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 23 May 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WCH02/01**

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Candidates must have: 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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- 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 This question is about the molecule propene, $CH_2{=}CH{-}CH_3$.

(a) How do bond length and bond enthalpy compare for the C=C and C—C bonds in propene?

(1)

☒ **A** The C=C bond is shorter and has a higher bond enthalpy.

☒ **B** The C=C bond is shorter and has a lower bond enthalpy.

☒ **C** The C=C bond is longer and has a higher bond enthalpy.

☒ **D** The C=C bond is longer and has a lower bond enthalpy.

(b) Electron pair repulsion theory predicts that the two different H—C—H bond angles in propene are approximately

(1)

☒ **A** 120° and 90°

☒ **B** 120° and 109.5°

☒ **C** 107° and 109.5°

☒ **D** 107° and 90°

(c) In propene, the shape around the **central** carbon atom is described as

(1)

☒ **A** linear.

☒ **B** pyramidal.

☒ **C** tetrahedral.

☒ **D** trigonal planar.

(Total for Question 1 = 3 marks)

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2 Which form of the element carbon does **not** contain delocalised electrons?

☒ **A** Buckminsterfullerene

☒ **B** Carbon nanotubes

☒ **C** Diamond

☒ **D** Graphite

(Total for Question 2 = 1 mark)

3 This question is about the following organic compounds all of which are liquids at room temperature.

A Diiodomethane

B Ethanol

C Propanal

D Tetrachloromethane

(a) Which liquid would **not** be deflected significantly by a charged rod when run from a burette?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which compound would give a coloured precipitate when warmed with aqueous silver nitrate?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 3 = 2 marks)

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4 During iodine and thiosulfate titrations, the following reaction occurs.

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

(a) The oxidation number of sulfur in $S_2O_3^{2-}$ is

(1)

☒ **A** +2

☒ **B** +3

☒ **C** +4

☒ **D** +8

(b) The oxidation number of sulfur in $S_4O_6^{2-}$ is

(1)

☒ **A** +2.5

☒ **B** +3

☒ **C** +3.5

☒ **D** +7

(Total for Question 4 = 2 marks)

5 A nitrate compound of a Group 2 metal, M, was thermally decomposed.

0.164 g of the metal nitrate gave 2.5×10^{-3} mol of gas.

The equation for the reaction is

$$2M(NO_3)_2(s) \rightarrow 2MO(s) + 4NO_2(g) + O_2(g)$$

What is metal M?

☒ **A** Magnesium

☒ **B** Calcium

☒ **C** Strontium

☒ **D** Barium

(Total for Question 5 = 1 mark)

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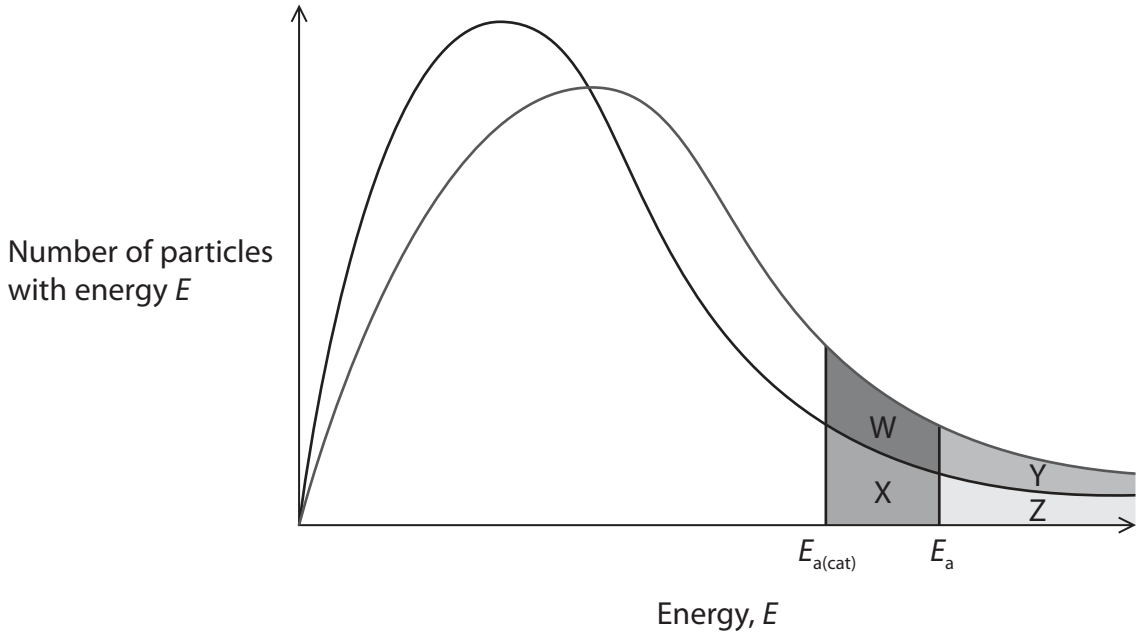
6 The diagram below shows the Maxwell-Boltzmann distribution for the molecular energies of a gaseous system at two temperatures, and the activation energy for both uncatalysed, E_a, and catalysed, $E_{a(cat)}$, reactions.



