CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2026**

1 hour 15 minutes

7058029326

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 or tape.
- 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.

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[Turn over

1 What is the electronic configuration of Cr^{3+}?

A [Ar] $3d^1$ $4s^2$

B [Ar] $3d^2$ $4s^2$

C [Ar] $3d^3$ $4s^0$

D [Ar] $3d^4$ $4s^0$

2 Which molecule has the greatest bond angle?

A SCl_2 **B** BCl_3 **C** PCl_3 **D** CCl_4

3 Antimony is produced in a 2-stage process from its sulfide, Sb_2S_3.

- Sb_2S_3 is heated in oxygen, producing Sb_2O_3 and SO_2.
- The Sb_2O_3 is then reduced by carbon, producing Sb and CO_2.

What is the maximum volume of CO_2, measured at room conditions, produced from 20 mol of Sb_2S_3?

A 30 dm^3 **B** 360 dm^3 **C** 720 dm^3 **D** 1440 dm^3

4 The ^{68}Ge isotope undergoes a natural radioactive process to give an isotope of a different element, ^{68}X. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

A It has 37 neutrons.

B It has 13 electrons in its 4th shell.

C It has 4 electrons in its 4p orbital.

D Its proton number is 32.

5 Oxygen reacts with ammonia to form nitrogen(II) oxide, NO, and steam.

How many moles of oxygen are required to convert 10.0 mol of ammonia into nitrogen(II) oxide and steam?

A 5.0 **B** 12.5 **C** 15.0 **D** 25.0

6 Some orbital overlaps that occur in molecules are listed.

1 a p orbital with a p orbital
2 a p orbital with an sp hybrid orbital
3 an s orbital with an sp hybrid orbital
4 an sp hybrid orbital with an sp hybrid orbital

Which orbital overlaps occur in the ethyne molecule, H–C≡C–H?

A 1, 2, 3 and 4

B 1, 3 and 4 only

C 1 and 4 only

D 2, 3 and 4 only

7 In the ideal gas equation $pV = nRT$, what do the symbols n and T represent?

	n	***T***
A	number of molecules	temperature in °C
B	number of molecules	temperature in K
C	number of moles	temperature in °C
D	number of moles	temperature in K

8 Bond energy data can be used to calculate the enthalpy change of a reaction.

Bromoethane, CH_3CH_2Br, can be made by reacting ethene with hydrogen bromide.

$$CH_2{=}CH_2 + HBr \rightarrow CH_3CH_2Br$$

bond	energy / kJ mol^{-1}
C=C	610
C–C	350
C–H	410
C–Br	280
H–Br	366

What is the enthalpy change for this reaction?

A $-346\,kJ\,mol^{-1}$

B $-64\,kJ\,mol^{-1}$

C $+64\,kJ\,mol^{-1}$

D $+346\,kJ\,mol^{-1}$

9 Sulfur can be oxidised in two ways.

$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H^{\ominus} = -296.5\,kJ\,mol^{-1}$$

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g) \qquad \Delta H^{\ominus} = -791.4\,kJ\,mol^{-1}$$

Sulfur trioxide can be made from sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the standard enthalpy change for this reaction?

A $-1384.4\,kJ\,mol^{-1}$

B $-989.8\,kJ\,mol^{-1}$

C $-494.9\,kJ\,mol^{-1}$

D $-198.4\,kJ\,mol^{-1}$

10 Aqueous sodium chlorate(I) is added to aqueous iron(II) sulfate and a reaction takes place.

Aqueous sodium chlorate(I) behaves as an oxidising agent in this reaction.

Which statement about the reaction is correct?

A Iron(II) ions gain electrons to become iron atoms.

B Iron(II) ions gain electrons to become iron(III) ions.

C Iron(II) ions lose electrons to become iron atoms.

D Iron(II) ions lose electrons to become iron(III) ions.

11 Which conversion involves the oxidation of an element in the reactant shown?

A $CO_2 \rightarrow CO_3^{2-}$

B $FeCl_3 \rightarrow FeCl_2$

C $NH_4^+ \rightarrow NH_3$

D $SO_2 \rightarrow SF_6$

12 Solid ammonium chloride is heated to a certain temperature in a 0.500 dm^3 container. Ammonia and hydrogen chloride are formed.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

When the initial amount of ammonium chloride is 1.00 mol there is 0.300 mol of ammonium chloride present at equilibrium.

