Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **February/March 2025**

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.

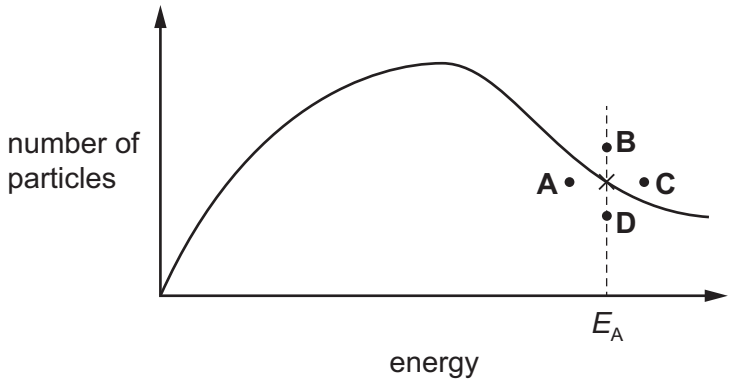
This document has **20** pages. Any blank pages are indicated.

1 A Boltzmann distribution for a sample of a reacting gas at a constant temperature is shown. The activation energy, E_A, for the reaction is marked.

Point × shows the number of particles whose energy is equal to the activation energy.

The temperature of the sample of gas is decreased. The shape of the distribution curve changes.

Which point could show the number of particles whose energy is the same as the activation energy at the new temperature?



2 Crystals of copper(II) nitrate are prepared by adding an excess of malachite to nitric acid.

The formula of malachite is $Cu(OH)_2 \cdot CuCO_3$. (M_r = 221.0)

12.0 g of malachite is added to 30.0 cm^3 of 1.50 mol dm^{-3} nitric acid.

Which mass of malachite is left unreacted when the reaction is complete?

A 2.05 g **B** 2.49 g **C** 7.03 g **D** 9.51 g

3 X and Y are elements from the same group of the Periodic Table.

The 5th to 9th ionisation energies for X and Y are shown.

	ionisation energy / kJ mol^{-1}				
	5th	6th	7th	8th	9th
element X	11 020	15 160	17 870	92 040	106 437
element Y	6 540	9 360	11 020	33 360	38 600

Which row identifies elements X and Y?

	element X	element Y
A	argon	neon
B	chlorine	fluorine
C	fluorine	chlorine
D	neon	argon

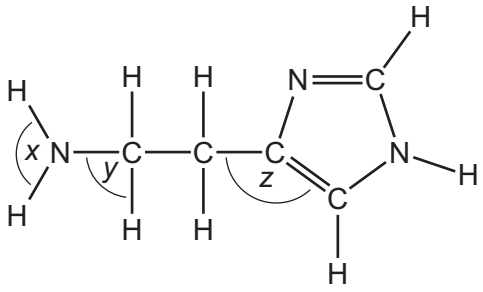
4 An ion with a charge of 2– contains 10 electrons and 14 neutrons.

What is its nucleon number?

A 14 **B** 22 **C** 24 **D** 26

5 The structure of the hormone histamine is shown.

histamine



Which row contains the bond angles *x*, *y* and *z* in histamine in the correct order from the smallest to the largest?

	smallest bond angle →		largest bond angle
A	*x*	*y*	*z*
B	*y*	*x*	*z*
C	*y*	*z*	*x*
D	*z*	*y*	*x*

6 When an organic acid reacts with an alcohol, a reversible reaction takes place producing an ester and water.

0.40 mol of an organic acid and 0.30 mol of an alcohol are mixed and allowed to stand at 25 °C until equilibrium is reached.

At equilibrium, 0.20 mol of ester is produced.

What is the value of the equilibrium constant, K_c, under the conditions used?

A 0.33 **B** 0.50 **C** 2.0 **D** 10

7 Information about two substances is given.

substance	electrical conductivity	effect of adding to water	melting point / K
P	good when solid and when molten	reacts vigorously to produce an alkaline solution	454
Q	does not conduct in any state	reacts vigorously to produce an acidic solution	317

Which row describes the structure and bonding in substances P and Q?

