Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Tuesday 20 May 2025

Morning (Time: 1 hour 30 minutes)

Paper reference **8CH0/02**

Chemistry

Advanced Subsidiary

PAPER 2: Core Organic and Physical Chemistry

You must have:
Scientific calculator, Data Booklet, 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.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- 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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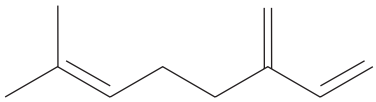
Pearson

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about a naturally-occurring compound called myrcene, which is found in many plants.

The skeletal formula of myrcene is shown.



(a) What is the molecular formula of myrcene?

(1)

☒ **A** C_5H_5

☒ **B** C_5H_8

☒ **C** $C_{10}H_{10}$

☒ **D** $C_{10}H_{16}$

(b) What is the **maximum** number of moles of bromine **molecules** that could react with one mole of myrcene in the dark?

(1)

☒ **A** 2

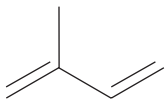
☒ **B** 3

☒ **C** 4

☒ **D** 6

(c) Myrcene is a dimer of isoprene.

Isoprene has the skeletal formula shown.



Which is the IUPAC name for isoprene?

(1)

☒ **A** 2-methylbut-1,3-ene

☒ **B** 2-methylbuta-1,3-diene

☒ **C** 1,3-diene-2-methylbutane

☒ **D** 2-methylpent-1,3-ene

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(d) Which reagent would convert an alkene group into a diol?

(1)

- ☒ **A** hydrogen gas and a nickel catalyst
- ☒ **B** acidified potassium dichromate(VI)
- ☒ **C** acidified potassium manganate(VII)
- ☒ **D** steam and an acid catalyst

(Total for Question 1 = 4 marks)

2 Which compound must be named using the *E*/*Z* system and could not be named using the cis/trans system?

- ☒ **A** HOOC—CH_2—CH_2—COOH
- ☒ **B** HOOC—CH_2—CBr═CH—COOH
- ☒ **C** HOOC—CH_2—CBr═CBr_2
- ☒ **D** HOOC—$(CH_2)_2$—CH═CH—$(CH_2)_2$—COOH

(Total for Question 2 = 1 mark)

3 This question is about the combustion of alcohols.

The table shows the enthalpy change of combustion for a series of alcohols.

Name	Formula	Enthalpy change of combustion / kJ mol^{-1}
methanol	CH_3OH	–726
ethanol	C_2H_5OH	–1367
propan-1-ol	C_3H_7OH	–2021
butan-1-ol	C_4H_9OH	–2676

(a) Predict the enthalpy change of combustion of hexan-1-ol, $C_6H_{13}OH$.

(1)

..... kJ mol^{-1}

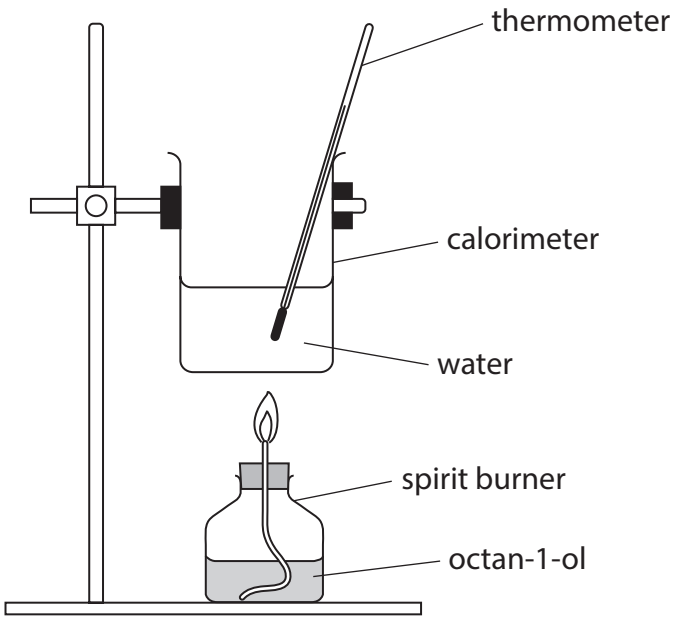
(b) The enthalpy change of combustion of octan-1-ol can be determined using the equipment shown in the diagram.

Procedure

A spirit burner was filled with liquid octan-1-ol.

The burner was weighed, lit and then used to raise the temperature of a quantity of water in a calorimeter.

The burner was then extinguished and reweighed.