(a) The **main** reason why an increase in temperature increases the rate of a chemical reaction is because

(1)

☒ **A** the activation energy increases.

☒ **B** the activation energy decreases.

☒ **C** collisions occur with greater energy.

☒ **D** collisions occur more frequently.

(b) Consider **only** the Maxwell-Boltzmann distribution at the **higher** temperature.

Which area of the graph shows the **additional** number of particles with energy greater than the activation energy, due to the presence of the catalyst?

(1)

☒ **A** Area X

☒ **B** Area W + X

☒ **C** Area X + Z

☒ **D** Area W + X + Y + Z

(Total for Question 6 = 2 marks)

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7 Which of the following is **not** a disproportionation reaction?

☒ **A** $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

☒ **B** $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$

☒ **C** $3IO^- \rightarrow 2I^- + IO_3^-$

☒ **D** $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

(Total for Question 7 = 1 mark)

8 Nitrogen dioxide, NO_2, a brown gas, **always** exists in equilibrium with dinitrogen tetroxide, N_2O_4, a colourless gas.

$$2NO_2 \rightleftharpoons N_2O_4 \qquad \Delta H = -57.2\,kJ\,mol^{-1}$$

(a) At equilibrium, a sample of these gases is brown in colour.
The pressure is **decreased**.

When the system has returned to equilibrium, the mixture will be

(1)

☒ **A** colourless.

☒ **B** darker brown.

☒ **C** lighter brown.

☒ **D** unchanged.

(b) The temperature of the system is **lowered**.

When the system has returned to equilibrium, the mixture will be

(1)

☒ **A** colourless.

☒ **B** darker brown.

☒ **C** lighter brown.

☒ **D** unchanged.

(Total for Question 8 = 2 marks)

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9 Which of the following is a secondary halogenoalkane?

☒ **A** $CH_3CH_2CHClCH_3$

☒ **B** $(CH_3)_2CClCH_3$

☒ **C** $CH_2ClCH_2CH_2CH_3$

☒ **D** $CH_2ClCH_2CH_2CH_2Cl$

(Total for Question 9 = 1 mark)

10 What is the mechanism and type of the reaction between ammonia and chloromethane?

☒ **A** Electrophilic addition

☒ **B** Nucleophilic addition

☒ **C** Free radical substitution

☒ **D** Nucleophilic substitution

(Total for Question 10 = 1 mark)

11 The first step in the reaction between chlorine and ethane involves

☒ **A** heterolytic bond breaking.

☒ **B** homolytic bond breaking.

☒ **C** electrophilic attack by chlorine.

☒ **D** nucleophilic attack by chlorine.

(Total for Question 11 = 1 mark)

12 Which statement about propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3 is **not** correct?

The compounds have

☒ **A** a different fingerprint region in the infrared spectrum.

☒ **B** an absorption in the infrared spectrum due to the carbonyl group.

☒ **C** different fragmentation patterns in the mass spectrum.

☒ **D** molecular ion peaks at different mass to charge ratios.

