Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Thursday 9 January 2020

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

Candidates 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, punctation and spelling.
- There is a Periodic Table 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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P 6 0 2 7 1 A 0 1 2 4

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 How many protons, neutrons and electrons are in a $^{37}Cl^-$ ion?

	Protons	Neutrons	Electrons
☒ **A**	17	20	16
☒ **B**	17	20	17
☒ **C**	17	20	18
☒ **D**	20	17	21

(Total for Question 1 = 1 mark)

2 A sample of an element **X** contains only the isotopes shown.

Isotope	Percentage abundance
^{58}X	68.077
^{60}X	26.223
^{61}X	1.140
^{62}X	3.634
^{64}X	0.926

What is the relative atomic mass of element **X** to **three** decimal places in this sample?

☒ **A** 58.760

☒ **B** 58.8

☒ **C** 59.4

☒ **D** 59.440

(Total for Question 2 = 1 mark)

3 How many **orbitals** are there, in total, in the first three quantum shells of an atom?

- ☒ **A** 3
- ☒ **B** 6
- ☒ **C** 9
- ☒ **D** 14

(Total for Question 3 = 1 mark)

4 Which element is in the **p-block** and has atoms containing **two** unpaired electrons in the ground state?

- ☒ **A** lithium
- ☒ **B** carbon
- ☒ **C** fluorine
- ☒ **D** titanium

(Total for Question 4 = 1 mark)

5 The first five ionisation energies of an element, in kJ mol^{-1}, are

578 1817 2745 11578 14831

This element could be

- ☒ **A** sodium
- ☒ **B** magnesium
- ☒ **C** aluminium
- ☒ **D** silicon

(Total for Question 5 = 1 mark)

6 What is the relative formula mass of hydrated barium hydroxide, $Ba(OH)_2.8H_2O$?

[A_r values: Ba = 137.3, O = 16.0, H = 1.0]

- ☒ **A** 171.3
- ☒ **B** 203.3
- ☒ **C** 299.3
- ☒ **D** 315.3

(Total for Question 6 = 1 mark)

7 An 11.0 g sample of anhydrous sodium sulfate, Na_2SO_4, is dissolved in deionised water to form 70 cm^3 of solution.

What is the concentration, in mol dm^{-3}, of Na_2SO_4 in the aqueous solution formed?

[M_r value: Na_2SO_4 = 142.1]

☒ **A** 0.0011

☒ **B** 0.90

☒ **C** 1.1

☒ **D** 900

(Total for Question 7 = 1 mark)

8 Which of these ionic compounds would be expected to have the **highest** melting temperature?

☒ **A** NaF

☒ **B** MgO

☒ **C** KCl

☒ **D** CaS

(Total for Question 8 = 1 mark)

9 Which of these compounds has the **greatest** covalent character?

☒ **A** MgF_2

☒ **B** MgI_2

☒ **C** BaF_2

☒ **D** BaI_2

(Total for Question 9 = 1 mark)

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

10 Barium chloride reacts with sodium sulfate:

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$$

[M_r values: $BaCl_2 = 208.3$, $Na_2SO_4 = 142.1$, $BaSO_4 = 233.4$, $NaCl = 58.5$]

(a) What would you **see** when this reaction is carried out?

(1)

☒ **A** blue solution turns colourless

☒ **B** effervescence

☒ **C** no visible change

☒ **D** white precipitate

(b) What is the ionic equation for this reaction?

(1)

☒ **A** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☒ **B** $Na^+(aq) + Cl^-(aq) \rightarrow NaCl(aq)$

☒ **C** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) + Na^+(aq) + Cl^-(aq) \rightarrow BaSO_4(s) + NaCl(aq)$

(c) What is the maximum mass of $BaSO_4$ that could be produced from 0.500 g of $BaCl_2$ in this reaction?

(1)

☒ **A** 0.446 g

☒ **B** 0.500 g

☒ **C** 0.560 g

☒ **D** 0.821 g

(d) What is the atom economy (by mass) for the formation of $BaSO_4$ in this reaction?

