GCE AS/A LEVEL

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 plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

	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	

ADDITIONAL MATERIALS

In addition to this paper you will need a:

- **calculator;**
- **DATA BOOKLET supplied by WJEC.**

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

Answer ALL questions in SECTION A.
Answer ALL questions in SECTION B.

Write your answers in the spaces provided.
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 Question 10 (a).

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.

SPACE FOR DIAGRAM:

[2 marks]

2. Complete the following sentence:

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 _____ .

[1 mark]

continued on the next page . . .

3. **Look at the diagram for Question 3 in the separate Diagram Booklet.**
The diagram shows the empty electron energy levels for an atom.

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

[1 mark]

4. Hydrazine can be manufactured from ammonia. The equation for this reaction is given below.

Calculate the atom economy of this reaction.

SPACE FOR WORKING:

atom economy = _____ %

[1 mark]

5. The ammonium ion contains a 'coordinate bond'.

Explain what is meant by this term.

_____

_____

_____

[1 mark]

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 mark]

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

fraction left = _____

[1 mark]

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.

SPACE FOR WORKING:

calcium mass = _____ g

[2 marks]

Total for SECTION A = 10 marks

SECTION B

ANSWER ALL QUESTIONS.

8. (a) Look at the diagrams for Question 8 (a) in the separate Diagram Booklet.

The diagrams represent the structures of cadmium metal, caesium chloride, graphite, ice, iodine and sodium chloride.

(i) Label the remaining structures in the spaces provided on the diagram.

[2 marks]

continued on the next page . . .

Question 8 (a) continued

8. (a) (ii) Complete the table below showing the trend in melting temperatures of the six substances.

Substance	Melting temperature
	Lowest ↓
caesium chloride	
sodium chloride	
	Highest

[2 marks]

continued on the next page . . .

Question 8 (a) continued

8. (a) (iii) For structure B, name the type of bond or force represented by the letter X.

_____

_____

[1 mark]

(iv) Name the TWO substances which are good electrical conductors in the solid state.

Substance 1

_____

_____

Substance 2

_____

_____

[1 mark]

continued on the next page . . .

Question 8 (a) continued

8. (a) (v) Explain why graphite is suitable for use in pencils.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 8 (a) continued

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

SPACE FOR WORKING:

[3 marks]

continued on the next page . . .

Question 8 continued

8. (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.

continued on the next page . . .

Question 8 (b) continued

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

I. sodium hydroxide solution.

_____

_____

[1 mark]

II. sodium sulfate solution.

_____

_____

[1 mark]

continued on the next page . . .

Question 8 (b) continued

8. (b) (ii) Write an ionic equation, including state symbols, for ONE of the observations from part (i).

_____

_____

[1 mark]

(Total for Question 8 = 14 marks)

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

[2 marks]

continued on the next page . . .

Question 9 (a) continued

9. (a) (ii) Give ONE difference in the appearance of absorption and emission spectra.

_____

_____

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 9 continued

9. (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.

SPACE FOR WORKING:

frequency = _____ MHz

[2 marks]

continued on the next page . . .

Question 9 continued

9. (c) Look at the diagram for Question 9 (c) in the separate Diagram Booklet.
The diagram 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 marks]

continued on the next page . . .

Question 9 (c) continued

9. (c) (ii) the forward reaction involves an increase or decrease in the number of moles of gas.

[2 marks]

continued on the next page . . .

Question 9 continued

9. (d) Look at the diagram for Question 9 (d) in the separate Diagram Booklet.

The Solvay process is the major industrial process for the manufacture of sodium carbonate. Two of the stages in the process are shown in the diagram.

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.

SPACE FOR WORKING:

SPACE FOR WORKING continued

maximum mass = _____ kg

[3 marks]

(Total for Question 9 = 12 marks)

---

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.**

You should include appropriate chemical equations in your answer.

[6 marks QER]

continued on the next page . . .

Question 10 continued

10. (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.

continued on the next page . . .

Question 10 (b) continued

Calculate the mass of the impurity.

SPACE FOR WORKING:

mass of impurity = _____ g

[3 marks]

continued on the next page . . .

Question 10 continued

10. (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 marks]

continued on the next page . . .

