Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 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 **16** pages.

1 Consider the following statements.

1 Silicon dioxide has a higher melting point than sulfur dioxide.

2 Ammonia has a higher boiling point than phosphine, PH_3.

Which statements are correct?

A both statement 1 and statement 2

B statement 1 only

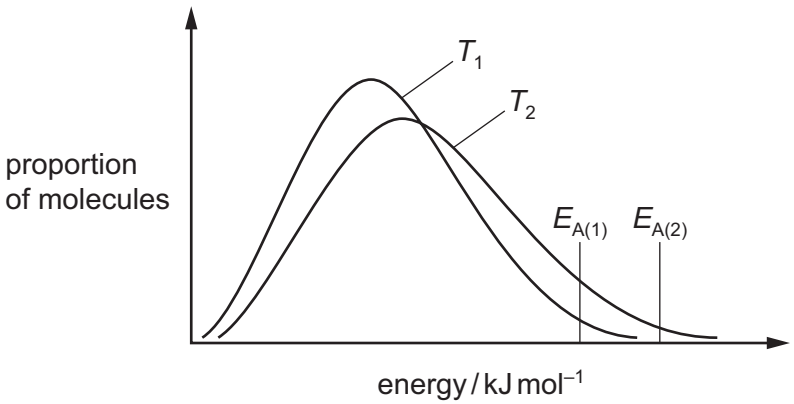
C statement 2 only

D neither statement 1 nor statement 2

2 How many neutrons are contained in an atom of iron with a mass number of 60?

A 26 **B** 30 **C** 34 **D** 60

3 The diagram shows a Boltzmann distribution of molecular energies for a gaseous reaction at two different temperatures and two different activation energies.



Which combination of temperature and activation energy will give the highest reaction rate?

A T_1 and $E_{A(1)}$ **B** T_1 and $E_{A(2)}$ **C** T_2 and $E_{A(2)}$ **D** T_2 and $E_{A(1)}$

4 The reaction between sulfur dioxide and oxygen has the equation shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197\,kJ\,mol^{-1}$$

1.0 mol of SO_2 and 1.0 mol of O_2 are placed in a closed container and heated to a constant temperature.

At this temperature, 0.8 mol of SO_3 are present in the equilibrium mixture.

Which statement is correct?

A The equilibrium partial pressure of SO_2 is greater than the equilibrium partial pressure of O_2.

B K_p has units of $mol\,dm^{-3}$.

C At a lower temperature, the equilibrium amount of SO_3 is lower than 0.8 mol.

D The mole fraction of SO_3 is less than 0.8.

5 'Red lead' is a red pigment with the formula Pb_3O_4. Every formula unit of 'red lead' is the same.

Each formula unit contains three lead ions and four oxide ions. Lead has two different oxidation states in 'red lead'.

What are the oxidation states of lead in 'red lead'?

A +1 and +2 **B** +1 and +3 **C** +2 and +4 **D** +2 and +6

6 Some standard enthalpy of combustion data are given.

substance	standard enthalpy change of combustion / $kJ\,mol^{-1}$
C(s)	–394
$H_2(g)$	–286
$CH_3OH(l)$	–726

Using these data, what is the enthalpy change of formation of methanol?

A $-240\,kJ\,mol^{-1}$ **B** $-46\,kJ\,mol^{-1}$ **C** $46\,kJ\,mol^{-1}$ **D** $240\,kJ\,mol^{-1}$

7 Which row is correct?

	smallest bond angle	⟶	largest bond angle
A	H_2O	NH_3	BF_3
B	BF_3	NH_3	H_2O
C	NH_3	H_2O	BF_3
D	H_2O	BF_3	NH_3

8 In the Haber process, the reaction between the two gaseous reactants requires the use of a catalyst that contains a transition element.

What is the metal and in which mole ratio do the gases react?

	metal	mole ratio
A	Fe	1 : 2
B	Fe	1 : 3
C	V	1 : 2
D	V	1 : 3

9 Aqueous hydrogen peroxide, H_2O_2, decomposes into water and oxygen in the presence of a suitable catalyst.

$50\,cm^3$ of a $0.50\,mol\,dm^{-3}$ solution of hydrogen peroxide produced $120\,cm^3$ of oxygen in 2.0 minutes.

