Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2025**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

1620770458

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.

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1 What is the electronic configuration for the particle $^{27}_{13}Al^{+}$?

A $1s^2 2s^2 2p^6 3s^1 3p^1$

B $1s^2 2s^2 2p^6 3s^2$

C $1s^2 2s^2 2p^6 3s^2 3p^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^1$

2 The data in the table gives the 5th to the 10th ionisation energies of three elements from Period 3 of the Periodic Table.

element	ionisation energy / kJ mol^{-1}					
	5th	6th	7th	8th	9th	10th
X	6274	21 269	25 398	29 855	35 868	40 960
Y	7012	8 496	27 107	31 671	36 579	43 140
Z	6542	9 362	11 018	33 606	38 601	43 963

What are the correct identities of these three elements?

	element X	element Y	element Z
A	Na	Mg	Al
B	Mg	Al	Si
C	P	S	Cl
D	S	Cl	Ar

3 What contains 9.03×10^{23} oxygen atoms?

A 0.25 mol aluminium oxide

B 0.75 mol sulfur dioxide

C 1.5 mol sulfur trioxide

D 3.0 mol water

4 Methane and steam react to produce hydrogen.

$$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$$

0.80 g of methane and 1.35 g of steam react. One of the reactants is used up.

Which volume of hydrogen, measured at room conditions, will be produced?

A 1.80 dm^3 **B** 3.60 dm^3 **C** 4.80 dm^3 **D** 7.20 dm^3

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5 Which statement explains why sodium and potassium have different melting points?

A The attraction between cations and delocalised electrons is stronger in sodium.

B The attraction between cations and anions is stronger in sodium.

C The attraction between atoms is stronger in sodium.

D The attraction between nuclei and shared electron pairs is stronger in sodium.

6 NH_3 and HCN react together to form NH_4CN, an ionic compound.

Which row states the number of coordinate bonds and the number of π bonds in one formula unit of NH_4CN?

	number of coordinate bonds	number of π bonds
A	0	2
B	1	2
C	0	3
D	1	3

7 When 1.0 mol of ethanoic acid, CH_3COOH, in aqueous solution is neutralised by an excess of aqueous sodium hydroxide, 55 kJ mol^{-1} of energy is released.

Which statement about this reaction is correct?

A The reaction is exothermic because only bond breaking takes place.

B The reaction is exothermic because only bond forming takes place.

C The reaction is exothermic because more energy is given out in breaking bonds than is taken in to form bonds.

D The reaction is exothermic because more energy is given out in forming bonds than is taken in to break bonds.

8 In an experiment, 1.60 g of a fuel is burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0 °C to 66.0 °C.

What is the total energy released per gram of fuel burnt?

A 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

9 Sulfite ions, SO_3^{2-}, react separately with zinc and with manganese dioxide.

a, *b*, *c*, *d*, *w*, *x*, *y* and *z* are all whole numbers.

$$a SO_3^{2-}(aq) + b H_2O(l) + Zn(s) \rightarrow Zn^{2+}(aq) + c OH^-(aq) + d S_2O_4^{2-}(aq)$$

$$MnO_2(s) + w SO_3^{2-}(aq) + x H^+(aq) \rightarrow Mn^{2+}(aq) + y S_2O_6^{2-}(aq) + z H_2O(l)$$

Which numbers are correct for *a*, *b*, *w* and *x*?

	a	*b*	*w*	*x*
A	1	2	2	4
B	2	2	2	4
C	1	2	4	2
D	2	2	4	2

10 Which equation shows hydrogen acting as an oxidising agent?

A $H_2 + 2K \rightarrow 2K^+H^-$

B $H_2 + I_2 \rightarrow 2HI$

C $H_2 + Cu_2S + ZnO \rightarrow 2Cu + ZnS + H_2O$

D $3H_2 + N_2 \rightarrow 2NH_3$

11 1.00 g of nitrogen gas is stored in a 2.00 dm^3 vessel at 40.0 °C.

What is the pressure in the vessel?

