Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 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.

IB25 11_9701_12/5RP
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1 What is the electrons in boxes notation for the Fe^{3+} ion?

		3d					4s
A	[Ar]	↑↓	↑				↑↓
B	[Ar]	↑	↑	↑			↑↓
C	[Ar]	↑↓	↑	↑	↑		
D	[Ar]	↑	↑	↑	↑	↑	

2 Which equation has an energy change that is equal to the first ionisation energy of bromine?

A $Br(g) \rightarrow Br^{+}(g) + e^{-}$

B $Br(g) \rightarrow Br^{-}(g) - e^{-}$

C $\frac{1}{2}Br_2(g) \rightarrow Br^{+}(g) + e^{-}$

D $\frac{1}{2}Br_2(g) \rightarrow Br^{-}(g) - e^{-}$

3 The reaction of hydrogen sulfide with sulfur dioxide gives sulfur as one of the products.

The two relevant redox equations are shown.

$$H_2S(aq) \rightleftharpoons S(s) + 2H^{+}(aq) + 2e^{-}$$

$$SO_2(aq) + 4H^{+}(aq) + 4e^{-} \rightleftharpoons S(s) + 2H_2O(l)$$

How many moles of hydrogen sulfide are needed to react with sulfur dioxide to produce 1 mol of sulfur?

A $\frac{1}{3}$ mol **B** $\frac{2}{3}$ mol **C** $\frac{3}{2}$ mol **D** 2 mol

4 Which statement is correct?

A The relative atomic mass of a ^{35}Cl atom is 35.5.

B The relative molecular mass of O_2 is 16.0.

C The relative formula mass of $CaCO_3$ is 100.1.

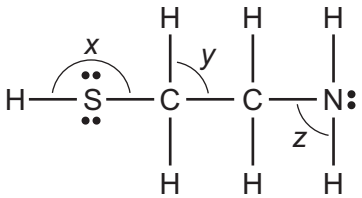
D The relative isotopic mass of a ^{24}Mg atom is 24.3.

5 The bonding between two atoms of nitrogen in an N_2 molecule involves the hybridisation of atomic orbitals to form sp orbitals.

Which row is correct?

	formation of the σ bond between the nitrogen atoms in N_2	type of orbital which contains the lone pair of electrons on each nitrogen atom in N_2
A	an sp orbital from one atom overlaps with an sp orbital of the other atom	p
B	an sp orbital from one atom overlaps with an sp orbital of the other atom	sp
C	an s orbital from one atom overlaps with a p orbital of the other atom	p
D	an s orbital from one atom overlaps with a p orbital of the other atom	sp

6 Three bond angles are labelled on the molecule shown.



represents a lone pair of electrons

What is the order of **decreasing** size of the bond angles *x*, *y* and *z*?

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

7 X and Y are different elements in Period 3.

Atoms of X and Y each have only one completely filled orbital in their highest occupied energy sub-shell.

Y has a greater first ionisation energy than X.

Which row shows the structure and bonding in X and Y?

	X	Y
A	giant metallic	giant metallic
B	giant metallic	simple molecular
C	giant covalent	simple molecular
D	simple molecular	simple molecular

8 A pure sample of a gas has a density of 2.62 g dm^{-3} at 101 000 Pa and 25 °C. The gas behaves ideally under these conditions.

Which expression gives the M_r of the gas?

A $\dfrac{101000 \times 0.001}{2.62 \times 8.31 \times 25}$

B $\dfrac{101000 \times 0.001}{2.62 \times 8.31 \times 298}$

C $\dfrac{2.62 \times 8.31 \times 25}{101000 \times 0.001}$

D $\dfrac{2.62 \times 8.31 \times 298}{101000 \times 0.001}$

9 When 0.47 g of a hydrocarbon is completely burnt in air, the energy released heats 200 g of water from 23.7 °C to 41.0 °C.

What is the amount of energy absorbed, in Joules, by the water?

A $0.47 \times 4.18 \times 17.3$

B $0.47 \times 4.18 \times (273 + 17.3)$

C $200 \times 4.18 \times 17.3$

D $200 \times 4.18 \times (273 + 17.3)$

10 One commercially available 'heat pad' contains iron, activated carbon and water. The 'heat pad' is activated by air. This causes the pad to get hotter.