Question 10 continued

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

[2 marks]

(Total for Question 10 = 13 marks)

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 mark]

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

_____

_____

[2 marks]

continued on the next page . . .

Question 11 continued

11. (b) As_2O_3 **is moderately soluble in water.**

100 cm^3 **of a saturated solution at** $25^\circ C$ **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.**

SPACE FOR WORKING:

concentration of H_3AsO_3

= _____ $mol\ dm^{-3}$ **[3 marks]**

Question 11 (b) continued

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

Calculate the hydrogen ion concentration of this solution.

SPACE FOR WORKING:

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

[1 mark]

continued on the next page . . .

Question 11 continued

11. (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.

SPACE FOR DIAGRAM:

[3 marks]

continued on the next page . . .

Question 11 continued

11. (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.

SPACE FOR WORKING:

[4 marks]

continued on the next page . . .

Question 11 continued

11. (e) Look at the diagram for Question 11 (e) in the separate Diagram Booklet.
The diagram shows the molecular ion region of the mass spectrum of PCl_3

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

_____

_____

[1 mark]

continued on the next page . . .

Question 11 (e) continued

11. (e) (ii) Explain why the height ratio of peaks C : E is 9 : 1.

[2 marks]

(Total for Question 11 = 17 marks)

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.

continued on the next page . . .

Question 12 continued

- **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.**

12. (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.

continued on the next page . . .

Question 12 (a) continued

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

Error 1

Error 2

[2 marks]

continued on the next page . . .

Question 12 continued

12. (b) State why he adds an indicator to this solution.

_____

_____

_____

[1 mark]

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

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 12 continued

12. (d) State what you understand by the term ‘concordant titres’.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 12 continued

12. (e) Look at the table for Question 12 (e) in the separate Diagram Booklet.
The table shows some of the student's results.

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

Look at the diagram for Question 12 (e) in the separate Diagram Booklet.
The diagram shows 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.

mean titre = _____ cm^3

[3 marks]

continued on the next page . . .

Question 12 continued

12. (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.

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

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

SPACE FOR WORKING:

number of moles = _____

[2 marks]

continued on the next page . . .

Question 12 (f) continued

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

You MUST show your working.

SPACE FOR WORKING:

continued on the next page . . .

SPACE FOR WORKING continued

group 1 metal = _____

[4 marks]

(Total for Question 12 = 14 marks)