A 5940 Pa **B** 11 900 Pa **C** 46 400 Pa **D** 92 900 Pa

12 One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the equation shown.

$$Hb(aq) + 4O_2(aq) \rightleftharpoons Hb(O_2)_4(aq)$$

When the equilibrium concentration of O_2 is 7.6×10^{-6} mol dm^{-3}, the equilibrium concentrations of Hb and $Hb(O_2)_4$ are equal.

What is the numerical value of K_c for this equilibrium?

A 3.0×10^{20} **B** 1.3×10^{5} **C** 7.6×10^{-6} **D** 3.3×10^{-21}

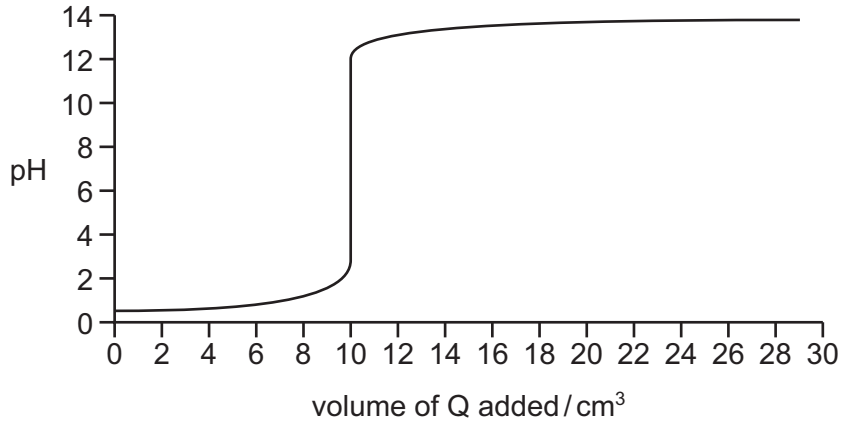
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13 Aqueous acid P and aqueous alkali Q have the same concentration.

$20\,cm^3$ of P is added to a conical flask.

Q is slowly added to the flask and the volume of Q and the pH are recorded.

The pH titration curve is shown.



Which row gives the identity of P and Q?

	P	Q
A	HCl	NaOH
B	H_2SO_4	NH_3
C	HCl	$Ba(OH)_2$
D	CH_3COOH	$Sr(OH)_2$

14 Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The darkness of the glass is due to the presence of silver atoms.

The following reactions are involved.

reaction 1 $Ag^+ + Cl^- \rightleftharpoons Ag + Cl$

reaction 2 $Cu^+ + Cl \rightarrow Cu^{2+} + Cl^-$

reaction 3 $Cu^{2+} + Ag \rightarrow Cu^+ + Ag^+$

Which statement about these reactions is correct?

A Cu^+ and Cu^{2+} ions act as catalysts.

B Cu^+ ions act as an oxidising agent in reaction 2.

C Reaction 3 increases the darkness of the glass.

D Silver atoms are reduced in reaction 3.

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15 The reversible reaction between methanol and ethanoic acid liquids is catalysed by adding a small volume of concentrated sulfuric acid.

Two statements about this reaction are listed.

1 The sulfuric acid is a homogeneous catalyst.

2 The sulfuric acid lowers the activation energy of the reverse reaction.

Which statements are correct?

A both 1 and 2

B 1 only

C 2 only

D neither 1 nor 2

16 The atomic radii and ionic radii for three elements in Period 3 are shown.

	atomic radius / nm	ionic radius / nm
element X	0.118	0.053
element Y	0.099	0.180
element Z	0.160	0.072

Using this data, which statement is correct?

A Element X has lower electrical conductivity than element Y.

B Element Y has a higher melting point than element X.

C Element Y and element Z react to form an ionic compound.

D Element Z forms ionic compounds by gaining electrons.

17 Three equations are listed. *x*, *y* and *z* are all whole numbers.

1 $x\mathrm{A}l + y\mathrm{O_2} \rightarrow z\mathrm{A}l_2\mathrm{O_3}$

2 $x\mathrm{Mg} + y\mathrm{O_2} \rightarrow z\mathrm{MgO}$

3 $x\mathrm{Na} + y\mathrm{O_2} \rightarrow z\mathrm{Na_2O}$

Which equations can be balanced if $x = 4$ and $z = 2$?

