Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2023**

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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1 When chlorine gas is analysed in a mass spectrometer $^{35}Cl^+$ ions are detected.

Which row is correct?

	number of neutrons in $^{35}Cl^+$	electronic configuration of $^{35}Cl^+$
A	17	$1s^2 2s^2 2p^6 3s^2 3p^4$
B	17	$1s^2 2s^2 2p^6 3s^2 3p^6$
C	18	$1s^2 2s^2 2p^6 3s^2 3p^4$
D	18	$1s^2 2s^2 2p^6 3s^2 3p^6$

2 Which species is a free radical?

A He **B** Be^- **C** O^{2-} **D** Zn

3 Which statement is correct?

A The first ionisation energy of chlorine is more than the first ionisation energy of argon.

B The second ionisation energy of calcium is more than the second ionisation energy of magnesium.

C The second ionisation energy of sulfur is equal to the first ionisation energy of phosphorus.

D The eighth ionisation energy of chlorine is more than the first ionisation energy of neon.

4 If 1 mole of hexane combusts in an excess of oxygen, how many moles of products are formed?

A 11 **B** 12 **C** 13 **D** 14

5 Separate samples, each of mass 1.0 g, of the compounds listed are treated with an excess of dilute acid.

Which compound releases the largest amount of CO_2?

A 1.0 g $CaCO_3$ **B** 1.0 g Li_2CO_3 **C** 1.0 g $MgCO_3$ **D** 1.0 g Na_2CO_3

6 Which statement about the C*l*–N=O molecule is correct?

A Each molecule contains one σ and two π bonds.

B It is a non-polar molecule.

C It is a linear molecule.

D The nitrogen atom is sp^2 hybridised .

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7 Which row is correct?

	molecule	shape	total number of pairs of electrons in the valence shell of the central atom
A	CO_2	linear	two
B	BF_3	trigonal planar	three
C	NH_3	regular tetrahedral	four
D	PF_5	octahedral	six

8 The volume of a vessel is $1.20 \times 10^{-3}\,m^3$. It contains pure argon at a pressure of $1.00 \times 10^5\,Pa$, and at a temperature of 25.0 °C. Under these conditions it can be assumed that argon behaves as an ideal gas.

Which mass of argon does it contain?

A 0.0485 g **B** 1.93 g **C** 10.4 g **D** 23.0 g

9 A student mixed $25.0\,cm^3$ of $4.00\,mol\,dm^{-3}$ hydrochloric acid with an equal volume of $4.00\,mol\,dm^{-3}$ sodium hydroxide. The initial temperature of both solutions was 15.0 °C. The maximum temperature recorded was 30.0 °C. The heat capacity of the final solution can be assumed to be $4.18\,J\,K^{-1}\,g^{-1}$ and the density of this solution can be assumed to be $1.00\,g\,cm^{-3}$.

Using these results, what is the enthalpy change of neutralisation of hydrochloric acid?

A $-62.7\,kJ\,mol^{-1}$

B $-31.4\,kJ\,mol^{-1}$

C $-15.7\,kJ\,mol^{-1}$

D $-3.14\,kJ\,mol^{-1}$

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10 Nitrogen monoxide is rapidly oxidised to nitrogen dioxide.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

Nitrogen dioxide can then dimerise to form dinitrogen tetroxide.

$$2NO_2(g) \rightarrow N_2O_4(g) \qquad \Delta H^{\ominus} = -58\,kJ\,mol^{-1}$$

$$\Delta H_f^{\ominus}NO = +91\,kJ\,mol^{-1} \text{ and } \Delta H_f^{\ominus}NO_2 = +34\,kJ\,mol^{-1}$$

What is the value of the standard enthalpy change for the reaction shown?

$$2NO(g) + O_2(g) \rightarrow N_2O_4(g)$$

A $+56\,kJ\,mol^{-1}$ **B** $-1\,kJ\,mol^{-1}$ **C** $-115\,kJ\,mol^{-1}$ **D** $-172\,kJ\,mol^{-1}$

11 $LiAlH_4$ contains AlH_4^- ions in which aluminium has an oxidation state of +3.

$LiAlH_4$ reacts with water, as shown.

$$LiAlH_4 + 4H_2O \rightarrow 4H_2 + LiOH + Al(OH)_3$$

In this reaction, each of the four water molecules produces one hydroxide ion. It does this by losing one H^+ ion, which reacts with the $LiAlH_4$.

Which changes in oxidation number occur in this reaction?

A Al increases by 1 and H decreases by 1.

B H decreases by 2 and also increases by 1.

C H increases by 1 and also decreases by 1.

D O decreases by 1 and H increases by 1.