(1)

☒ **A** 33.3%

☒ **B** 62.2%

☒ **C** 66.6%

☒ **D** 80.0%

(Total for Question 10 = 4 marks)

11 Which of these forms of carbon does **not** contain delocalised electrons?

- ☒ **A** diamond
- ☒ **B** C_{60} fullerene
- ☒ **C** graphene
- ☒ **D** graphite

(Total for Question 11 = 1 mark)

12 Which of these molecules is polar?

- ☒ **A** OF_2
- ☒ **B** BF_3
- ☒ **C** CF_4
- ☒ **D** PF_5

(Total for Question 12 = 1 mark)

13 Which species has its correct shape and bond angle shown?

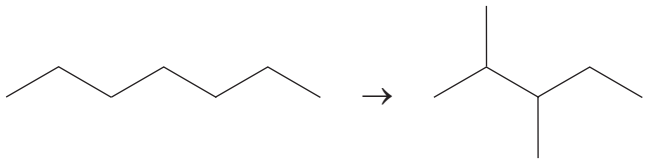
	Species	Shape	Bond angle
☒ **A**	CH_3^+	trigonal planar	120°
☒ **B**	NH_3	pyramidal	109.5°
☒ **C**	NH_4^+	square planar	90°
☒ **D**	H_2O	linear	180°

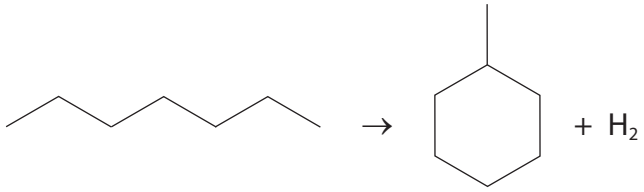
(Total for Question 13 = 1 mark)

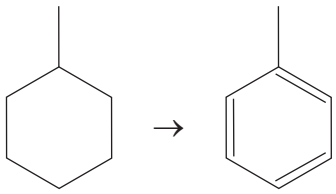
Use this space for any rough working. Anything you write in this space will gain no credit.

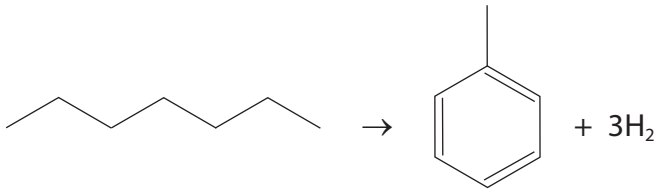
14 Some equations for reactions used in reforming crude oil fractions are shown.

Which equation is **not** balanced?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 14 = 1 mark)

15 A pure alkane fuel is burned in air.
Which substance is **not** a possible combustion product?

☒ **A** H_2

☒ **B** H_2O

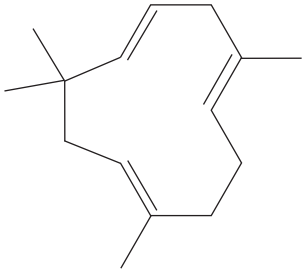
☒ **C** CO

☒ **D** CO_2

(Total for Question 15 = 1 mark)

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

16 What is the number of σ bonds and π bonds in one molecule of this compound?



	σ bonds	π bonds
☒ **A**	15	3
☒ **B**	39	3
☒ **C**	15	6
☒ **D**	39	6

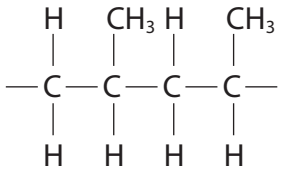
(Total for Question 16 = 1 mark)

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

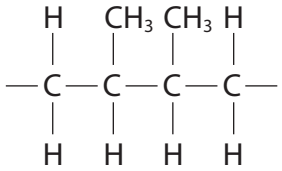
17 The polymers shown are all made from single monomers.

Which polymer is made from a monomer that has geometric isomers?

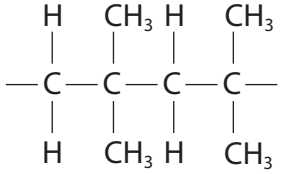
☒ **A**



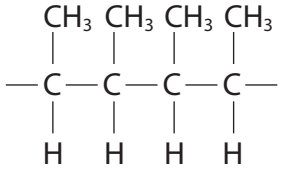
☒ **B**



☒ **C**



☒ **D**



(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 element chlorine.

(a) Give the electronic configuration, using the s, p, d notation, for a chlorine atom in the ground state.

(1)

(b) Write an equation for the **first** ionisation energy of chlorine.
Include state symbols.

(2)

(c) Explain the difference in the **first** ionisation energies of chlorine and bromine.

(3)

(d) Chlorine occurs naturally as a diatomic molecule.