	P	Q
A	giant metallic	simple molecular
B	simple molecular	giant metallic
C	giant ionic	simple molecular
D	giant metallic	giant ionic

8 An excess of zinc reacts with $x\,cm^3$ of $2.00\,mol\,dm^{-3}$ hydrochloric acid.

The gas produced is dried and collected.

The gas occupies $1.534\,dm^3$ at 101 000 Pa and 293 K.

The gas produced behaves as an ideal gas.

What is the value of x?

A $31.8\,cm^3$ **B** $34.7\,cm^3$ **C** $63.6\,cm^3$ **D** $69.4\,cm^3$

9 An aqueous solution of hydrogen peroxide is placed in a flask and decomposes, as shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The total volume of oxygen gas evolved is $180\,cm^3$ after 90 seconds, measured under room conditions.

The rate of the reaction is calculated using the equation shown.

$$\text{rate} = \frac{\text{change in moles of } H_2O_2}{\text{time}}$$

What is the average rate of the reaction, measured in $mol\,min^{-1}$, over the duration of the experiment?

A 8.33×10^{-5} **B** 1.67×10^{-4} **C** 0.0050 **D** 0.010

10 Methanol is manufactured by reacting carbon dioxide and hydrogen together.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49\,kJ\,mol^{-1}$$

What increases the equilibrium yield of methanol in this process?

A increasing the pressure

B adding an excess of steam

C adding a catalyst

D increasing the temperature

11 The equation for a reaction of $KClO_3$ is shown.

$$4KClO_3 \rightarrow KCl + 3KClO_4$$

Which row is correct?

	disproportionation reaction	oxidation number of chlorine in $KClO_4$
A	yes	+4
B	yes	+7
C	no	+4
D	no	+7

12 A student mixes $25.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ sodium hydroxide solution with $25.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ hydrochloric acid and the student records a temperature rise of 2.50 °C.

What is the enthalpy change of the reaction per mole of NaOH?

A $-209\,kJ\,mol^{-1}$

B $-104.5\,kJ\,mol^{-1}$

C $-209\,J\,mol^{-1}$

D $-522.5\,J\,mol^{-1}$

13 Carbon monoxide and methanol can react together to form ethanoic acid.

$$CO(g) + CH_3OH(l) \xrightarrow{\Delta H_r^{\ominus}} CH_3CO_2H(l)$$

Standard enthalpy changes of combustion are given in the table.

compound	standard enthalpy change of combustion, $\Delta H_c^{\ominus}$
CO	$-283.0\,kJ\,mol^{-1}$
CH_3OH	$-726.0\,kJ\,mol^{-1}$
CH_3CO_2H	$-874.1\,kJ\,mol^{-1}$

What is the value for $\Delta H_r^{\ominus}$ for the reaction between carbon monoxide and methanol?

A $-1883.1\,kJ\,mol^{-1}$

B $-134.9\,kJ\,mol^{-1}$

C $+134.9\,kJ\,mol^{-1}$

D $+1883.1\,kJ\,mol^{-1}$

14 Copper reacts with nitric acid under certain conditions. The products are copper(II) nitrate, water and an oxide of nitrogen.

3 mol of copper reacts with exactly 8 mol of nitric acid.

What is the oxidation state of nitrogen in the oxide produced?

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

15 All the reactants and products of an exothermic reaction are gaseous.

Which statement about this reaction is correct?

A The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is negative.

B The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is positive.

C The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is negative.

D The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is positive.

16 Propene, hydrogen cyanide and carbon dioxide each contain π bonds.

Which molecules contain two π bonds?

A carbon dioxide and hydrogen cyanide

B carbon dioxide and propene

C hydrogen cyanide and propene

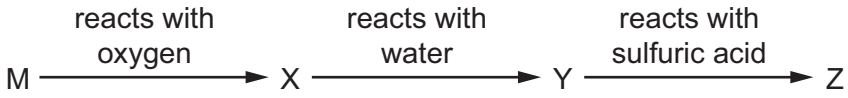
D hydrogen cyanide only

17 Q, R and S are consecutive elements in Period 3 of the Periodic Table. Element R has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of Q, R and S?

