C_{10}H_{22}$	–30	174
undecane	$C_{11}H_{24}$	–25	195

(i) A molecule of heptane contains seven carbon atoms.

Deduce the molecular formula of heptane.

..... [1]

(ii) Use the information in Table 4.2 to predict the melting point of octane, C_8H_{18}.

..... [1]

(g) When heated strongly in the presence of a catalyst, decane reacts to form smaller molecules.

(i) Name this type of endothermic reaction.

..... [1]

(ii) Ethene is one of the molecules formed when decane is heated strongly in the presence of a catalyst.

Draw the displayed formula of ethene. Show all the atoms and all the bonds.

[2]

(h) Ethene is polymerised to form the plastic poly(ethene).

(i) Name this type of polymerisation.

..... [1]

(ii) Describe **two** environmental challenges caused by the disposal of plastics such as poly(ethene).

1 .....

.....

2 .....

.....

[2]

[Total: 16]

5 This question is about elements in Group I and in Group VII of the Periodic Table and their compounds.

(a) Chlorine is in Group VII of the Periodic Table.

Give the colour and state of chlorine at room temperature and pressure.

colour .....

state .....
[2]

(b) State the use of chlorine in the treatment of the domestic water supply.

..... [1]

(c) Iodine is in Group VII of the Periodic Table.

Table 5.1 shows the melting point and the boiling point of iodine.

Table 5.1

melting point / °C	114
boiling point / °C	184

Use the information in Table 5.1 to deduce the physical state of iodine at 195 °C.

Give a reason for your answer.

physical state .....

reason .....

.....
[2]

(d) Potassium is an element in Group I of the Periodic Table.
Elements in Group I have a low density and relatively low melting and boiling points.

State **one other** physical property of potassium.

..... [1]

(e) When a sample of potassium is added to a large container of cold water, a chemical reaction occurs.

(i) Describe what is observed when potassium is added to water.

.....

.....

.....

.....

.....

..... [3]

(ii) The word equation for the reaction of potassium with water is shown.

potassium + water → potassium hydroxide + hydrogen

Describe a test for hydrogen.

test .....

observations .....

[1]

(f) Potassium reacts with oxygen to form potassium oxide, K_2O.

Complete the symbol equation for this reaction.

..... K + ... → $2K_2O$

[2]

(g) Solid potassium oxide, K_2O, dissolves in water to form an alkali.

Choose the pH value of the solution formed when solid potassium oxide is dissolved in water.

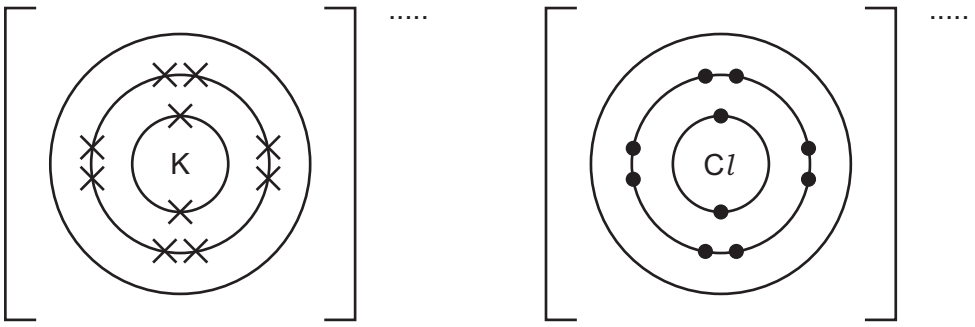
Draw a circle around your chosen answer.

pH 1 **pH 5** **pH 7** **pH 12** [1]

(h) Potassium reacts with chlorine to form the ionic compound potassium chloride.

Complete the dot-and-cross diagram in Fig. 5.1 for potassium chloride to show:

- the electronic configuration for each ion
- the charge on each ion.



....

Fig. 5.1

[3]

[Total: 16]

Question 6 starts on the next page.

6 This question is about metals.

(a) Iron is extracted from its ore using carbon (coke) and calcium carbonate in a blast furnace.

(i) Give **two** reasons why carbon is used in a blast furnace.

1 .....

2 .....

[2]

(ii) Slag is a waste product of this extraction.

Describe how slag is produced.

.....

.....

..... [2]

(iii) Iron ore contains iron(III) oxide.

The equation for the extraction of iron from iron(III) oxide is shown.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Explain how this equation shows that carbon monoxide is oxidised.

..... [1]

(b) Pure iron is less useful than its alloys such as stainless steel.

