



Cambridge International AS & A Level

CHEMISTRY

9701/12

Paper 1 Multiple Choice

October/November 2024

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages.



2

1 Which species contains a different number of electrons from the other three?

- A** ClO_4^- **B** H_2SO_4 **C** SO_4^{2-} **D** Te^{2-}

2 Which factor causes helium to have a higher first ionisation energy than hydrogen?

- A** In the 1s orbital in helium, electrons are paired.
B The lowest energy level in helium is filled.
C The nuclear charge in helium is higher than in hydrogen.
D There is less shielding of the outer shell in helium.

3 A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas. This is the only carbon-containing product formed in the reaction. This methane gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 produced at room temperature and pressure is 108 cm^3 .

What is the formula of aluminium carbide?

- A** Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_3

4 A reaction between two gases takes place on the surface of the catalytic converter of a petrol-engined car.

In this reaction, four reactant molecules produce three product molecules.

What could be the two reactant gases in this reaction?

- A** nitrogen and carbon dioxide
B nitrogen monoxide and carbon dioxide
C nitrogen monoxide and carbon monoxide
D nitrogen dioxide and carbon monoxide

5 An ion contains 1 nitrogen atom and 2 hydrogen atoms. It has an H–N–H bond angle of approximately 105° .

Which row is correct?

	number of lone pairs around N in ion	overall charge on ion
A	1	+1
B	2	+1
C	1	–1
D	2	–1

- 6 Why does ICl have a higher boiling point than Br_2 ?
- A because of the difference in the bond energies of the covalent bonds within ICl and Br_2
 B because of the difference in the polar nature of ICl and Br_2
 C because of the difference in the number of electrons contained within ICl and Br_2
 D because of the difference in the relative molecular mass of ICl and Br_2
- 7 In this question you may assume that nitrogen behaves as an ideal gas. One atmosphere pressure = 101 kPa.
- Which volume does 1.0 g of nitrogen occupy at 50°C and a pressure of 2.0 atmospheres?
- A 70 cm^3 B 150 cm^3 C 470 cm^3 D 950 cm^3
- 8 Which statement about the properties associated with the different types of bonding involved is correct?
- A Any covalent compound that contains both oxygen and hydrogen in its molecule forms hydrogen bonds.
 B Ionic bonds and covalent bonds cannot both occur in the same compound.
 C Ionic compounds differ from metals in that ionic compounds do not conduct electricity in the solid state.
 D The only covalent compounds with high melting points are those in which hydrogen bonds occur.
- 9 For which reaction is the enthalpy change an enthalpy change of formation?
- A $\text{C(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$
 B $\frac{1}{2}\text{N}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NO(g)}$
 C $\text{Na}_2\text{O(s)} + \text{SO}_3\text{(g)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)}$
 D $\text{PCl}_3\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow \text{PCl}_5\text{(g)}$

- 10 Two standard enthalpy change of formation values are given.

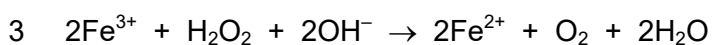
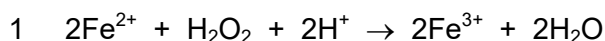
$$\Delta H_f^\ominus [\text{VCl}_2] = -452\text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{VCl}_3] = -573\text{ kJ mol}^{-1}$$

What is the enthalpy change for the reaction $3\text{VCl}_2 \rightarrow 2\text{VCl}_3 + \text{V}$?

- A -210 kJ mol^{-1} B -121 kJ mol^{-1} C $+121\text{ kJ mol}^{-1}$ D $+210\text{ kJ mol}^{-1}$

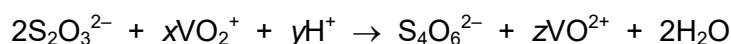
11 Equations for some reactions of hydrogen peroxide are given.



In which reactions is hydrogen peroxide acting as a reducing agent?

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

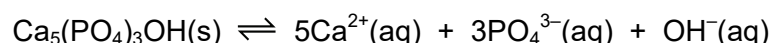
12 The equation for the reaction of aqueous thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$, and aqueous dioxo-vanadium ions, VO_2^+ , is shown.



