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Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

October 2021

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference **WCH11/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 1: Structure, Bonding and Introduction to Organic Chemistry

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The maximum permitted concentration of sulfur in diesel fuel is 10 mg of sulfur in 1 kg of diesel fuel.

(a) What is this concentration of sulfur in ppm?

(1)

☒ **A** 0.00001

☒ **B** 0.01

☒ **C** 10

☒ **D** 10 000

(b) 3.2 kg of this diesel fuel is burned in air.

What is the maximum volume, in dm^3, of sulfur dioxide which can be produced, measured at room temperature and pressure (r.t.p.)?

[Molar volume of a gas at r.t.p. = 24 dm^3 mol^{-1}]

(1)

☒ **A** 0.024

☒ **B** 0.77

☒ **C** 2.4

☒ **D** 24

(Total for Question 1 = 2 marks)

2 Which equation represents the **second** ionisation energy of chlorine?

☒ **A** $Cl^-(g) + e^- \rightarrow Cl^{2-}(g)$

☒ **B** $Cl(g) + 2e^- \rightarrow Cl^{2-}(g)$

☒ **C** $2Cl(g) \rightarrow 2Cl^+(g) + 2e^-$

☒ **D** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

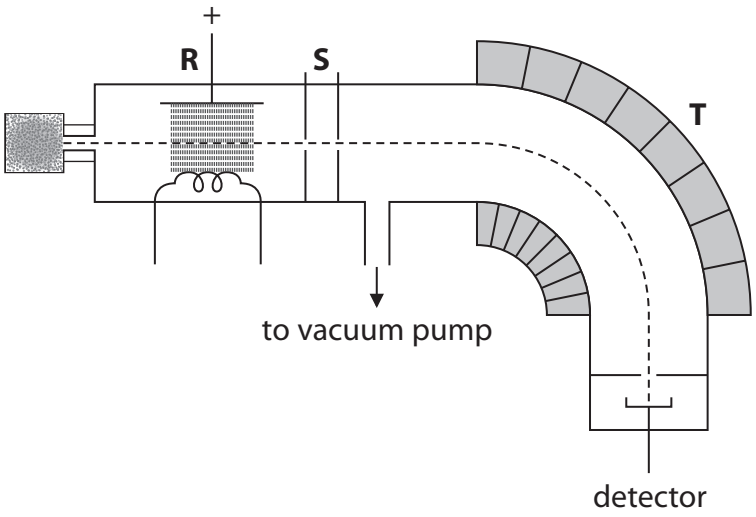
(Total for Question 2 = 1 mark)

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3 The diagram shows a mass spectrometer.



(a) Which process occurs in region **R**?

(1)

- ☒ **A** the sample is vaporised using a heater
- ☒ **B** electrons are removed from molecules or atoms and positive ions are formed
- ☒ **C** electrons are added to the molecules or atoms and negative ions are formed
- ☒ **D** ions are accelerated by an electric field

(b) Which statement is correct for region **T**?

(1)

- ☒ **A** ions with a greater mass have a smaller deflection
- ☒ **B** ions with a greater mass have a greater deflection
- ☒ **C** ions with a greater charge have a smaller deflection
- ☒ **D** ions are speeded up by a magnetic field

(Total for Question 3 = 2 marks)

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4 A mass of 0.23 g of sodium was added to 350 cm^3 water to form hydrogen and a solution of sodium hydroxide.

$$Na(s) + H_2O(l) \rightarrow NaOH(aq) + \tfrac{1}{2}H_2(g)$$

(a) What is the concentration, in mol dm^{-3}, of sodium hydroxide in the solution formed?

(1)

- ☒ **A** 0.010
- ☒ **B** 0.029
- ☒ **C** 0.29
- ☒ **D** 0.66

(b) What is the maximum volume, in cm^3, of hydrogen which could be formed, measured at r.t.p.?