(Total for Question 12 = 1 mark)

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13 Samples of the isomers propan-1-ol and propan-2-ol can be identified by mass spectrometry.

Only propan-1-ol would be expected to have a significant peak in its mass spectrum at *m* / *e* value of

☒ **A** 15

☒ **B** 31

☒ **C** 45

☒ **D** 60

(Total for Question 13 = 1 mark)

14 Which of these contributes to global warming by absorbing infrared radiation?

☒ **A** Argon gas

☒ **B** Nitrogen gas

☒ **C** Oxygen gas

☒ **D** Water vapour

(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

15 Magnesium oxide, known as magnesia, can be produced by the thermal decomposition of magnesium carbonate.

The equation for the reaction is

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

*(a) Other Group 2 carbonates also undergo thermal decomposition.

State and explain the trend in thermal stability of carbonates down Group 2.

(4)

(b) Magnesia absorbs water from the air to form magnesium hydroxide, $Mg(OH)_2$.

$$MgO(s) + H_2O(g) \rightarrow Mg(OH)_2(s)$$

Both magnesium oxide and magnesium hydroxide react with hydrochloric acid as shown in the equations.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

An old bottle, labelled magnesia, contained a mixture of magnesium oxide and magnesium hydroxide.

0.180 g of this mixture was dissolved in 50.0 cm^3 of hydrochloric acid, with a concentration of 0.200 mol dm^{-3}.

The excess hydrochloric acid was titrated with a solution of sodium hydroxide, with a concentration of 0.100 mol dm^{-3}.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

18.50 cm^3 of the sodium hydroxide solution was needed to neutralise the excess acid.

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(i) Give the name of a suitable indicator for this titration and the colour of the indicator at the end point of the reaction.

(2)

Indicator .....

Colour at the end point .....

(ii) Calculate the number of moles of hydrochloric acid that reacted with the sodium hydroxide solution.

(1)

(iii) Calculate the number of moles of hydrochloric acid originally added to 0.180 g of the mixture.

Use this answer and your answer to (b)(ii) to calculate the number of moles of hydrochloric acid that have reacted with the mixture of magnesium oxide and magnesium hydroxide.

(2)

(iv) Calculate the mass of pure magnesium oxide that would react with the number of moles of hydrochloric acid in (b)(iii).

(2)

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(v) The difference in the mass of the impure sample and the mass of magnesium oxide in (b)(iv) is due to water absorbed from the air to form magnesium hydroxide.

$$MgO(s) + H_2O(g) \rightarrow Mg(OH)_2(s)$$

Use your answer to (b)(iv) to calculate the mass of water absorbed by the sample, and hence find the mass of magnesium hydroxide present in 0.180 g of the mixture.

(3)

*(c) State why carrying out a flame test is **not** an appropriate way to confirm the presence of magnesium ions in the sample of magnesia.

(1)

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(Total for Question 15 = 15 marks)

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16 Ozone (O_3) is present in the upper atmosphere.

(a) Chlorine atoms catalyse the decomposition of ozone and contribute to the depletion of the ozone layer. These chlorine atoms are formed from chlorofluorocarbons (CFCs) such as CCl_2F_2.

(i) Give the IUPAC name for CCl_2F_2.

(1)

.....

(ii) Complete the following equation that shows the formation of a chlorine atom from a molecule of CCl_2F_2.
Curly arrows are not required.

(1)

(iii) State what the dot (•) represents in $Cl^{\bullet}$

(1)

.....

.....

(iv) Write two equations to show how a chlorine atom catalyses the decomposition of ozone into oxygen.
State symbols and curly arrows are not required.

(2)

Equation 1

Equation 2

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(b) Most scientists supported the legislation to ban the use of CFCs.
Many modern refrigerators use pentane as the refrigerant instead of CFCs.

State why pentane is a more environmentally acceptable refrigerant.

