Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number

Candidate Number

Chemistry

Advanced Subsidiary
Paper 2: Core Organic and Physical Chemistry

Friday 9 June 2017 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
8CH0/02

You must have:
Data Booklet
Scientific calculator

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 may use a scientific calculator.
- For questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.

Advice

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

Turn over ▶

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P 4 9 8 5 7 A 0 1 2 4

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 Which compound does **not** have hydrogen bonding between its molecules?

	Name of compound	Formula of compound
☒ **A**	fluoromethane	CH_3F
☒ **B**	hydrogen fluoride	HF
☒ **C**	hydrogen peroxide	H_2O_2
☒ **D**	methanol	CH_3OH

(Total for Question 1 = 1 mark)

2 Which molecule has a linear shape?

☒ **A** H_2S

☒ **B** SO_2

☒ **C** CO_2

☒ **D** $CH_2{=}CH_2$

(Total for Question 2 = 1 mark)

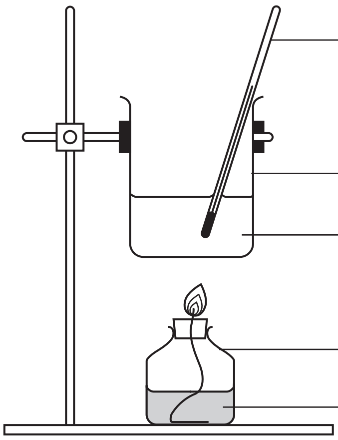
3 (a) In an experiment, 1.000 g of a hydrocarbon, **A**, was burned completely in oxygen to produce 3.143 g of carbon dioxide and 1.284 g of water.

In a different experiment, the molar mass of the hydrocarbon, **A**, was found to be 84.0 g mol^{-1}.

Calculate the empirical formula and the molecular formula of the hydrocarbon, **A**.

(4)

(b) A spirit burner was filled with the liquid hydrocarbon, **A**. The burner was weighed, lit and then used to raise the temperature of a quantity of water in a beaker, as shown in the diagram. The burner was then reweighed.



Results

Mass of spirit burner + hydrocarbon **A** before use	112.990 g
Mass of spirit burner + hydrocarbon **A** after use	112.732 g
Volume of water in the beaker	250 cm^3
Temperature of water before heating	21.3 °C
Temperature of water after heating	29.5 °C

Other data

Density of water	1.00 g cm^{-3}
Specific heat capacity of water	4.18 J g^{-1} $°C^{-1}$
Molar mass of hydrocarbon **A**	84.0 g mol^{-1}

(i) Use these results to calculate the enthalpy change of combustion of hydrocarbon **A** in kJ mol^{-1}.

Give your answer to an appropriate number of significant figures and include a sign.

(3)

(ii) The beaker used in this experiment was made of copper rather than glass. Give a reason for this.

(1)

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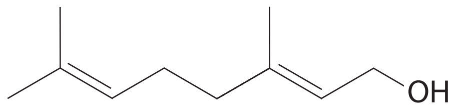
(Total for Question 3 = 8 marks)