The table shows the results.

Results	
Mass of burner + octan-1-ol before burner was lit	20.95 g
Mass of burner + octan-1-ol after burner was extinguished	20.15 g
Mass of water in calorimeter	200 g
Temperature of water after heating	48.3 °C
Temperature of water before heating	21.0 °C
Other data	
Specific heat capacity of water	4.18 J g^{-1} $°C^{-1}$
Molar mass of octan-1-ol	130 g mol^{-1}

Calculate the enthalpy change of combustion of octan-1-ol, in kJ mol^{-1}, using these data.
Include a sign in your answer.
You must show your working.

(4)

(c) In the experiment, the calorimeter is not insulated.

Explain the difference between the enthalpy change of combustion of octan-1-ol determined in this experiment and that quoted in a data book.

(2)

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(d) A student carried out this experiment leaving the thermometer at the bottom of the calorimeter and not stirring.

Explain the effect this would have on the calculated enthalpy change of combustion for octan-1-ol.

(2)

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(Total for Question 3 = 9 marks)

4 This question is about some reactions and properties of unbranched alcohols.

(a) Butan-1-ol can be produced from the reaction of aqueous potassium hydroxide with 1-bromobutane.

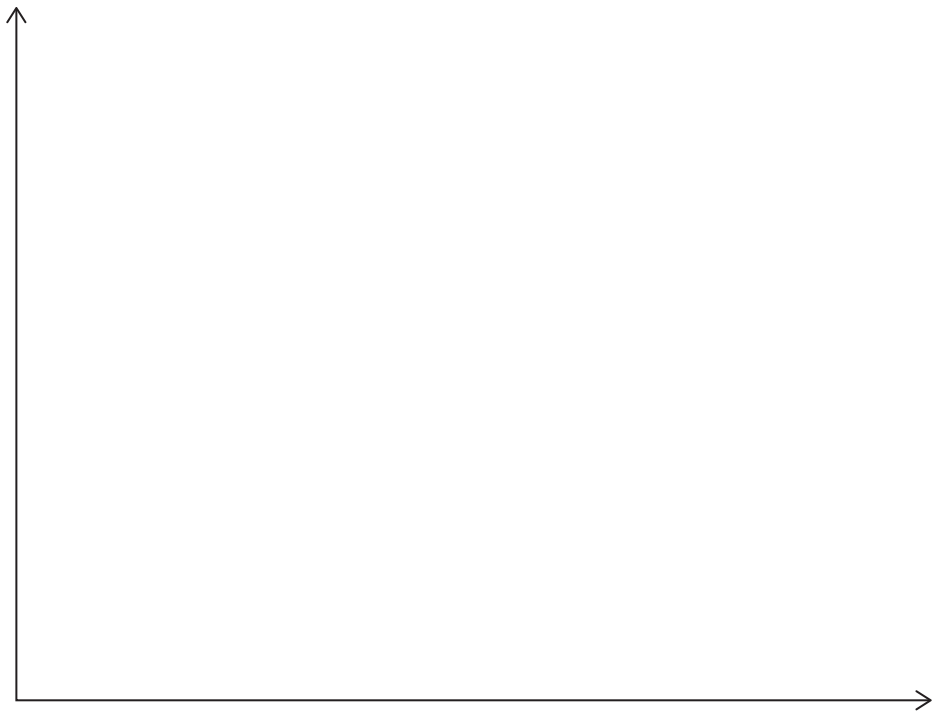
Draw the reaction mechanism for this reaction.
Include curly arrows and any relevant lone pairs and dipoles.

(3)

(b) Butan-1-ol can also be produced from the reaction of water with 1-bromobutane.

Draw a fully labelled enthalpy level diagram for this endothermic reaction.
Include the formulae of all the species involved.
State symbols are not required.

(2)



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(c) The melting and boiling temperatures of alcohols depend upon intermolecular forces.

(i) As the number of carbon atoms increases in the homologous series of unbranched primary alcohols, the state at room temperature changes from liquid to solid.

Explain this trend in change of state from liquid to solid.

(2)

(ii) The boiling temperatures of three isomeric alcohols are shown.

