Cambridge Assessment International Education

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.

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[Turn over

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

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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 $C(g) + 2H_2(g) \rightarrow CH_4(g)$

B $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g)$

C $Na_2O(s) + SO_3(g) \rightarrow Na_2SO_4(s)$

D $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$

10 Two standard enthalpy change of formation values are given.

$$\Delta H_f^{\ominus} [VCl_2] = -452\ kJ\ mol^{-1}$$

$$\Delta H_f^{\ominus} [VCl_3] = -573\ kJ\ mol^{-1}$$

What is the enthalpy change for the reaction $3VCl_2 \rightarrow 2VCl_3 + V$?

A –210 kJ mol^{-1} **B** –121 kJ mol^{-1} **C** +121 kJ mol^{-1} **D** +210 kJ mol^{-1}

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11 Equations for some reactions of hydrogen peroxide are given.

1 $2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$

2 $2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

3 $2Fe^{3+} + H_2O_2 + 2OH^- \rightarrow 2Fe^{2+} + O_2 + 2H_2O$

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, $S_2O_3^{2-}$, and aqueous dioxo-vanadium ions, VO_2^+, is shown.

$$2S_2O_3^{2-} + xVO_2^+ + yH^+ \rightarrow S_4O_6^{2-} + zVO^{2+} + 2H_2O$$

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 $Ca_5(PO_4)_3OH$ is added to a beaker of water, an equilibrium is set up.

$$Ca_5(PO_4)_3OH(s) \rightleftharpoons 5Ca^{2+}(aq) + 3PO_4^{3-}(aq) + OH^-(aq)$$

Which compound, when added to the equilibrium mixture, increases the amount of $Ca_5(PO_4)_3OH(s)$ present?

A NH_3 **B** NH_4Cl **C** CH_3CO_2H **D** $NaCl$

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

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

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.

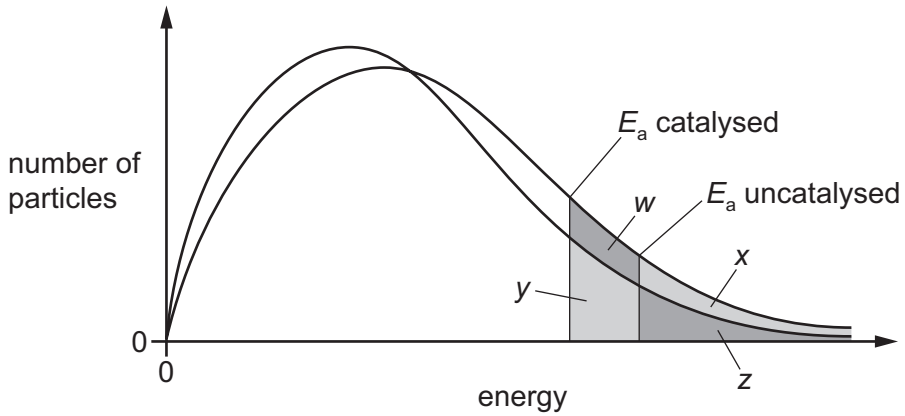
B The particles have more space in which to move.

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

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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 AgC*l*, 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	AgC*l*
B	cream	AgI
C	yellow	AgC*l*
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.

$$4ICl + 2H_2O \rightarrow 4HCl + O_2 + 2I_2$$

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.

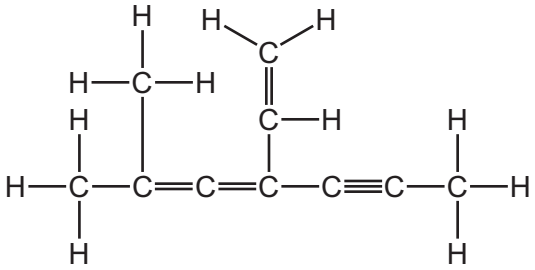
B Nitrogen monoxide, NO, reacts with peroxyacetyl nitrate to produce a component of photochemical smog.

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

$CH_3(CH_2)_{17}CH{=}CH(CH_2)_{17}CH(OH)CH(CH_3)CO_2H$

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 $C_4H_8Cl_2$?

A 6 **B** 7 **C** 8 **D** 9

28 What is true of **every** nucleophile?

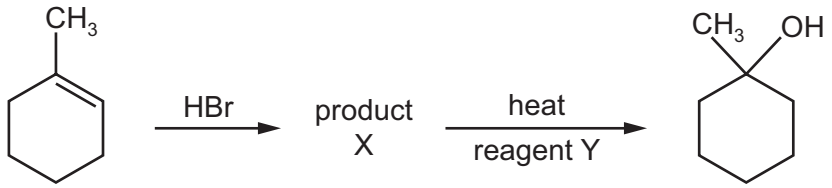
A It attacks a double bond.