[Molar volume of a gas at r.t.p. = 24 dm^3 mol^{-1}]

(1)

- ☒ **A** 120
- ☒ **B** 240
- ☒ **C** 480
- ☒ **D** 2800

(c) The sodium hydroxide solution was neutralised with sulfuric acid.

Which is the ionic equation for this reaction?

(1)

- ☒ **A** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
- ☒ **B** $SO_4^{2-}(aq) + 2Na^+(aq) \rightarrow Na_2SO_4(aq)$
- ☒ **C** $H_2SO_4(aq) + 2Na^+(aq) + 2OH^-(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
- ☒ **D** $2H^+(aq) + SO_4^{2-}(aq) + 2Na^+(aq) + 2OH^-(aq) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq) + 2H_2O(l)$

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(d) Sodium hydroxide solution was added to magnesium sulfate solution.

The equation for the reaction is shown.

$$2NaOH(aq) + MgSO_4(aq) \rightarrow Mg(OH)_2(s) + Na_2SO_4(aq)$$

What is the atom economy (by mass) for the production of magnesium hydroxide?

[A_r values: H = 1.0 O = 16.0 Na = 23.0 Mg = 24.3 S = 32.1]

(1)

☒ **A** 29.1 %

☒ **B** 41.0 %

☒ **C** 48.4 %

☒ **D** 50.0 %

(Total for Question 4 = 4 marks)

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5 In which series are the ions in order of **decreasing** ionic radius?

- ☒ **A** $Al^{3+} > Mg^{2+} > Na^{+}$
- ☒ **B** $Li^{+} > Na^{+} > K^{+}$
- ☒ **C** $N^{3-} > O^{2-} > F^{-}$
- ☒ **D** $O^{2-} > S^{2-} > Se^{2-}$

(Total for Question 5 = 1 mark)

6 A stable ion, $\mathbf{M^{3+}}$, contains 18 electrons.

In which block of the Periodic Table is element **M** found?

- ☒ **A** s
- ☒ **B** p
- ☒ **C** d
- ☒ **D** f

(Total for Question 6 = 1 mark)

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7 Ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$, is a double salt that is used as a source of iron(II) ions.

(a) What is the relative formula mass of the double salt?

[A_r values: H = 1.0 N = 14.0 O = 16.0 S = 32.1 Fe = 55.8]

(1)

- ☒ **A** 277.9
- ☒ **B** 284.0
- ☒ **C** 392.0
- ☒ **D** 447.8

(b) Ammonium sulfate is used in the preparation of the double salt.

What types of bond are present in ammonium sulfate?

(1)

- ☒ **A** ionic only
- ☒ **B** covalent and ionic only
- ☒ **C** dative covalent and ionic only
- ☒ **D** ionic, covalent and dative covalent

(c) What is the **total** number of ions present in 0.1 mol of the double salt?

[Avogadro constant (L) = 6.02×10^{23} mol^{-1}]

(1)

- ☒ **A** 1.80×10^{23}
- ☒ **B** 2.41×10^{23}
- ☒ **C** 3.01×10^{23}
- ☒ **D** 6.62×10^{23}

(Total for Question 7 = 3 marks)

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8 In which series are the elements in order of **increasing** melting temperature?

- ☒ **A** $I_2 < Br_2 < Cl_2 < F_2$
- ☒ **B** Li < Be < B < C
- ☒ **C** Li < Na < K < Rb
- ☒ **D** Si < P < S < Cl

(Total for Question 8 = 1 mark)

9 Which row gives the correct polarities of the S—F bond and the SF_6 molecule?

	Polarity of S—F bond	Polarity of SF_6 molecule
☒ **A**	polar	polar
☒ **B**	polar	non-polar
☒ **C**	non-polar	polar
☒ **D**	non-polar	non-polar

(Total for Question 9 = 1 mark)

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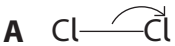
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10 Methane reacts with excess chlorine in UV light.