Draw a dot-and-cross diagram to show the bonding in a molecule of chlorine.
Show outer shell electrons only.

(1)

(e) Chlorine is a gas at room temperature and pressure.

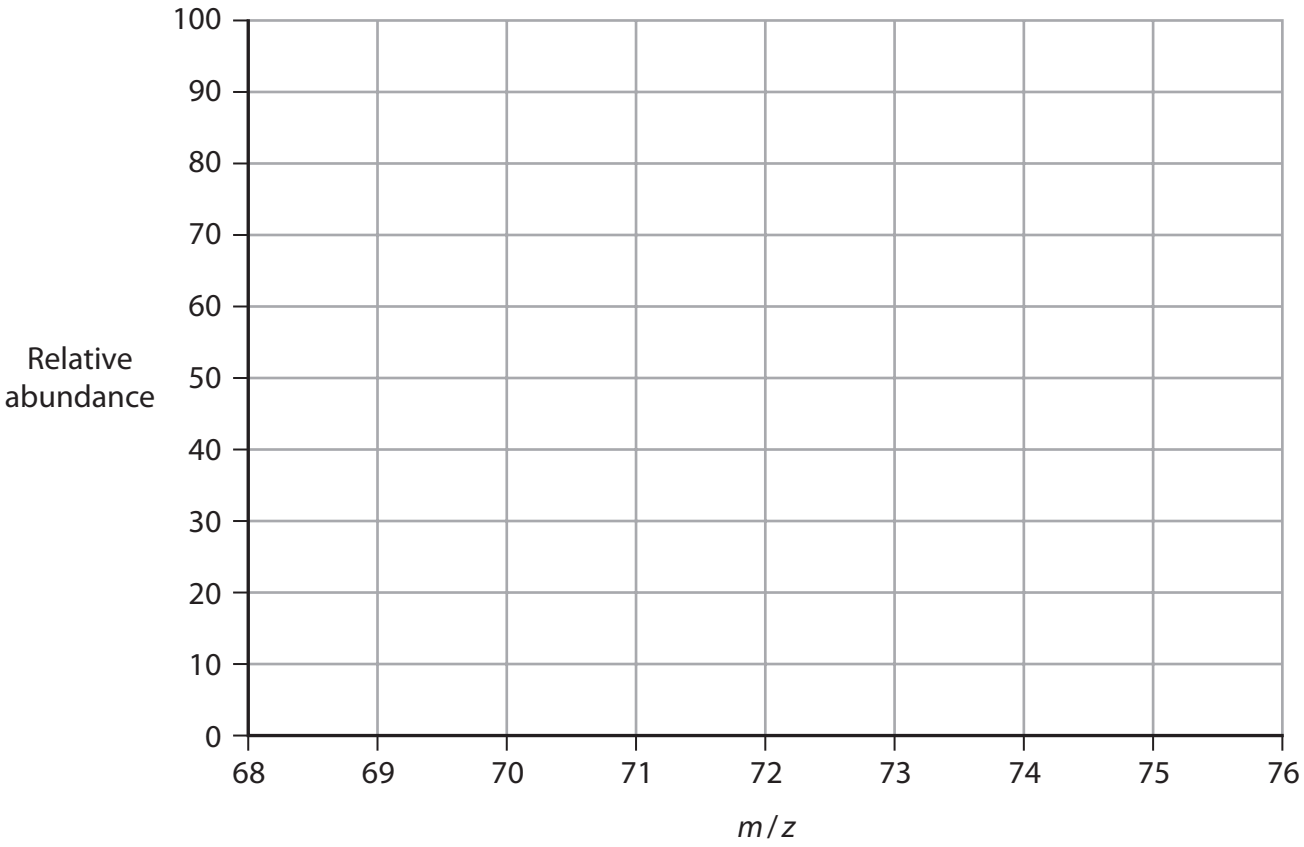
Explain why chlorine has a low boiling temperature.

(2)

(f) Chlorine has two stable isotopes. The isotopes have mass numbers 35 and 37, with relative abundance in the ratio 3 : 1.

(i) Complete the mass spectrum for a sample of chlorine gas to show the expected molecular ion peaks due to Cl_2^+.

(2)



(ii) Suggest why there could be a small peak at $m/z = 36$ in the mass spectrum of chlorine gas.

