Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

Z22-2410U10-1

2410U10-1

TUESDAY, 17 MAY 2022 – MORNING

CHEMISTRY – AS unit 1

The Language of Chemistry, Structure of Matter and Simple Reactions

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 7.**	**10**	
Section B	**8.**	**14**	
	9.	**12**	
	10.	**13**	
	11.	**17**	
	12.	**14**	
	Total	**80**	

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01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid. You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.10**(a).

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SECTION A

Answer **all** questions.

1. Using **outer** electrons only, draw a dot and cross diagram to show the formation of the bonding in sodium oxide. [2]

2. Complete the following sentence: [1]

Hydrogen bonding is an intermolecular force that occurs between molecules containing hydrogen atoms bonded to small, ... atoms which have lone pairs of electrons for example ..... .

3. By inserting arrows to represent electrons, show the electronic configuration of a calcium atom. [1]

1s	2s	2p			3s	3p			3d					4s

4. Hydrazine can be manufactured from ammonia.

$$2NH_3 + H_2O_2 \longrightarrow N_2H_4 + 2H_2O$$

Calculate the atom economy of this reaction. [1]

atom economy = ... %

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5. The ammonium ion contains a 'coordinate bond'. Explain what is meant by this term. [1]

.....

.....

6. Uranium is used in nuclear fuel reactors. One of its isotopes, uranium-235, has a half-life of 7.03×10^8 years and decays by α-emission.

(a) Give the mass number and symbol of the element formed as a product of the radioactive decay of uranium-235. [1]

.....

(b) If a quantity of uranium-235 decays, state what fraction is left after 2.812×10^9 years. [1]

fraction left = ...

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7. Calculate the mass of calcium that contains the same number of atoms as there are molecules in 9.1 g of sulfur dioxide, SO_2. [2]

calcium mass = ... g

10

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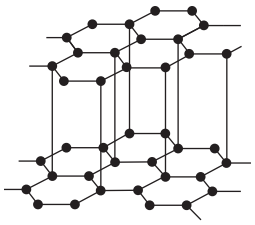
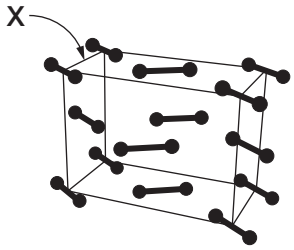
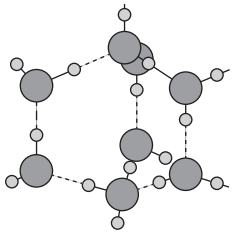
SECTION B

Answer **all** questions.

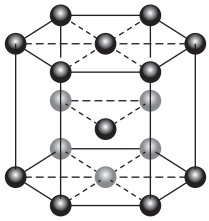
8. (a) The diagrams below represent the structures of cadmium metal, caesium chloride, graphite, ice, iodine and sodium chloride.

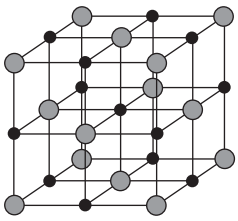


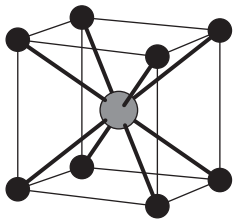




A graphite **B** ..... **C** .....







D cadmium **E** ..... **F** .....

(i) Label the remaining structures in the spaces provided. [2]

(ii) Complete the table showing the trend in melting temperatures of the six substances. [2]

Substance	Melting temperature
.....	Lowest
.....	↓
.....	
caesium chloride	
sodium chloride	
.....	Highest

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(iii) For structure **B**, name the type of bond or force represented by the letter **X**. [1]

.....

(iv) Name the **two** substances which are good electrical conductors in the solid state. [1]

.....

.....

(v) Explain why graphite is suitable for use in pencils. [2]

.....

.....

.....

(vi) Cadmium is a typical metal.
Give a brief description of metallic bonding. [3]
You may include a diagram to support your answer.

.....

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.....

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(b) Many houses have been built on disused industrial sites. A housing developer wants to test whether the soil on a particular site is contaminated with cadmium ions (Cd^{2+}).