(1)

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(Total for Question 16 = 6 marks)

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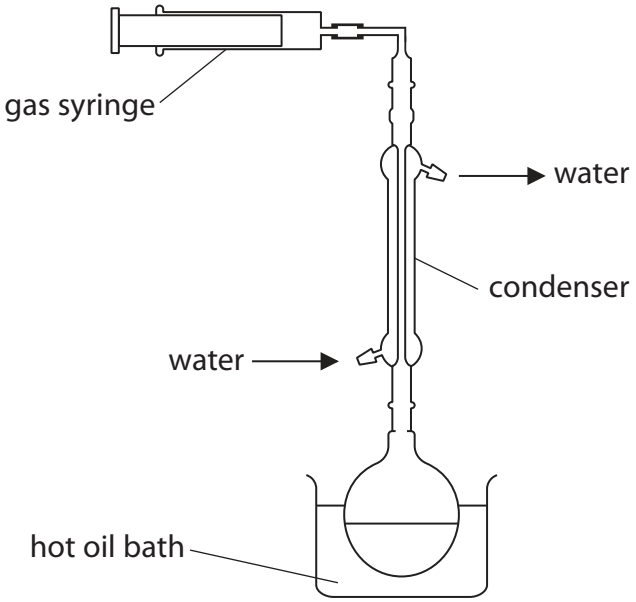
17 The reaction between 2-chlorobutane and alcoholic potassium hydroxide solution produces a mixture of organic products.

The mixture is heated under reflux using the apparatus shown in the diagram.

Three products, **A**, **B** and **C**, were produced by an elimination reaction.
These products passed through the condenser and were collected in the gas syringe.

A small amount of a fourth organic product, **D**, remained in the reaction mixture.
Product **D** was produced by a substitution reaction.



(a) The four products were isolated and purified. Their boiling temperatures were measured and each was treated with bromine water.
The results are shown in the table.

Product	Boiling temperature / K	Observation when mixed with bromine water
A	267	Yellow to colourless
B	274	Yellow to colourless
C	277	Yellow to colourless
D	373	No change

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(i) Use the data to state why products **A**, **B** and **C** were collected in the gas syringe but **D** remained in the reaction mixture.

(1)

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.....

(ii) State what can be deduced from the results of the test with bromine water.

(1)

.....

.....

.....

.....

(b) Products **B** and **C** both react with hydrogen bromide to give the same compound **X** as the only product.

A also reacts with hydrogen bromide to give compound **X**, but also gives a second compound **Y** in lower yield.

Identify **A**, **B**, **C**, **X** and **Y** by name or formula.

(5)

A .....

B and **C** ..... and .....

X .....

Y .....

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(c) (i) Draw the **displayed** formula of the organic product **D**.

(1)

(ii) Give the change required to the conditions so that the same reactants, potassium hydroxide and 2-chlorobutane, produce a high yield of product **D** with very low yields of products **A**, **B** and **C**.

(1)

(iii) Draw the mechanism for the substitution reaction producing **D** from 2-chlorobutane.

Show curly arrows, and relevant lone pairs and dipoles.

(3)

(Total for Question 17 = 12 marks)

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18 This question is about the alcohol propan-1-ol.

(a) Under suitable conditions, propan-1-ol, $CH_3CH_2CH_2OH$, can be oxidised to propanal, CH_3CH_2CHO.

(i) Give the reagents and conditions for this oxidation.

(2)

(ii) Propanal has a lower boiling temperature than propan-1-ol.

Identify **all** the intermolecular forces in each substance and hence explain this difference in boiling temperature. A detailed description of the forces involved is not required.

(3)

(b) Describe a **chemical** test and its result which would distinguish propan-1-ol from propanal.

(2)

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(c) Under different conditions, propan-1-ol can be oxidised to propanoic acid.

Complete the equation for this oxidation.

(1)

$$CH_3CH_2CH_2OH \quad + \quad [O] \rightarrow \quad + \quad$$

(Total for Question 18 = 8 marks)

TOTAL FOR SECTION B = 41 MARKS

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SECTION C

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

19 This question is about the Group 7 element iodine.

Iodine is the least abundant of the stable halogens, comprising only 0.46 parts per million by mass of the Earth's crust.

Until the 19th century, the main source of iodine was extraction from the seaweed, kelp. Kelp uses iodide ions in seawater to form iodine containing organic compounds as it grows. Burning the kelp converts the iodine in these compounds into iodide ions.