TOTAL FOR SECTION B = 70 marks

END OF PAPER

TOTAL FOR PAPER = 80 MARKS

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

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

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

GCE AS/A LEVEL

2410U10-1

TUESDAY, 17 MAY 2022 – MORNING

CHEMISTRY – AS UNIT 1

THE LANGUAGE OF CHEMISTRY, STRUCTURE OF MATTER AND SIMPLE REACTIONS

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Diagram Booklet

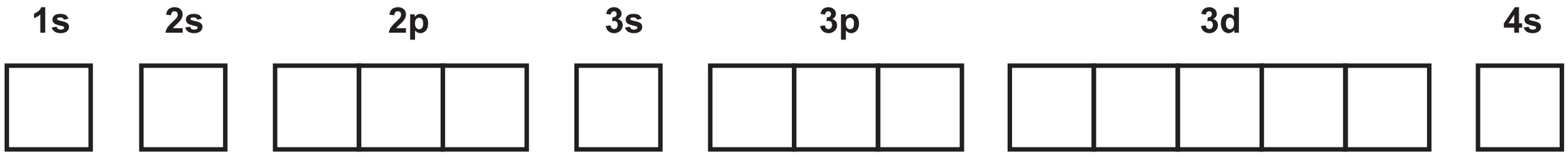
Surname: _____

First name(s): _____

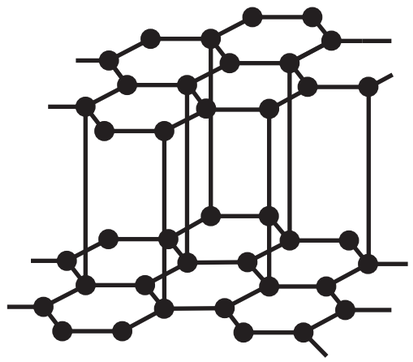
Centre Number: _____

Candidate Number: 2 _____

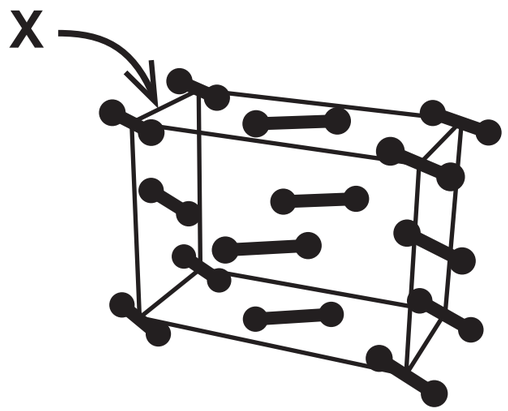
Question 3



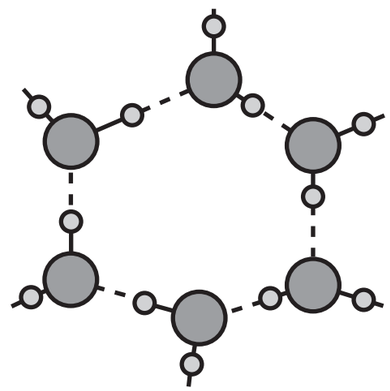
Question 8 (a)