They extract a sample and prepare a solution. Cadmium ions behave in the same way as magnesium ions when treated with sodium hydroxide solution and sodium sulfate solution.

(i) State what the developer would see if cadmium ions were present when they added:

I. sodium hydroxide solution. [1]

.....

II. sodium sulfate solution. [1]

.....

(ii) Write an ionic equation, including state symbols, for **one** of the above observations. [1]

.....

14

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9. (a) (i) Explain the origins of emission spectra. [2]

.....

.....

.....

.....

.....

(ii) Give **one** difference in the appearance of absorption and emission spectra. [1]

.....

.....

.....

(b) A line in the emission spectrum of an element has a wavelength of 95.0 nm.
Calculate the frequency of this line in megahertz, MHz. [2]

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frequency = ... MHz

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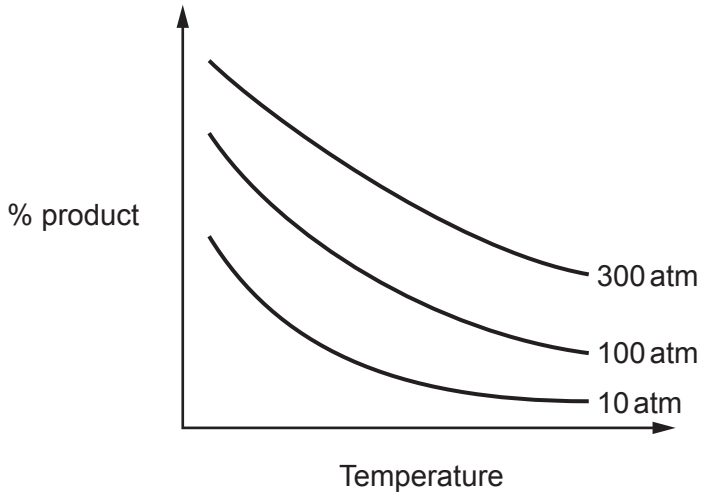
(c) The diagram below shows how the percentage product varies with temperature and pressure for an equilibrium process.



Use the diagram and Le Chatelier's principle to explain whether:

(i) the forward reaction is endothermic or exothermic. [2]

.....

.....

.....

.....

(ii) the forward reaction involves an increase or decrease in the number of moles of gas. [2]

.....

.....

.....

.....

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(d) The Solvay process is the major industrial process for the manufacture of sodium carbonate. Two of the stages in the process are shown below:

$$NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate, in kg, which could be obtained from 15.0 tonnes of sodium chloride. Give your answer to an appropriate number of significant figures. [3]

maximum mass = ... kg

12

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10. (a) Group 1 and Group 2 metals are in the s-block of the Periodic Table. Using potassium and calcium as examples, discuss the similarities and differences between Group 1 and Group 2 with respect to:

- the reaction of the metals with cold water.
- the solubility of the carbonates. [6 QER]

You should include appropriate chemical equations in your answer.

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(b) The equation for the reaction between potassium carbonate and hydrochloric acid is given below.

$$K_2CO_3 + 2HCl \longrightarrow 2KCl + H_2O + CO_2$$

A 1.40 g sample of impure potassium carbonate was added to excess dilute hydrochloric acid. The impurity is unreactive and only the potassium carbonate reacts with the acid.

The volume of carbon dioxide released was 186 cm^3 when measured at 298 K and 1.01×10^5 Pa.

Calculate the mass of the impurity. [3]

mass of impurity = ... g

(c) A solution is thought to contain potassium chloride. Describe suitable tests that a student could do to confirm this. Include the expected observations. [2]

.....

.....

.....

.....

(d) By referring to ionisation energies, explain why stable compounds containing K^{2+} ions are unlikely to form. [2]

.....

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.....

13

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11. (a) Arsenic oxide, As_2O_3, is prepared on an industrial scale by roasting arsenic-containing ores such as arsenopyrite, FeAsS, in air. The other products formed are iron(III) oxide and sulfur dioxide.

(i) State the oxidation state of arsenic in As_2O_3. [1]

.....

(ii) Give a balanced chemical equation for the industrial production of As_2O_3 from FeAsS. [2]

.....

