Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 10 October 2023

Morning (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 ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P75070A

P 7 5 0 7 0 A 0 1 2 8

Pearson

SECTION A

Answer ALL the questions in this section.

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

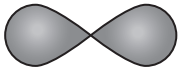
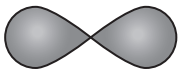
For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 An atom of $^{27}_{13}Al$ forms the ion, Al^{3+}.
What are the numbers of protons, electrons and neutrons in this ion?

	protons	electrons	neutrons
☒ **A**	13	13	14
☒ **B**	10	13	14
☒ **C**	14	10	13
☒ **D**	13	10	14

(Total for Question 1 = 1 mark)

2 What is the shape of a p orbital and the maximum number of electrons it can hold?

	shape	maximum number of electrons
☒ **A**		2
☒ **B**		6
☒ **C**		2
☒ **D**		6

(Total for Question 2 = 1 mark)

3 The formula of calcium carbide is CaC_2.

(a) What is the formula of the carbide ion?

(1)

- ☒ **A** C_2^-
- ☒ **B** C_2^+
- ☒ **C** C_2^{2-}
- ☒ **D** C_2^{2+}

(b) Excess calcium carbide and 10 g of water react to form the hydrocarbon ethyne, C_2H_2.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

What is the mass of ethyne that forms, assuming a yield of 100 %?

[M_r values: $H_2O = 18.0$ $C_2H_2 = 26.0$]

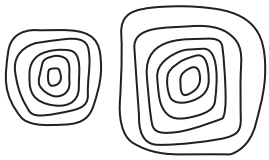
(1)

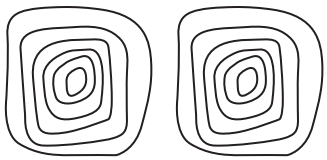
- ☒ **A** 7.22 g
- ☒ **B** 14.4 g
- ☒ **C** 23.4 g
- ☒ **D** 28.9 g

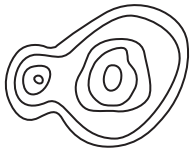
(Total for Question 3 = 2 marks)

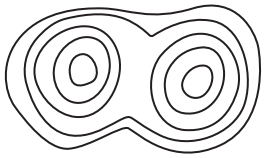
Use this space for any rough working. Anything you write in this space will gain no credit.

4 Which diagram best represents the electron density map of sodium chloride?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 What types of bonding are present in the compound ammonium chloride, NH_4Cl?

	Ionic	Covalent	Dative covalent
☒ **A**	✓	×	✓
☒ **B**	×	✓	×
☒ **C**	✓	✓	×
☒ **D**	✓	✓	✓

(Total for Question 5 = 1 mark)

6 The electronic configurations of the atoms of four elements are shown.

What is the electronic configuration of the atom of element which has the **lowest** first ionisation energy?

☒ **A** $1s^2 2s^2 2p^6 3s^2$

☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^1$

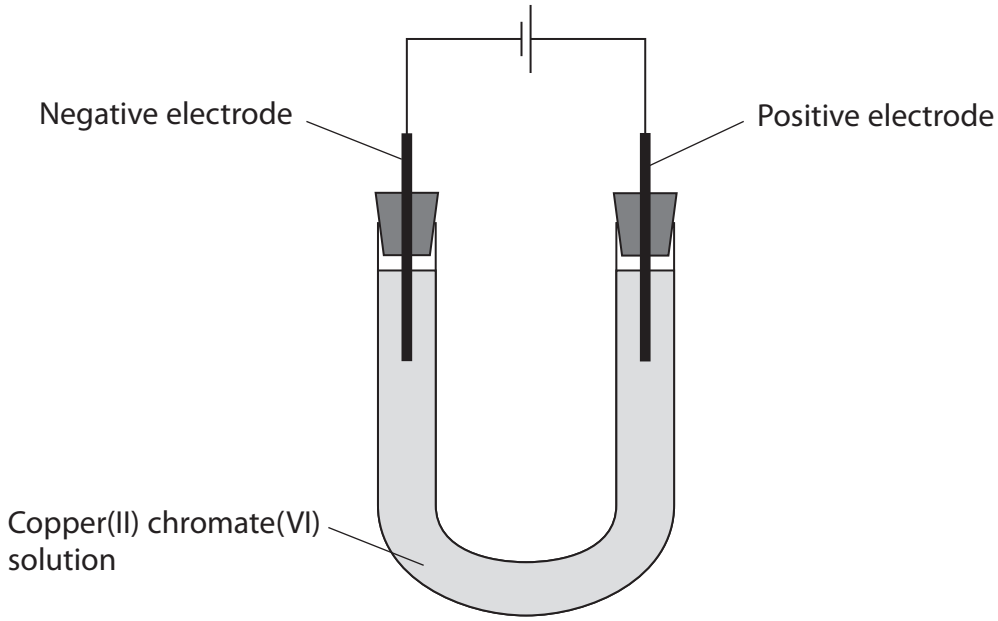
☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^2$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^3$