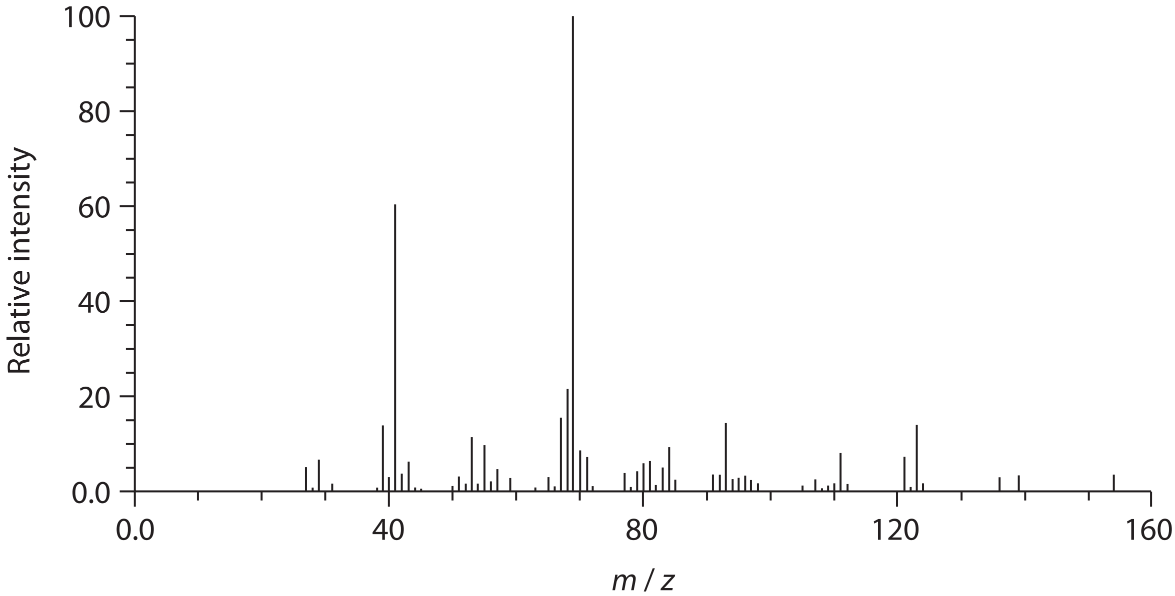
4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in g mol^{-1}.

(2)

(b) The mass spectrum of geraniol is shown.



(i) Show that this mass spectrum can be used to confirm the molar mass of geraniol.

(1)

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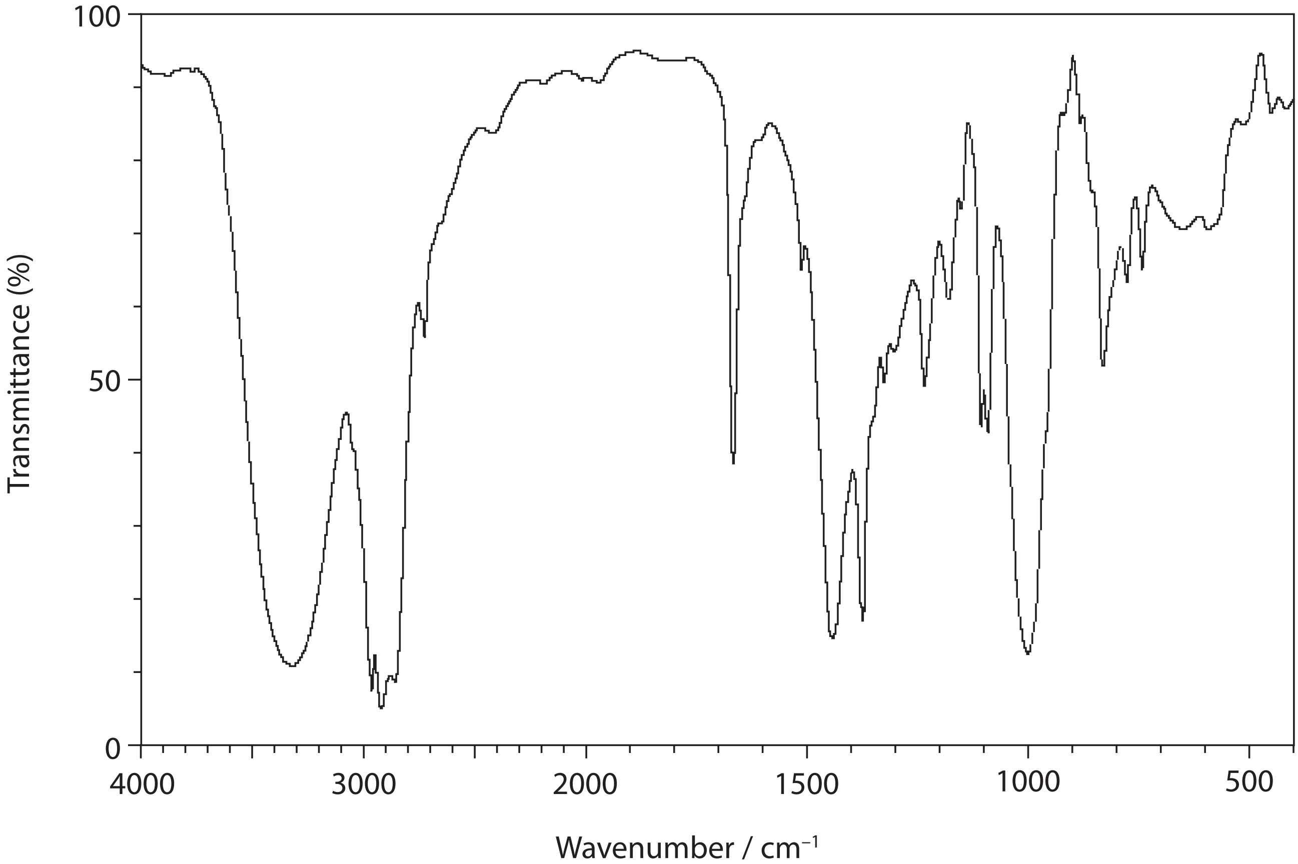
(ii) Identify an ion that could be responsible for the peak at $m / z = 69$.

