GCSE

3410UA0-1

THURSDAY, 13 JUNE 2024 – MORNING

CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources

HIGHER TIER

1 hour 45 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

In addition to this paper you will need a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

A separate Data 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 or your usual method.

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

Answer ALL questions.

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

INFORMATION FOR CANDIDATES

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

Question 8 is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table and the formulae for some common ions are printed in the separate data booklet.

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	7	
2.	6	
3.	7	
4.	5	
5.	9	
6.	5	
7.	7	
8.	6	
9.	7	
10.	12	
11.	9	
Total	80	

Answer ALL questions.

1 **TABLE 1 in the separate diagram booklet gives information about seven elements, A-G.**

(a) **Use information from TABLE 1 to answer parts (i)-(iii).**

(i) **Give the LETTER of the element that has the greatest difference between its melting point and boiling point. [1 mark]**

_____

(ii) **Give the LETTERS of the TWO elements that are gases at room temperature, 20 °C.**

Give a reason for your choice. [2 marks]

Letters _____ and _____

Reason _____

_____

_____

1 (a)(iii) **Give the LETTER of the element that is a metalloid.**

Explain your choice. [2 marks]

Letter _____

Explanation _____

_____

_____

_____

_____

(b) **One of the elements is aluminium. It reacts spectacularly with iron(III) oxide in the thermit reaction.**

Complete and balance the equation for the reaction between aluminium and iron(III) oxide to produce aluminium oxide and iron. [2 marks]

$\square\ Al + Fe_2O_3 \longrightarrow$ _____ $+ 2\,Fe$

7

2 (a) **Amanda wanted to determine what coloured dyes were present in a sample of orange ink.**

DIAGRAM 2.1 in the separate diagram booklet shows a piece of chromatography paper, supported by a pencil, placed in a beaker at the start of her experiment.

COMPLETE DIAGRAM 2.1 by showing

- **the position of the ink sample at the start**
- **the water level in the beaker [2 marks]**

(b) **TABLE 2.2 in the separate diagram booklet shows the R_f values for some coloured dyes that are found in inks.**

(i) **Explain why coloured dyes have different R_f values. [2 marks]**

2 (b)(ii)

Orange ink separates into red and yellow dyes.

ON CHROMATOGRAM 2.3 in the separate diagram booklet, draw the positions of the spots you would expect to see after a sample of orange ink has been analysed by chromatography. [2 marks]

Use the formula

$$\frac{\text{distance travelled by dye}}{\text{distance travelled by solvent}} = R_f \text{ value}$$

6

3 (a) **Wegener's theory of continental drift was not accepted by other scientists during his lifetime because he had no explanation of how the continents moved.**

We now know that the continents sit on tectonic plates which move very slowly.

State why these plates move. [1 mark]

3 (b) **DIAGRAMS 3.1 and 3.2 in the separate diagram booklet show two different types of plate boundary.**

At a constructive plate boundary, the plates move away from each other.

At a destructive plate boundary, the plates move towards each other.

Describe what happens at each type of boundary. [4 marks]

Constructive

Destructive

3 (c) The cities of Los Angeles and San Francisco are on opposite sides of a conservative plate boundary at a distance of 600 km apart.

They are moving closer together as the plates slide past one another at a relative speed of about 40 mm per year.

Use the formula below to calculate the amount of time before the cities are next to one another. [2 marks]

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

1 km = 1 000 m 1 m = 1 000 mm

Time = _____ years

7

4 **TABLE 4 in the separate diagram booklet shows the composition of four particles, W, X, Y and Z.**

(a) **Use information from TABLE 4 to answer parts (i)-(iii).**

(i) **State how the information shows that particle X is an atom. [1 mark]**

(ii) **State how the information shows that particle Y is a positive ion. [1 mark]**

(iii) **State how the information shows that particles W and X are isotopes of the same element. [1 mark]**

4 (b)(i) Give the electronic structure of element *Z*. [1 mark]

_____

(ii) State the group and period number of element *Z* in the Periodic Table. [1 mark]

Group _____

Period _____

5

5 Zinc reacts with sulfuric acid, H_2SO_4, to produce zinc sulfate and hydrogen gas.

(a) Write the formula of zinc sulfate to complete the equation for this reaction. [1 mark]

$$Zn + H_2SO_4 \longrightarrow \_\_\_\_\_ + H_2$$

(b) Some Year 10 students decided to investigate the rate of this reaction at 20 °C.