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 A direct electrical current was passed through a green solution of copper(II) chromate(VI) in the apparatus shown.



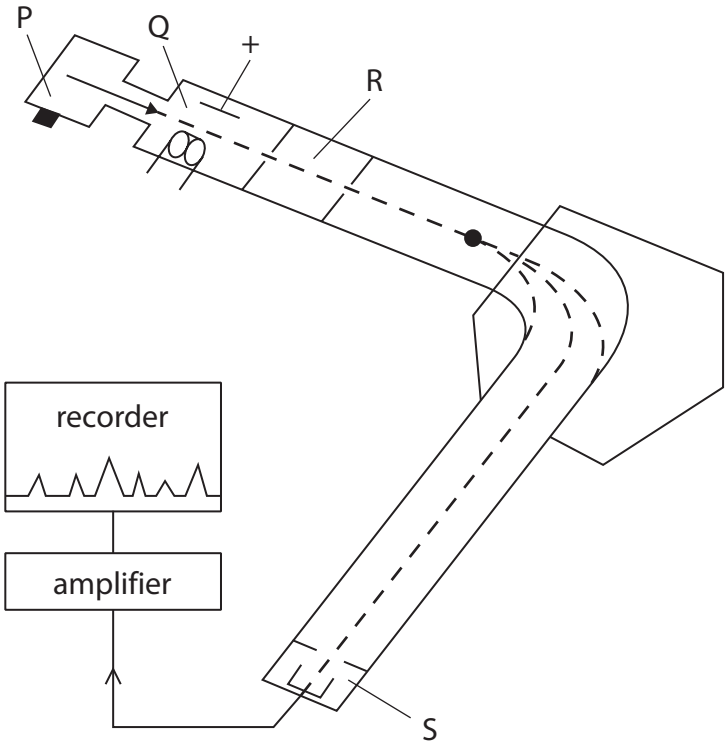
Which colours would be seen at each electrode after several minutes?

		Negative electrode	Positive electrode
☒	**A**	blue	green
☒	**B**	green	blue
☒	**C**	blue	yellow
☒	**D**	yellow	blue

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 In which region of a mass spectrometer are particles ionised?



- ☒ **A** region P
- ☒ **B** region Q
- ☒ **C** region R
- ☒ **D** region S

(Total for Question 8 = 1 mark)

9 A sample of the element chlorine, Cl_2, was analysed in a mass spectrometer.
Chlorine has **two** isotopes.

What is the **total** number of peaks, due to ions with a single positive charge, which could be seen in the mass spectrum?

- ☒ **A** two
- ☒ **B** four
- ☒ **C** five
- ☒ **D** six

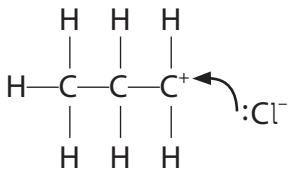
(Total for Question 9 = 1 mark)

10 Propene, $CH_3CH{=}CH_2$, reacts with hydrogen chloride, HCl, to form halogenoalkanes.

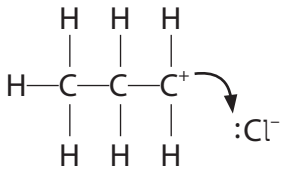
(a) Which of these steps is most likely to occur in the reaction?