Which statement describes the chemical reaction occurring in the 'heat pad' when it is exposed to air?

A The reaction is endothermic and iron gains electrons.

B The reaction is endothermic and iron loses electrons.

C The reaction is exothermic and iron gains electrons.

D The reaction is exothermic and iron loses electrons.

11 In which substance is the average oxidation number of sulfur the highest?

A S_8 **B** $Na_2S_4O_6$ **C** $Na_2S_2O_3$ **D** SO_2Cl_2

12 An equilibrium can be represented by the equation shown.

$$P(aq) + Q(aq) \rightleftharpoons 2R(aq) + S(aq)$$

In a certain mixture, of volume 1.0 dm^3, the equilibrium concentration of Q is 10 mol dm^{-3}.

What will be the new equilibrium concentration of Q if 5.0 mol of pure Q is completely dissolved in the mixture?

A 15 mol dm^{-3}

B between 10 mol dm^{-3} and 15 mol dm^{-3}

C 10 mol dm^{-3}

D between 5.0 mol dm^{-3} and 10 mol dm^{-3}

13 In the Contact process, sulfur dioxide and oxygen react to form sulfur trioxide.

In the Haber process, nitrogen and hydrogen react to form ammonia.

Which statement about these processes is correct?

A K_p for the Haber process has no unit.

B In the Contact process, the value of K_p falls when pressure is increased at constant T.

C The Haber process uses a homogeneous catalyst.

D When V_2O_5 is used in the Contact process, the position of equilibrium is unchanged.

14 20.0 cm^3 of hydrogen peroxide decomposes to water and oxygen in the presence of a suitable catalyst.

160 cm^3 of oxygen, measured at room conditions, is produced in 5.00 minutes.

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

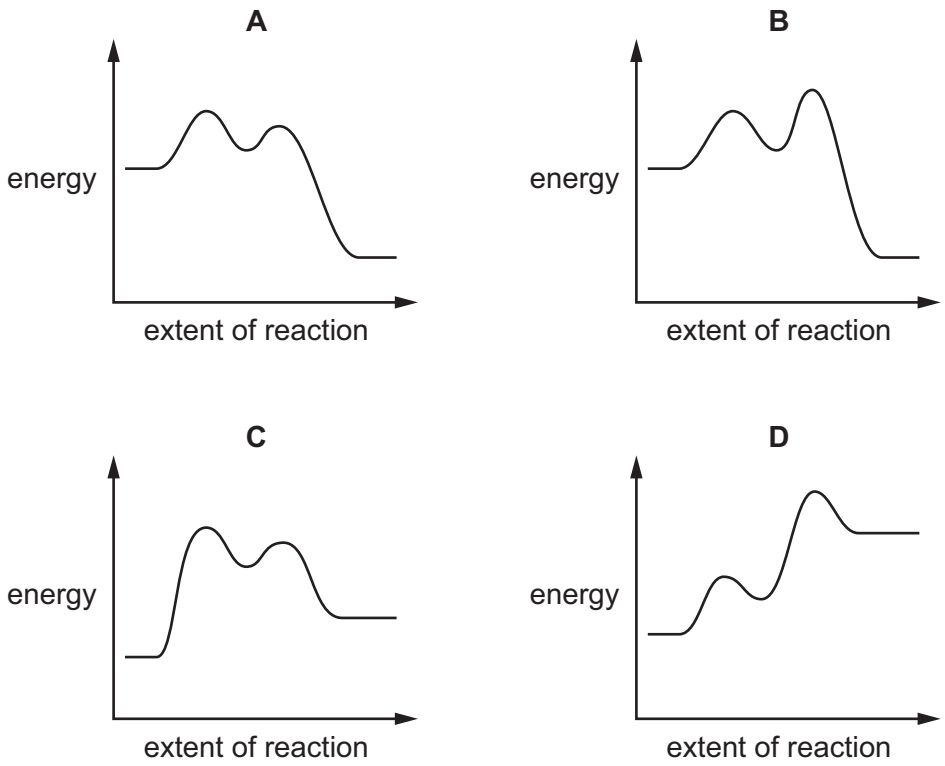
A $2.22 \times 10^{-5}\,mol\,s^{-1}$

B $4.44 \times 10^{-5}\,mol\,s^{-1}$

C $1.76 \times 10^{-4}\,mol\,s^{-1}$

D $2.67 \times 10^{-3}\,mol\,s^{-1}$

15 Which reaction pathway diagram shows an endothermic reaction that occurs in two steps and in which the second step of the reaction is likely to be faster than the first?