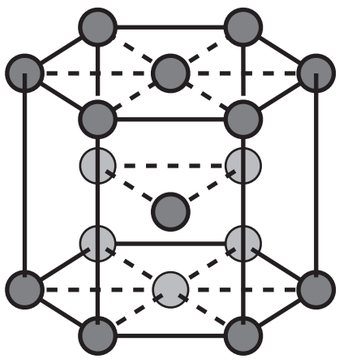
A graphite



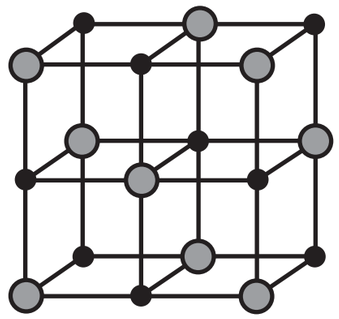
B



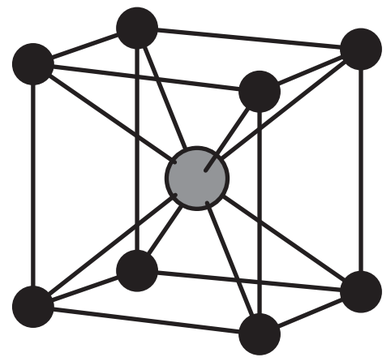
C



D cadmium

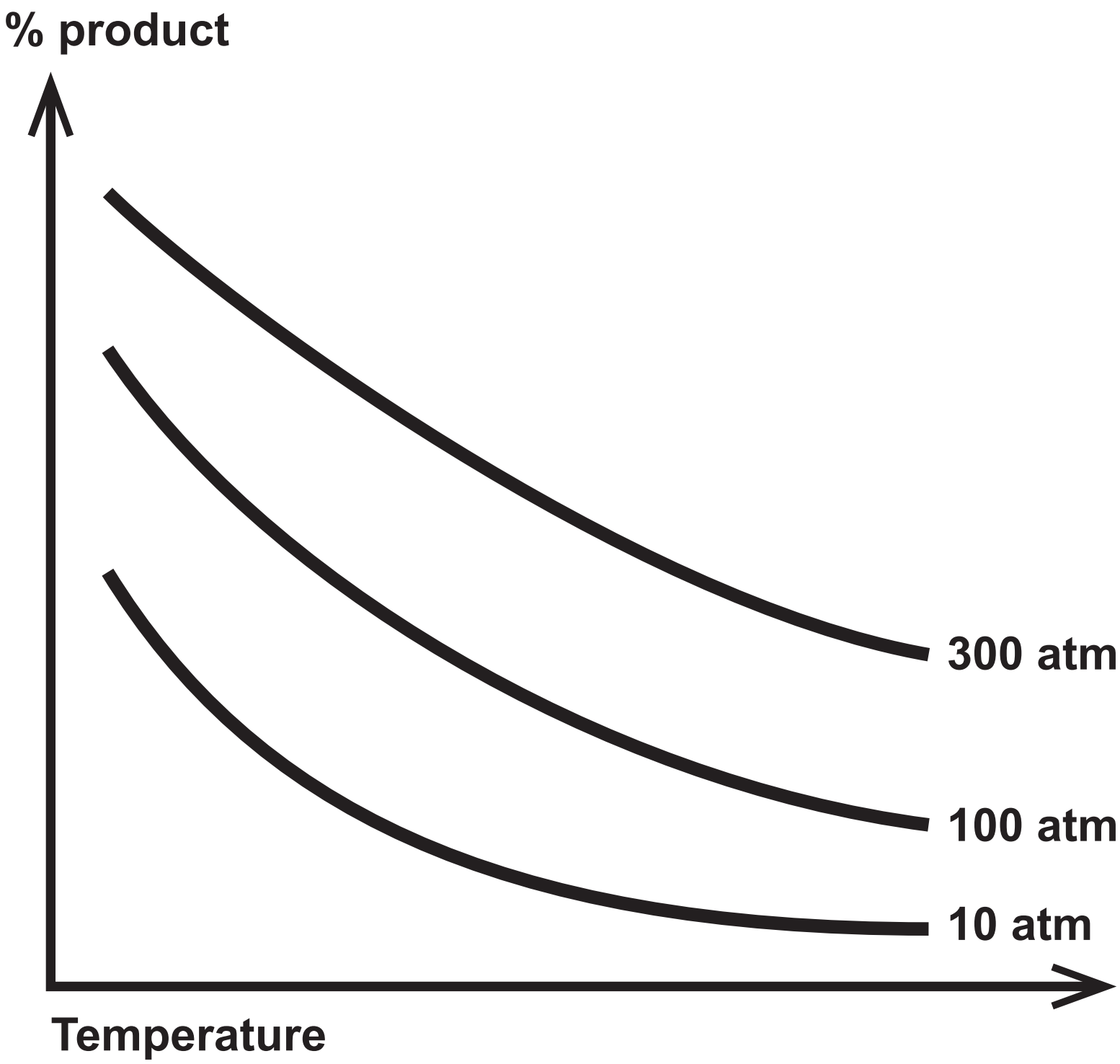


E



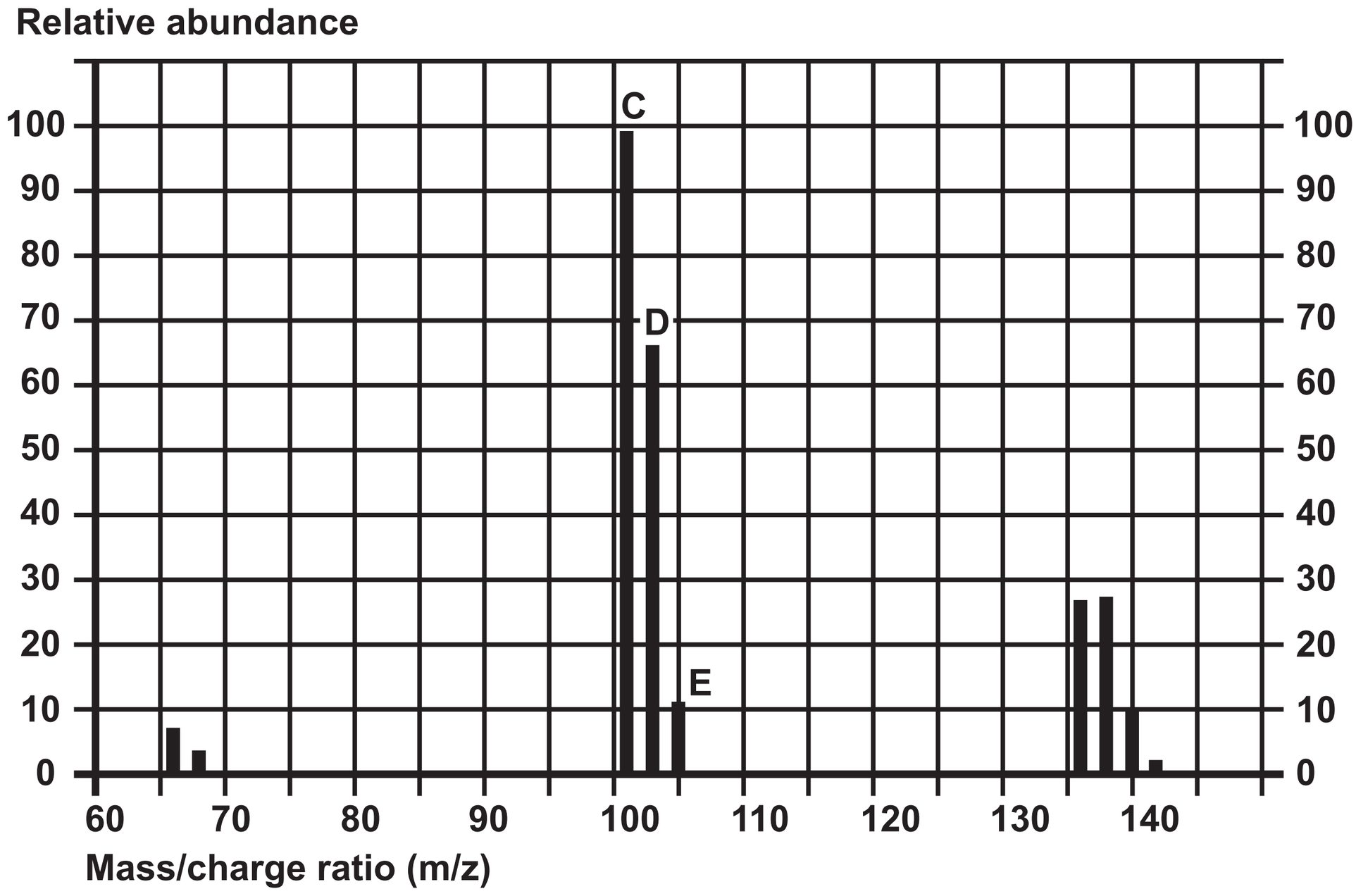
F

Question 9 (c)



Question 9 (d)

Question 11 (e)



Question 12 (e)

Table

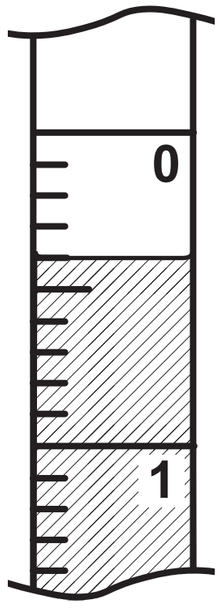
Mass of weighing bottle + carbonate / g	13.73
Mass of weighing bottle / g	12.48

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

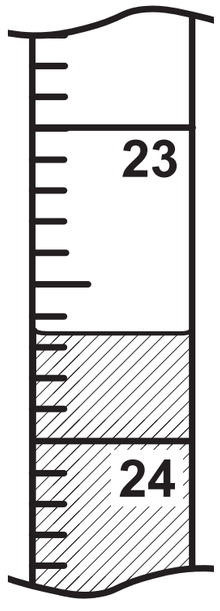
Question 12 (e)