The volume of gas was measured at room conditions.

What is the average rate of decomposition of hydrogen peroxide during this 2.0 minute period?

A $0.000083\,mol\,dm^{-3}\,s^{-1}$

B $0.00083\,mol\,dm^{-3}\,s^{-1}$

C $0.0017\,mol\,dm^{-3}\,s^{-1}$

D $0.10\,mol\,dm^{-3}\,s^{-1}$

10 The average intermolecular forces in water are much stronger than the average intermolecular forces in steam.

The average intermolecular forces in ice are slightly stronger than the average intermolecular forces in water.

Enthalpy changes are associated with the equilibrium processes shown.

$$H_2O(l) \rightleftharpoons H_2O(g) \qquad \Delta H_b$$

$$H_2O(s) \rightleftharpoons H_2O(l) \qquad \Delta H_m$$

Which statements are correct?

1 ΔH_b and ΔH_m are both negative.

2 ΔH_b is greater than ΔH_m.

3 The intermolecular forces in ice and water are of the same type.

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

11 An experiment is carried out to determine the value of x in hydrated lithium hydroxide, $LiOH•xH_2O$. A sample of the solid is heated in a crucible over a Bunsen flame.

Complete dehydration takes place; decomposition does **not** occur.

mass of empty crucible / g = Q

mass of crucible with $LiOH•xH_2O$ / g = R

mass of crucible and residue after heating / g = S

Which equation gives the correct value of x?

A $\frac{S-R}{18}$ **B** $\frac{R-S}{18}$ **C** $\frac{23.9(R-S)}{18(S-Q)}$ **D** $\frac{23.9(S-R)}{18(S-Q)}$

12 A sample of an ideal gas occupies 240 cm^3 at 37 °C and 100 kPa.

How many moles of gas are present in the sample?

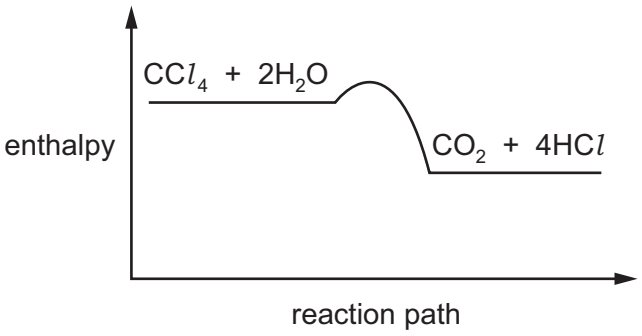
A 9.32×10^{-6} **B** 9.32×10^{-3} **C** 0.0781 **D** 78.1

13 Under certain conditions, CCl_4 and H_2O react as shown. The activation energy for the reaction is $+62\,kJ\,mol^{-1}$.

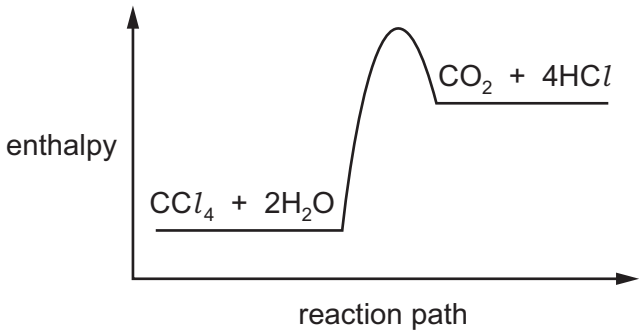
$$CCl_4 + 2H_2O \rightarrow CO_2 + 4HCl \qquad \Delta H = -61.5\,kJ\,mol^{-1}$$

Which enthalpy profile diagram best fits this reaction?