What is the numerical value of K_c for this reaction under these conditions?

A 0.490 **B** 1.63 **C** 1.96 **D** 3.27

13 When ethanoic acid is mixed with ethanol a reversible reaction occurs.

Which statement describes this reaction when it reaches dynamic equilibrium?

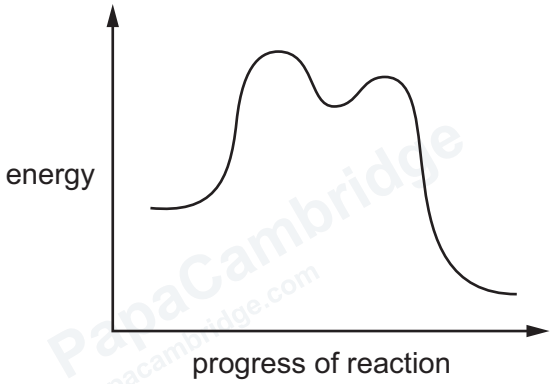
A The concentrations of the reactants and products are constant.

B This dynamic equilibrium can only be reached by the forward reaction.

C The rates of the forward and backward reactions are **not** equal.

D The forward and backward reactions have stopped.

14 The reaction pathway diagram shows the reaction which occurs when $(CH_3)_3CCl$ reacts with OH^-.



Which statements are correct?

	statement 1	statement 2
A	rate of formation of $(CH_3)_3C^+$ from $(CH_3)_3CCl$ is slower than rate of formation of $(CH_3)_3COH$ from $(CH_3)_3C^+$	the overall reaction is exothermic
B	rate of formation of $(CH_3)_3C^+$ from $(CH_3)_3CCl$ is slower than rate of formation of $(CH_3)_3COH$ from $(CH_3)_3C^+$	the overall reaction is endothermic
C	rate of formation of $(CH_3)_3C^+$ from $(CH_3)_3CCl$ is faster than rate of formation of $(CH_3)_3COH$ from $(CH_3)_3C^+$	the overall reaction is exothermic
D	rate of formation of $(CH_3)_3C^+$ from $(CH_3)_3CCl$ is faster than rate of formation of $(CH_3)_3COH$ from $(CH_3)_3C^+$	the overall reaction is endothermic

15 The graph shows a Boltzmann distribution for a sample of reacting gas at a temperature TK. The activation energy, E_A, for the reaction is marked. Point Q is the point of intercept of the curve with the value of the activation energy, E_A.

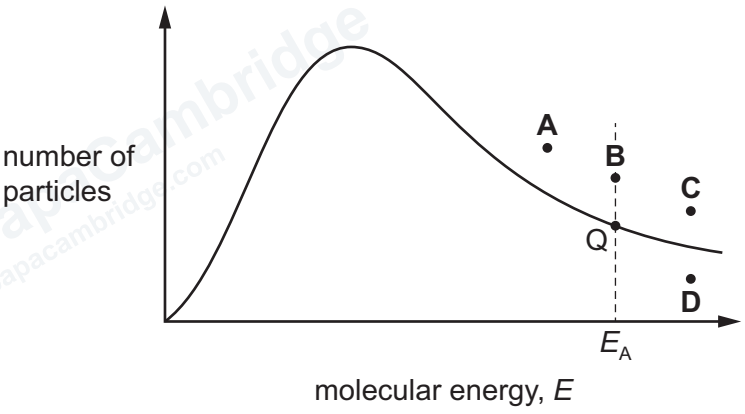
Two changes are made.

1 The temperature is increased to $(T+10)$K.

2 A catalyst is added which increases the rate of the reaction.

As a result of the change in temperature, the shape of the distribution curve will change.

Which point shows the intercept of the new distribution curve with the value of the activation energy for the catalysed reaction?



16 Elements W, X, Y and Z are different elements in Period 3 of the Periodic Table.

Four statements about W, X, Y and Z are given.