Alcohol	Boiling temperature / K
pentan-1-ol	411
2-methylbutan-1-ol	401
2,2-dimethylpropan-1-ol	386

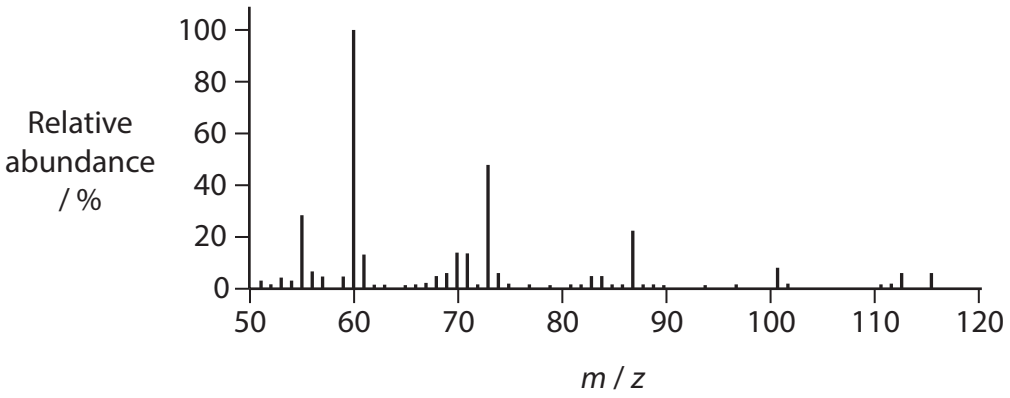
Explain the differences in the boiling temperatures of these three isomers.

(2)

(Total for Question 4 = 9 marks)

5 This question is about mass spectrometry and infrared spectroscopy.

(a) Part of the mass spectrum of an **unbranched** carboxylic acid is shown.



(i) Identify the relative molecular mass of this carboxylic acid, using information from the spectrum.

(1)

.....

(ii) Write the formula of a possible fragment **ion** with a peak at $m/z = 15$.

(2)

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(iii) Identify, by name or formula, this carboxylic acid.

(1)

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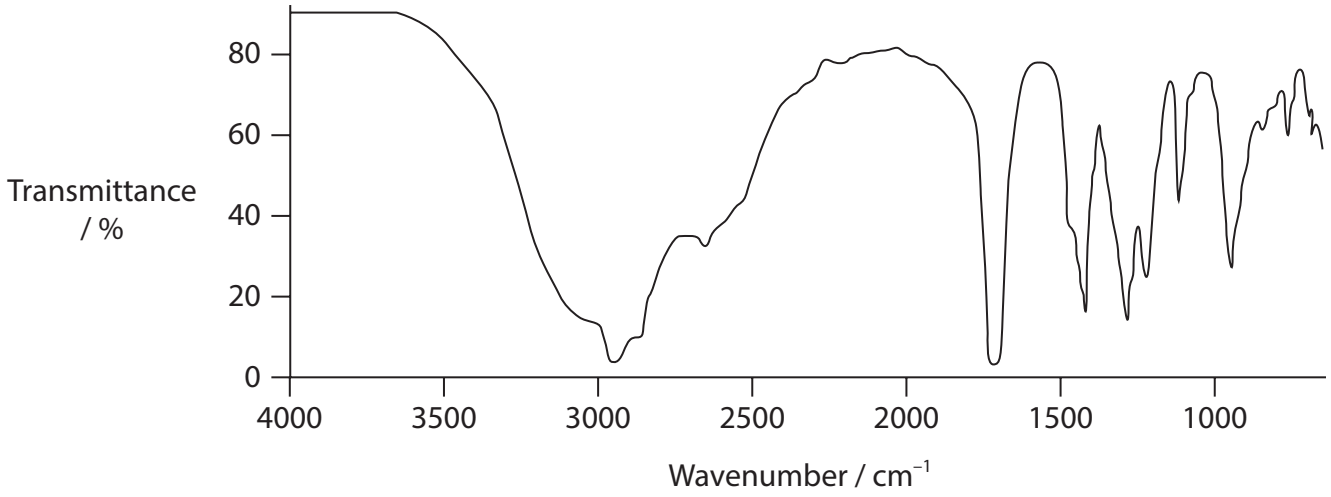
(b) The infrared spectrum of the same carboxylic acid is shown.



(i) Explain why identification of the carboxylic acid from the information provided by this infrared spectrum **alone** would be very difficult.

(2)

(ii) Identify the bond responsible for the absorption in the range 1725–1700 cm^{-1} in this infrared spectrum.

(1)

(iii) Give a possible explanation, with reference to the intermolecular forces involved, why the peak in the range 3300–2500 cm^{-1} is **broad**.

(2)

(Total for Question 5 = 9 marks)

6 This question is about some reactions of butan-1-ol and butan-2-ol.

(a) Which is the equation for the reaction of butan-1-ol with phosphorus(V) chloride?