	Q	R	S
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

18 A reaction scheme for a Group 2 metal, M, is shown.



Which row is correct as M descends Group 2 from Mg to Ba?

	solubility of Y in water	solubility of Z in water
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

19 U, V and W represent different halogens. The table shows the results of nine experiments in which aqueous solutions of U_2, V_2 and W_2 were separately added to separate aqueous solutions containing U^-, V^- and W^- ions.

	$U^-(aq)$	$V^-(aq)$	$W^-(aq)$
$U_2(aq)$	no reaction	no reaction	no reaction
$V_2(aq)$	U_2 formed	no reaction	W_2 formed
$W_2(aq)$	U_2 formed	no reaction	no reaction

Which row contains the ions U^-, V^- and W^- in order of their **decreasing** strength as reducing agents?

	strongest →		weakest
A	U^-	V^-	W^-
B	U^-	W^-	V^-
C	V^-	W^-	U^-
D	W^-	U^-	V^-

20 J is either $MgCl_2$ or $AlCl_3$.

K is either SiO_2 or $SiCl_4$.

J(aq) —(add drops of aqueous sodium hydroxide)→ white precipitate —(add an excess of aqueous sodium hydroxide)→ precipitate dissolves

K —(add water)→ misty white fumes and a white precipitate in a solution with pH less than 7

Which row is correct?

	identity of J	identity of K
A	$AlCl_3$	$SiCl_4$
B	$AlCl_3$	SiO_2
C	$MgCl_2$	$SiCl_4$
D	$MgCl_2$	SiO_2

21 River water in an agricultural area contains NH_4^+, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. This water is treated by adding a calculated quantity of calcium hydroxide.

What is precipitated from the river water when calcium hydroxide is added?

A $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** NH_4OH

22 Four atmospheric pollutants are listed.

1 nitrogen oxides

2 carbon monoxide

3 unburnt hydrocarbons

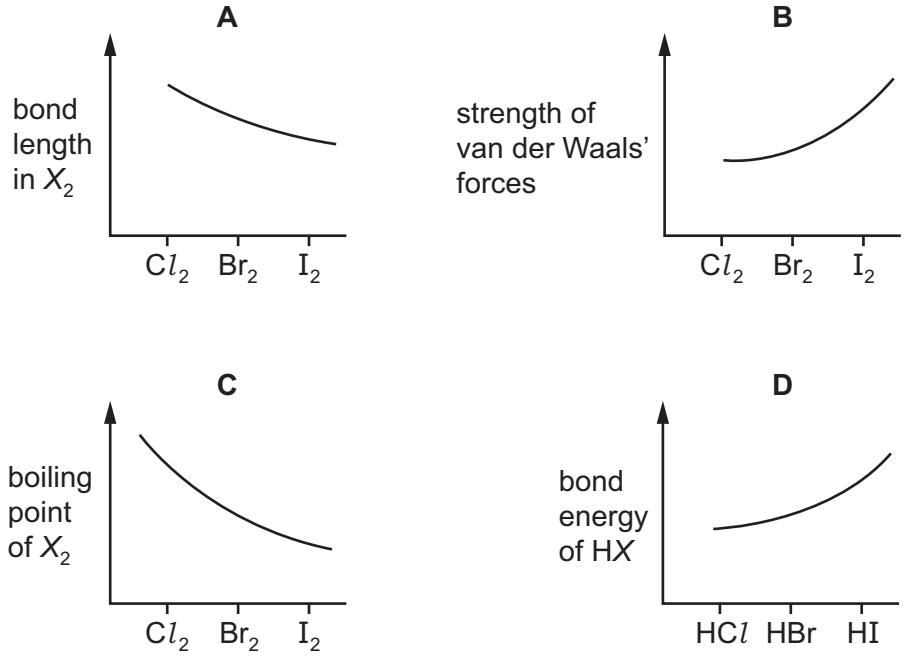
4 sulfur dioxide

Which pair of pollutants react to form peroxyacetyl nitrate, PAN?

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

23 Which graph correctly describes a trend found in Group 17?

[*X* represents a halogen atom.]