1 X has the greatest electronegativity value of the four elements.

2 W reacts with X to produce a liquid at room temperature that reacts with water to form an acidic solution.

3 Z reacts with water to form an alkaline solution.

4 The oxide of Y will react with the solutions formed in statements 2 and 3.

What is the correct order of these elements in order of **increasing** atomic radius?

A X → Y → W → Z

B X → W → Y → Z

C Z → Y → W → X

D Z → Y → X → W

17 The table shows the melting points of SiO_2 and P_4O_6.

oxide	SiO_2	P_4O_6
melting point / K	1986	297

Which statement explains the difference between the melting points of SiO_2 and P_4O_6?

A The bonding of the oxides changes from ionic to covalent.

B The metallic character of the elements decreases across Period 3.

C The oxidation number of the elements increases from Si to P.

D The structure changes from giant molecular to simple molecular.

18 Which statement explains the relative reactivities of calcium and strontium with hydrochloric acid?

A Calcium is more reactive because it contains fewer protons in its nucleus.

B Calcium is more reactive because it has a smaller atomic radius.

C Calcium is less reactive because it contains fewer protons in its nucleus.

D Calcium is less reactive because it has a smaller atomic radius.

19 When hydrated magnesium nitrate, $Mg(NO_3)_2 \cdot 7H_2O$, is heated, which three gases are given off?

A nitrogen(II) oxide, oxygen and water vapour

B hydrogen, nitrogen and oxygen

C hydrogen, nitrogen(IV) oxide and oxygen

D nitrogen(IV) oxide, oxygen and water vapour

20 Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

Which property shows an **increase** from magnesium to barium?

A the electronegativity of the elements

B the solubility of the hydroxides

C the solubility of the sulfates

D the first ionisation energy of the elements

21 Chlorine gas reacts with hot dilute aqueous sodium hydroxide as shown.

$$u\mathrm{Cl}_2 + v\mathrm{OH}^- \rightarrow w\mathrm{Cl}^- + y\mathrm{ClO}_3^- + z\mathrm{H}_2\mathrm{O}$$

What is the simplest ratio of w : y in the balanced equation?

A 1 : 1 **B** 1 : 5 **C** 5 : 1 **D** 7 : 1

22 Concentrated sulfuric acid is added to KX(s), where X is Br, Cl or I. The element sulfur and the halogen molecule, X_2, are two of the products made in this reaction.

What is the colour of X_2 in the gaseous state?

A brown

B colourless

C purple

D yellow-green

23 Which statement about the reactions of nitrogen oxides in the atmosphere is correct?

A NO oxidises SO_2.

B NO reduces SO_2.

C NO_2 reduces SO_2.

D NO_2 oxidises SO_2.

24 Ammonium sulfate is heated with calcium hydroxide. Two statements about the reaction are listed.

1 The ammonium ion acts as a base during the reaction.

2 The H–N–H bond angle decreases during the reaction.

Which statements are correct?

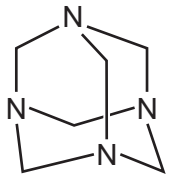
A both statement 1 and statement 2

B statement 1 only

C statement 2 only

D neither statement 1 nor statement 2

25 The skeletal structure of hexamine is shown.



What is the empirical formula of hexamine?

A CH_2N **B** $C_3H_6N_2$ **C** $C_4H_8N_4$ **D** $C_6H_{12}N_4$

26 A student looks at the structure of chloroethene and of poly(chloroethene) and draws two conclusions.

1 The carbon atoms are sp^3 hybridised in each substance.

2 Chloroethene and poly(chloroethene) contain chiral carbon atoms.

Which conclusions are true or false?

	conclusion 1	conclusion 2
A	false	false
B	false	true
C	true	false
D	true	true

27 Alkenes react with hydrogen bromide. The reaction proceeds via an intermediate carbocation. The more stable the intermediate, the faster the reaction.

Which sequence correctly shows an **increase** in the rate of reaction of the alkenes with hydrogen bromide?

A ethene → propene → 2-methylpropene

B 2-methylpropene → propene → ethene

C ethene → 2-methylpropene → propene

D propene → 2-methylpropene → ethene

28 Ethane reacts with bromine by a free-radical substitution mechanism.

The mechanism for this reaction has three steps: initiation, propagation and termination.