12 The vanadium salt, $VOSO_4$, is soluble in water and reacts readily with powdered manganese in dilute sulfuric acid.

The equation for the reaction is shown.

$$Mn(s) + 2VOSO_4(aq) + 2H_2SO_4(aq) \rightarrow V_2(SO_4)_3(aq) + MnSO_4(aq) + 2H_2O(l)$$

Which statement about this reaction is correct?

A Hydrogen is oxidised in the reaction.

B Manganese is the reducing agent in this reaction.

C Sulfuric acid is the oxidising agent in this reaction.

D The oxidation state of the vanadium changes from +5 to +3.

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13 In which equilibrium will an increase in pressure at constant temperature increase the yield of the products on the right-hand side of the equation?

A $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

B $4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g)$

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

D $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

14 Hydrogen iodide is added to an evacuated reaction vessel. The vessel is sealed and warmed. A decomposition reaction occurs. Hydrogen and iodine are formed. Some hydrogen iodide remains.

When equilibrium is established, the total pressure is 1.20×10^5 Pa. The partial pressure of hydrogen is 4.00×10^3 Pa.

Hydrogen iodide, hydrogen and iodine are all gaseous under the conditions used.

What is the value of K_p for the equilibrium at this temperature, assuming the decomposition is the forward reaction?

A 1.19×10^{-3} **B** 1.28×10^{-3} **C** 1.38×10^{-3} **D** 1.43×10^{-3}

15 The equations for two reactions are shown.

reaction X $2NOBr \rightarrow 2NO + Br_2$

reaction Y $2NOCl \rightarrow 2NO + Cl_2$

The two reactions have similar reaction mechanisms.

The initial rate of reaction X is greater than that of reaction Y when measured under identical conditions of temperature, pressure and reactant concentration.

Which statements explain this difference?

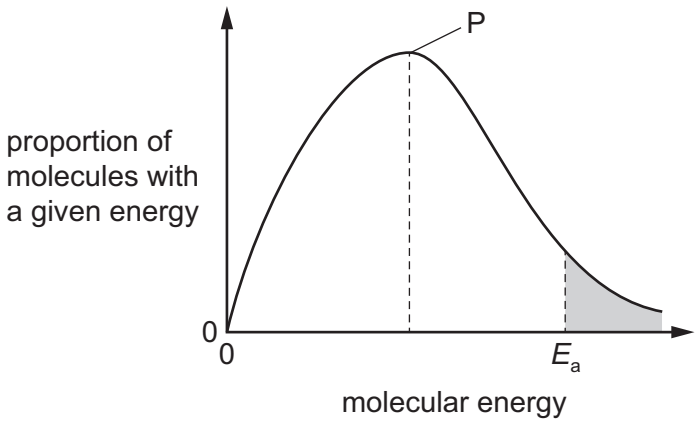
1 The activation energy for reaction X is less than that of reaction Y.

2 The Br−Br bond is weaker than the Cl−Cl bond.

3 A higher frequency of collisions between molecules of NOBr occur than between molecules of NOCl.

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

16 The diagram shows the Boltzmann distribution of energies in a gas. The gas can take part in a reaction with an activation energy, E_a. The gas is maintained at a constant temperature.



Which statement is correct?

A If a catalyst is added, peak P will be lower and E_a will move to the left.

B If a catalyst is added, peak P will be lower and E_a will move to the right.

C If a catalyst is added, peak P will be the same and E_a will move to the left.

D If a catalyst is added, peak P will be the same and E_a will move to the right.

17 L, M and N are three different elements from Period 3 of the Periodic Table.

L is the element whose atoms have three unpaired electrons in its 3p sub-shell.

M is the element with the highest electrical conductivity in the period.

N is the element with the highest melting point in the period.

Which statement about element L is correct?

A L has a higher atomic number than M and a lower atomic number than N.

B L has a lower atomic number than M and a higher atomic number than N.

C L has a lower atomic number than both M and N.

D L has a higher atomic number than both M and N.

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18 In reactions 1 and 2, X represents an element in Period 3.

In each reaction, X is forming a product where X is in its highest oxidation state.

reaction 1 chlorine + element X $\rightarrow$ X_yCl_z

reaction 2 oxygen + element X $\rightarrow$ X_pO_q

Which ratios show a steady increase from sodium to phosphorus?

A neither z : y nor q : p

B z : y only

C q : p only

D both z : y and q : p

19 Sodium, magnesium, aluminium, silicon and phosphorus are all elements in Period 3 of the Periodic Table.

Three statements about the oxides and chlorides of these elements are given.

1 The ionically bonded oxides all react with dilute hydrochloric acid.

2 All metal chlorides produce neutral solutions when added to water.

3 The two most electronegative elements both form covalently bonded chlorides.

Which statements are correct?