They added 0.2 g of zinc to 50 cm^3 of sulfuric acid and measured the volume of hydrogen gas produced every 20 seconds for 160 seconds using a gas syringe.

Their results are shown in TABLE 5.1 in the separate diagram booklet.

Draw appropriate scales on both axes on the grid in GRAPH 5.2 in the separate diagram booklet.

Plot the volume of hydrogen produced against time and draw a suitable line.
[3 marks]

The first two points have been plotted for you.

5 (c) **ON THE SAME GRID in GRAPH 5.2, sketch the graph you would expect to obtain if the experiment were repeated at 40 °C using the same mass of zinc and the same volume and concentration of sulfuric acid. [1 mark]**

(d) **Use the particle theory to explain what you would expect to happen to the rate of the reaction if the experiment were repeated at 20 °C using sulfuric acid of LOWER CONCENTRATION. [3 marks]**

5 (e) **Copper is a useful catalyst in the reaction between zinc and sulfuric acid.**

State how a catalyst increases the rate of a reaction. [1 mark]

9	

6 **FLOW DIAGRAM 6 in the separate diagram booklet shows some of the reactions of Group 1 metals.**

(a) **Identify the Group 1 metal chloride that would give a red flame test. [1 mark]**

_____

(b) **Give the FORMULA of the alkaline compound formed when sodium is added to water. [1 mark]**

_____

(c) **Complete the balanced equation for the reaction of lithium and oxygen to form lithium oxide. [3 marks]**

☐ Li + _____ ⟶ 2 _____

5

7 Although the Group 0 gases are unreactive elements, some Group 0 compounds have been made.

The heavier Group 0 gases have more electron shells than the lighter ones. Their outermost electrons are shielded from the attraction of the nucleus by the inner electrons. These atoms can therefore form bonds with very reactive atoms under certain conditions.

As a rule, Group 0 gases having an atomic radius greater than 80 picometres (pm) can form compounds. The atomic radii of Group 0 elements are shown in TABLE 7.1 in the separate diagram booklet.

The most common compounds of Group 0 gases are those formed with Group 7 elements. For example, krypton difluoride (KrF_2) and xenon dichloride ($XeCl_2$).

The stability of these compounds increases with increasing atomic number of the Group 0 gas and decreasing atomic number of the Group 7 element.

The oxidation state of the Group 0 gas in these compounds varies. Oxidation state is linked to the number of bonds formed. The melting points of these compounds decrease as the oxidation state of the Group 0 gas increases. An example of this is shown in TABLE 7.2 in the separate diagram booklet.

7 (a)(i) Tick (✓) the box next to the three Group 0 gases that are most likely to form compounds. [1 mark]

- ☐ helium, argon, xenon
- ☐ helium, neon, argon
- ☐ argon, krypton, xenon
- ☐ krypton, xenon, radon

(ii) Tick (✓) the box next to the most stable Group 0 compound. [1 mark]

- ☐ XeF_2
- ☐ KrF_2
- ☐ $XeCl_2$
- ☐ $KrCl_2$

7 (a)(iii)

Use the trend shown in TABLE 7.2 and the information in TABLE 7.3 in the separate diagram booklet to suggest the most likely melting point for $KrCl_6$.

Tick (✓) the box next to your answer. [1 mark]

- ☐ **23 °C**
- ☐ **71 °C**
- ☐ **110 °C**

(iv) Explain why neon does not form compounds. [2 marks]

7 (b) Give ONE use of helium and explain this use in terms of its properties. [2 marks]

_____

_____

_____

7

8 **The reactivity of the halogens changes on going down the group.**

You are provided with samples of the halogens and solutions of the halides shown in TABLE 8 in the separate diagram booklet.

State how you would carry out an investigation to determine the order of reactivity of the halogens using these chemicals.

Describe the observations made and explain how these are used to draw your conclusion.