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?

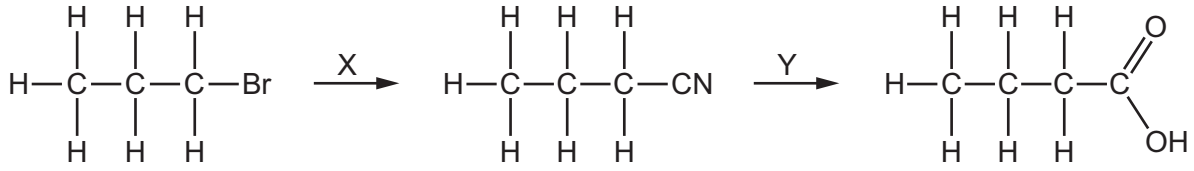
A aqueous NaOH

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_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HCl(aq)
D	HCN	NaOH(aq)

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

	reagents	reaction conditions
1	$CH_2C(CH_3)CH_3$ and HCl(g)	room temperature
2	$CH_3C(CH_3)(OH)CH_3$ and SOCl_2	room temperature
3	$CH_3CH(CH_3)CH_3$ 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

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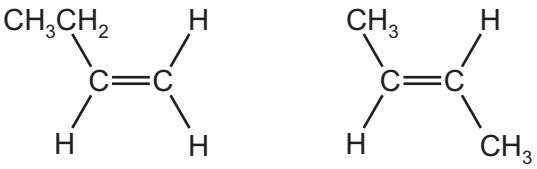
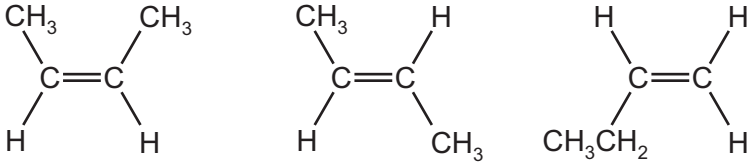
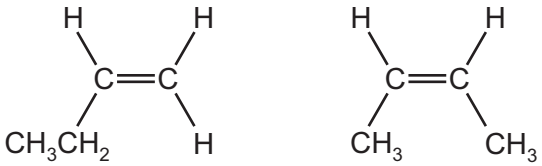
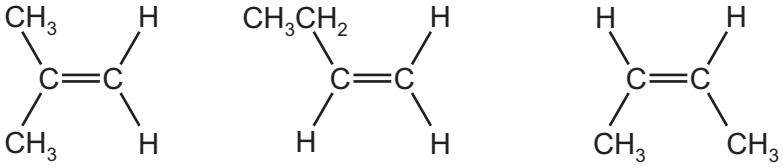
32 What are the **only** structures formed when butan-2-ol is heated with concentrated H_2SO_4?

A	
B	
C	
D	

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

leaf alcohol

$CH_3CH_2CH{=}CHCH_2CH_2OH$

What will be formed when 'leaf alcohol' is oxidised using an excess of hot acidified $K_2Cr_2O_7(aq)$?

A $CH_3CH_2CH(OH)CH(OH)CH_2CO_2H$

B $CH_3CH_2COCOCH_2CO_2H$

C $CH_3CH_2CH{=}CHCH_2CO_2H$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

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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 $C_2H_5CH_2OH$

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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 $H_2C{=}C(CH_3)CH_2CO_2CH_3$ is correct?

A It can be hydrolysed to a secondary alcohol.

B It can be made using ethanoic acid and a suitable alcohol.

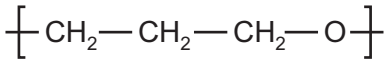
C It gives a positive test with alkaline I_2(aq).

D When treated with hot concentrated acidified $KMnO_4$ it gives CH_3COCH_2COOH as one product.

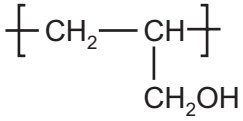
39 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2{=}CHCH_2OH$.

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

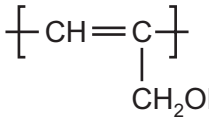
A



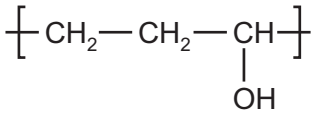
B



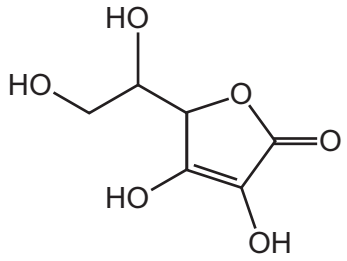
C



D



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%

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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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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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 –