(a) Which process occurs in the initiation step?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(b) Which of these molecules could **not** be formed in a termination step?

(1)

☒ **A** C_2H_6

☒ **B** CH_3Cl

☒ **C** CH_2Cl_2

☒ **D** HCl

(Total for Question 10 = 2 marks)

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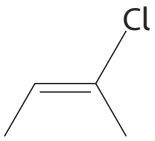
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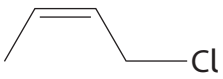
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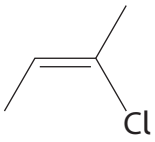
11 Geometric isomerism is shown by 2-chlorobut-2-ene.

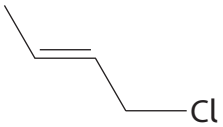
(a) What is the skeletal formula of *E*-2-chlorobut-2-ene?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(b) What is the **total** number of sigma bonds in *Z*-2-chlorobut-2-ene?

(1)

☒ **A** 3

☒ **B** 4

☒ **C** 10

☒ **D** 11

(Total for Question 11 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

12 This question is about the chlorides of beryllium and calcium.

(a) Complete the electronic configurations of the atoms of beryllium and calcium using the s, p, d notation.

(2)

Be $1s^2$

Ca $1s^2$

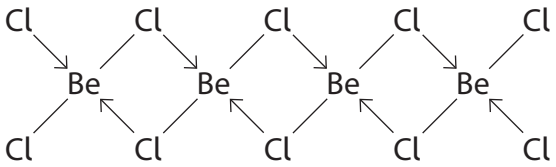
(b) In the gaseous state, beryllium chloride is molecular.

Draw a dot-and-cross diagram to show the bonding in a molecule of beryllium chloride, $BeCl_2$.

(2)

(c) In the solid state, beryllium chloride forms a polymeric structure.

The diagram shows part of this structure.



The diagram uses lines and arrows to represent the two different types of covalent bond.

Describe how each type of bond is formed.

(2)

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(d) The Cl—Be—Cl bond angle is different in the two forms of beryllium chloride.

Predict the two bond angles, justifying your answers by referring to electron-pair repulsion theory.

(4)

(e) Anhydrous calcium chloride is a crystalline, ionic solid which melts at 772 °C.

Draw a dot-and-cross diagram for calcium chloride.
Show the outer electrons only.

(2)

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(f) Explain why gaseous beryllium chloride and solid calcium chloride have different types of bonding.

(3)

(Total for Question 12 = 15 marks)

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13 This question is about silicon and carbon.

(a) Silicon is a semiconductor.

(i) Data obtained using the mass spectrum of silicon are shown.

Isotope mass number	Relative abundance
28	92.17
29	4.71
30	3.12

Calculate the relative atomic mass of silicon to **two** decimal places.

(2)

(ii) Suggest a reason why there is a small peak in the mass spectrum of silicon at $m/z = 14$

(1)

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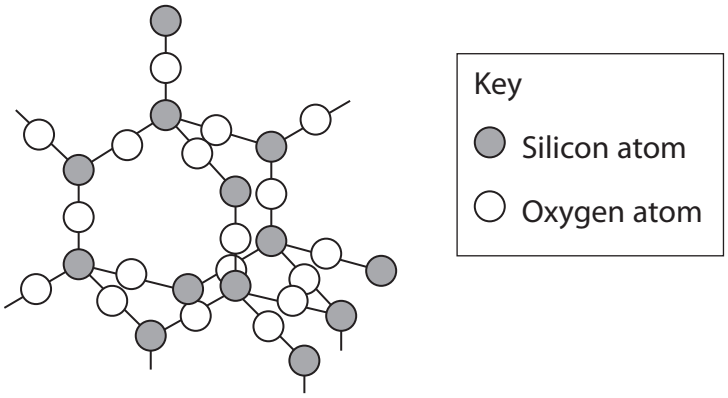
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(iii) Complete the table to show the number of protons and neutrons in each isotope of silicon.