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

18 Which oxide has a simple structure rather than a giant structure?

A MgO **B** $\mathrm{A}l_2\mathrm{O_3}$ **C** $\mathrm{SiO_2}$ **D** $\mathrm{P_4O_{10}}$

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19 The trends seen in Group 2 can be used to predict the properties of radium and its compounds.

Which statement is correct?

A Radium has the highest second ionisation energy of the elements in Group 2.

B Radium hydroxide is the least soluble of the hydroxides of the elements in Group 2.

C Radium carbonate has the lowest thermal stability of the carbonates of the elements in Group 2.

D Radium reacts faster with water than the other elements in Group 2.

20 Equal masses of $CaCO_3$, $Ca(NO_3)_2$, $BaCO_3$ and $Ba(NO_3)_2$ are thermally decomposed. The volume of gas produced in each experiment is measured under the same conditions.

Which compound will produce the greatest volume of gas?

A $CaCO_3$ **B** $Ca(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

21 Equation 1 and equation 2 show two different reactions of halide ion Q^- with concentrated sulfuric acid.

equation 1 $H_2SO_4 + Q^- \rightarrow HSO_4^- + HQ$

equation 2 $H_2SO_4 + 2Q^- + 2H^+ \rightarrow SO_2 + Q_2 + 2H_2O$

What is Q?

A Cl^- or Br^- **B** Br^- or I^- **C** Cl^- only **D** I^- only

22 What happens when iodine solution is added to a solution of sodium bromide?

A A reaction occurs without changes in oxidation state.

B Bromide ions are oxidised; iodine atoms are reduced.

C Bromide ions are reduced; iodine atoms are oxidised.

D No reaction occurs.

23 Which statement is correct?

A Nitrogen is unreactive due to the absence of lone pairs in the molecule.

B Aqueous ammonia contains both $NH_3(aq)$ and $NH_4^+(aq)$. The $NH_4^+(aq)$ ion is a Brønsted–Lowry acid.

C High temperatures are needed to supply the energy to break the strong double bonds in nitrogen molecules when they react.

D Atmospheric SO_2 reacts with unburnt hydrocarbons to form a component of photochemical smog.

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24 When dry ammonia and hydrogen chloride gases are mixed, a solid white ionic compound is formed.

Two statements are listed.

1 The formation of the ionic compound is a redox reaction.

2 During the formation of the ionic compound, the H–N–H bond angle increases.

Which statements are correct?

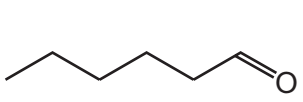
A both 1 and 2

B 1 only

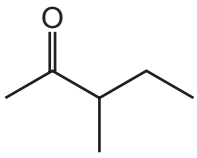
C 2 only

D neither 1 nor 2

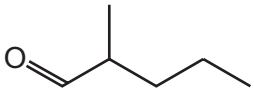
25 The diagrams show skeletal formulas of some isomers of $C_6H_{12}O$.



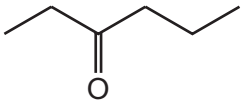
1



2



3



4

Which statement is correct?

A 1 and 3 are chain isomers of each other and positional isomers of each other.

B 2 and 3 are functional group isomers of each other and both have a chiral centre.

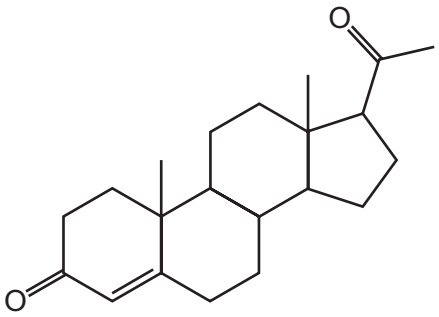
C 1 and 4 are functional group isomers of each other and both have a chiral centre.

D 2 and 4 are positional isomers of each other and functional group isomers of each other.