24 Gas M is produced when $NH_4Cl(aq)$ is heated with CaO(s).

Which row is correct?

	type of reaction	identity of M
A	acid–base	N_2
B	redox	NH_3
C	acid–base	NH_3
D	redox	N_2

25 Two nitrates decompose on heating according to the equations shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

$$2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(l)$$

One mole of each nitrate is heated separately. The gas produced in each reaction is bubbled through NaOH(aq).

The volume of any gas that does not react with NaOH(aq) is then collected and measured.

Which nitrate:

- shows the greater percentage loss in mass
- produces the greater volume of gas collected?

	greater percentage loss of mass	greater volume of gas collected
A	NH_4NO_3	NH_4NO_3
B	NH_4NO_3	$Pb(NO_3)_2$
C	$Pb(NO_3)_2$	NH_4NO_3
D	$Pb(NO_3)_2$	$Pb(NO_3)_2$

26 Organic compound X has the empirical formula C_2H_4O.

Compound X is reduced by $LiAlH_4$, but **not** by $NaBH_4$.

What is compound X?

A ethanoic acid

B ethanal

C butan-1-ol

D butanoic acid

27 What is the mechanism of the reaction of hydrogen cyanide with propanone?

A electrophilic addition

B electrophilic substitution

C nucleophilic addition

D nucleophilic substitution

28 Which compound may be synthesised from an alkene, with formula C_4H_8, by an addition reaction?

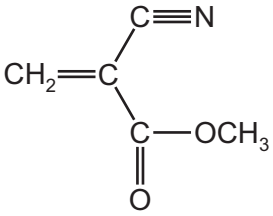
A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 1,3-dibromomethylpropane

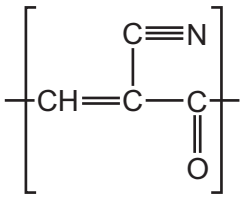
29 The structure of compound G is shown.



Compound G undergoes addition polymerisation.

Which diagram shows the repeat unit of the polymer formed?

A



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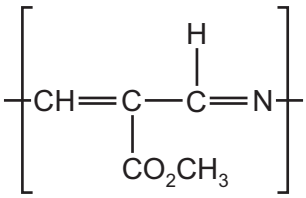

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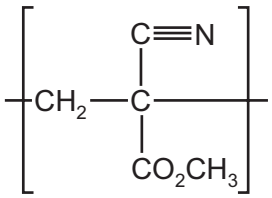
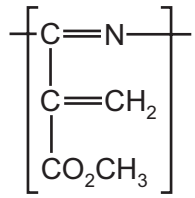


D



30 Compound T is tested with three reagents and gives the results shown.

reagent	result
2,4-DNPH	orange precipitate
Fehling's solution	no reaction
acidified $K_2Cr_2O_7$	no reaction

What is compound T?

A $(CH_3)_2CHCHO$

B $(CH_3)_2CHCH_2OH$

C $CH_3CH(OH)COCH_3$

D $(CH_3)_2CHCOCH_3$

31 Reagent X is added separately to 2-methylbutan-1-ol and 3-methylbutan-2-ol.

The visible results are different.

What is reagent X?

A Na(s)

B alkaline I_2(aq)

C PCl_5

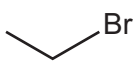
D acidified $KMnO_4$

32 Compound Y is hydrolysed by warm aqueous silver nitrate to form a precipitate that is soluble in dilute aqueous ammonia.

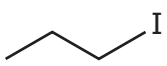
Compound Y undergoes an elimination reaction to form an alkene.

What is the skeletal formula of compound Y?

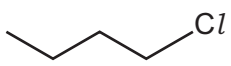
A



B



C



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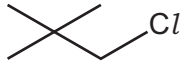
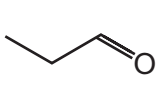


33 Propan-2-ol can be converted into 2-chloropropane using reagent M followed by reagent N.

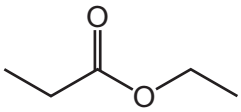
Which row is correct?

	reagent M	reagent N
A	concentrated NaOH	Cl_2
B	concentrated H_2SO_4	Cl_2
C	concentrated H_3PO_4	HCl
D	concentrated NaOH	HCl

34 Skeletal formulae of four organic compounds are shown.



1



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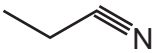

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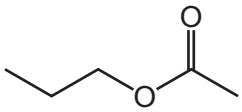


4

Which two compounds when separately heated with dilute sulfuric acid produce propanoic acid as one of the products?