Which row shows two correct statements about the equation for this reaction?

	comparison of x and y to z	change in oxidation number of vanadium
A	x and z are the same value and quarter the value of y	from +4 to +5
B	x and z are the same value and quarter the value of y	from +5 to +4
C	x and z are the same value and half the value of y	from +5 to +4
D	x and z are the same value and half the value of y	from +4 to +5

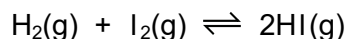
13 When some solid $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ is added to a beaker of water, an equilibrium is set up.



Which compound, when added to the equilibrium mixture, increases the amount of $\text{Ca}_5(\text{PO}_4)_3\text{OH}(\text{s})$ present?

- A** NH_3 **B** NH_4Cl **C** $\text{CH}_3\text{CO}_2\text{H}$ **D** NaCl

- 14 Gaseous hydrogen and gaseous iodine react to form gaseous hydrogen iodide.



In an experiment, 2.0 mol of hydrogen and 2.0 mol of iodine are placed in a sealed container of volume 1.0 dm^3 .

The K_c value for this reaction under the conditions used is 9.0.

How many moles of hydrogen iodide are present at equilibrium?

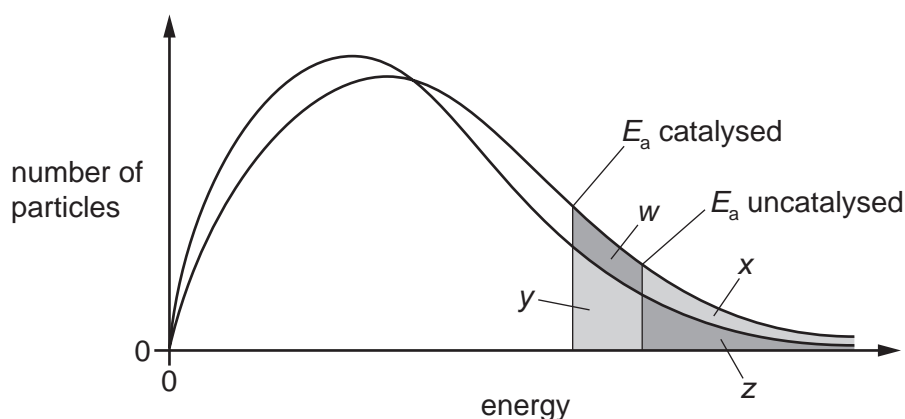
- A** 0.57 mol **B** 1.2 mol **C** 1.5 mol **D** 2.4 mol

- 15 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

- A** More particles have energy that exceeds the activation energy.
B The particles have more space in which to move.
C The particles move faster.
D There are more frequent collisions between particles.

- 16 The Boltzmann distribution for a mixture of gases capable of reaction is shown.

The two curves represent the mixture of gases at 25°C and at 35°C . The activation energies for the catalysed and uncatalysed reactions are shown.



Which row is correct?

	number of particles with enough energy to react at 25°C in the catalysed reaction	number of particles with enough energy to react at 35°C in the uncatalysed reaction
A	$w + x + y + z$	z
B	$w + x + y + z$	$x + z$
C	$y + z$	z
D	$y + z$	$x + z$

17 Which oxide is insoluble in aqueous sodium hydroxide?

- A** MgO **B** Al_2O_3 **C** P_4O_{10} **D** SO_2

18 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O ₂	S + O ₂
A	white flame	blue flame
B	white flame	yellow flame
C	yellow flame	blue flame
D	yellow flame	yellow flame

19 X and Y are elements in Period 3 of the Periodic Table.

Y has a greater atomic number than X.

The stable ion formed by Y has a greater radius than the stable ion formed by X.

The stable ion formed by Y has 18 electrons.

Which row is correct?

	number of electrons in the stable ion of X	element with the greater atomic radius
A	10	X
B	10	Y
C	18	X
D	18	Y

- 20 X is a Group 2 element in either Period 3 or Period 5. $X(OH)_2$ is less soluble in water than $Ca(OH)_2$.

When $X(NO_3)_2$ is heated, it decomposes.