(i) Name **two** metals most commonly used in stainless steel, other than iron.

1 .....

2 .....

[2]

(ii) State **one** use of stainless steel.

..... [1]

(c) Table 6.1 shows the observations when four different metals are added separately to dilute ethanoic acid.

Table 6.1

metal	observations
zinc	a few bubbles of gas given off slowly and the temperature of the mixture increases very slowly
titanium	no bubbles of gas given off and no temperature increase of the mixture
calcium	many bubbles of gas given off very quickly and the temperature of the mixture increases rapidly
magnesium	bubbles of gas given off quickly and the temperature of the mixture increases slowly

(i) Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[ ] [ ] [ ] [ ]

[2]

(ii) Complete the word equation for the reaction of calcium with ethanoic acid.

calcium + ethanoic acid ⟶ .... + ...

[2]

[Total: 12]

7 Fig. 7.1 shows the apparatus used to electrolyse dilute sulfuric acid using inert electrodes.

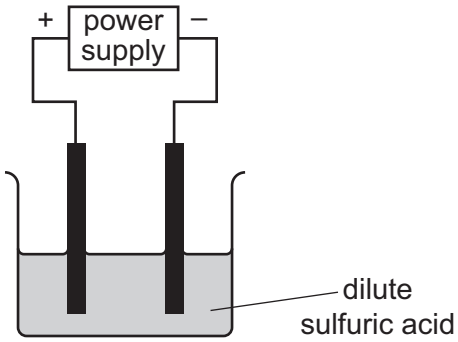


Fig. 7.1

(a) State what is meant by the term electrolysis.

.....

..... [2]

(b) Label the cathode in Fig. 7.1. [1]

(c) Name **one** product formed at the anode.

..... [1]

(d) The inert electrodes used are made of graphite.

(i) Explain what is meant by the term inert.

..... [1]

(ii) State **one other** use for graphite.

..... [1]

(e) Excess solid copper(II) carbonate is added to dilute sulfuric acid.
Aqueous copper(II) sulfate, water and carbon dioxide gas are produced.

(i) State with a reason if this is a chemical or a physical change.

.....

..... [1]

(ii) Name a method to remove the excess copper(II) carbonate from the mixture.

..... [1]

(iii) Name **one other** substance which can be added to dilute sulfuric acid to form aqueous copper(II) sulfate.

..... [1]

(f) Copper(II) sulfate, $CuSO_4$, exists in different forms.

Draw **one** line from each form of copper(II) sulfate to its description.

form of copper(II) sulfate	**description**
aqueous $CuSO_4$	solid $CuSO_4$ chemically combined with water
hydrated $CuSO_4$	$CuSO_4$ dissolved in water
anhydrous $CuSO_4$	solid $CuSO_4$ containing no water

[2]

[Total: 11]

8 A student investigates the reaction of small pieces of magnesium with excess dilute hydrochloric acid.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Fig. 8.1 shows the total volume of hydrogen gas, H_2, produced as the reaction proceeds.

