

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

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## Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper  
reference

**WCH12/01**

### Chemistry

International Advanced Subsidiary/Advanced Level

**UNIT 2: Energetics, Group Chemistry,**

**Halogenoalkanes and Alcohols**

**You must have:**

Scientific calculator, Data Booklet

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.*
- In 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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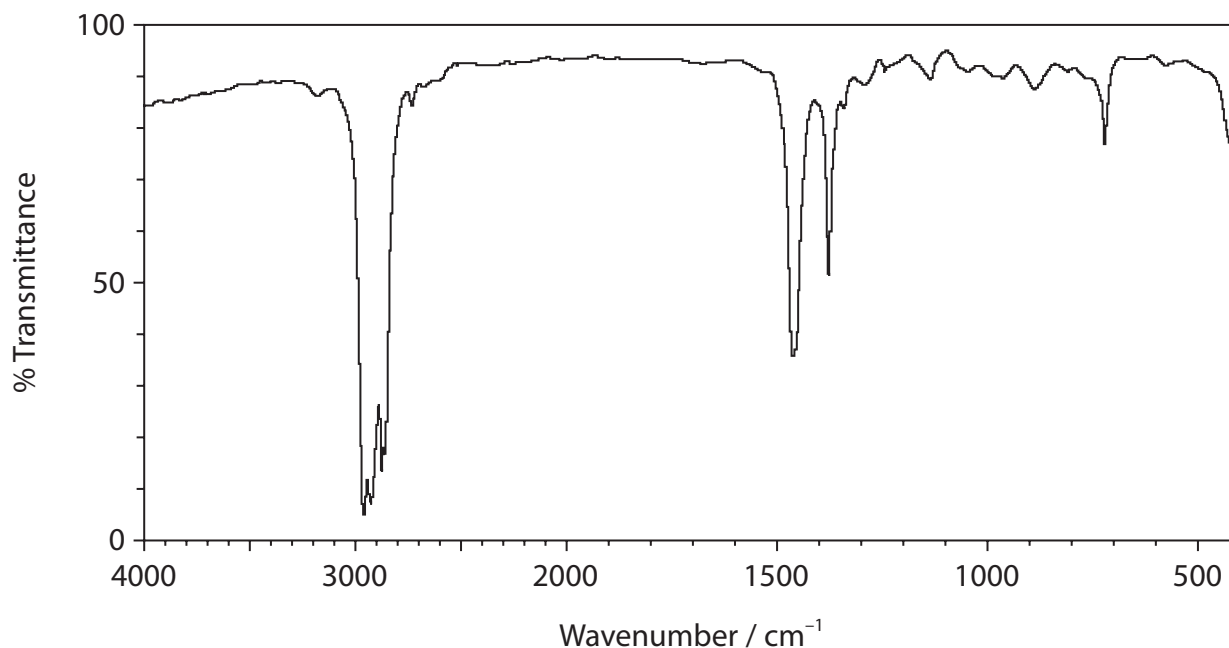
## SECTION A

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 . If you change your mind, put a line through the box  and then mark your new answer with a cross .

- 1 The infrared spectrum of an organic compound is shown.



Which of these compounds would give this infrared spectrum?

- A hexanal  
 B hexane  
 C hexanoic acid  
 D hexan-1-ol

(Total for Question 1 = 1 mark)

- 2 Which of these compounds does **not** react with acidified potassium dichromate(VI)?

- A  $\text{CH}_3\text{CH}_2\text{OH}$   
 B  $\text{CH}_3\text{CHOHCH}_3$   
 C  $\text{CH}_3\text{CH}_2\text{CHO}$   
 D  $\text{CH}_3\text{COCH}_3$

(Total for Question 2 = 1 mark)



3 Which of these compounds is a tertiary alcohol?

- A 2-methylpropan-2-ol
- B 3-methylbutan-2-ol
- C 2,2-dimethylpropan-1-ol
- D 3,3-dimethylbutan-2-ol

(Total for Question 3 = 1 mark)

4 In a mass spectrum, the molecular ion is the ion which always has the

- A greatest abundance
- B greatest stability
- C highest charge
- D highest mass/charge ratio

(Total for Question 4 = 1 mark)

5 Butan-1-ol and butan-2-ol are isomers.

Which  $m/z$  value would be expected to have a significant peak in the mass spectrum of butan-1-ol but **not** that of butan-2-ol?