Which row is correct?

	identity of X	equation describing decomposition of $X(NO_3)_2$
A	Mg	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
B	Mg	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$
C	Sr	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
D	Sr	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$

- 21 Which statement comparing magnesium and barium, or their compounds, is correct?

- A** Magnesium reacts with dilute hydrochloric acid more rapidly than barium does.
- B** One mole of magnesium carbonate gives off a greater amount of gas when it reacts with an excess of dilute hydrochloric acid than one mole of barium carbonate does.
- C** The solubility of magnesium sulfate in water is greater than the solubility of barium sulfate in water.
- D** Magnesium carbonate undergoes thermal decomposition **less** readily than barium carbonate does.

- 22 The colours of the silver halides $AgCl$, $AgBr$ and AgI differ.

The solubilities of these halides in aqueous ammonia also differ.

Which row is correct?

	colour of $AgBr$	silver halide that is most soluble in $NH_3(aq)$
A	cream	$AgCl$
B	cream	AgI
C	yellow	$AgCl$
D	yellow	AgI

- 23** The name 'chlorate' is used for an anion consisting of chlorine and oxygen only.

In a molecule of ICl , the iodine atom has oxidation number x and the chlorine atom has oxidation number y .

When ICl is added to H_2O , iodine is reduced.

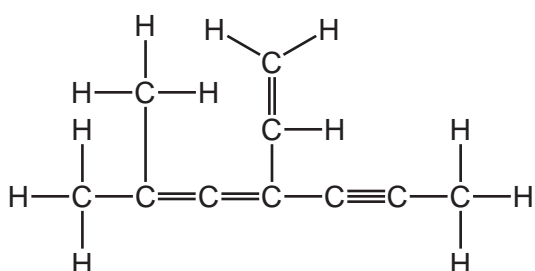


Which statement about the value of x or y is correct?

- A** x is the same as the oxidation number of Cl in the chlorate ion formed when $Cl_2(aq)$ is added to cold $NaOH(aq)$.
- B** x is the same as the oxidation number of Cl in the chlorate ion formed when $Cl_2(aq)$ is added to hot $NaOH(aq)$.
- C** y is the same as the oxidation number of Cl in the chlorate ion formed when $Cl_2(aq)$ is added to cold $NaOH(aq)$.
- D** y is the same as the oxidation number of Cl in the chlorate ion formed when $Cl_2(aq)$ is added to hot $NaOH(aq)$.
- 24** Which statement is correct?
- A** An ammonium ion is basic due to a lone pair of electrons on the nitrogen atom.
- B** Nitrogen monoxide, NO , reacts with peroxyacetyl nitrate to produce a component of photochemical smog.
- C** Nitrogen dioxide catalyses the oxidation of atmospheric sulfur dioxide.
- D** Nitrogen is very unreactive due to the very strong permanent dipole–permanent dipole attractions between the nitrogen atoms.

- 25** The diagram shows the structural formula of a hydrocarbon molecule Q.

molecule Q

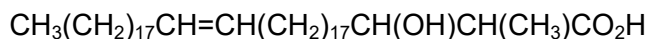


How many of the carbon atoms in molecule Q are sp^2 hybridised?

- A** 3 **B** 4 **C** 7 **D** 10

- 26 Compound X is found in cell walls of some bacteria. Its structural formula is shown.

compound X



How many stereoisomers are there with this structural formula?

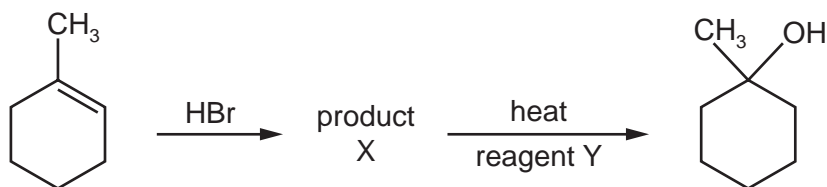
- A 2 B 4 C 6 D 8
- 27 Structural isomerism **only** should be considered when answering this question.

How many straight-chain isomers are there with molecular formula $\text{C}_4\text{H}_8\text{Cl}_2$?

- A 6 B 7 C 8 D 9
- 28 What is true of **every** nucleophile?