Titration 2

Initial reading

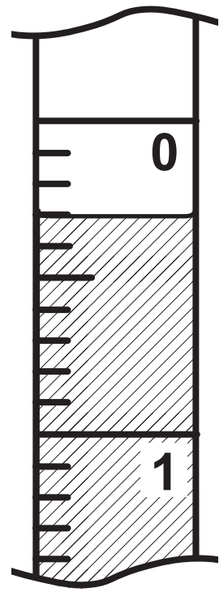


Final reading

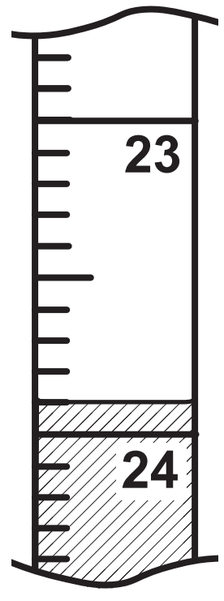


Titration 3

Initial reading



Final reading



GCE AS/A LEVEL

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

$1\ \text{atm} = 1.01 \times 10^5\ \text{Pa}$

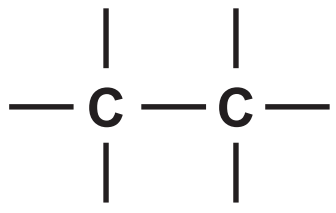
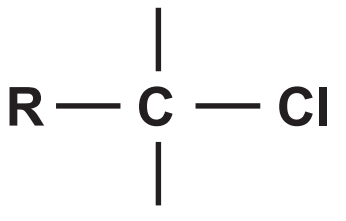
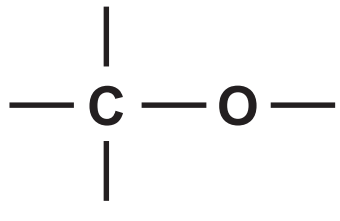
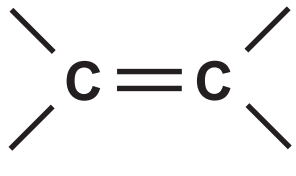
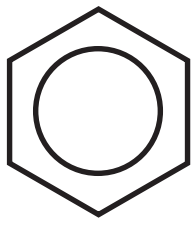
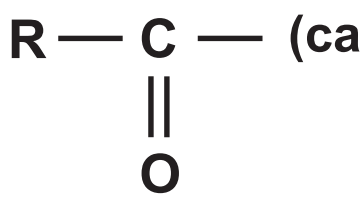
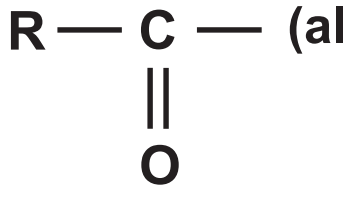
Multiple	Prefix	Symbol
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

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

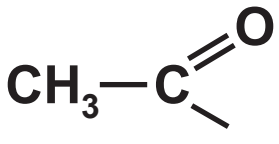
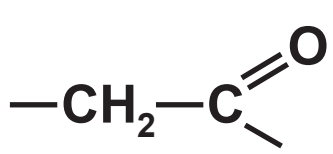
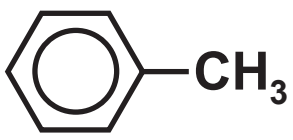
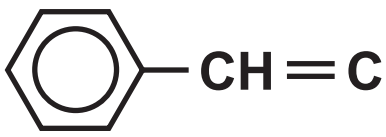
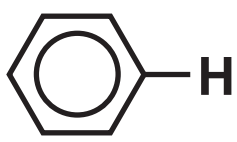
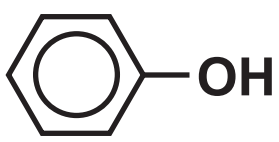
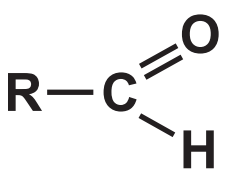
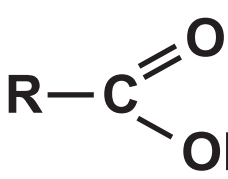
INFRARED ABSORPTION VALUES

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
 or 	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

^{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
	2.0 to 2.5
	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 *
	9.8 *
	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE