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

20 The table compares calcium with barium and calcium carbonate with barium carbonate.

Which row is correct?

	reactivity of the element with water	thermal stability of the metal carbonate
A	barium is more reactive	barium carbonate is more stable
B	barium is more reactive	calcium carbonate is more stable
C	calcium is more reactive	barium carbonate is more stable
D	calcium is more reactive	calcium carbonate is more stable

21 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+} and the other contains Ba^{2+}. Tests are carried out on separate 5 cm^3 samples of P and Q.

test 1: add 1 cm^3 of 0.1 mol dm^{-3} Na_2SO_4(aq)

test 2: add 1 cm^3 of 0.1 mol dm^{-3} NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

22 J dissolves in water to give an aqueous solution K.

K gives a dense white precipitate when aqueous silver nitrate is added.

When heated with aqueous potassium hydroxide, K gives off a gas that turns moist universal indicator paper blue.

What is J?

A ammonium chloride

B ammonium sulfate

C sodium chloride

D sodium hydroxide

23 Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3, are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

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24 The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

Which statement is correct?

A The catalyst used is finely divided iron.

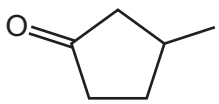
B The reaction prevents greenhouse gas emissions into the atmosphere.

C The reaction reduces the possibility of the formation of photochemical smog.

D The reaction results in increased ozone depletion.

25 Which compound has the molecular formula $C_6H_{10}O$?

A



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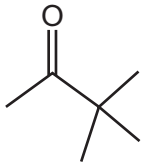

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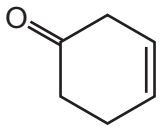

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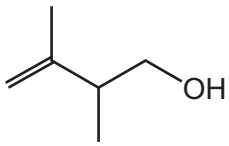

26 The general formula for a non-cyclic alcohol is $C_nH_{2n+1}OH$.

How many different structural isomers are there for $n = 3$ and $n = 4$?

	$n = 3$	$n = 4$
A	2	2
B	2	4
C	3	4
D	3	8

27 Compound X, $C_5H_{10}O_3$, has one chiral carbon atom per molecule. Compound X produces bubbles with Na but **not** with Na_2CO_3.

Which formula could represent compound X?

A $(CH_3)_2C(OH)CO_2CH_3$

B $HOCH_2CH(CH_3)CO_2CH_3$

C $CH_3CH_2C(CH_3)(OH)CO_2H$

D $CH_3CH(OH)CH(CH_3)CO_2H$

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28 Ethane reacts with an excess of chlorine in the presence of ultraviolet light to form a mixture of products.

How many of these products contain two carbon atoms and one or more chlorine atoms?

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

29 When bromoethane reacts with hot ethanolic sodium hydroxide a colourless gas is formed. This gas decolourises aqueous bromine.

What is the colourless gas?

A 1,2-dibromoethane

B ethanol

C ethene

D hydrogen bromide

30 Alkynes are hydrocarbons that contain one triple C≡C bond.

Like alkenes, alkynes take part in addition reactions. A saturated compound can be formed.

For example, ethyne, H–C≡C–H, reacts with an excess of hydrogen to form ethane.

Propyne, C_3H_4, undergoes an addition reaction with an excess of hydrogen bromide in two stages. Markovnikov's rule applies to the addition of HBr at each stage.

What is the main product obtained when propyne reacts with an excess of hydrogen bromide?

A $CH_2BrCH_2CH_2Br$

B $CH_3CH_2CHBr_2$

C $CH_3CHBrCH_2Br$

D $CH_3CBr_2CH_3$

31 Bromine reacts with alkenes by an electrophilic addition mechanism in which a cation is formed as an intermediate.

Which mixture will produce the most stable intermediate cation?

A 3,3-dimethylpent-1-ene + bromine

B ethene + bromine

C methylpropene + bromine

D propene + bromine

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32 Halogenoalkanes react with hot ethanolic potassium cyanide.

The reaction mechanism is either S_N1 or S_N2.

Which statement is correct?

A All secondary halogenoalkanes react by the S_N2 mechanism only.

B Both the halogenoalkane and the cyanide ion are involved in the initial step of the S_N1 mechanism.

C Chloroethane reacts with cyanide ions by the S_N1 mechanism only.

D The S_N2 mechanism involves a short-lived negatively charged transition state.

33 X, Y and Z are three isomeric alcohols.

X $CH_3CH_2CH_2CH_2CH_2OH$

Y $CH_3CH_2CH(OH)CH_2CH_3$

Z $(CH_3)_2C(OH)CH_2CH_3$

Separate samples of each alcohol are warmed with a mild oxidising agent and the results noted.

One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10}.

Which row is correct?

	reacts with mild oxidising reagents	gives cis/trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

34 Compound G gives a pale yellow precipitate with alkaline I_2(aq).

What could be compound G?