(1)

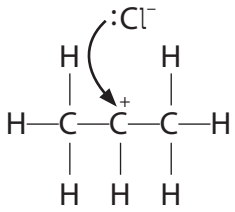
☒ **A**



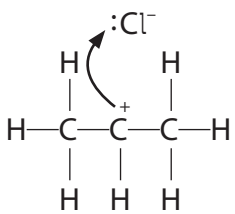
☒ **B**



☒ **C**



☒ **D**



(b) The reaction of propene with hydrogen chloride is an example of

(1)

☒ **A** free radical substitution

☒ **B** free radical addition

☒ **C** electrophilic substitution

☒ **D** electrophilic addition

(Total for Question 10 = 2 marks)

11 Ethene reacts with acidified potassium manganate(VII). A student makes four statements about the reaction.

- the organic product can show geometric isomerism
- the type of reaction that takes place is oxidation
- the bond angles around each carbon atom are greater in the product than in ethene
- the acidified potassium manganate(VII) decolourises in the reaction

How many of these statements are correct?

☒ **A** one

☒ **B** two

☒ **C** three

☒ **D** four

(Total for Question 11 = 1 mark)

12 Concentrations in mixtures can be given in units of parts per million (ppm).

(a) A sample of a gaseous mixture contains 2.19 % carbon dioxide by mass.

What is the concentration of carbon dioxide in parts per million (ppm) by mass in this sample?

(1)

☒ **A** 2.19×10^{6}

☒ **B** 2.19×10^{4}

☒ **C** 2.19×10^{-4}

☒ **D** 2.19×10^{-6}

(b) A solution of lead nitrate has a concentration of 15 ppm by mass.

What is the mass of lead nitrate in 400 g of this solution?

(1)

☒ **A** 6.00×10^{-3} g

☒ **B** 6.00×10^{-6} g

☒ **C** 6.00×10^{-3} kg

☒ **D** 6.00×10^{0} kg

(Total for Question 12 = 2 marks)

13 Which solution contains chloride ions with a concentration of 0.0500 mol dm^{-3}?

[A_r values: Ca = 40.1 Cl = 35.5 Na = 23.0]

	Solute	Mass of solute / g	Volume of solution / cm^3
☒ **A**	calcium chloride	1.39	250
☒ **B**	calcium chloride	1.39	500
☒ **C**	sodium chloride	1.46	250
☒ **D**	sodium chloride	1.46	1000

(Total for Question 13 = 1 mark)

14 The formula of phosgene is $COCl_2$.
What is the total number of **atoms** in 9.9 g of phosgene?

[Avogadro constant (L) = 6.02×10^{23} mol^{-1} M_r value: $COCl_2$ = 99.0]

☒ **A** 1.51×10^{22}

☒ **B** 6.02×10^{22}

☒ **C** 1.81×10^{23}

☒ **D** 2.41×10^{23}

(Total for Question 14 = 1 mark)

15 What is the number of structural isomers with the molecular formula C_5H_{12}?

☒ **A** six

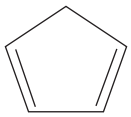
☒ **B** five

☒ **C** four

☒ **D** three

(Total for Question 15 = 1 mark)

16 A cyclic hydrocarbon has the structure shown.

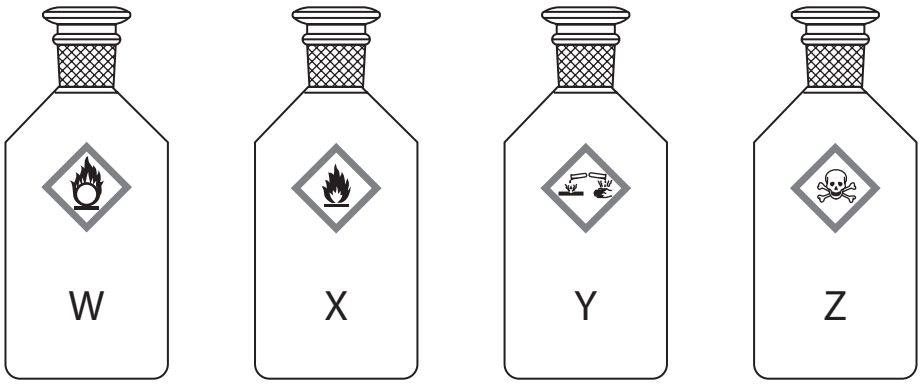


How many pi (π) and sigma (σ) bonds are present in the molecule?

		pi (π) bonds	sigma (σ) bonds
☒	**A**	2	11
☒	**B**	2	5
☒	**C**	4	3
☒	**D**	4	10

(Total for Question 16 = 1 mark)

17 A technician is asked to store four reagent bottles safely. The only information about each substance is the hazard label on the bottle.