Include an equation in your answer.
[6 marks QER]

continue your answer on the next page

6

9 (a) **FLOW DIAGRAM 9 in the separate diagram booklet shows the reactions carried out to prepare calcium hydroxide from calcium carbonate, $CaCO_3$.**

(i) **Name the type of reaction taking place in step 1. [1 mark]**

(ii) **Give the name of gas X. [1 mark]**

(iii) **Give ONE observation that shows that step 2 is exothermic. [1 mark]**

(iv) **Write a balanced equation for the reaction of calcium oxide and water to form calcium hydroxide. [2 marks]**

---

9 (b) **Give a reason why no reaction occurs when sodium carbonate is heated with a Bunsen burner. [1 mark]**

(c) **Barium hydroxide is another Group 2 hydroxide.**

Solutions of calcium hydroxide and barium hydroxide are both alkalis and turn pH paper purple.

State how you could distinguish between calcium hydroxide and barium hydroxide using a flame test. [1 mark]

7

10 Some students carried out an experiment to investigate the relative hardness of four water samples, **A**, **B**, **C** and **D**.

The students measured 20 cm^3 of sample **A** into a measuring cylinder. They added soap solution, 1 cm^3 at a time. After each addition the mixture was shaken. The volume of soap solution needed to produce 1 cm of lather was recorded.

Samples **B**, **C** and **D** were tested in the same way.

They then repeated each experiment with samples that had been boiled and others that had been treated with washing soda.

Their results are shown in TABLE **10.1** in the separate diagram booklet.

10 (a) Use the results in TABLE 10.1 to answer parts (i) and (ii).

(i) Identify the type of hardness found in sample A.

Give a reason for your answer. [2 marks]

(ii) Identify the sample containing both temporary and permanent hardness.

Give a reason for your answer. [2 marks]

10 (b) Another group of students carried out the same experiment on the same four water samples.

However, this group measured smaller volumes of each sample into the measuring cylinder. Their results are shown in TABLE 10.2 in the separate diagram booklet.

Compare the conclusions that can be drawn by the two groups. [2 marks]

10 (c) Permanent hardness is removed by ion exchange.

Explain how ion exchange works. [2 marks]

10 (d) Magnesium ions cause hardness in water.

(i) 1.00 dm^3 of a hard water sample contains 0.384 g of dissolved magnesium sulfate.

Calculate the number of moles of magnesium sulfate present.

Give your answer in STANDARD FORM.
[2 marks]

$$M_r(MgSO_4) = 120$$

$$\text{number of moles} = \frac{\text{mass}}{M_r}$$

Number of moles = _____ mol

10 (d)(ii)

1.00 dm^3 of another hard water sample contains the same mass (0.384 g) of dissolved magnesium chloride.

$$M_r(MgCl_2) = 95$$

State which water sample has more hardness.

Give your reasoning. [2 marks]

12

11 (a) Iron reacts with halogens forming iron halides.

(i) Write a balanced equation for the formation of iron(III) bromide. [3 marks]

(ii) You are provided with solutions of iron(III) bromide and iron(II) iodide.

Describe a test to identify which is which.

Your answer should include the expected observation for both compounds. [3 marks]

11 (b) **Bromine and fluorine react to produce a compound called bromine fluoride.**

In a reaction 16.3 g of bromine reacted with 19.4 g of fluorine. Calculate the simplest formula for the bromine fluoride produced.

You MUST show your working. [3 marks]

A_r(Br) = 80 A_r(F) = 19

Simplest formula _____

9

END OF PAPER

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

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CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources

HIGHER TIER

1 hour 45 minutes plus your additional time allowance

DIAGRAM BOOKLET

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

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

TABLE 1

Element	Melting point (°C)	Boiling point (°C)	Electrical conductivity	Malleability
A	839	1484	good	good
B	−23	115	poor	
C	1414	3265	poor	poor
D	−102	−34	poor	
E	10	112	poor	poor
F	−188	−42	poor	
G	660	2470	good	good