16 Oxides of nitrogen, NO_x, are involved in formation of photochemical smog and acid rain.

Which oxides of nitrogen are involved in each of these processes?

	photochemical smog		acid rain	
	NO	NO_2	NO	NO_2
A	✓	✓	✓	✓
B	✗	✓	✗	✓
C	✓	✓	✗	✓
D	✗	✓	✓	✓

17 Sodium and sulfur react together to form sodium sulfide, Na_2S.

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sulfur is greater	sodium is greater
B	sulfur is greater	sulfur is greater
C	sodium is greater	sodium is greater
D	sodium is greater	sulfur is greater

18 Compound X is an oxide of a Period 3 element.

Compound X is a white solid at 25 °C. It reacts with water to form an acidic solution.

What is compound X?

A aluminium oxide

B silicon dioxide

C sulfur dioxide

D phosphorus(V) oxide

19 When heated, magnesium nitrate decomposes.

Which equation for the thermal decomposition of magnesium nitrate is correct?

A $Mg(NO_3)_2 \rightarrow MgO + NO_2 + NO + O_2$

B $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO + 3O_2$

C $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

D $3Mg(NO_3)_2 \rightarrow Mg_2N_3 + MgO + 3NO + 7O_2$

20 R is the aqueous solution of an ionic compound.

- A white precipitate is formed when R is added to $Sr(NO_3)_2$(aq).
- No visible reaction is seen when R is added to dilute HNO_3(aq).

What is the anion present in compound R?

A Cl^- **B** SO_4^{2-} **C** HCO_3^- **D** CO_3^{2-}

21 In an experiment, 0.600 mol of chlorine gas, Cl_2, is reacted with an excess of hot aqueous sodium hydroxide. One of the products is $NaClO_3$.

Which mass of $NaClO_3$ is formed?

A 21.3 g **B** 44.7 g **C** 63.9 g **D** 128 g

22 X and Y are sodium salts of Group 17 elements.

When X reacts with concentrated sulfuric acid, hydrogen sulfide, H_2S, is produced.

When Y reacts with concentrated sulfuric acid, there is no change in the oxidation number of the sulfur.

Which statement is correct?

A Aqueous X reduces aqueous bromine.

B Aqueous Y reacts with aqueous silver nitrate to give a precipitate which is insoluble in concentrated aqueous ammonia.

C X and Y react separately with concentrated sulfuric acid to produce halogens.

D When X reacts with concentrated sulfuric acid, six halide ions are needed to reduce one sulfur atom to H_2S.

23 Element E is in Period 3. It forms a chloride which reacts with a small amount of water to produce a white precipitate and steamy fumes. This precipitate is soluble in NaOH(aq) and in HCl(aq).

What is element E?

A magnesium

B aluminium

C silicon

D phosphorus

24 Four reaction mixtures are listed.

1 $(NH_4)_2SO_4$(aq) and NaOH

2 NH_4Cl(aq) and $Ba(OH)_2$

3 NH_4Cl(aq) and Na_2O

4 $(NH_4)_3PO_4$(aq) and HCl

Which reaction mixtures produce ammonia as a product?

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

25 Two statements about a molecule of methanal are given.

1 It is planar.

2 It contains three σ bonds.

Which statements are correct?

A both 1 and 2

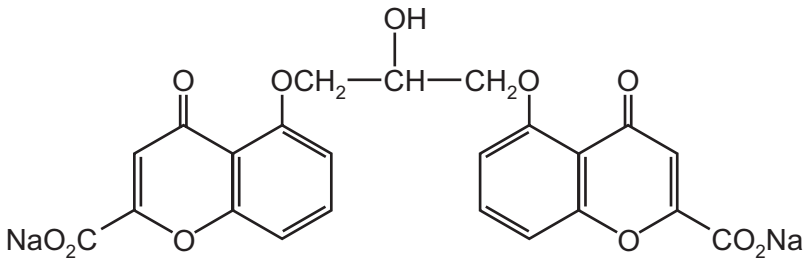
B 1 only

C 2 only

D neither 1 nor 2

26 The structure of disodium cromoglycate is shown.

disodium cromoglycate



How many chiral centres are there in this molecule?