(2)

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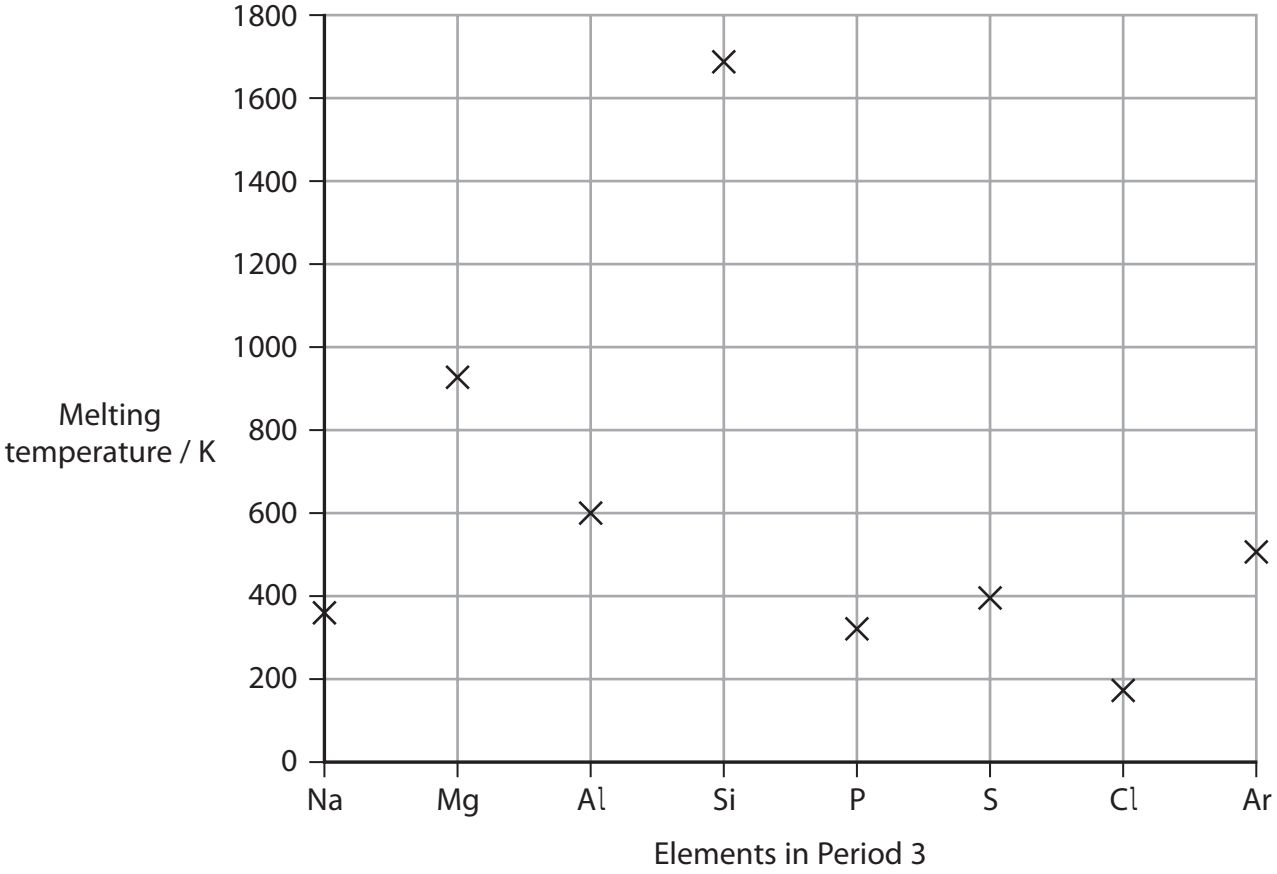
.....

(Total for Question 18 = 13 marks)

19 This question is about the bonding, structure and properties of the elements in Period 3 of the Periodic Table and their compounds.

(a) A student plotted a graph to show the melting temperatures of the elements in Period 3.



(i) The student incorrectly plotted **two** values: one for a metal and one for a non-metal.

Identify these elements, by name or formula.

(2)

.....

.....

(ii) Explain, with reference to structure and bonding, why silicon has a very high melting temperature.

(3)

(b) Aluminium has the greatest electrical conductivity of the Period 3 elements.

(i) Describe how metals conduct electricity.

(2)

(ii) Give a possible reason why aluminium has a higher electrical conductivity than sodium.

(1)

(c) Aluminium is extracted by the electrolysis of aluminium oxide in the liquid state.