Isotope	Number of protons	Number of neutrons
^{28}Si		
^{29}Si		
^{30}Si		

(1)

(b) Silicon dioxide, SiO_2, is the main constituent of sand and has a giant lattice structure similar to that of diamond.



Crystalline silicon dioxide is used on the surface of semiconductor devices to provide a heat-resistant, electrically insulating layer.

Explain how the structure and bonding of silicon dioxide make it useful for this application.

(3)

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(c) Calcium silicate is formed in the removal of silicon dioxide impurities in the extraction of iron from its ores. A sample of calcium silicate composed of calcium, silicon and oxygen was found to contain 12.0 g of calcium, 8.43 g of silicon and 14.47 g of oxygen.

Determine the empirical formula of calcium silicate.
You **must** show your working.

(3)

(d) Carbon dioxide is a gas at room temperature. A fizzy drink is canned at 5.0 °C and 1.3×10^5 Pa and contains approximately 3 g of carbon dioxide.

Calculate the volume, in cm^3, occupied by 3.00 g of carbon dioxide gas at 5.0 °C and 1.3×10^5 Pa.

[$pV = nRT$ $R = 8.31\ J\,mol^{-1}\,K^{-1}$]

(4)

(Total for Question 13 = 14 marks)

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14 Aluminium is an abundant metal with many uses.

(a) The first four ionisation energies of aluminium are shown.

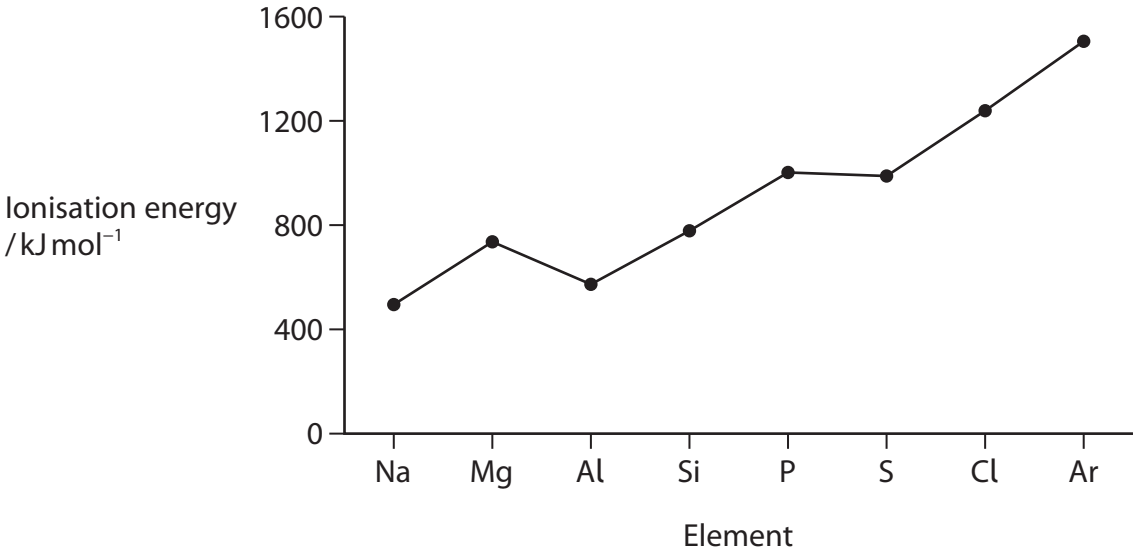
Ionisation number	Energy / kJ mol^{-1}
1	578
2	1820
3	2750
4	11 600

Explain how this information shows that aluminium is in Group 3 of the Periodic Table.

(2)

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(b) The graph shows the first ionisation energies for the elements in Period 3.



(i) Explain the general increase in the first ionisation energy from sodium to argon.