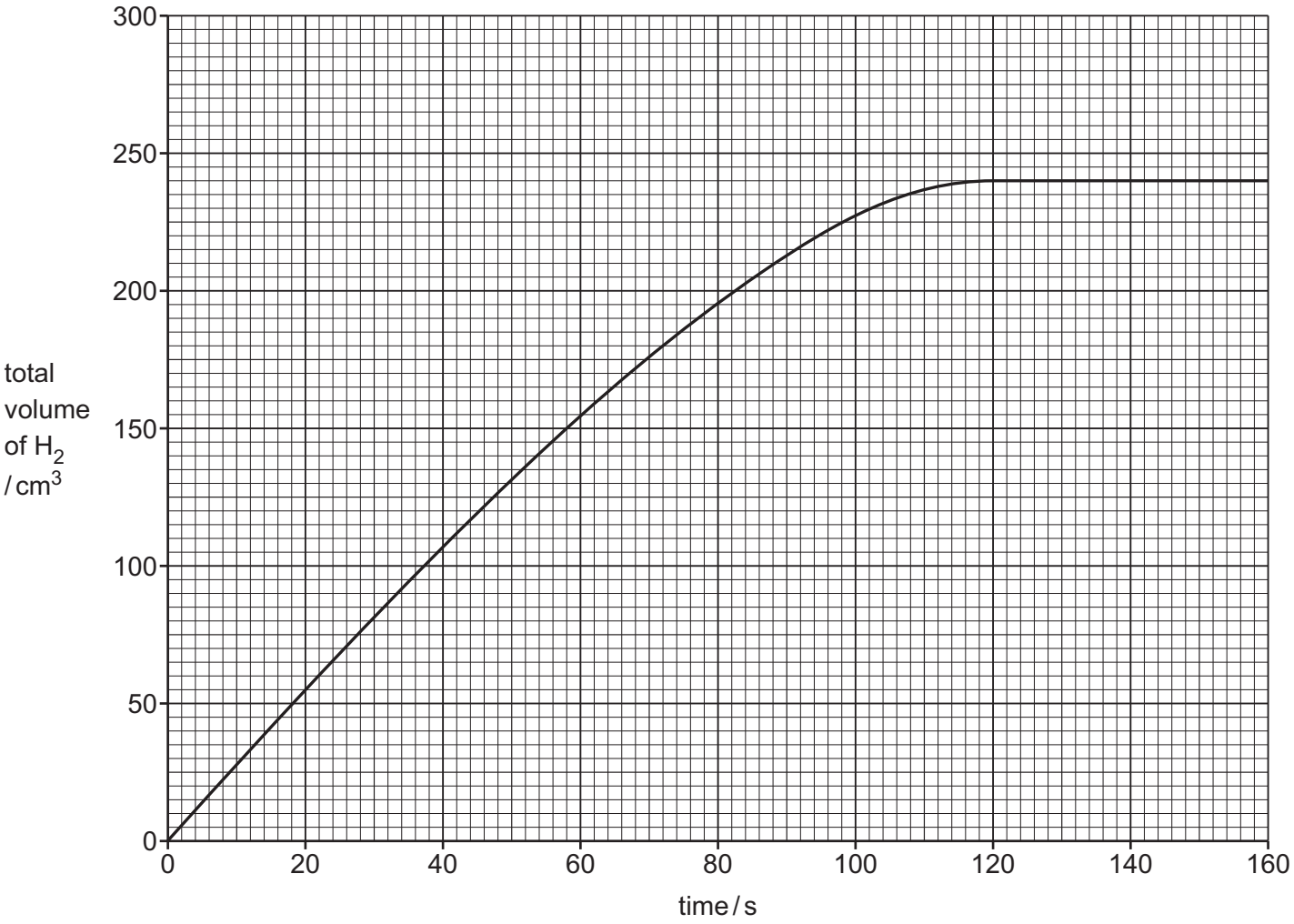


Fig. 8.1

(a) Use Fig. 8.1 to deduce the time taken for the reaction to finish.

time taken for reaction to finish = ... s [1]

(b) The reaction is repeated using larger pieces of magnesium of the same total mass.

All other conditions stay the same.

State the effect, if any, on:

(i) the time taken for the reaction to finish

..... [1]

(ii) the total volume of H_2 produced when the reaction is complete.

..... [1]

(c) Fig. 8.2 shows the reaction pathway diagram for the reaction of magnesium with dilute hydrochloric acid.

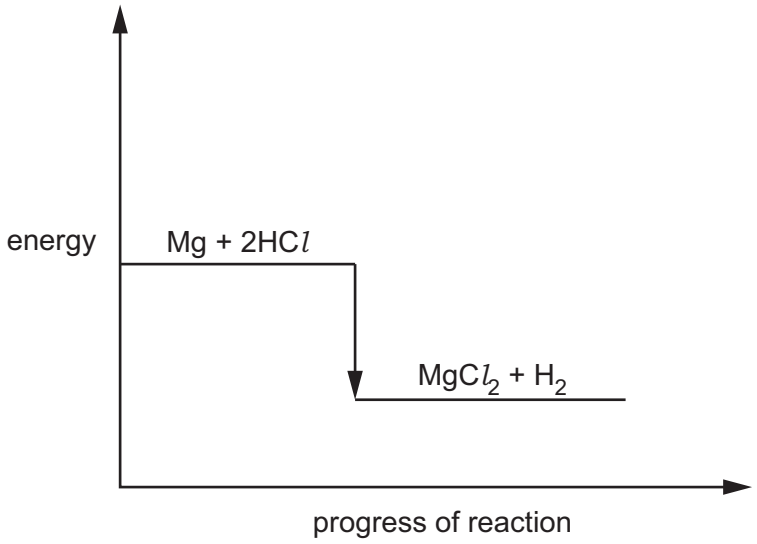


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 5]

The Periodic Table of Elements

Group I	Group II						Group III	Group IV	Group V	Group VI	Group VII	Group 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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).