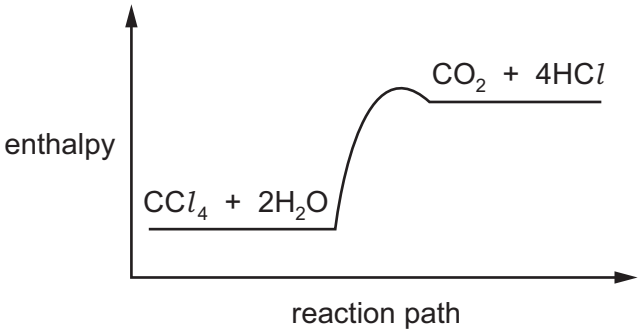
A



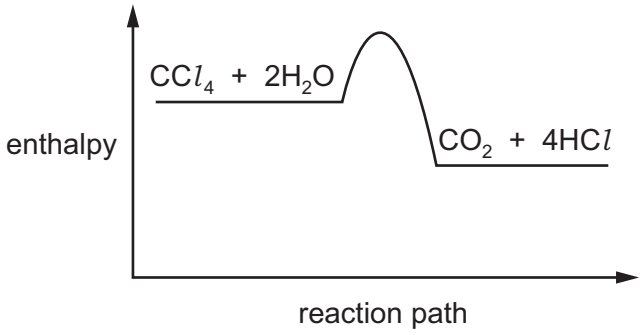
B



C



D

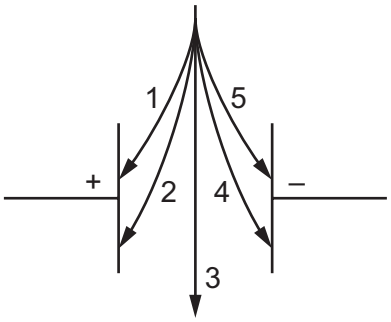


14 A helium ion contains two protons, two neutrons and one electron.

This helium ion and a proton are passed separately through a uniform electric field.

The particles are travelling at the same velocity.

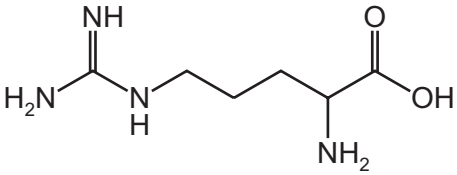
Which arrow describes the path of each particle?



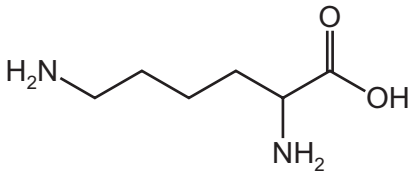
	helium ion	proton
A	1	2
B	2	1
C	4	5
D	5	4

15 The skeletal formulae of arginine and lysine are shown.

arginine



lysine



Which row is correct?

	substance	empirical formula	M_r
A	arginine	$C_3H_7N_2O$	174
B	arginine	$C_3H_8N_2O$	176
C	lysine	C_3H_7NO	144
D	lysine	C_3H_8NO	146

16 The oxide and chloride of an element X are separately mixed with water. The two resulting solutions have the same effect on litmus.

What could element X be?

A A*l* **B** Ca **C** Na **D** P

17 Why do the halogens become less volatile as Group 17 is descended?

A The halogen–halogen bond energy decreases.

B The halogen–halogen bond energy increases.

C The number of electrons in each molecule increases.

D The van der Waals' forces between molecules become weaker.

18 Compound M is a white solid. It is the chloride of a Period 3 element.

Information about some reactions starting with compound M is given in the table.

reaction	observation
compound M + non-polar solvent	colourless solution
compound M added a little at a time to water	steamy fumes, Q colourless solution, R
fumes Q tested with moist blue litmus paper	paper turns red
solution R + a few drops of NaOH(aq) + excess NaOH(aq)	white precipitate dissolves to give a colourless solution

What is compound M?

A aluminium chloride

B magnesium chloride

C phosphorus pentachloride

D sodium chloride

19 Which statement about strontium and its compounds is correct?

A Strontium hydroxide is more soluble than barium hydroxide.

B Strontium sulfate is more soluble than magnesium sulfate.

C Strontium nitrate has a lower thermal stability than calcium nitrate.

D Strontium is a stronger reducing agent than magnesium.