- A 15
- B 29
- C 43
- D 57

(Total for Question 5 = 1 mark)

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

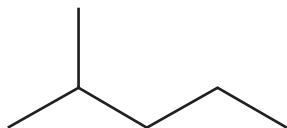


6 Which of these isomers has the **highest** boiling temperature?

A



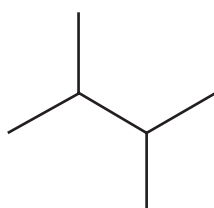
B



C



D



(Total for Question 6 = 1 mark)

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7 Organic reactions can be classified in different ways.

(a) How should the reaction shown be classified?

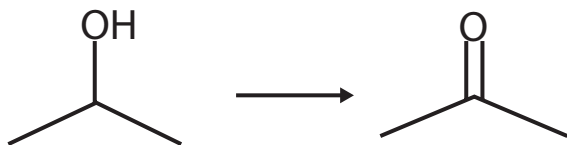
(1)



- A addition
- B oxidation
- C polymerisation
- D substitution

(b) How should the reaction shown be classified?

(1)



- A addition
- B oxidation
- C reduction
- D substitution

(Total for Question 7 = 2 marks)

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



8 Data for some Group 1 and Group 2 cations are shown in the table.

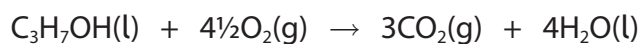
Cation	Ionic radius / nm	Ionic charge
W	0.100	+2
X	0.138	+1
Y	0.113	+2
Z	0.149	+1

Which cation would be expected to form the nitrate with the **greatest** thermal stability?

- A W
- B X
- C Y
- D Z

(Total for Question 8 = 1 mark)

9 The equation for the complete combustion of propan-1-ol is shown.



$2.00 \times 10^{-3}$  mol of propan-1-ol undergoes complete combustion.

What mass of carbon dioxide is formed?

- A 0.0293 g
- B 0.0880 g
- C 0.132 g
- D 0.264 g

(Total for Question 9 = 1 mark)

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



10 This question is about the reaction shown.



(a) What values of  $x$ ,  $y$  and  $z$  are needed to balance the equation?

(1)

	$x$	$y$	$z$
<input type="checkbox"/> <b>A</b>	5	6	8
<input type="checkbox"/> <b>B</b>	10	3	4
<input type="checkbox"/> <b>C</b>	5	3	8
<input type="checkbox"/> <b>D</b>	10	6	4

(b) What is the reducing agent in the reaction?

(1)

- A**  $\text{H}^+$
- B**  $\text{C}_2\text{O}_4^{2-}$
- C**  $\text{MnO}_4^-$
- D**  $\text{SO}_4^{2-}$

(Total for Question 10 = 2 marks)

11 What is the oxidation number of phosphorus in the phosphate ion,  $\text{PO}_4^{3-}$ ?

- A** -3
- B** +3
- C** +5
- D** +7

(Total for Question 11 = 1 mark)

12 Which reaction is **not** a redox reaction?

- A**  $4\text{KClO}_3(\text{s}) \rightarrow 3\text{KClO}_4(\text{s}) + \text{KCl}(\text{s})$
- B**  $2\text{HCl}(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- C**  $\text{Zn}(\text{s}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu}(\text{s})$
- D**  $\text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HCl}(\text{aq}) + \text{HClO}(\text{aq})$

(Total for Question 12 = 1 mark)



13 A student is provided with  $25.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  hydrochloric acid.

What volume of distilled water should the student add to this solution to make a  $0.0500 \text{ mol dm}^{-3}$  solution?