(b) As_2O_3 is moderately soluble in water. 100 cm^3 of a saturated solution at 25 °C contains 2.06 g.

When dissolved in water, the oxide reacts to form arsenous acid.

$$As_2O_3 + 3H_2O \longrightarrow 2H_3AsO_3$$

(i) Calculate the concentration of the arsenous acid, in mol dm^{-3}, in the saturated solution. [3]

concentration of H_3AsO_3 = ... mol dm^{-3}

(ii) A solution of arsenous acid has a pH of 5.11.

Calculate the hydrogen ion concentration of this solution. [1]

$[H^+]$ = ... mol dm^{-3}

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(c) The formula for arsenous acid can be written as $As(OH)_3$ since it contains three hydroxyl (OH) groups bonded to arsenic.

Suggest the shape around the arsenic atom in $As(OH)_3$. Justify your answer by using VSEPR theory. [3]

.....

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.....

(d) Phosphorus can form two chlorides, PCl_3 and PCl_5.

0.181 g of a chloride of phosphorus gave 39 cm^3 of vapour at 1 atm pressure when heated to 87 °C. The sample was completely vapourised.

Show that the chloride of phosphorus was PCl_3. [4]

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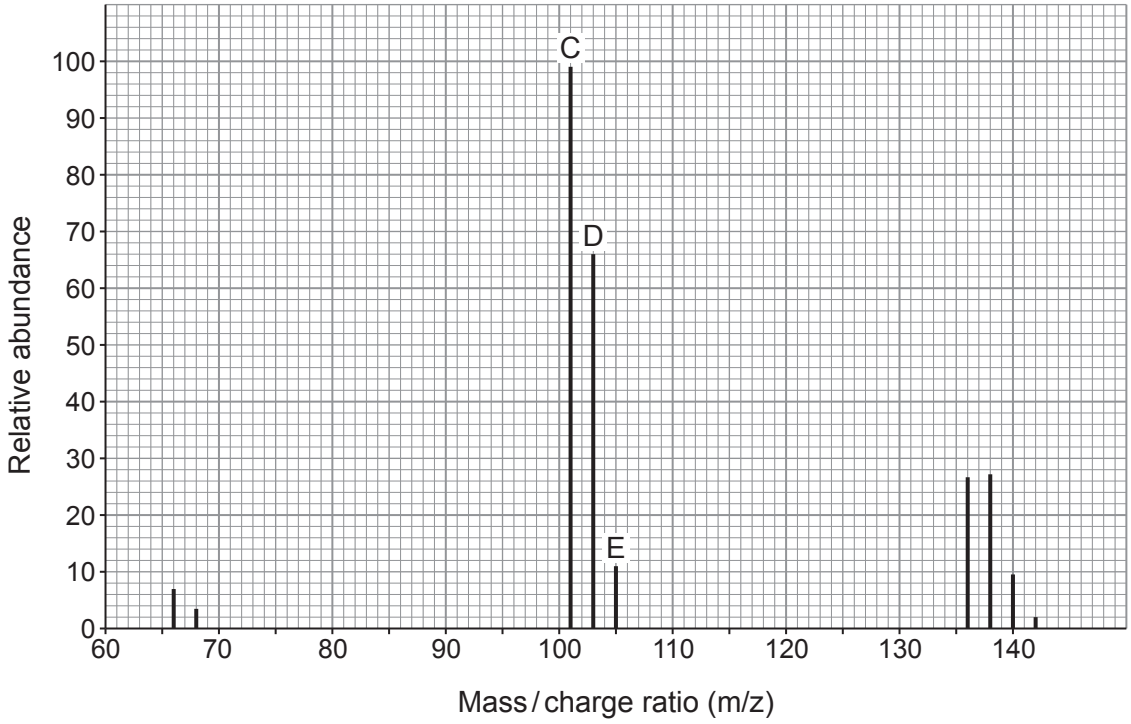
(e) The molecular ion region of the mass spectrum of PCl_3, is shown below.



(i) Identify the species responsible for peak C at m/z 101. [1]

.....

(ii) Explain why the height ratio of peaks C:E is 9:1. [2]

.....

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.....