(1)

☒ **A** $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + POCl_3 + HCl$

☒ **B** $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + PO + HCl + 1½Cl_2$

☒ **C** $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + P + 1½Cl_2 + HOCl$

☒ **D** $2C_4H_9OH + PCl_5 \rightarrow 2C_4H_9Cl + POCl_3 + H_2O$

(b) A student was asked to prepare pure, dry butanone, starting from butan-2-ol, solid anhydrous sodium dichromate(VI) and sulfuric acid.

The equation for the reaction is shown.

$$Cr_2O_7^{2-} + 8H^+ + 3CH_3CH(OH)CH_2CH_3 \rightarrow 3CH_3COCH_2CH_3 + 2Cr^{3+} + 7H_2O$$

(i) Calculate the **minimum** mass of sodium dichromate(VI), $Na_2Cr_2O_7$, required to oxidise 0.150 mol of butan-2-ol.

(3)

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*(ii) Describe, in detail, the steps in the procedure to make pure, dry butanone from butan-2-ol.

For each step, include the names of the pieces of equipment needed. Diagrams of laboratory apparatus are **not** required.

[Boiling temperature of butanone = 353 K
Boiling temperature of butan-2-ol = 372 K]

(6)

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(c) Butan-2-ol reacts with a mixture of 50 % concentrated sulfuric acid and potassium bromide.

Draw the **skeletal** formula of the organic compound formed in this reaction.

(1)

(d) Red phosphorus reacts with iodine to form phosphorus triiodide, PI_3.

$$P_4 + 6I_2 \rightarrow 4PI_3$$

Phosphorus triiodide reacts with butan-2-ol to form 2-iodobutane.

$$3CH_3CH(OH)CH_2CH_3 + PI_3 \rightarrow 3CH_3CHICH_2CH_3 + H_3PO_3$$

(i) Calculate the number of iodine molecules needed to produce 22.1 g of PI_3.

[$L = 6.02 \times 10^{23}\,mol^{-1}$
Molar mass of phosphorus triiodide = $411.7\,g\,mol^{-1}$]

(3)

(ii) 11.9 g of butan-2-ol was reacted with excess phosphorus triiodide.
22.8 g of pure 2-iodobutane was formed.

Calculate the percentage yield of 2-iodobutane.

[Molar mass of butan-2-ol = 74 g mol^{-1}
Molar mass of 2-iodobutane = 183.9 g mol^{-1}]

(3)

(e) The organic product formed when butan-1-ol is partially oxidised is isomeric with the butanone synthesised in (b).

Give the **structural** and **molecular** formulae of these two products stating how they are isomeric.

(2)

.....

.....

(Total for Question 6 = 19 marks)

7 This question is about the industrial preparation of methanol.

The equation for the reaction of hydrogen with carbon dioxide to form methanol is shown.

$$3H_2(g) + CO_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49\,kJ\,mol^{-1}$$

The reaction is carried out at a temperature of 700 K and a pressure of 90 atm in the presence of a catalyst.

(a) (i) Explain why the reaction is carried out at a temperature of 700 K rather than 400 K or 1000 K.

(3)

(ii) Explain why the reaction is carried out at a pressure of 90 atm rather than 40 atm or 140 atm.

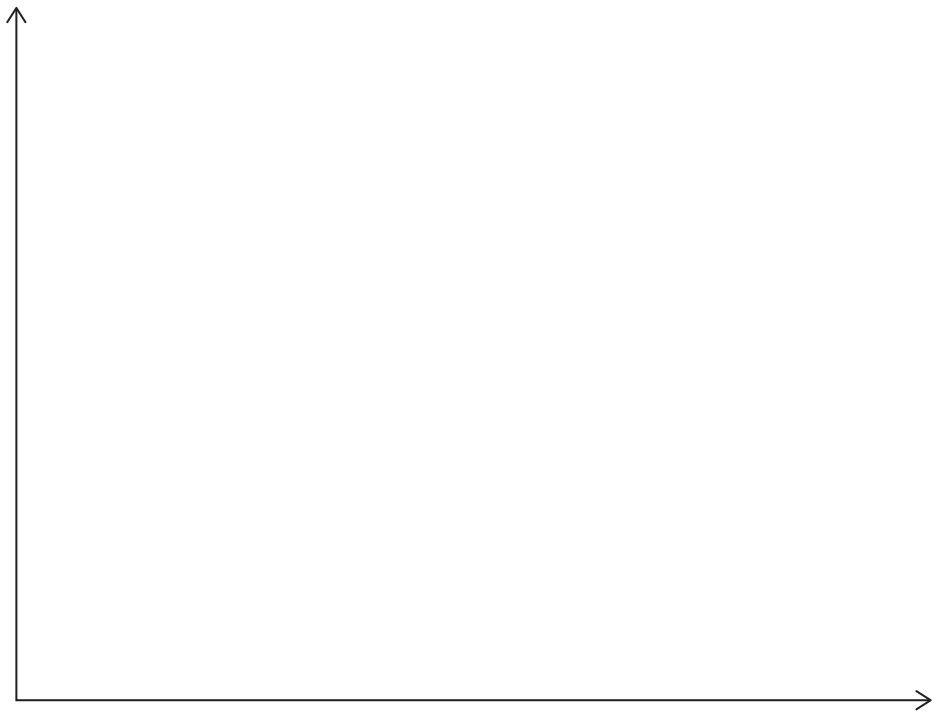
(3)