DIAGRAM 2.1

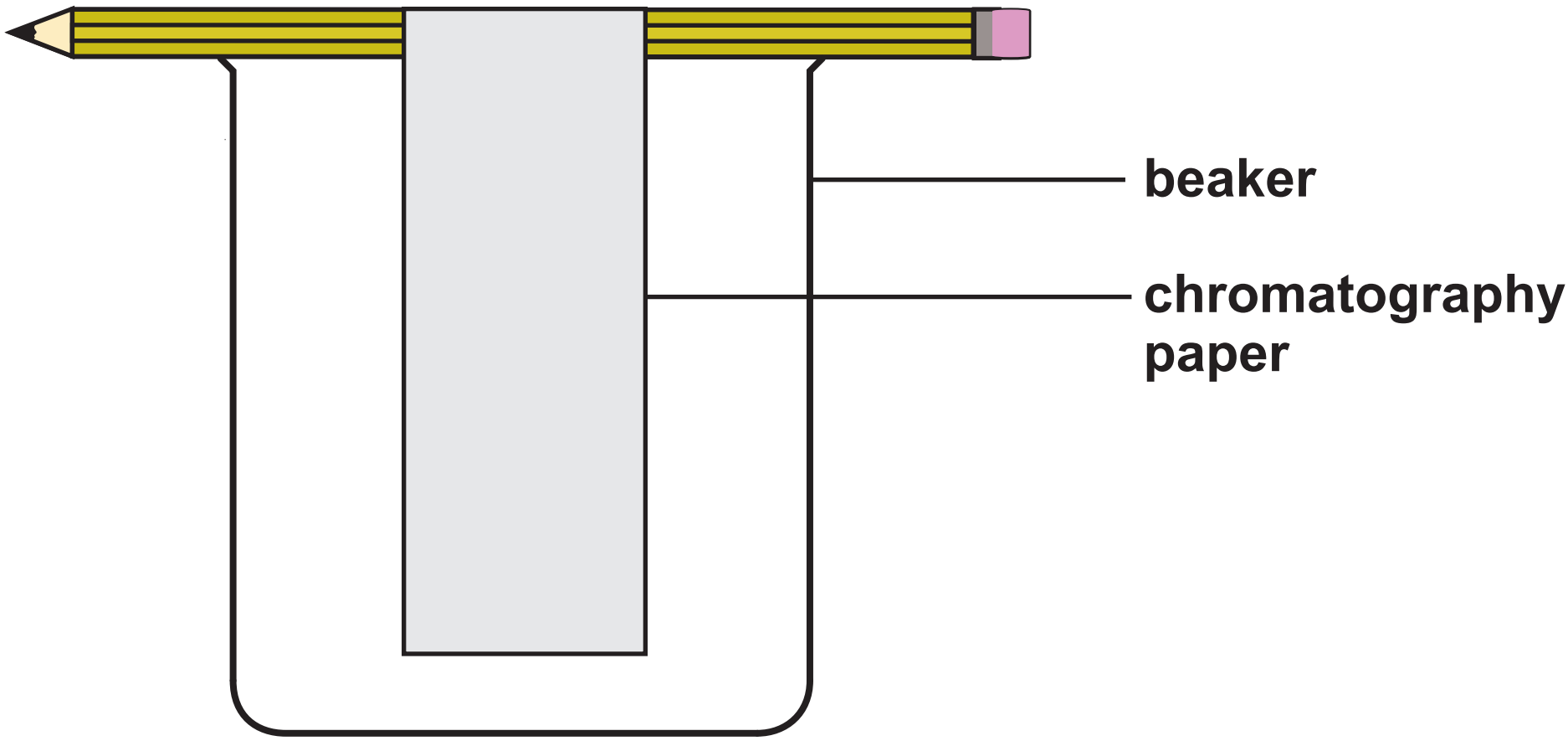

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TABLE 2.2

Dye colour	R_f value