(2)

(ii) Explain why the first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

(2)

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(c) (i) Describe the bonding in aluminium metal.

(2)

(ii) Give two possible reasons why aluminium is used for overhead power cables.

(2)

(d) New uses for waste aluminium cans are being investigated. One possible use is to make nanoparticle alloys to produce hydrogen for fuel.

(i) Aluminium nanoparticles react with water to produce aluminium oxide and hydrogen.

Complete the following equation. State symbols are not required.

(1)

..... Al + ... H_2O → ..... + ...

(ii) Give **two** possible reasons for producing hydrogen from aluminium rather than from fossil fuels.

(2)

(Total for Question 14 = 13 marks)

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15 Alkanes and alkenes are obtained from crude oil.

(a) Describe how a sample of octadecane can be obtained from a mixture of alkanes.

(2)

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(b) (i) Octadecane can be cracked to produce butene and **one** other product.

Complete the equation. State symbols are not required.

$$C_{18}H_{38} \rightarrow 2C_4H_8 \quad +$$

(1)

(ii) One of the products of this cracking reaction is but-1-ene.

Give the **skeletal** formulae for the other three **alkene** isomers of C_4H_8

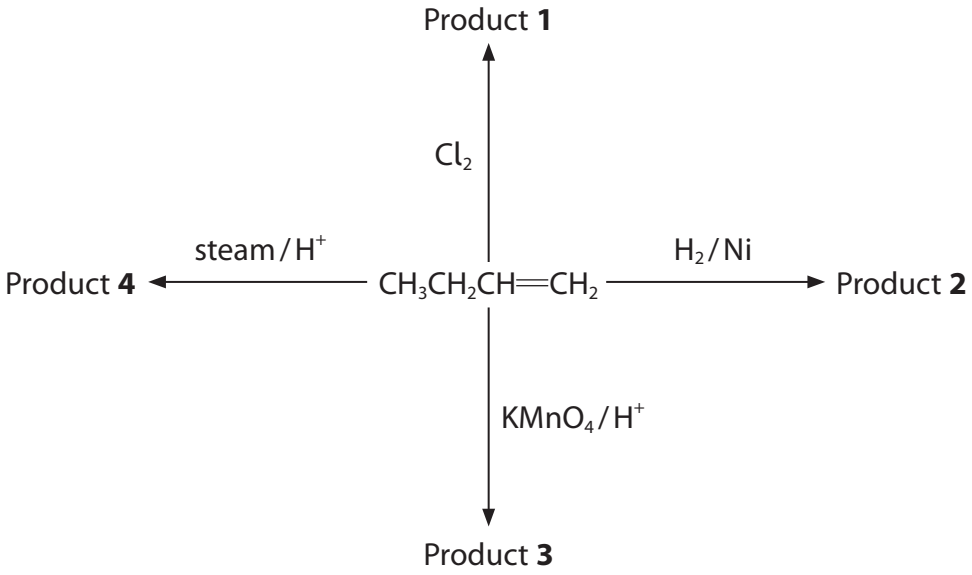
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(iii) Some reactions of but-1-ene are shown.



Give the name and **structural** formula of each of the products.

(4)

Product	Name	Structural formula
1		
2		
3		
4		

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(c) Draw the displayed formula of poly(but-1-ene) showing two repeat units.

(2)

(d) State **one** advantage and **one** disadvantage of using incineration for the disposal of polymers, other than the effect on climate.

(2)

.....

.....

.....

.....

(e) (i) Butane is used as a fuel.

The equation for the complete combustion of butane is shown.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

35.0 cm^3 butane is completely burned in 300 cm^3 oxygen.

Calculate the final total volume of gas in cm^3.

All volumes are measured at the same temperature and pressure.

(3)

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(ii) Explain the main hazard when using butane as a fuel in a portable heater in an enclosed space.

(2)

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(Total for Question 15 = 18 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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