A pentan-1-ol

B pentan-2-ol

C pentan-3-ol

D 2-methylpentan-2-ol

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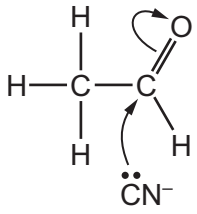
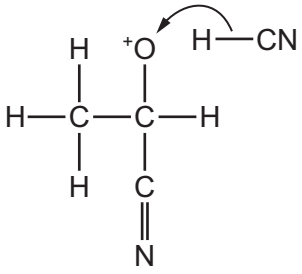
35 The mechanism for the reaction between ethanal and hydrogen cyanide starts with the step shown.



What is the correct structure of the intermediate ion formed, and what is the next step in this mechanism?

A



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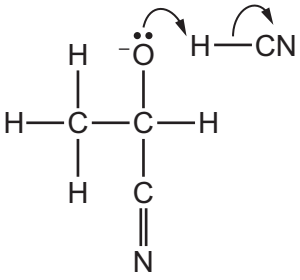

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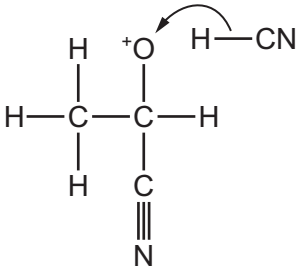

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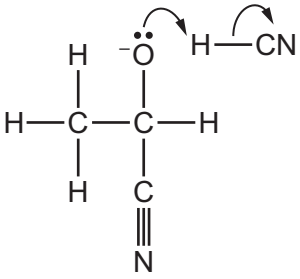


36 Which compound reacts with 2,4-dinitrophenylhydrazine reagent but does **not** react with Tollens' reagent?

A CH_3COCO_2H

B $CH_3CH(OH)CHO$

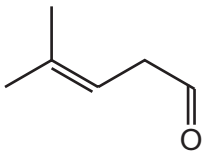
C CH_3COCHO

D $CH_3CH(OH)CH_3$

37 Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.

What could be the structure of compound X?

A



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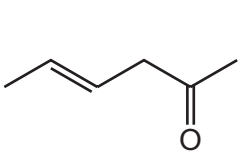

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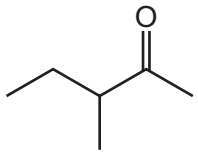

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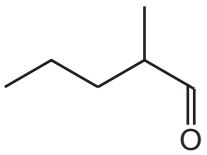

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38 Which reaction will form propanoic acid?

A acidic hydrolysis of propyl ethanoate

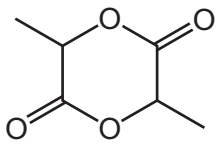
B alkaline hydrolysis of ethyl propanoate

C acidic hydrolysis of propanenitrile

D acidic hydrolysis of ethanenitrile

39 Lactide is an intermediate in the manufacture of a synthetic fibre.

lactide



Which compound, on heating with an acid catalyst, can produce lactide?

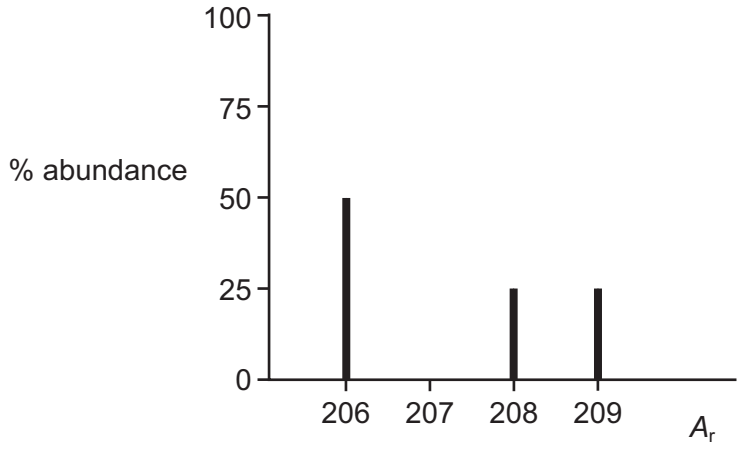
A hydroxyethanoic acid

B 2-hydroxybutanoic acid

C 2-hydroxypropanoic acid

D 3-hydroxypropanoic acid

40 The diagram shows the relative abundance of different isotopes of lead in a sample of lead ore. The abundance of 208 is half that of 206. The abundances of 208 and 209 are equal.



What is the relative atomic mass of the lead in the sample?

A 207.00 **B** 207.25 **C** 207.50 **D** 207.67

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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		Key: atomic number / atomic symbol / name / relative atomic mass									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 –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	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 –