20 Sodium bromide is warmed with concentrated sulfuric acid.

Which row describes the change in the oxidation number of the sulfur and the role of the bromide ions in the reaction?

	change in oxidation number of sulfur	role of bromide ions
A	+6 to +4	oxidising agent
B	+6 to +4	reducing agent
C	+4 to 0	oxidising agent
D	+4 to 0	reducing agent

21 A reaction occurs when ammonium chloride is added to calcium hydroxide.

What is the role of the ammonium ions in this reaction?

A acid

B base

C oxidising agent

D reducing agent

22 Elements Y and Z are both in Period 3. Element Y has the smallest atomic radius in Period 3.

There are only two elements in Period 3 that have a lower melting point than element Z.

Elements Y and Z react together to form compound R.

Which compound could be R?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

23 1.0 g of each of four different compounds of Group 2 elements are thermally decomposed. The residue in each decomposition is the oxide of the Group 2 element.

The volume of gas produced from each reaction is measured at room conditions.

Which substance produces the greatest volume of gas?

A calcium carbonate

B calcium nitrate

C strontium carbonate

D strontium nitrate

24 Sulfur dioxide in the atmosphere can form acid rain. This occurs in two steps.

1 oxidation of SO_2 to SO_3

2 formation of dilute H_2SO_4

Which row identifies the atmospheric catalyst for step 1 and the reagent for step 2?

	catalyst	reagent
A	O_2	H_2O
B	O_2	O_2
C	NO_2	H_2O
D	NO_2	O_2

25 Which statement about the mechanism of an S_N1 reaction of a halogenoalkane is correct?

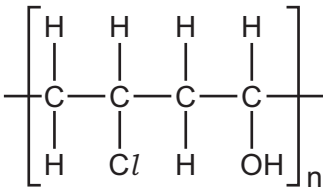
A A nucleophile is substituted by an electrophile.

B One intermediate is formed from two reacting molecules.

C The intermediate is stabilised by adjacent alkyl groups.

D The intermediate is uncharged.

26 The repeat unit of a polymer is shown.



Three statements about this polymer are listed.

1 Its disposal is hazardous because it produces toxic gases when burned.

2 Two different monomers are used to make this polymer.

3 The monomer for this polymer is 3-chlorobut-2-ene-1-ol.

Which statements are correct?

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

27 Methanoic acid, HCO_2H, has acidic properties similar to those of other carboxylic acids. In addition, it can be oxidised by the same oxidising agents that are capable of oxidising aldehydes.

Which pair consists of two compounds that will give the same observations with Fehling's reagent?

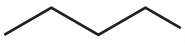
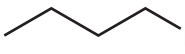
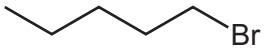
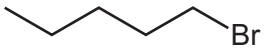
A HCO_2H and CH_3CO_2H

B HCO_2H and $CH_3CO_2CH_3$

C HCO_2H and $CH_3CH_2COCH_3$

D HCO_2H and CH_3CH_2CHO

28 Which row gives pentanenitrile as one product?

	halogenoalkane	reagents and conditions
A		heat with HCN
B		heat with KCN using ethanol as solvent
C		heat with HCN
D		heat with KCN using ethanol as solvent

29 An ester, $R'CO_2R''$, is hydrolysed in alkaline conditions. R' and R" are different alkyl groups.

Which row identifies the two products formed?

	product 1	product 2
A	$R'CO_2H$	R"OH
B	$R'CO_2^-$	R"OH
C	$R'CO_2H$	$R''O^-$
D	$R'CO_2^-$	$R''O^-$

30 Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?

A $(CH_3)_3COH$

B $CH_3COCH_2CH_3$

C $CH_3CH_2CH_2CH_2OH$

D $CH_3CH_2CH(OH)CH_3$

31 Butan-2-one reacts with alkaline I_2(aq). An excess of dilute sulfuric acid is then added to the reaction mixture.

The organic products of this reaction sequence are triiodomethane and product M.

What is product M?

A ethanoate ion

B ethanoic acid

C propanoate ion

D propanoic acid

32 Four reagents are listed.

1 aqueous KCl

2 dilute HCl

3 liquid SOCl_2

4 solid PCl_5

Which reagents, when added to ethanol, will rapidly produce a gas that turns blue litmus red?