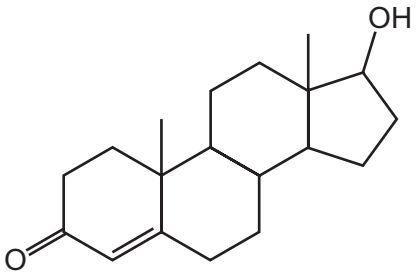
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26 The skeletal formulas of two compounds are shown.

progesterone



testosterone



Which statements about progesterone and testosterone are correct?

A They both contain a ketone group, and they both have geometrical isomers due to the C=C bond.

B They have the same molecular formula, and they both have geometrical isomers.

C They have the same number of chiral carbons, and they have the same molecular formula.

D They have the same number of chiral carbons, and they both contain a ketone group.

27 Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

A $CH_3CH^+CH_3$

B $CH_3CH_2CH_2^+$

C $CH_3CH^-CH_2Br$

D $CH_3CHBrCH_2^-$

28 Two hydrocarbons, $R–CH_3$ and $R'–CH_3$, react separately with bromine in the presence of ultraviolet light. One of these hydrocarbons is unsaturated.

In each case, free radical substitution reactions occur.

R is $CH_3CHC(CH_3)$.

R' is $CH_3CH(CH_3)CH_2$.

Which row is correct?

	a propagation stage for the saturated hydrocarbon	a termination stage for the unsaturated hydrocarbon
A	$R–CH_2• + Br• \rightarrow R–CH_2Br$	$R'–CH_2• + Br• \rightarrow R'–CH_2Br$
B	$R–CH_2• + Br_2 \rightarrow R–CH_2Br + Br•$	$R'–CH_2• + Br_2 \rightarrow R'–CH_2Br + Br•$
C	$R'–CH_3 + Br• \rightarrow R'–CH_2• + HBr$	$2R–CH_2• \rightarrow R–CH_2CH_2–R$
D	$2R'–CH_2• \rightarrow R'–CH_2CH_2–R'$	$R–CH_3 + Br• \rightarrow R–CH_2• + HBr$

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29 The fumes from the exhausts of petrol-burning cars contain the following pollutants.

1 unburnt hydrocarbons

2 nitrogen dioxide

3 carbon monoxide

Which pollutants are removed by oxidation in a catalytic converter?

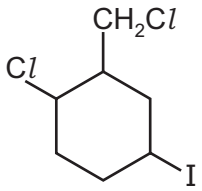
A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

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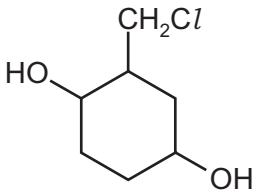
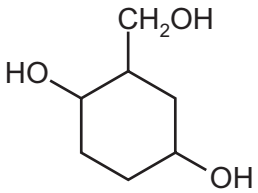
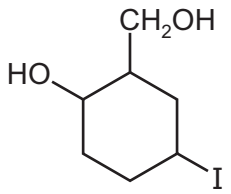
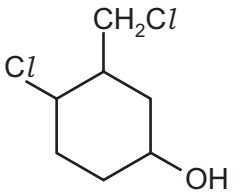
30 Compound X, $C_7H_{11}IC\mathit{l}_2$, is dissolved in ethanol and the solution mixed with warm aqueous silver nitrate.

A precipitate is seen immediately.

compound X



What is the colour of this precipitate and what is the structural formula of the **first** organic product?

	colour of the precipitate	structural formula of the **first** organic product
A	cream	
B	cream	
C	white	
D	yellow	

31 1,4-dibromobutane reacts with an excess of ethanolic sodium hydroxide until no further reaction takes place.

What is the relative formula mass of the major organic product?

A 54 **B** 56 **C** 74 **D** 90

32 A small section of a polymer produced from two monomers is shown.

$$–CH_2–C(CH_3)_2–CH(CH_3)–CH_2–$$

What are the two monomers?

A but-1-ene and propene

B but-2-ene and propene

C ethene and pent-2-ene

D methylpropene and propene

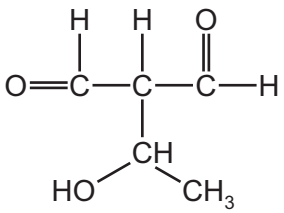
33 The balanced equation for the reaction of X with an excess of acidified $K_2Cr_2O_7$ is shown.

$$X + 3[O] \rightarrow Y + H_2O$$

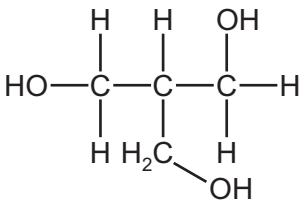
Compound Y is the only organic product of the reaction.