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

35 1-chloro-2-methylpropane and 2-bromo-2-methylbutane react separately with aqueous silver nitrate in ethanol.

Both reactions proceed via nucleophilic substitution and a precipitate is formed.

The time taken for 1-chloro-2-methylpropane to form a precipitate is T_1.

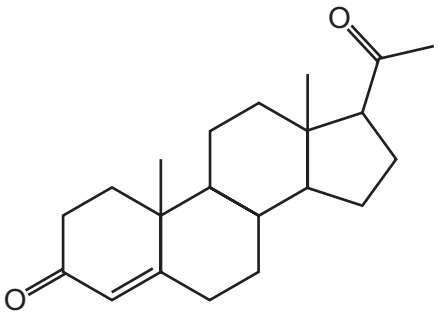
The time taken for 2-bromo-2-methylbutane to form a precipitate is T_2.

Which row is correct?

	compound	main reaction mechanism	time taken for precipitate to appear
A	1-chloro-2-methylpropane	S_N1	$T_2 > T_1$
B	1-chloro-2-methylpropane	S_N2	$T_1 > T_2$
C	2-bromo-2-methylbutane	S_N1	$T_2 > T_1$
D	2-bromo-2-methylbutane	S_N2	$T_1 > T_2$

36 The diagram shows the structure of progesterone.

progesterone



Which statement about progesterone is correct?

A One molecule contains four chiral carbon atoms only; the molecular formula is $C_{19}H_{26}O_2$.

B One molecule contains four chiral carbon atoms only; the molecular formula is $C_{21}H_{30}O_2$.

C One molecule contains six chiral carbon atoms; the molecular formula is $C_{19}H_{26}O_2$.

D One molecule contains six chiral carbon atoms; the molecular formula is $C_{21}H_{30}O_2$.

37 A molecule of hexane can be cracked in a number of different ways.

Three compounds are listed.

1 C_3H_8

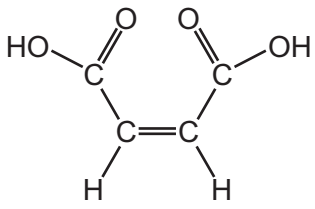
2 C_4H_8

3 C_5H_{12}

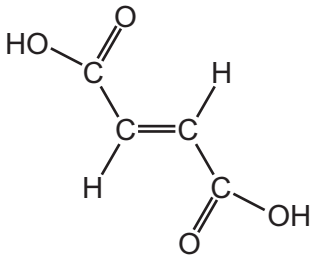
Which compounds are found in the mixture of products from the cracking of hexane molecules?

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

38 The diagrams show the structures of two isomeric dicarboxylic acids, X and Y.



X



Y

X can be reduced to compound P with empirical formula C_2H_5O.

Y can be reduced to compound Q, also with empirical formula C_2H_5O.

Which statement is correct?

A X is a cis isomer; compound P and compound Q are identical.

B X is a cis isomer; compound P and compound Q are isomers of each other.

C X is a trans isomer; compound P and compound Q are identical.

D X is a trans isomer; compound P and compound Q are isomers of each other.

39 What is the total number of sp^3 hybridised atomic orbitals used in the bonding of but-2-ene?

A 2 **B** 4 **C** 6 **D** 8

40 Compound L contains carbon atoms. It is analysed in a mass spectrometer.

The table shows the relative abundance of the only two peaks recorded with m/e greater than 127.

m/e	relative abundance
128	50
129	5.5

How many carbon atoms are present in one molecule of compound L?

A 5 **B** 7 **C** 8 **D** 10

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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	$L = 6.022 \times 10^{23}\,\text{mol}^{-1}$
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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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 –