- A  $25.0 \text{ cm}^3$
- B  $50.0 \text{ cm}^3$
- C  $475 \text{ cm}^3$
- D  $500 \text{ cm}^3$

(Total for Question 13 = 1 mark)

14 Which statement about the Group 7 elements chlorine, bromine and iodine is **not** correct?

- A boiling temperature increases down the group
- B reactivity increases down the group
- C first ionisation energy decreases down the group
- D electronegativity decreases down the group

(Total for Question 14 = 1 mark)

15 When iodine is dissolved in a non-polar organic solvent, the solution formed is

- A purple
- B orange
- C colourless
- D brown

(Total for Question 15 = 1 mark)

16 Which row shows the hydrogen halides in order of **increasing** boiling temperature?

	Lowest	→			Highest
HF	HCl	HBr	HI		
HI	HBr	HCl	HF		
HCl	HBr	HI	HF		
HF	HI	HBr	HCl		

(Total for Question 16 = 1 mark)





17 Solid potassium bromide reacts with concentrated sulfuric acid.

Which of these substances does **not** form?

- A bromine
- B hydrogen bromide
- C hydrogen sulfide
- D sulfur dioxide

(Total for Question 17 = 1 mark)

18 10.00 g of hydrated magnesium sulfate,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , is heated to remove the water of crystallisation.

What mass of anhydrous magnesium sulfate,  $\text{MgSO}_4$ , is formed?

[Molar mass of  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O} = 246.4 \text{ g mol}^{-1}$ ]

- A 2.84 g
- B 4.89 g
- C 5.11 g
- D 7.16 g

(Total for Question 18 = 1 mark)

**TOTAL FOR SECTION A = 20 MARKS**



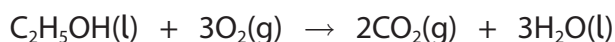
## SECTION B

Answer ALL the questions in this section.

Write your answers in the spaces provided.

19 This question is about enthalpy changes.

- (a) An experiment was carried out to determine the enthalpy change of combustion for ethanol.



1.19 g of ethanol was burned in a spirit burner. The heat energy from this combustion raised the temperature of 100 g of water from 21.6 °C to 63.9 °C.

- (i) Calculate the number of moles of ethanol in 1.19 g.

[Molar mass of ethanol = 46.0 g mol<sup>-1</sup>]

(1)

- (ii) Calculate the heat energy required to raise the temperature of 100 g of water from 21.6 °C to 63.9 °C.

[Specific heat capacity of water = 4.18 J g<sup>-1</sup> °C<sup>-1</sup>]

(2)

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(iii) Use your answers to (a) (i) and (ii) to calculate a value for the enthalpy change of combustion of ethanol.  
Give your answer to an appropriate number of significant figures and include a sign and units.

(3)

(iv) The value of the enthalpy change of combustion from this experiment was very inaccurate.

Give two reasons why this value was so inaccurate, apart from heat loss.

(2)

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(b) Mean bond enthalpies can be used to calculate a value for the enthalpy change of combustion of a compound.

(i) Give the meaning of the term 'mean bond enthalpy'.

(2)

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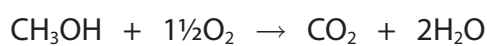
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(ii) Calculate a value for the enthalpy change of combustion of methanol, using the information in the table and the equation shown.

(3)



	C—H	C—O	O—H	O=O	C=O
Mean bond enthalpy / $\text{kJ mol}^{-1}$	413	358	464	498	805

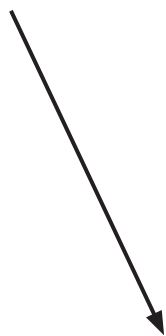
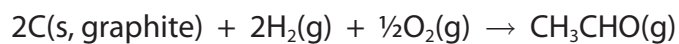


(c) Enthalpy changes of combustion can be used to calculate the enthalpy change of formation of a compound.