Which species is a possible product in one of the steps?

A C_3H_8 **B** C_4H_{10} **C** $H^{\bullet}$ **D** CH_4

29 Structural isomerism and stereoisomerism should be taken into account when answering this question.

Two compounds, X and Y, both have the molecular formula $C_5H_{11}Br$. On heating with ethanolic NaOH, X produces three isomeric organic products and Y produces two isomeric organic products.

What could X and Y be?

	X	Y
A	$CH_3CH_2CH_2CHBrCH_3$	$CH_3CH_2CBr(CH_3)_2$
B	$CH_3CH_2CH_2CHBrCH_3$	$CH_3CH_2CH(CH_3)CH_2Br$
C	$(CH_3CH_2)_2CHBr$	$CH_3CH_2CBr(CH_3)_2$
D	$(CH_3CH_2)_2CHBr$	$CH_3CH_2CH(CH_3)CH_2Br$

30 Which halogenoalkane tends to react with water by an S_N1 mechanism and produces a yellow precipitate when $AgNO_3(aq)$ is added to it?

A 1-chlorobutane

B 1-iodobutane

C 2-chloro-2-methylpropane

D 2-iodo-2-methylpropane

31 Compound Q with molecular formula $C_4H_{10}O$ gives compound R with molecular formula C_4H_8O upon oxidation.

R gives a yellow precipitate with alkaline $I_2(aq)$.

What is Q?

A $CH_3CH_2CH(OH)CH_3$

B $(CH_3)_2CHCH_2OH$

C $CH_3CH_2CH_2CH_2OH$

D $(CH_3)_3COH$

32 Propanoic acid is used to make propene in two steps.

What are the reagents for step 1 and step 2?

	step 1	step 2
A	$LiAlH_4$	concentrated H_2SO_4
B	$LiAlH_4$	ethanolic NaOH
C	$NaBH_4$	concentrated H_2SO_4
D	$NaBH_4$	ethanolic NaOH

33 Two reactions are described.

1 1-bromopropane with ammonia

2 propanal with hydrogen cyanide

Which of these reactions has a nucleophilic mechanism?

A both reactions

B only reaction 1

C only reaction 2

D neither reaction

34 The structures of compound S and compound T are shown.

$HOCH_2CH(OH)CHO$ S $\quad$ $HOCH_2COCH_2OH$ T

Which reagent can be used to distinguish between compound S and compound T?

A $Br_2(aq)$

B hot acidified $KMnO_4$

C Tollens' reagent

D warm acidified $K_2Cr_2O_7$

35 Compound Y has the molecular formula $C_4H_6O_2$ and reacts with Na but **not** with Na_2CO_3.

On warming Y with Fehling's reagent, followed by acidification, the organic product reacts with both Na and Na_2CO_3.

What could be the structural formula of Y?

A $CH_3CH{=}CHCO_2H$

B $OCHCH_2CH_2CHO$

C $OCHCH{=}CHCH_2OH$

D $CH_2{=}CHCOCH_2OH$

36 Which pair of substances could react to give the ester $CH_3CH_2CO_2CH_3$?

A ethanol and ethanoic acid

B methanol and ethanoic acid

C methanol and propanoic acid

D propan-1-ol and methanoic acid

37 2-methyl-1-bromopropane is reacted with a reagent under certain conditions to form primary amine Z.

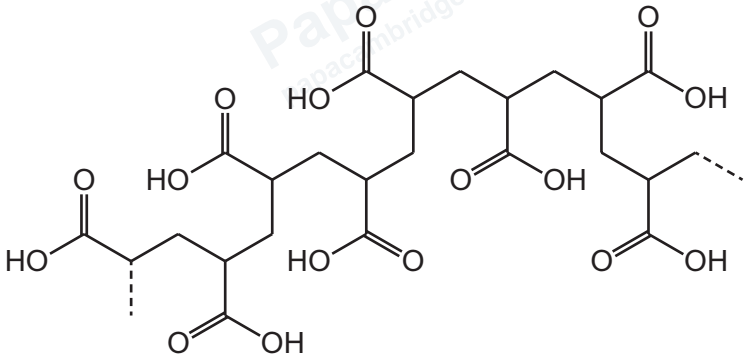
The reaction produces 4.50 g of Z with a 56.0% yield.