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

33 Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane are put separately into three test-tubes containing 1.0 cm^3 of aqueous silver nitrate at 60 °C. In each case, a hydrolysis reaction occurs.

$$H_2O(l) + R–X(l) + Ag^+(aq) \rightarrow R–OH(aq) + AgX(s) + H^+(aq)$$

R represents C_4H_9 and X represents the halogen atom.

The rate of formation of cloudiness in the test-tubes is in the order RCl < RBr < RI.

Why is this?

A The bond energy of R–X decreases from RCl to RI.

B The first ionisation energy of the halogen decreases from Cl to I.

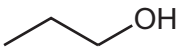
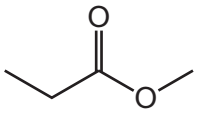
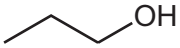
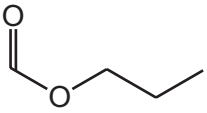
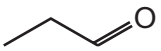
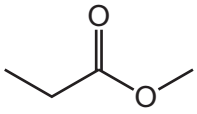
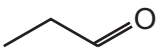
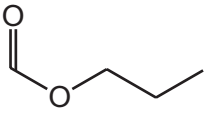
C The solubility of AgX(s) decreases from AgCl to AgI.

D The R–X bond polarity decreases from RCl to RI.

34 Propanoic acid reacts with $LiAlH_4$ to give organic product P.

Methanoic acid reacts with organic product P, in the presence of a few drops of concentrated sulfuric acid, to give organic product Q.

What are the skeletal formulae of the two organic products?

	organic product P	organic product Q
A		
B		
C		
D		

35 Samples of the gases CH_3Cl and Cl_2 are mixed together and irradiated with ultraviolet light.

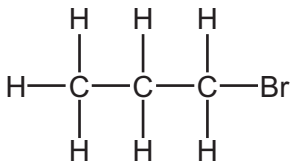
Which compound is produced by a termination step in the reaction?

A HCl **B** $CH_2{=}CH_2$ **C** CH_2ClCH_2Cl **D** H_2

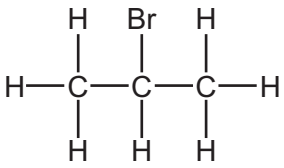
36 Propan-1-ol, C_3H_7OH, is dehydrated by passing its vapour over hot aluminium oxide to give a hydrocarbon.

Which structural formula represents the product obtained when the hydrocarbon reacts with bromine?

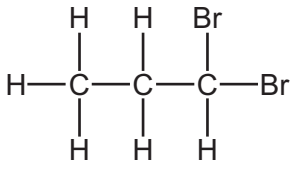
A



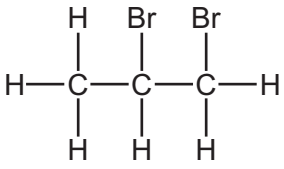
B



C



D



37 Alkane S has molecular formula C_4H_{10}.

S reacts with Cl_2(g) in the presence of sunlight to produce only two different monochloroalkanes, C_4H_9Cl. Both of these monochloroalkanes are treated with hot ethanolic KOH. They both produce the same alkene T, and no other organic products.

What is produced when T is treated with hot concentrated acidified $KMnO_4$?

A CO_2 and $CH_3CH_2CO_2H$

B CO_2 and CH_3COCH_3

C HCO_2H and CH_3COCH_3

D CH_3CO_2H only

38 Including structural isomers and stereoisomers, how many isomers are there of $C_2H_2Br_2$?

A 2 **B** 3 **C** 4 **D** 5

39 Which compound exhibits stereoisomerism?

A 1,1-dichloropropene

B 2,3-dichloropropene

C 1,2-dichloropropane

D 1,3-dichloropropane

40 The mass spectrum of CH_3Cl shows a molecular ion peak, M^+, at the m/e value of 50 with a relative abundance of 18.0%.

Other peaks are present in the mass spectrum.

What is seen in the mass spectrum at the m/e value of 52?

A a peak with relative abundance of 4.5%

B a peak with relative abundance of 6.0%

C a peak with relative abundance of 18.0%

D a peak with relative abundance of 54.0%

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 –