Substance	Standard enthalpy change of combustion, $\Delta_c H^\ominus / \text{kJ mol}^{-1}$
C(s,graphite)	-394
H <sub>2</sub> (g)	-286
CH <sub>3</sub> CHO(g)	-1167

Complete the Hess cycle and use it to calculate the standard enthalpy change of formation for ethanal, CH<sub>3</sub>CHO.

(3)



(Total for Question 19 = 16 marks)

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P 6 7 1 2 8 A 0 1 3 2 8

**20** This question is about halogenoalkanes.

(a) The rates of hydrolysis of 1-chloropropane, 1-bromopropane and 1-iodopropane in reactions with aqueous silver nitrate solution were compared.

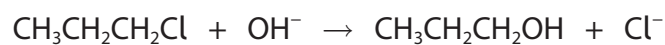
(i) State what would be measured in the experiment to compare the rates of hydrolysis.

(1)

(ii) State which of these halogenoalkanes would hydrolyse the fastest. Justify your answer.

(2)

(b) The equation for the hydrolysis of 1-chloropropane by aqueous hydroxide ions is shown.



Give the mechanism for this hydrolysis. Include curly arrows, and relevant dipoles and lone pairs.

(2)



(c) The boiling temperatures of some halogenoalkanes are shown.

Halogenoalkane	Boiling temperature / °C
1-chloropropane	47
1-bromopropane	71
1-iodopropane	103

Explain the trend in boiling temperature of these halogenoalkanes by comparing the intermolecular forces involved.

Detailed explanations of the forces involved are not required.

(4)

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(d) In another experiment, 2-bromobutane is heated with ethanolic potassium hydroxide and an elimination reaction occurs.

Draw the **skeletal** formulae of the three possible organic products, giving their names.

(3)

Skeletal formula	Name

(Total for Question 20 = 12 marks)





21 This question is about Group 1 metals.

(a) When potassium is placed into a beaker of cold water, potassium hydroxide and hydrogen are formed.

(i) Write the equation for this reaction. Include state symbols.

(2)

(ii) This is a redox reaction.

State which element is oxidised and which is reduced.

Justify your answer by giving the initial and final oxidation numbers of any element that changes oxidation state.

(2)

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(iii) The reaction of potassium with water is very vigorous and a flame is seen.

State the colour of the flame.

(1)

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(b) The label has come off a bottle known to contain **M**, a Group 1 metal which is stored in oil.

A student carried out an experiment to determine the identity of **M**.

### Procedure

**Step 1** A small piece of **M** was wiped with tissue paper to remove the oil. The piece of **M** was weighed and placed in a beaker of distilled water.

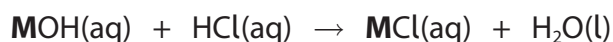
**Step 2** After the reaction had finished, the contents of the beaker and washings were transferred to a 250.0 cm<sup>3</sup> volumetric flask. The solution was made up to the mark with distilled water and mixed thoroughly.

**Step 3** A pipette was used to transfer 25.0 cm<sup>3</sup> portions of this solution to conical flasks. Each portion was then titrated with hydrochloric acid of concentration 0.400 mol dm<sup>-3</sup>.

### Results

Mass of metal, <b>M</b>	0.37 g
Mean titre of hydrochloric acid	12.80 cm <sup>3</sup>

The reaction taking place is shown.



(i) The indicator used was phenolphthalein.

State the colour **change** at the end-point.

(2)

from ..... to .....



(ii) Calculate the relative atomic mass of **M** and use it to identify the Group 1 metal, **M**.

(4)

(c) Another student repeated the experiment, using a different sample of metal **M**, but did not wipe off the oil before weighing it.

State how this would change the calculated value of the relative atomic mass of **M**. Justify your answer.

(2)

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**(Total for Question 21 = 13 marks)**

**TOTAL FOR SECTION B = 41 MARKS**

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## SECTION C

Answer ALL the questions in this section.