(1)

(c) The infrared spectrum of geraniol is shown.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the **names** of the two functional groups present in geraniol.
To confirm these functional groups, give the wavenumber ranges and their corresponding bonds.

(2)

First functional group ....

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Second functional group ....

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(d) Give **one** chemical test that you could use to confirm the presence of each of the two functional groups suggested in part (c). Predict a result for each test.

(4)

Test and result for first functional group ....

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Test and result for second functional group ....

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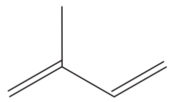
(e) Some plants are able to make terpenes by linking together several molecules of 2-methylbuta-1,3-diene, also known as isoprene.
The skeletal formula of 2-methylbuta-1,3-diene is



Predict the number of isoprene molecules that would be needed to make a single geraniol molecule. Justify your answer.

(2)

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(f) 2-methylbuta-1,3-diene can react with hydrogen bromide.

When 2-methylbuta-1,3-diene reacts with **excess** hydrogen bromide, several isomeric products are possible. Give the structures of **four** isomeric products.

(4)

(Total for Question 4 = 16 marks)

P 4 9 8 5 7 A 0 9 2 4

Turn over

5 (a) State what is meant by the term **molar volume of a gas**.

(1)

(b) The following steps were carried out by a student to find the molar mass of a gas. The experiment was carried out at 20 °C and one atmosphere pressure. The dry gas was supplied in a plastic bag fitted with a self-sealing device. The student had a choice of two different gas syringes. The student decided to use a 50 cm^3 syringe.

Step **1.** The 50 cm^3 syringe was fitted with a needle and then emptied of air by pushing in the plunger to zero. The needle was sealed by pushing the needle into a rubber bung and the syringe and bung were then weighed on a balance.

Step **2.** The syringe was checked for leaks by pulling the plunger out by about 10 cm^3 for a few seconds before releasing it.

Step **3.** The rubber bung was removed from the needle which was then inserted through the self-sealing device in the plastic bag of the dry gas.

Step **4.** 50 cm^3 of the dry gas was withdrawn from the plastic bag into the syringe and the needle resealed with the same rubber bung used in step **1**.

Step **5.** The syringe and rubber bung were then reweighed on the balance.

Results

volume of gas used	50 cm^3
initial mass of empty syringe	107.563 g
final mass of syringe + gas	107.655 g

(i) The gas syringe has a total uncertainty of ±0.5 cm^3.
Each reading on the balance has an uncertainty of ±0.0005 g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)

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(ii) The student repeated the experiment with 100 cm^3 of the gas using a 100 cm^3 syringe.

The total uncertainty for this larger syringe was also ±0.5 cm^3.

Determine the effect, if any, on the volume and mass uncertainties.

(2)

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(iii) Calculate the molar mass of the gas used in the procedure outlined in part (b).

You may assume that one mole of gas occupies 24 000 cm^3 under these conditions.

Give your answer to an appropriate number of significant figures and include units in your answer.

(2)

(iv) Explain how the student would know if the syringe had a leak in step **2** and what effect this leak would have on the molar mass determined in part (b)(iii).

(2)

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(c) If the temperature had been less than 20 °C and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

(d) Give a reason why the gas should be dry.