[A_r: C, 12.0; H, 1.0; Br, 79.9; N, 14.0]

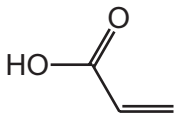
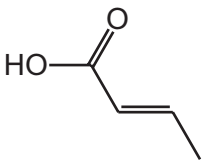
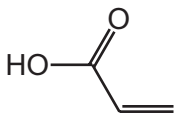
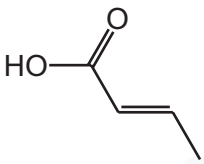
Which row is correct?

	reagent and conditions for reaction	mass of 2-methyl-1-bromopropane used in reaction / g
A	KCN in ethanol with heat	8.04
B	KCN in ethanol with heat	15.07
C	NH_3 in ethanol heated under pressure	8.04
D	NH_3 in ethanol heated under pressure	15.07

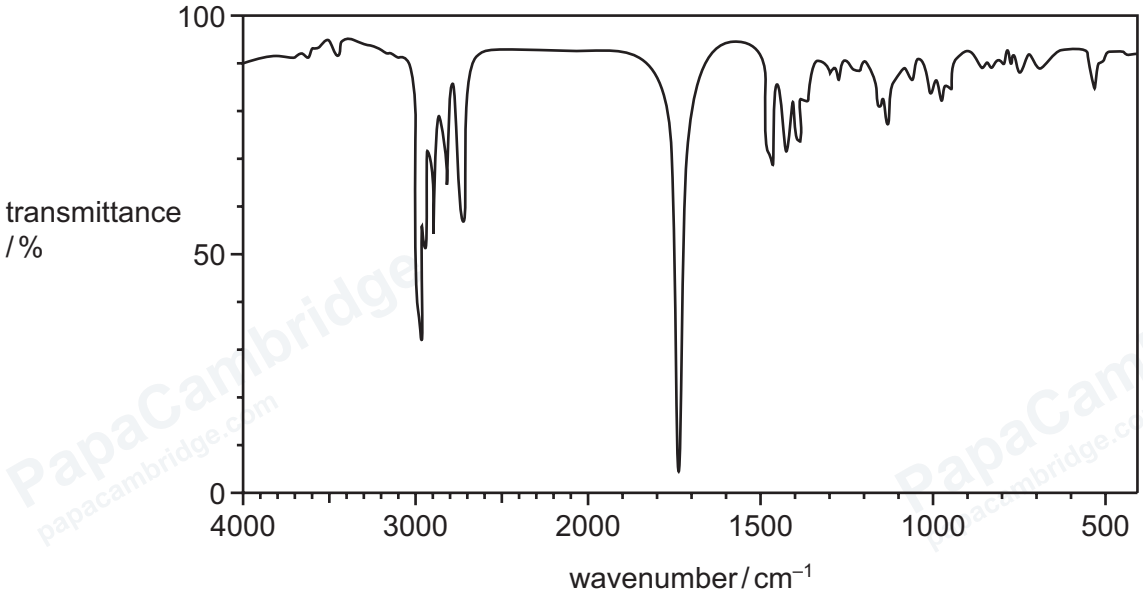
38 The structure of part of an addition polymer chain is shown.



Which row gives the monomer used and the number of repeat units in the structure shown?

	monomer	number of repeat units in the structure shown
A		6
B		6
C		8
D		8

39 The infrared spectrum of compound X is shown.



bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

What is compound X?

A butane

B butanal

C butan-1-ol

D butanoic acid

40 The mass spectra of pentane and methylbutane are compared.

Which statement is correct?

A The methylbutane spectrum has an M+1 peak but the pentane spectrum does **not**.

B The molecular ion peak has a higher *m* / *e* value on the pentane spectrum.

C Both spectra have a peak at *m* / *e* 43.

D The pentane spectrum has a peak at *m* / *e* 29 but the methylbutane spectrum does **not**.

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

Key

atomic number
atomic symbol
name
relative atomic mass

Group																	
1	2	3	4	5	6	7	8	9	10	11	12	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											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 144.2	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 –