Write your answers in the spaces provided.

22 This question is about ethanol and bioethanol.

The main fuel used as a petrol substitute is bioethanol. Bioethanol is ethanol that has been produced by fermentation. The starting material is usually some form of plant material rich in starch, such as wheat, maize or potatoes. Enzymes in yeast convert this material to simple carbohydrates such as glucose ( $C_6H_{12}O_6$ ) and then to ethanol and carbon dioxide.



The mixture is left for several days until fermentation is complete. The percentage of ethanol is never greater than 15% because higher concentrations of ethanol kill the yeast.

A common blend of fuel is 95% petrol and 5% bioethanol. The engine does not need to be modified for this mixture.

(a) Give **one** advantage and **one** disadvantage of using bioethanol in petrol.

(2)

Advantage

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.....

Disadvantage

.....  
.....

(b) Suggest why this fermentation must be carried out in the absence of air.

(1)

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(c) Suggest how the ethanol can be obtained, after filtering the fermentation mixture.

(1)

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(d) Ethanol is hygroscopic, which means it readily absorbs water from the air.

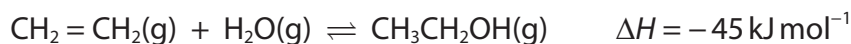
(i) Give a possible reason why ethanol is able to absorb water.

(1)

(ii) Suggest a problem arising from the hygroscopic nature of ethanol when using this fuel in a motor vehicle.

(1)

(e) Ethanol can also be produced by the hydration of ethene.



\*(i) Typical conditions are 300 °C and 60 atm with a catalyst of phosphoric acid.

Explain why these conditions are used, by describing the effect of changing the temperature and pressure on rate of reaction, equilibrium yield and cost.

(6)



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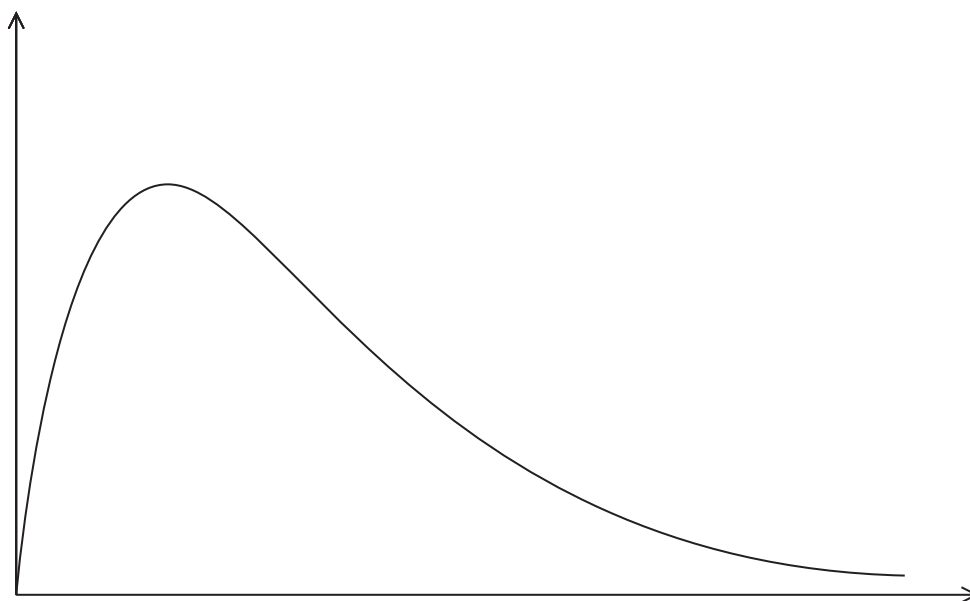
Handwriting practice area with 20 sets of horizontal dotted lines.



(ii) The rate of this reaction is increased by using a catalyst of phosphoric acid.

Label the axes on the Maxwell–Boltzmann distribution curve and use it to explain how a catalyst increases the rate of reaction.