- A It attacks a double bond.
 B It donates a lone pair of electrons.
 C It is a single atom.
 D It is negatively charged.

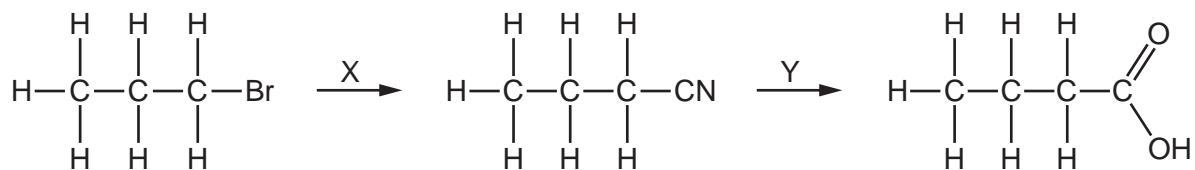
- 29 The diagram shows a synthetic route to produce 1-methylcyclohexanol.



What is reagent Y?

- A aqueous NaOH
 B cold dilute KMnO_4
 C ethanolic NaOH
 D hot concentrated KMnO_4

30 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of reagents X and Y?

	X	Y
A	NH ₃	HCl(aq)
B	KCN in C ₂ H ₅ OH	NaOH(aq)
C	KCN in C ₂ H ₅ OH	HCl(aq)
D	HCN	NaOH(aq)

31 The table shows three sets of reagents and reaction conditions.

	reagents	reaction conditions
1	CH ₂ C(CH ₃)CH ₃ and HCl(g)	room temperature
2	CH ₃ C(CH ₃)(OH)CH ₃ and SOCl ₂	room temperature
3	CH ₃ CH(CH ₃)CH ₃ and Cl ₂	the presence of ultraviolet light

Which sets of reagents and conditions can be used to produce 2-chloro-2-methylpropane as one of the organic products?

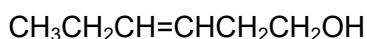
A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

32 What are the **only** structures formed when butan-2-ol is heated with concentrated H_2SO_4 ?

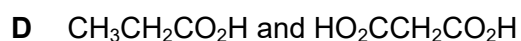
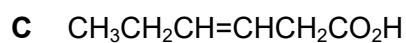
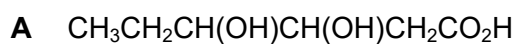
A	$\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{CH}_3 \end{array}$
B	$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{CH}_3 \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3\text{CH}_2 \quad \text{H} \end{array}$
C	$\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3\text{CH}_2 \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$
D	$\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$

33 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

leaf alcohol



What will be formed when 'leaf alcohol' is oxidised using an excess of hot acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$?



34 Compound X:

- does **not** react with Tollens' reagent
- forms a yellow precipitate with alkaline $I_2(aq)$
- does **not** react with sodium.

What could be the identity of X?

- A CH_3CHO
- B $C_2H_5COCH_3$
- C $CH_3COOC_2H_5$
- D $CH_3CHOHCH_3$

35 Which compound can undergo nucleophilic addition?

- A bromoethane, C_2H_5Br
- B ethanal, CH_3CHO
- C ethane, C_2H_6
- D ethene, C_2H_4

36 $C_2H_5COOCH_3$ is reacted with aqueous acid.

The products from this reaction are reacted with $LiAlH_4$ to form two molecules Y and Z.

What are the identities of molecules Y and Z?

- A both molecules are C_2H_5OH
- B CH_3OH and $CH_3CHOHCH_3$
- C CH_3OH and C_2H_5OH
- D CH_3OH and $C_2H_5CH_2OH$

37 A sample of propanoic acid of mass 3.70 g reacts with an excess of magnesium.

A second sample of propanoic acid of mass 3.70 g reacts with an excess of sodium.

Both reactions go to completion forming a gas.

Which row is correct?