Key

relative atomic mass

A_r

Symbol

Period	Group 1	2	3	4	5	6	7	0
	s Block							
1	1.01 H							4.00 He
						p Block		
2	6.94 Li	9.01 Be	10.8 B	12.0 C	14.0 N	16.0 O	19.0 F	20.2 Ne
3	23.0 Na	24.3 Mg	27.0 Al	28.1 Si	31.0 P	32.1 S	35.5 Cl	40.0 Ar
		d Block						
4	39.1 K	40.1 Ca	45.0 Sc	47.9 Ti	50.9 V	52.0 Cr	54.9 Mn	55.8 Fe	58.9 Co	58.7 Ni	63.5 Cu	65.4 Zn	69.7 Ga	72.6 Ge	74.9 As	79.0 Se	79.9 Br	83.8 Kr
5	85.5 Rb	87.6 Sr	88.9 Y	91.2 Zr	92.9 Nb	95.9 Mo	98.9 Tc	101 Ru	103 Rh	106 Pd	108 Ag	112 Cd	115 In	119 Sn	122 Sb	128 Te	127 I	131 Xe
6	133 Cs	137 Ba	139 La ►	179 Hf	181 Ta	184 W	186 Re	190 Os	192 Ir	195 Pt	197 Au	201 Hg	204 Tl	207 Pb	209 Bi	(210) Po	(210) At	(222) Rn
7	(223) Fr	(226) Ra	(227) Ac ►►															

f Block

►Lanthanoid elements	140 Ce	141 Pr	144 Nd	(147) Pm	150 Sm	(153) Eu	157 Gd	159 Tb	163 Dy	165 Ho	167 Er	169 Tm	173 Yb	175 Lu
►►Actinoid elements	232 Th	(231) Pa	238 U	(237) Np	(242) Pu	(243) Am	(247) Cm	(245) Bk	(251) Cf	(254) Es	(253) Fm	(256) Md	(254) No	(257) Lr

THE PERIODIC TABLE – KEY

ATOMIC NUMBER – SYMBOL – NAME

1 H - Hydrogen	38 Sr - Strontium	75 Re - Rhenium
2 He - Helium	39 Y - Yttrium	76 Os - Osmium
3 Li - Lithium	40 Zr - Zirconium	77 Ir - Iridium
4 Be - Beryllium	41 Nb - Niobium	78 Pt - Platinum
5 B - Boron	42 Mo - Molybdenum	79 Au - Gold
6 C - Carbon	43 Tc - Technetium	80 Hg - Mercury
7 N - Nitrogen	44 Ru - Ruthenium	81 Tl - Thallium
8 O - Oxygen	45 Rh - Rhodium	82 Pb - Lead
9 F - Fluorine	46 Pd - Palladium	83 Bi - Bismuth
10 Ne - Neon	47 Ag - Silver	84 Po - Polonium
11 Na - Sodium	48 Cd - Cadmium	85 At - Astatine
12 Mg - Magnesium	49 In - Indium	86 Rn - Radon
13 Al - Aluminium	50 Sn - Tin	87 Fr - Francium
14 Si - Silicon	51 Sb - Antimony	88 Ra - Radium
15 P - Phosphorus	52 Te - Tellurium	89 Ac - Actinium
16 S - Sulfur	53 I - Iodine	90 Th - Thorium
17 Cl - Chlorine	54 Xe - Xenon	91 Pa - Protactinium
18 Ar - Argon	55 Cs - Caesium	92 U - Uranium
19 K - Potassium	56 Ba - Barium	93 Np - Neptunium
20 Ca - Calcium	57 La - Lanthanum	94 Pu - Plutonium
21 Sc - Scandium	58 Ce - Cerium	95 Am - Americium
22 Ti - Titanium	59 Pr - Praseodymium	96 Cm - Curium
23 V - Vanadium	60 Nd - Neodymium	97 Bk - Berkelium
24 Cr - Chromium	61 Pm - Promethium	98 Cf - Californium
25 Mn - Manganese	62 Sm - Samarium	99 Es - Einsteinium
26 Fe - Iron	63 Eu - Europium	100 Fm - Fermium
27 Co - Cobalt	64 Gd - Gadolinium	101 Md - Mendelevium
28 Ni - Nickel	65 Tb - Terbium	102 No - Nobelium
29 Cu - Copper	66 Dy - Dysprosium	103 Lr - Lawrencium
30 Zn - Zinc	67 Ho - Holmium	
31 Ga - Gallium	68 Er - Erbium	
32 Ge - Germanium	69 Tm - Thulium	
33 As - Arsenic	70 Yb - Ytterbium	
34 Se - Selenium	71 Lu - Lutetium	
35 Br - Bromine	72 Hf - Hafnium	
36 Kr - Krypton	73 Ta - Tantalum	
37 Rb - Rubidium	74 W - Tungsten	