(b) A diagram showing the Maxwell–Boltzmann distribution of molecular energies is useful to chemists.

(i) Sketch a graph to show the Maxwell–Boltzmann distribution of molecular energies for the industrial preparation of methanol.

Include the activation energies for a catalysed and an uncatalysed reaction. Both axes must be clearly labelled.

(4)



(ii) Explain how your Maxwell–Boltzmann graph shows the effect of a catalyst on this reaction.

(2)

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(Total for Question 7 = 12 marks)

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8 This question is about catalysts.

(a) Hydrogen can be manufactured by reacting methane gas with steam over a solid nickel catalyst.

The equation for the reaction is shown.

$$H_2O + CH_4 \rightleftharpoons 3H_2 + CO$$

(i) Which is the expression for the equilibrium constant K_c?

(1)

☒ **A** $K_c = \dfrac{3[H_2][CO]}{[H_2O][CH_4]}$

☒ **B** $K_c = \dfrac{[H_2O][CH_4]}{3[H_2][CO]}$

☒ **C** $K_c = \dfrac{[H_2]^3[CO]}{[H_2O][CH_4]}$

☒ **D** $K_c = \dfrac{[H_2O][CH_4]}{[H_2]^3[CO]}$

(ii) The use of an industrial catalyst reduces the time for 1 tonne of product to be made from 4 hours to 1 hour.

How many **more** tonnes of product can be produced in an 8-hour period?

(1)

☒ **A** 2

☒ **B** 4

☒ **C** 6

☒ **D** 8

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(b) Vehicle exhaust systems contain catalysts to decrease the quantity of pollutants emitted.

(i) State what is meant by a heterogeneous catalyst.

(1)

(ii) Describe how a heterogeneous catalyst is able to increase the rate of reaction in a vehicle exhaust system.

(2)

(iii) Identify **three** of the major pollutants and the products they form having passed over the heterogeneous catalyst.

(3)

(Total for Question 8 = 8 marks)

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9 This question is about the complete combustion of hydrocarbons.

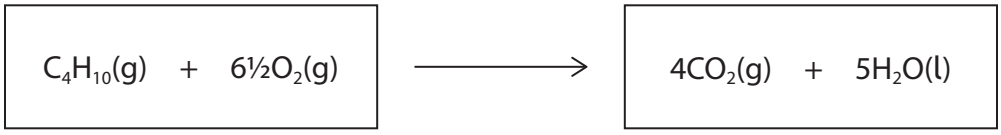
(a) The equation for the complete combustion of butane is shown.

$$C_4H_{10}(g) + 6\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

The enthalpy changes of combustion can be used in the determination of the enthalpy change of formation.

(i) Complete an enthalpy cycle for these reactions including relevant arrows, labels, species and state symbols.

(4)



(ii) Calculate the enthalpy change for the formation of butane gas from its elements, using the information provided.

$\Delta_c H^{\ominus}$ [C(graphite/s)] = –394 kJ mol^{-1}
$\Delta_c H^{\ominus}$ [H_2(g)] = –286 kJ mol^{-1}
$\Delta_c H^{\ominus}$ [butane(g)] = –2877 kJ mol^{-1}

(3)

(b) State the relevant conditions indicated by the standard symbol in the expression for the standard enthalpy change of combustion of butane, $\Delta_c H^{\ominus}$[butane].

(2)

(Total for Question 9 = 9 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									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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	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