(4)



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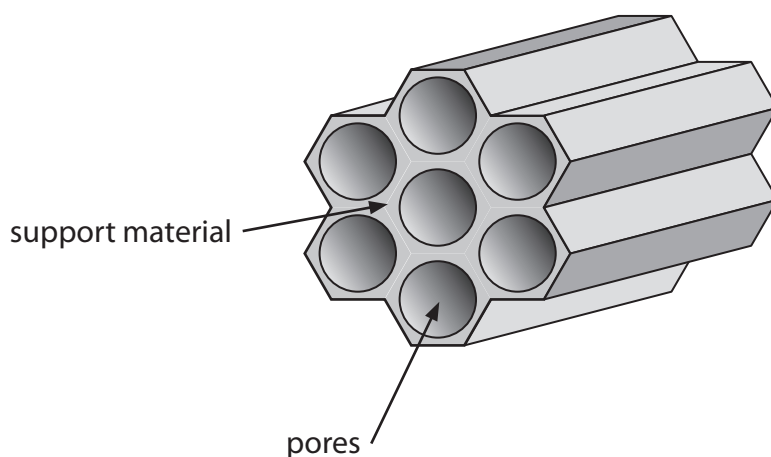
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- (f) Catalysts such as phosphoric acid are bonded to a support material that contains lots of pores.



- (i) Suggest the advantage of using support materials containing lots of pores.

(1)

- (ii) Under these conditions, only about 5% of the ethene is converted into ethanol as it passes over the catalyst.

Suggest how the overall yield of this process can be improved to make it economically viable.

(2)