In a laboratory, iodine can be extracted from kelp in five stages:

Stage **1** Formation of an ash containing iodide ions by burning kelp in air

Stage **2** Dissolving the iodide ions in boiling water

Stage **3** Conversion of iodide ions in solution into iodine

Stage **4** Extraction of the iodine into the organic solvent cyclohexane

Stage **5** Evaporation of the solvent to leave iodine crystals.

(a) State why iodine is described as a p-block element.

(1)

.....

.....

(b) Calculate the average number of moles of iodine **atoms** in 1 tonne (1000 kg) of the Earth's crust.

(2)

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(c) One method for the conversion of iodide ions to iodine in Stage **3** is to acidify the aqueous solution of iodide ions and then add hydrogen peroxide.

(i) Write the half-equation for the conversion of iodide ions to iodine.
State symbols are not required.

(1)

(ii) Write the half-equation for the conversion of hydrogen peroxide, H_2O_2, to water in **acid** conditions.
State symbols are not required.

(1)

(iii) Use your answers in (c)(i) and (c)(ii) to write the ionic equation for the conversion of iodide ions to iodine using acidified hydrogen peroxide.
State symbols are not required.

(1)

(iv) Describe what you would **see** when this reaction is carried out.

(1)

.....

.....

(v) State the role of the hydrogen peroxide in this reaction.
Justify your answer using oxidation numbers.

(2)

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(vi) The ash contains chloride and bromide ions as well as iodide ions.

Explain why iodide ions are converted to iodine, but chlorine and bromine are only formed if excess hydrogen peroxide is added.

(2)

(d) The extraction of iodine relies on the different solubilities of the compounds containing iodide ions in Stage **2** and iodine in Stage **4** in the solvents water and cyclohexane.

(i) Describe what happens in terms of the interactions of iodide ions with water when iodide ions dissolve in water.

(2)

(ii) Explain why iodine is more soluble in cyclohexane than in water.

(2)

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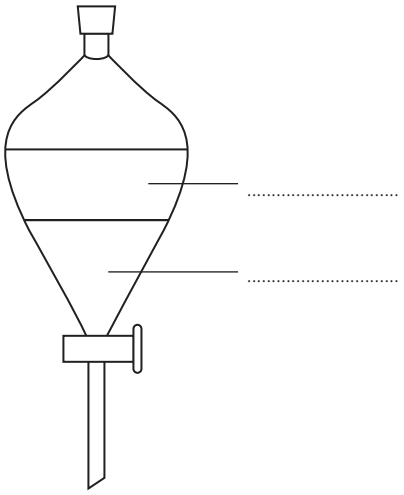
(e) Stage **4** is carried out using a separating funnel.

Cyclohexane was carefully added to the aqueous solution of iodine and the separating funnel sealed with a stopper. The mixture was then shaken vigorously, releasing the pressure at intervals.

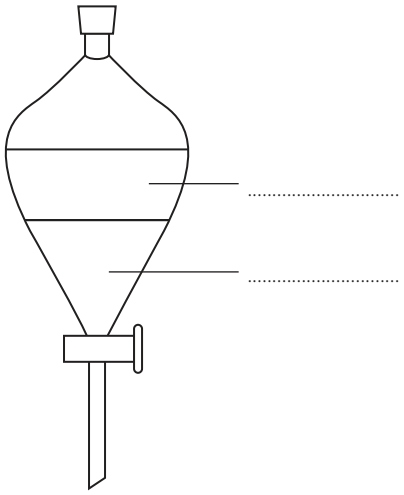
Label the **colours** of the layers in the separating funnels both before and after shaking.

[Cyclohexane density $0.78\,g\,cm^{-3}$ Aqueous solution density $>1.0\,g\,cm^{-3}$]

(2)



Before shaking



After shaking

(f) Suggest why, in Stage **5**, the solution is left in a fume cupboard so the cyclohexane can evaporate, and is not heated.

(2)

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(Total for Question 19 = 19 marks)

TOTAL FOR SECTION C = 19 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

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

* Lanthanide series

* Actinide series

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