Which compound is X?

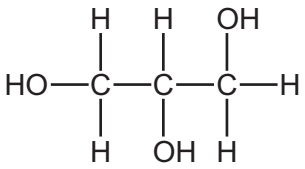
A



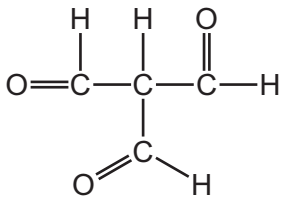
B



C



D



34 Three mixtures are heated under reflux.

Which mixtures will produce sodium propanoate as one product?

1 $CH_3CH_2CHO + NaBH_4(aq)$

2 $CH_3CH_2CH_2OH + Na(s)$

3 $CH_3CH_2CN + NaOH(aq)$

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

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35 Which compound is a product of the hydrolysis of $CH_3CO_2CH_2C_2H_5$ using aqueous sodium hydroxide?

A $CH_3CO_2^-Na^+$

B CH_3CO_2H

C $C_2H_5CH_2O^-Na^+$

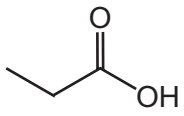
D $C_2H_5CH_2CO_2^-Na^+$

36 Compound Q reacts when heated with HCN in the presence of a catalyst to produce compound R.

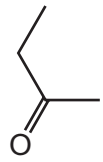
Molecules of compound R each contain four carbon atoms.

What is compound Q?

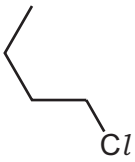
A



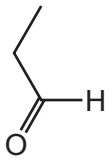
B



C



D



37 The table shows the reagents and products of three reactions.

	reagents	products
1	ethanoic acid + Na_2CO_3	$CH_3CO_2Na + H_2O + CO_2$
2	ethanoic acid + Mg	$(CH_3CO_2)_2Mg + H_2O$
3	ethanoic acid + CH_3OH	$CH_3CO_2CH_3 + H_2O$

Which rows are correct?

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

38 Seven aldehydes and ketones

- contain only **one** oxygen atom per molecule
- have four or fewer carbon atoms in their structures.

Alkaline I_2(aq) is added to each of these carbonyl compounds separately.

How many of these carbonyl compounds produce a yellow precipitate with alkaline I_2(aq)?

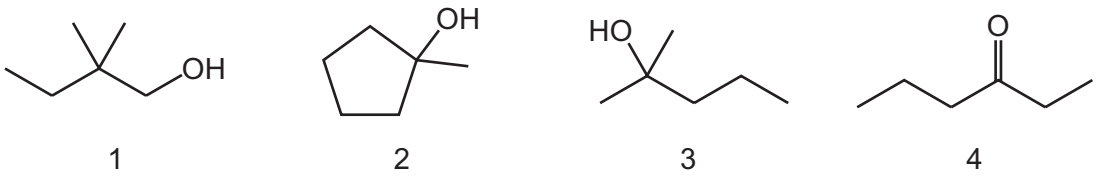
A 1 **B** 2 **C** 3 **D** 4

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39 Some properties of compound X are listed.

- 1.0 mol X reacts with exactly 8.5 mol oxygen when completely combusted.
- X does **not** react when heated with acidified $KMnO_4$.

What are the possible identities of X?



1 2 3 4

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

40 A sample of magnesium contains the isotopes ^{24}Mg, ^{25}Mg and ^{26}Mg only.

The percentage abundance of ^{25}Mg and ^{26}Mg is the same.

The relative atomic mass of magnesium in the sample is 24.3.

What is the percentage abundance of ^{24}Mg?

A 10% **B** 20% **C** 60% **D** 80%

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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	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	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 –	89–103 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 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 europium 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
actinoids	89 Ac actinium –	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 –