(1)

(Total for Question 5 = 12 marks)

6 One of the stages in the production of sulfuric acid from sulfide ores involves the oxidation of sulfur dioxide to sulfur trioxide. The equation for the reaction is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197 \text{ kJ mol}^{-1}$$

The conditions used in one industrial process are: 420 °C and a pressure of 1.7 atm together with a vanadium(V) oxide catalyst.

It is proposed to change the conditions to 600 °C and 10 atm pressure, while still using the same catalyst.

*(a) Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

(6)

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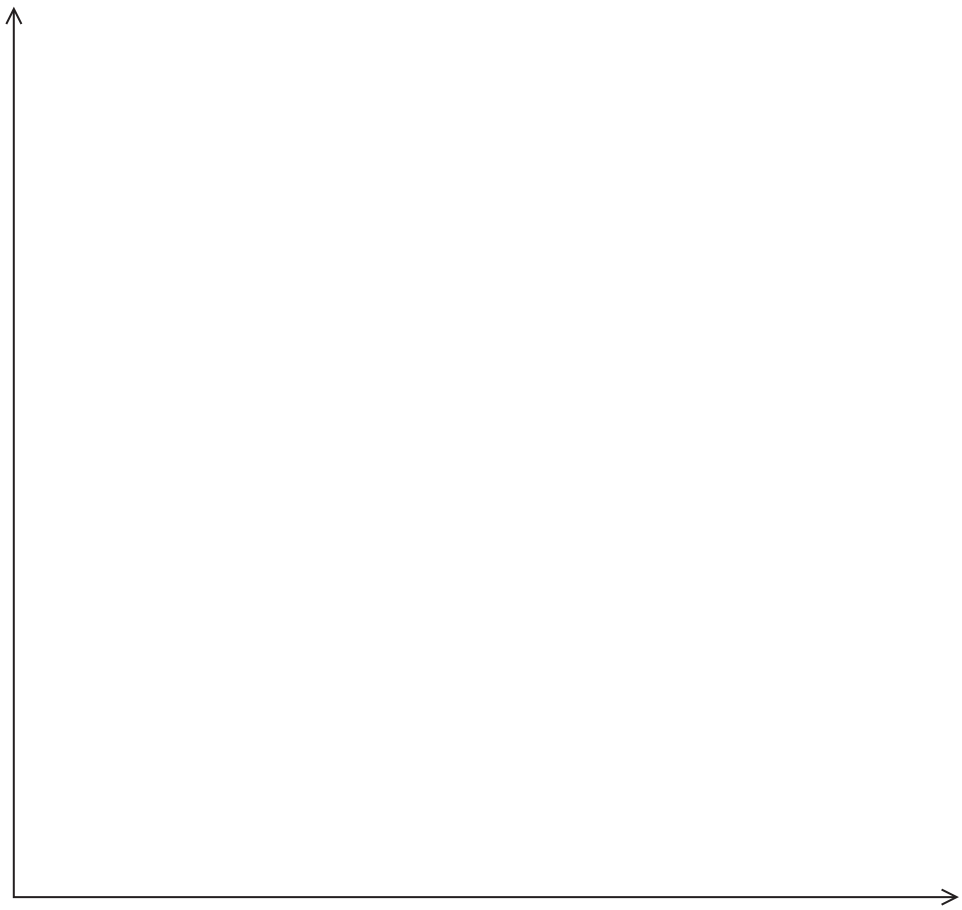
(b) (i) On the axes provided, sketch the reaction profiles for the uncatalysed and catalysed reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta_r H = -197 \text{ kJ mol}^{-1}$$

Label the uncatalysed reaction, **A**, and the reaction catalysed by vanadium(V) oxide, **B**.

(3)



(ii) On your reaction profile, identify and label both the enthalpy change and the activation energy for the catalysed reaction.

(2)

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(c) (i) Write the expression for the equilibrium constant K_c for this reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(1)

(ii) What are the units, if any, of the equilibrium constant, K_c?

(1)

☒ **A** mol dm^{-3}

☒ **B** dm^3 mol^{-1}

☒ **C** no units

☒ **D** mol^2 dm^{-6}

(Total for Question 6 = 13 marks)

7 This question is about halogenoalkanes.

The tables show some relevant data.