17

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12. A student was asked to find the identity of a Group 1 metal carbonate by titration.

He was told to use the following method.

- Weigh a sample of the carbonate in a weighing bottle.
- Transfer the carbonate into a beaker and weigh the bottle afterwards.
- Add water to the beaker to dissolve the carbonate.
- Transfer the solution to a volumetric flask.
- Add more water to make the final volume 250.0 cm^3 of solution.
- Accurately transfer 25.0 cm^3 of this solution into a conical flask.
- Add 2–3 drops of a suitable indicator to this solution.
- Fill a burette with 0.100 mol dm^{-3} hydrochloric acid solution.
- Carry out a rough titration of the carbonate solution with the hydrochloric acid.
- Accurately repeat the titration until you get concordant titres and calculate a mean titre.

(a) Another student said that there were two errors in making the 250.0 cm^3 carbonate solution.

Error 1: A small amount of solid remained in the weighing bottle.

Error 2: A small amount of solution remained in the beaker.

Comment on the suggested errors.
If the student is correct suggest how the method could be improved.
If the student is incorrect, explain why. [2]

Error 1 .....

.....

.....

Error 2 .....

.....

.....

(b) State why he adds an indicator to this solution. [1]

.....

.....

(c) Suggest why he was told to carry out a rough titration first. [1]

.....

.....

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(d) State what you understand by the term 'concordant titres'. [1]

.....

.....

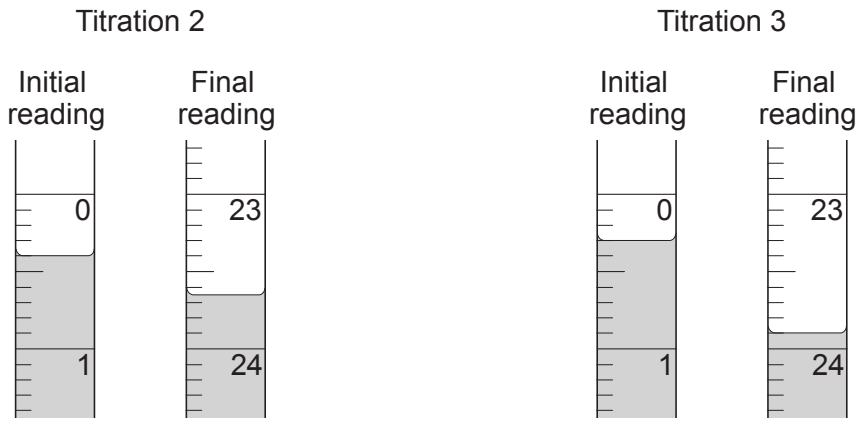
(e) Some of the student's results are shown below:

Mass of weighing bottle + carbonate / g	13.73
Mass of weighing bottle / g	12.48

Titration	Rough	1	2	3
Final reading / cm^3	24.20	23.70	.....	.....
Initial reading / cm^3	0.00	0.10	.....	.....
Titre / cm^3	.....	.....	.....	.....

concentration of hydrochloric acid = 0.100 mol dm^{-3}

The diagrams below show the initial burette reading and the final burette reading for the second and third titrations.



Complete the student's table and calculate the mean titre. [3]

mean titre = ... cm^3

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(f) The equation for the reaction between the metal carbonate and hydrochloric acid is given below. **M** represents the symbol of the Group 1 metal.

$$\mathbf{M}_2CO_3 + 2HCl \longrightarrow 2\mathbf{M}Cl + H_2O + CO_2$$

(i) Calculate the number of moles of M_2CO_3 in 25.0 cm^3 of the solution. [2]

number of moles = ...

(ii) Calculate the relative formula mass of the carbonate and hence deduce the Group 1 metal in the carbonate.

You **must** show your working. [4]

group 1 metal = ...