**(Total for Question 22 = 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) (18)

1.0  
**H**  
hydrogen  
1

### Key

relative atomic mass  
**atomic symbol**  
name  
atomic (proton) number

(1)	6.9 <b>Li</b> lithium 3	9.0 <b>Be</b> beryllium 4	11 <b>Na</b> sodium	12 <b>Mg</b> magnesium	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)																																	
	23.0 <b>K</b> potassium 19	39.1 <b>Ca</b> calcium 20	88.9 <b>Sc</b> scandium 21	45.0 <b>Ti</b> titanium 22	47.9 <b>V</b> vanadium 23	50.9 <b>Cr</b> chromium 24	52.0 <b>Mn</b> manganese 25	54.9 <b>Fe</b> iron 26	55.8 <b>Co</b> cobalt 27	58.9 <b>Ni</b> nickel 28	63.5 <b>Cu</b> copper 29	65.4 <b>Zn</b> zinc 30	69.7 <b>Ga</b> gallium 31	72.6 <b>Ge</b> germanium 32	74.9 <b>As</b> arsenic 33	79.0 <b>Se</b> selenium 34	79.9 <b>Br</b> bromine 35	83.8 <b>Kr</b> krypton 36	85.5 <b>Rb</b> rubidium 37	87.6 <b>Sr</b> strontium 38	88.9 <b>Y</b> yttrium 39	88.9 <b>Zr</b> zirconium 40	91.2 <b>Nb</b> niobium 41	92.9 <b>Mo</b> molybdenum 42	95.9 <b>Tc</b> technetium 43	101.1 <b>Ru</b> ruthenium 44	102.9 <b>Rh</b> rhodium 45	106.4 <b>Pd</b> palladium 46	107.9 <b>Ag</b> silver 47	112.4 <b>Cd</b> cadmium 48	114.8 <b>In</b> indium 49	118.7 <b>Sn</b> tin 50	121.8 <b>Sb</b> antimony 51	127.6 <b>Te</b> tellurium 52	126.9 <b>I</b> iodine 53	131.3 <b>Xe</b> xenon 54	132.9 <b>Cs</b> caesium 55	137.3 <b>Ba</b> barium 56	138.9 <b>La*</b> lanthanum 57	178.5 <b>Hf</b> hafnium 72	178.5 <b>Ta</b> tantalum 73	180.9 <b>W</b> tungsten 74	183.8 <b>Re</b> rhenium 75	186.2 <b>Os</b> osmium 76	190.2 <b>Ir</b> iridium 77	192.2 <b>Pt</b> platinum 78	195.1 <b>Au</b> gold 79	200.6 <b>Hg</b> mercury 80	204.4 <b>Tl</b> thallium 81	207.2 <b>Pb</b> lead 82	209.0 <b>Bi</b> bismuth 83	209.0 <b>Po</b> polonium 84	210 <b>At</b> astatine 85	222 <b>Rn</b> radon 86
	[223] <b>Fr</b> francium 87	[226] <b>Ra</b> radium 88	[227] <b>Ac*</b> actinium 89	[261] <b>Rf</b> rutherfordium 104	[262] <b>Db</b> dubnium 105	[266] <b>Sg</b> seaborgium 106	[264] <b>Bh</b> bohrium 107	[277] <b>Hs</b> hassium 108	[268] <b>Mt</b> meitnerium 109	[271] <b>Ds</b> darmstadtium 110	[272] <b>Rg</b> roentgenium 111	200.6 <b>Cd</b> cadmium 48	112.4 <b>In</b> indium 49	118.7 <b>Sn</b> tin 50	121.8 <b>Sb</b> antimony 51	127.6 <b>Te</b> tellurium 52	126.9 <b>I</b> iodine 53	131.3 <b>Xe</b> xenon 54	209.0 <b>Po</b> polonium 84	209.0 <b>Bi</b> bismuth 83	207.2 <b>Pb</b> lead 82	204.4 <b>Tl</b> thallium 81	200.6 <b>Hg</b> mercury 80	197.0 <b>Au</b> gold 79	195.1 <b>Pt</b> platinum 78	192.2 <b>Ir</b> iridium 77	190.2 <b>Os</b> osmium 76	186.2 <b>Re</b> rhenium 75	183.8 <b>W</b> tungsten 74	180.9 <b>Ta</b> tantalum 73	178.5 <b>Hf</b> hafnium 72	178.5 <b>Ta</b> tantalum 73	180.9 <b>W</b> tungsten 74	186.2 <b>Re</b> rhenium 75	190.2 <b>Os</b> osmium 76	192.2 <b>Ir</b> iridium 77	195.1 <b>Pt</b> platinum 78	197.0 <b>Au</b> gold 79	200.6 <b>Hg</b> mercury 80	204.4 <b>Tl</b> thallium 81	207.2 <b>Pb</b> lead 82	209.0 <b>Bi</b> bismuth 83	209.0 <b>Po</b> polonium 84	[210] <b>At</b> astatine 85	[222] <b>Rn</b> radon 86									

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

140 <b>Ce</b> cerium 58	141 <b>Pr</b> praseodymium 59	144 <b>Nd</b> neodymium 60	147 <b>Pm</b> promethium 61	150 <b>Sm</b> samarium 62	152 <b>Eu</b> europium 63	157 <b>Gd</b> gadolinium 64	159 <b>Tb</b> terbium 65	163 <b>Dy</b> dysprosium 66	165 <b>Ho</b> holmium 67	167 <b>Er</b> erbium 68	169 <b>Tm</b> thulium 69	173 <b>Yb</b> ytterbium 70	175 <b>Lu</b> lutetium 71
232 <b>Th</b> thorium 90	[231] <b>Pa</b> protactinium 91	238 <b>U</b> uranium 92	[237] <b>Np</b> neptunium 93	[242] <b>Pu</b> plutonium 94	[243] <b>Am</b> americium 95	[247] <b>Cm</b> curium 96	[245] <b>Bk</b> berkelium 97	[251] <b>Cf</b> californium 98	[254] <b>Es</b> einsteinium 99	[253] <b>Fm</b> fermium 100	[256] <b>Md</b> mendelevium 101	[254] <b>No</b> nobelium 102	[257] <b>Lr</b> lawrencium 103

\* Lanthanide series

\* Actinide series

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