Bond	**Bond enthalpy / kJ mol^{-1}**
C—F	467
C—Cl	346
C—Br	290
C—I	228

Atom	**Electronegativity**
C	2.5
F	4.0
Cl	3.0
Br	2.8
I	2.5

(a) In an experiment, 1 cm^3 of ethanol and 5 cm^3 of 0.1 mol dm^{-3} silver nitrate were placed in each of three test tubes X, Y and Z. The test tubes and their contents were placed in a water bath at 50 °C for five minutes.

Two drops of 1-chlorobutane were then added to test tube X and the tube was shaken to mix the contents. The time taken for a precipitate to appear was measured.

The experiment was repeated using two drops of 1-bromobutane in test tube Y and two drops of 1-iodobutane in test tube Z.

(i) The time taken for a precipitate to appear increases in the order

(1)

☒ **A** X, Y, Z

☒ **B** Z, Y, X

☒ **C** Y, X, Z

☒ **D** Z, X, Y

(ii) Give a reason for the addition of ethanol to each test tube.

(1)

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(iii) Give a reason why the test tubes were left in the water bath for five minutes before adding the halogenoalkanes.

(1)

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(iv) The precipitates form as a result of reactions between aqueous silver ions and aqueous halide ions.

Explain why halide ions are present in the mixture containing a halogenoalkane which has only covalent bonds.

(2)

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(v) Write the ionic equation, including state symbols, for the reaction involving the silver nitrate in test tube X.

(1)

(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

Time/s	**[1-bromo-2-methylpropane]/mol dm^{-3}**
0	0.1000
50	0.0500
100	0.0250
200	0.0063
300	0.0016

(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)

P 4 9 8 5 7 A 0 1 8 2 4

(ii) Use your graph to calculate a value for the rate of reaction at 100 s. Include units in your answer.

(3)

(c) (i) Which term best describes the role of the OH^- ion in the reaction in (b)?

(1)

- ☒ **A** catalyst
- ☒ **B** electrophile
- ☒ **C** free radical
- ☒ **D** nucleophile

(ii) Draw a diagram to show the mechanism for the hydrolysis of 1-bromo-2-methylpropane by the hydroxide ion.
Include any appropriate lone pairs and dipoles.

(4)

(iii) The hydrolysis reaction described in part (b) may also be classified as

(1)

☒ **A** addition

☒ **B** elimination

☒ **C** redox

☒ **D** substitution

(Total for Question 7 = 18 marks)

8 This question is about the chemistry of propane-1,3-diol and propanedioic acid.

(a) Give the structures of propane-1,3-diol and another diol which is an isomer of propane-1,3-diol.

(2)

(b) Propane-1,3-diol can be oxidised to propanedioic acid in the same way as other primary alcohols.

(i) Suitable reagents and conditions are

(1)

	Reagents	Conditions
☒ **A**	sodium dichromate(VI) + sulfuric acid	heating under reflux
☒ **B**	sodium dichromate(VI) + hydrochloric acid	heating under reflux
☒ **C**	potassium dichromate(VI) + sulfuric acid	room temperature
☒ **D**	potassium dichromate(VI) + hydrochloric acid	room temperature

(ii) The colour change in this reaction is

(1)

☒ **A** green to orange

☒ **B** orange to green

☒ **C** orange to colourless

☒ **D** colourless to orange

(c) In an experiment, 15.2 g of propane-1,3-diol was oxidised to propanedioic acid, which is a solid **dibasic** acid. This acid may be represented as H_2X.

250 cm^3 of a solution was prepared from all of the acid in a volumetric flask.

10.0 cm^3 portions of this solution were then titrated with 0.400 mol dm^{-3} sodium hydroxide solution. The mean titre was 18.45 cm^3.

$$H_2X + 2NaOH \rightarrow Na_2X + 2H_2O$$

[Relative formula masses: propane-1,3-diol = 76.0; propanedioic acid = 104.0]

(i) Calculate the moles of propanedioic acid in 10.0 cm^3 of the acid solution.

(2)

(ii) Calculate the mass of propanedioic acid in the 250 cm^3 solution.

(2)

(iii) Calculate the percentage yield for the oxidation of propane-1,3-diol to propanedioic acid.

(2)

(iv) Give **one** reason why the yield calculated in (iii) is less than 100%.

(1)

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(Total for Question 8 = 11 marks)

TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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