Based on the hazard labels alone, which two bottles should **never** be stored together?

☒ **A** W and Z

☒ **B** Y and Z

☒ **C** W and X

☒ **D** Y and X

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

18 This question is about the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of some elements in Period 2 are shown.

Element	Li	Be	B	C	N	O	F	Ne
First ionisation energy / kJ mol^{-1}	520	900	801	1086	1402		1681	2081

(i) Explain the **general** trend in first ionisation energy across Period 2.

(2)

(ii) Predict a value for the first ionisation energy of oxygen.
Justify your answer.

(3)

(b) The second ionisation energy of lithium, Li, is 7298 kJ mol^{-1}.

(i) Write the equation for the second ionisation energy of lithium.
Include state symbols.

(2)

(ii) Explain the large difference between the first and second ionisation energies of lithium.

(2)

(c) Beryllium reacts with chlorine to form beryllium chloride.

In the gas phase, beryllium chloride exists both as a simple molecule, $BeCl_2$, and as a dimer, Be_2Cl_4.

(i) Draw a dot-and-cross diagram of the molecule, $BeCl_2$.

(1)

(ii) Explain the shape and bond angle in the molecule $BeCl_2$.

(4)

Shape

.....

Bond angle

.....

Explanation

.....

.....

.....

.....

.....

(iii) Draw a diagram to show how two beryllium chloride molecules bond together to form the dimer, Be_2Cl_4, stating the type of bond involved.

(2)

Type of bond

.....

(Total for Question 18 = 16 marks)

19 Many cars use fuels containing ethanol as well as hydrocarbons. The E numbers of these fuels show the percentage by volume of ethanol in the fuel. For example, an E5 fuel contains 5% ethanol and 95% hydrocarbons by volume.

(a) A brand of E10 fuel contains 92.2% hydrocarbons and 7.80% ethanol **by mass**.

The energy density is the amount of energy released per kg of a fuel burned. The energy densities of the two components of this brand of fuel are shown.

energy density of hydrocarbons $= 46.5\ \text{MJ kg}^{-1}$

energy density of ethanol $= 29.7\ \text{MJ kg}^{-1}$

(i) Calculate the **mean** energy density of this E10 fuel in MJ kg^{-1}.
Give your answer to an appropriate number of significant figures.

(2)

(ii) The density of the E10 fuel is $0.729\ \text{g cm}^{-3}$.

Calculate the mass of $1500\ \text{cm}^3$ of the fuel.

(1)

(iii) Calculate the energy released when $1500\ \text{cm}^3$ of the E10 fuel is burned in excess oxygen, using your answers from (a)(i) and (a)(ii).

[If you did not calculate a value for the **mean** energy density of the E10 fuel in (a)(i), use a value of $38.1\ \text{MJ kg}^{-1}$. This is not the correct value.]

(1)

(b) Many countries are gradually replacing E5 fuels with E10 fuels.

Explain how this change might result in a more sustainable fuel.

(3)

(c) The straight-chain alkane hexane can be reformed to give a range of products.
It was suggested that one such reaction may produce a cyclic hydrocarbon and hydrogen gas as the only products.
The cyclic hydrocarbon contains a ring of five carbon atoms.

(i) Write the equation for this reaction using molecular formulae.
State symbols are not required.

(1)

(ii) Draw the structure of the cyclic hydrocarbon formed in this reaction.

(1)

(d) Hexane will react with chlorine in the presence of ultraviolet light to form a number of products.

(i) Describe the role of the ultraviolet light in the initiation step of this reaction.

(2)

.....

.....

.....

.....

.....

(ii) The alkane dodecane, $C_{12}H_{26}$, is formed in this reaction.
Write equations for the propagation step and for the termination step for the formation of this product.
Use molecular formulae in your equations.

(2)

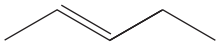
Propagation step

Termination step

(Total for Question 19 = 13 marks)

20 This question is about alkenes.

(a) A straight-chain alkene, **X**, has the structure shown.



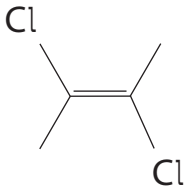
(i) Draw the skeletal formulae of the four structural isomers of **X** that are alkenes.
Do not include geometric isomers.

(4)

(ii) Explain why **X** can exist as **geometric** isomers.