A 0 **B** 1 **C** 2 **D** 3

27 What is the major product when 2-methylpent-2-ene reacts with hydrogen bromide?

A 1-bromo-2-methylpentane

B 2-bromo-2-methylpentane

C 3-bromo-2-methylpentane

D 4-bromo-2-methylpentane

28 Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.

What is the major product?

A $CH_3CH_2CH(OH)CH(OH)CH_3$

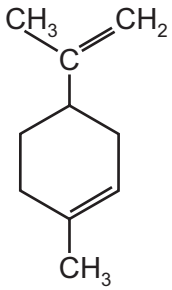
B $CH_3CH_2COCOCH_3$

C a mixture of $CH_3CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH_2CH(OH)CH_3$

D CH_3CH_2COOH and CH_3COOH

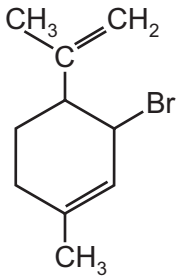
29 Limonene is an oil formed in the peel of citrus fruits.

limonene



Which product is formed when an excess of bromine, $Br_2(l)$, reacts with limonene at room temperature in the dark?

A



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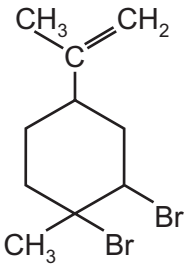

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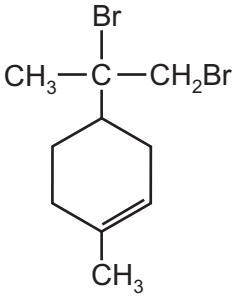

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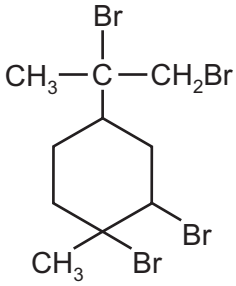


30 Which reaction mixture produces a nitrile?

A halogenoalkane with KCN in ethanol

B halogenoalkane with NH_3 in ethanol

C ketone with 2,4-DNPH

D carboxylic acid with NH_3 in water

31 Which reaction is classified as S_N1?

A the reaction of 1-chloropropane with ammonia in ethanol

B the reaction of 1-chloropropane with potassium hydroxide in ethanol

C the reaction of 2-chloro-2-methylpropane with potassium cyanide in ethanol

D the reaction of 2-chloro-2-methylpropane with potassium hydroxide in ethanol

32 Which reaction mixture produces a primary alcohol as the major product?

A propanone with $NaBH_4$

B propene with steam in the presence of H_3PO_4

C butanoic acid with $LiAlH_4$

D ethene with hot concentrated acidified $KMnO_4$

33 $HOCH_2CHO$ is heated under reflux with an excess of acidified $K_2Cr_2O_7$ until there is no further reaction.

What is the final product of this reaction?

A HOOCCHO

B $HOCH_2COOH$

C HOOCCOOH

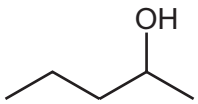
D $HOOCCH_2COOH$

34 An organometallic lithium compound, RLi, contains the nucleophile R^-.

CH_3CH_2Li reacts with pentan-2-one. The mechanism is nucleophilic addition. The first step produces an anion which is then protonated to form the final product.

Which organic product is formed?

A



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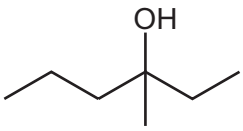

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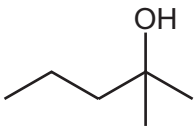

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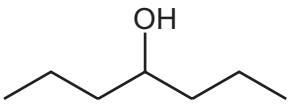
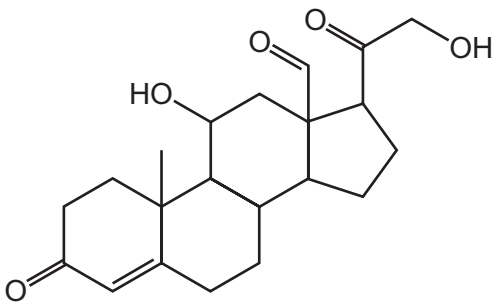


35 The structure of a naturally occurring compound, Q, is shown.

compound Q



Compound Q is heated under reflux with an excess of acidified $KMnO_4$.