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.	Examiner only

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2410U10-1A

Z22-2410U10-1A

TUESDAY, 17 MAY 2022 – MORNING

CHEMISTRY – AS unit 1

Data Booklet

Avogadro constant	N_A	$= 6.02 \times 10^{23}\ \text{mol}^{-1}$
molar gas constant	R	$= 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
molar gas volume at 273 K and 1 atm	V_m	$= 22.4\ \text{dm}^3\ \text{mol}^{-1}$
molar gas volume at 298 K and 1 atm	V_m	$= 24.5\ \text{dm}^3\ \text{mol}^{-1}$
Planck constant	h	$= 6.63 \times 10^{-34}\ \text{J s}$
speed of light	c	$= 3.00 \times 10^{8}\ \text{m s}^{-1}$
density of water	d	$= 1.00\ \text{g cm}^{-3}$
specific heat capacity of water	c	$= 4.18\ \text{J g}^{-1}\ \text{K}^{-1}$
ionic product of water at 298 K	K_w	$= 1.00 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$
fundamental electronic charge	e	$= 1.60 \times 10^{-19}\ \text{C}$

temperature (K) = temperature (°C) + 273

$1\ \text{dm}^3 = 1000\ \text{cm}^3$
$1\ \text{m}^3 = 1000\ \text{dm}^3$
1 tonne = 1000 kg
$1\ \text{atm} = 1.01 \times 10^5\ \text{Pa}$

Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

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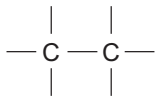
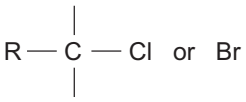
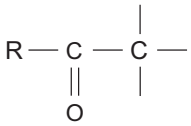
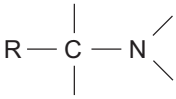
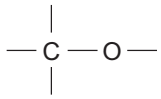
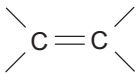
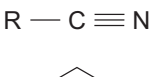
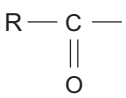
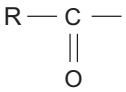
Infrared absorption values

Bond	Wavenumber / cm^{-1}
C — Br	500 to 600
C — Cl	650 to 800
C — O	1000 to 1300
C = C	1620 to 1670
C = O	1650 to 1750
C ≡ N	2100 to 2250
C — H	2800 to 3100
O — H (carboxylic acid)	2500 to 3200 (very broad)
O — H (alcohol / phenol)	3200 to 3550 (broad)
N — H	3300 to 3500

^{13}C NMR chemical shifts relative to TMS = 0

Type of carbon	Chemical shift, δ (ppm)
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
	110 to 125
	110 to 160
 (carboxylic acid / ester)	160 to 185
 (aldehyde / ketone)	190 to 220

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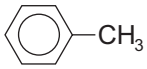
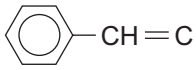
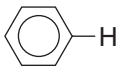
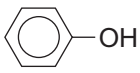
^{1}H NMR chemical shifts relative to TMS = 0

Type of proton	Chemical shift, δ (ppm)
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
$CH_3-C(=O)-$	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
	2.2 to 2.3
$HC-Cl$ or $HC-Br$	3.1 to 4.3
$HC-O$	3.3 to 4.3
$R-OH$	4.5 *
$-C=CH$	4.5 to 6.3
$-C=CH-CO$	5.8 to 6.5
	6.5 to 7.5
	6.5 to 8.0
	7.0 *
$R-C(=O)-H$	9.8 *
$R-C(=O)-OH$	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE

Key

A_r	relative atomic mass
Symbol	
Name	
Z	atomic number

Period	1	2	3	4	5	6	7	0
	s block							
1	1.01 H Hydrogen 1							4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 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
3	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	40.0 Ar Argon 18
4	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
5	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	98.9 Tc Technetium 43	101 Ru Ruthenium 44
								103 Rh Rhodium 45
								106 Pd Palladium 46
								108 Ag Silver 47
								112 Cd Cadmium 48
								115 In Indium 49
								119 Sn Tin 50
								122 Sb Antimony 51
								128 Te Tellurium 52
								127 I Iodine 53
								131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 ▸	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76
								192 Ir Iridium 77
								195 Pt Platinum 78
								197 Au Gold 79
								201 Hg Mercury 80
								204 Tl Thallium 81
								207 Pb Lead 82
								209 Bi Bismuth 83
								(210) Po Polonium 84
								(210) At Astatine 85
								(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac Actinium 89 ▸▸					

d block

p block

f block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) 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
▸▸ Actinoid elements	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

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