(i) Draw a dot-and-cross diagram to show the bonding in aluminium oxide. Show outer shell electrons only.

(3)

(ii) Give a reason why aluminium oxide must be in the liquid state before electrolysis can occur.

(1)

.....

.....

(Total for Question 19 = 12 marks)

20 This question is about hexane, C_6H_{14}.

(a) The skeletal formula of hexane is

Draw the four structural isomers of hexane in the boxes.

(4)

Isomer 1	Isomer 2
Isomer 3	**Isomer 4**

(b) Hexane reacts with bromine in the presence of ultraviolet radiation to form a mixture of bromoalkanes.

(i) Draw the initiation step of this reaction, using curly half-arrows.

(2)

(ii) Write equations for two propagation steps to show how $C_6H_{13}Br$ is formed. Curly arrows are **not** required.

(2)

(iii) Give the **molecular** formula of an alkane formed in a termination step in this reaction.

(1)

(iv) Calculate the percentage by mass of bromine in the heaviest molecule containing **six** carbon atoms that could form when hexane reacts with a **large excess** of bromine.

[A_r values: C = 12.0, Br = 79.9]

(3)

(Total for Question 20 = 12 marks)

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21 This question is about ethene, C_2H_4.

(a) The global production of ethene is about 150 million tonnes per year.

Calculate the number of **molecules** in 150 million tonnes of ethene.

[1 tonne = 1000 kg Avogadro constant = 6.02×10^{23} mol^{-1}]

(2)

(b) Ethene is used commercially to speed up the ripening of bananas.
Ethene levels of 100 parts per million (ppm) are used in ripening rooms.

Calculate the amount, in **moles**, of ethene in a ripening room of volume 220 m^3 at a temperature of 21°C and pressure of 1.01×10^5 Pa.

Give your answer to an appropriate number of significant figures.

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

(5)

(c) Ethene and chlorine react to form 1,2-dichloroethane.

(i) Draw the mechanism for the reaction between ethene and chlorine to form 1,2-dichloroethane.
Include curly arrows, and relevant lone pairs and dipoles.

(4)

(ii) One hazard symbol for 1,2-dichloroethane is shown.

By identifying this hazard, give **one** way of minimising the risk when working with 1,2-dichloroethane in a laboratory.

Assume the use of safety goggles and a laboratory coat.

(2)

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(d) Ethene reacts with oxygen, O_2, in the presence of a silver catalyst, to form compound **Y** as the only product.

(i) When 10.0 g of ethene reacts completely with oxygen, the mass of compound **Y** formed is 15.7 g.

Calculate the empirical formula of **Y**.

You **must** show your working.

[A_r values: H = 1.0, C = 12.0, O = 16.0]

(2)

(ii) Compound **Y** reacts with water to form compound **Z**.
Compound **Z** is also produced in the reaction between ethene and acidified potassium manganate(VII).

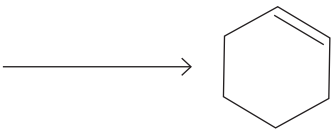
Give the **displayed** formula of compound **Z**.

(1)

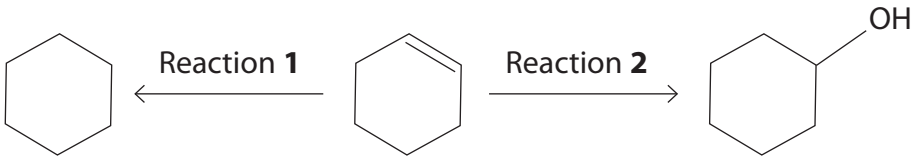
(e) Ethene reacts with buta-1,3-diene to form cyclohexene as the only product.

Complete the equation for the formation of cyclohexene from ethene and buta-1,3-diene using **skeletal** formulae.

(1)



(f) Two reactions of cyclohexene are shown.



(i) Classify the type of reaction occurring in Reaction **1**.

(1)

.....

(ii) Give the reagents and conditions needed for Reaction **2**.

(2)

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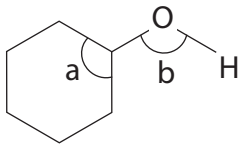
(iii) Cyclohexanol is the product of Reaction **2**.



Bond angle a = 109.5°

Explain why bond angle b is smaller than bond angle a.
Include the expected value for bond angle b in your answer.

(3)

(Total for Question 21 = 23 marks)

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

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