Organic product R is formed.

Which row is correct?

	results of tests with compound Q	results of tests with organic product R
A	orange precipitate with 2,4-DNPH and no reaction with alkaline I_2(aq)	yellow precipitate with alkaline I_2(aq) and no reaction with Fehling's reagent
B	red precipitate with Fehling's reagent and no reaction with alkaline I_2(aq)	orange precipitate with 2,4-DNPH and no reaction with alkaline I_2(aq)
C	yellow precipitate with alkaline I_2(aq) and orange precipitate with 2,4-DNPH	no reaction with alkaline I_2(aq) and no reaction with Fehling's reagent
D	yellow precipitate with alkaline I_2(aq) and red precipitate with Fehling's reagent	yellow precipitate with alkaline I_2(aq) and orange precipitate with 2,4-DNPH

36 Which organic starting material could be used in a single reaction to produce propanoic acid?

A ethanenitrile

B propan-2-ol

C propanal

D propyl ethanoate

37 In four separate reactions, W, X, Y and Z, 1 mol of an organic compound reacts with an excess of a reagent.

	organic compound	reagent
W	$(CH_2COOH)_2$	Na
X	$CH_3CH(OH)CH_2COOH$	Na_2CO_3
Y	$CH_3CH(OH)CH_2COOH$	NaOH
Z	$CH(OH)(COOH)CH_2COOH$	Na

The volume of any gas produced is collected and measured. All gas volumes are measured at the same temperature and pressure.

What is the order of the reactions from greatest total volume of gas collected to least total volume of gas collected?

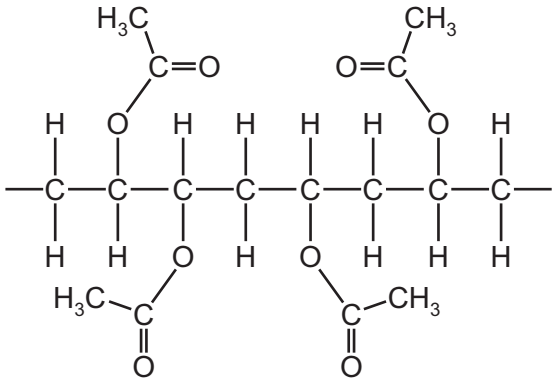
	greatest volume →			least volume
A	W	Y	Z	X
B	W	Z	Y	X
C	Z	W	X	Y
D	Z	X	W	Y

38 Butylamine can be produced by the reaction of butanenitrile with hydrogen in the presence of a suitable catalyst.

Which volume of hydrogen, measured at room conditions, is required to react completely with 0.500 g of butanenitrile?

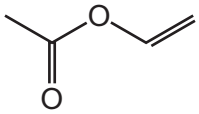
A 145 cm^3 **B** 174 cm^3 **C** 289 cm^3 **D** 348 cm^3

39 A section of an addition polymer is shown.



Which monomer is used to make this polymer?

A



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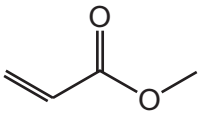

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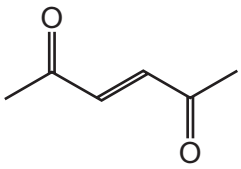

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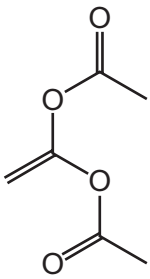

40 The purity of a compound can be determined using infrared spectroscopy.

The table gives the characteristic infrared absorption frequencies for some selected bonds.

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

Propan-2-ol is made by hydration of propene. A sample of the product is obtained.

Which feature of the infrared spectrum of the product would show that **no** propene remains in the product?

A absorption in the 2900 cm^{-1} region

B strong absorption below 1000 cm^{-1}

C the lack of absorption at or near 1250 cm^{-1}

D the lack of absorption at or near 1550 cm^{-1}

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Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

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 –

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 –

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