(2)

(b) Another compound, **Y**, has the structure shown.



(i) Give the IUPAC name for **Y**.

(1)

(ii) A student stated that

'Compound **Y** has polar bonds so it is a polar molecule'.

Comment on this statement.

(3)

(c) Bisabolenes are a group of compounds found in plants and fungi.
Bisabolene molecules contain several carbon–carbon double bonds.

5.51 g of α-bisabolene reacted with 1873 cm^3 of hydrogen gas, H_2.
The reaction occurred at a temperature of 150 °C and a pressure of 152 000 Pa.

[M_r value: α-bisabolene = 204.0]

(i) Calculate the amount, in mol, of α-bisabolene in 5.51 g.

(1)

(ii) Calculate the amount, in mol, of hydrogen gas that reacted with α-bisabolene.
Use the ideal gas equation, $pV = nRT$.

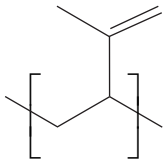
[$R = 8.31\ J\,mol^{-1}\,K^{-1}$]

(3)

(iii) Deduce the number of carbon-carbon double bonds in a molecule of α-bisabolene, using your answers to (c)(i) and (c)(ii).

(1)

(d) The repeat unit of the polymer polyisoprene is shown.



polyisoprene

(i) Draw the **skeletal** formula of the monomer of polyisoprene.

(1)

(ii) A sample of polyisoprene has a relative molecular mass of 50 250.
Calculate the number of repeat units in the sample.

(2)

(e) Incinerators used to dispose of polymer waste have a system to remove waste gases.
Suggest why these systems contain solid calcium hydroxide and why it is finely powdered.

(2)

.....

.....

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.....

.....

.....

(Total for Question 20 = 20 marks)

21 This question is about minerals containing metallic elements.

(a) The green mineral zaratite contains basic nickel(II) carbonate, $Ni_3CO_3(OH)_4 \cdot 4H_2O$.

Basic nickel(II) carbonate can be formed by the reaction of nickel(II) sulfate with sodium carbonate under alkaline conditions, as shown.

$$3NiSO_4(aq) + Na_2CO_3(aq) + 4NaOH(aq) + 4H_2O(l) \rightarrow Ni_3CO_3(OH)_4 \cdot 4H_2O(s) + 3Na_2SO_4(aq)$$

[A_r values: H = 1.0 C = 12.0 O = 16.0 Na = 23.0 S = 32.1 Ni = 58.7]

(i) Calculate the relative formula mass of basic nickel(II) carbonate, $Ni_3CO_3(OH)_4 \cdot 4H_2O$.

(1)

(ii) Calculate the atom economy by mass for the formation of basic nickel(II) carbonate by the reaction shown.

(2)

(iii) Give the reason why use of the term 'relative molecular mass' is not appropriate in (a)(i).

(1)

.....

.....

.....

.....

(b) Chemists often simplify full chemical equations into ionic equations by removing spectator ions.

(i) Give the electronic configuration of the nickel ion present in nickel(II) compounds.

(1)

.....

(ii) Write the **ionic** equation for the formation of basic nickel(II) carbonate from nickel(II) sulfate.
State symbols are not required.

$3NiSO_4(aq) + Na_2CO_3(aq) + 4NaOH(aq) + 4H_2O(l) \rightarrow Ni_3CO_3(OH)_4 \cdot 4H_2O(s) + 3Na_2SO_4(aq)$

(1)

(c) Another basic carbonate found in minerals contains the metal element **X** and is formed by the reaction shown.

$$2\mathbf{X}SO_4 + 2Na_2CO_3 + H_2O \rightarrow \mathbf{X}_2CO_3(OH)_2 + 2Na_2SO_4 + CO_2$$

1.995 g of $\mathbf{X}SO_4$ is reacted with excess Na_2CO_3 forming 150.0 cm^3 of carbon dioxide gas, CO_2, at room temperature and pressure, r.t.p.

[Molar volume of a gas at r.t.p. = 24.0 $dm^3\,mol^{-1}$]

(i) Calculate the relative formula mass of $\mathbf{X}SO_4$, using these data.

(4)

(ii) Deduce the identity of **X**, using your answer to (c)(i).

(1)

(Total for Question 21 = 11 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) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(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							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

* Lanthanide 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
* Actinide series	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