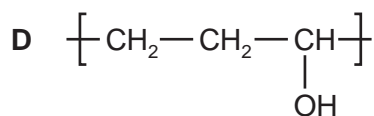
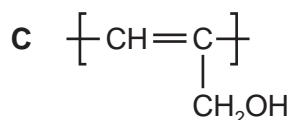
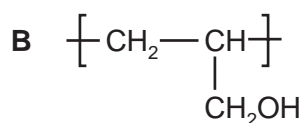
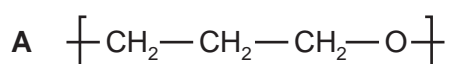
	volume of gas formed with magnesium at s.t.p. / cm ³	volume of gas formed with sodium at s.t.p. / cm ³
A	560	560
B	560	1120
C	1120	560
D	1120	1120

38 Which statement about $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{CH}_3$ is correct?

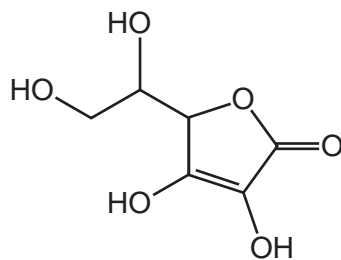
- A** It can be hydrolysed to a secondary alcohol.
- B** It can be made using ethanoic acid and a suitable alcohol.
- C** It gives a positive test with alkaline $\text{I}_2(\text{aq})$.
- D** When treated with hot concentrated acidified KMnO_4 it gives $\text{CH}_3\text{COCH}_2\text{COOH}$ as one product.

39 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $\text{CH}_2=\text{CHCH}_2\text{OH}$.

Which structure represents the repeat unit in the polymer poly(prop-2-en-1-ol)?



40 Vitamin C has the structure shown.



The mass spectrum of vitamin C has a molecular ion peak with an m/e value of 176 and a relative abundance of 7.0%.

What is the abundance of the $M + 1$ peak?

- A** 0.462% **B** 0.539% **C** 0.616% **D** 0.693%

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($4.18 \text{ J g}^{-1} \text{ K}^{-1}$)

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The Periodic Table of Elements

Group																	
1	2	Key										13	14	15	16	17	18
		atomic number atomic symbol name relative atomic mass															
3	4																
Li lithium 6.9	Be beryllium 9.0																
11	12																
Na sodium 23.0	Mg magnesium 24.3																
19	20																
K potassium 39.1	Ca calcium 40.1																
37	38																
Rb rubidium 85.5	Sr strontium 87.6																
55	56																
Cs caesium 132.9	Ba barium 137.3																
87	88																
Fr francium —	Ra radium —																
		3	4	5	6	7	8	9	10	11	12						
		Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4						
		39	40	41	42	43	44	45	46	47	48						
		Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4						
		57–71 lanthanoids	72	73	74	75	76	77	78	79	80						
			Hf hafnium 178.5	Ta tantalum 180.9	W tungsten 183.8	Re rhenium 186.2	Os osmium 190.2	Ir iridium 192.2	Pt platinum 195.1	Au gold 197.0	Hg mercury 200.6						
		89–103 actinoids	104	105	106	107	108	109	110	111	112						
			Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —						

lanthanoids

57	La	lanthanum	138.9
58	Ce	cerium	140.1
59	Pr	praseodymium	140.9
60	Nd	neodymium	144.2
61	Pm	promethium	—
62	Sm	samarium	150.4
63	Eu	europlum	152.0
64	Gd	gadolinium	157.3
65	Tb	terbium	158.9
66	Dy	dysprosium	162.5
67	Ho	holmium	164.9
68	Er	erbium	167.3
69	Tm	thulium	168.9
70	Yb	ytterbium	173.1
71	Lu	lutetium	175.0
72	Hf	hafnium	178.5
73	Ta	tantalum	180.9
74	W	tungsten	183.8
75	Re	rhenium	186.2
76	Os	osmium	190.2
77	Ir	iridium	192.2
78	Pt	platinum	195.1
79	Au	gold	197.0
80	Hg	mercury	200.6
81	Tl	thallium	204.4
82	Pb	lead	207.2
83	Bi	bismuth	209.0
84	Po	polonium	—
85	At	astatine	—
86	Rn	radon	—
87	Fr	francium	—
88	Ra	radium	—
89	Ac	actinium	227.0
90	Th	thorium	232.0
91	Pa	protactinium	231.0
92	U	uranium	238.0
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	—

actinoids