blue	0.40
yellow	0.25
red	0.70
green	0.15

CHROMATOGRAM 2.3

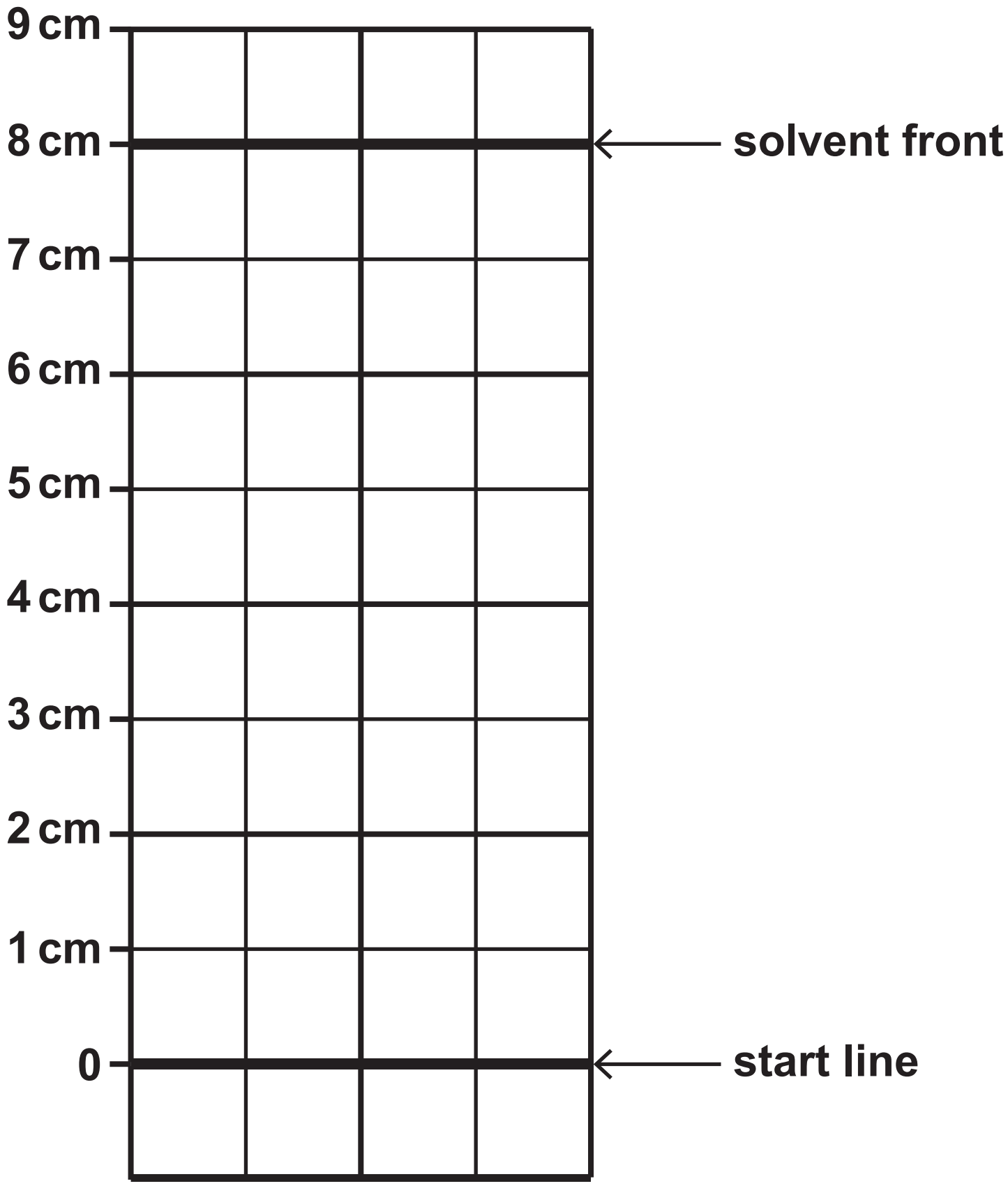
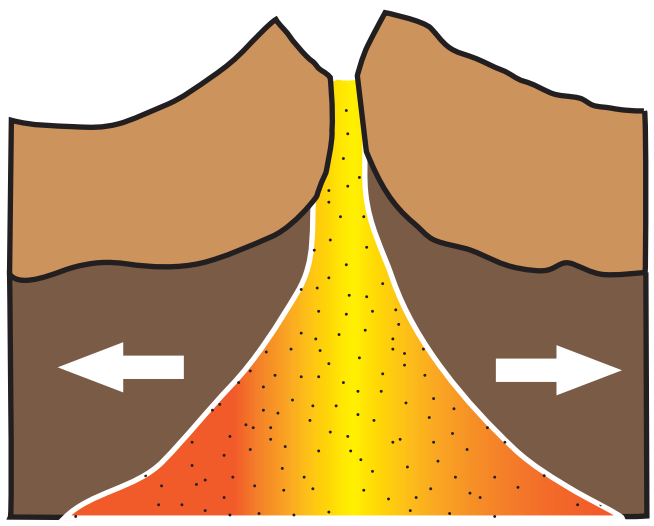
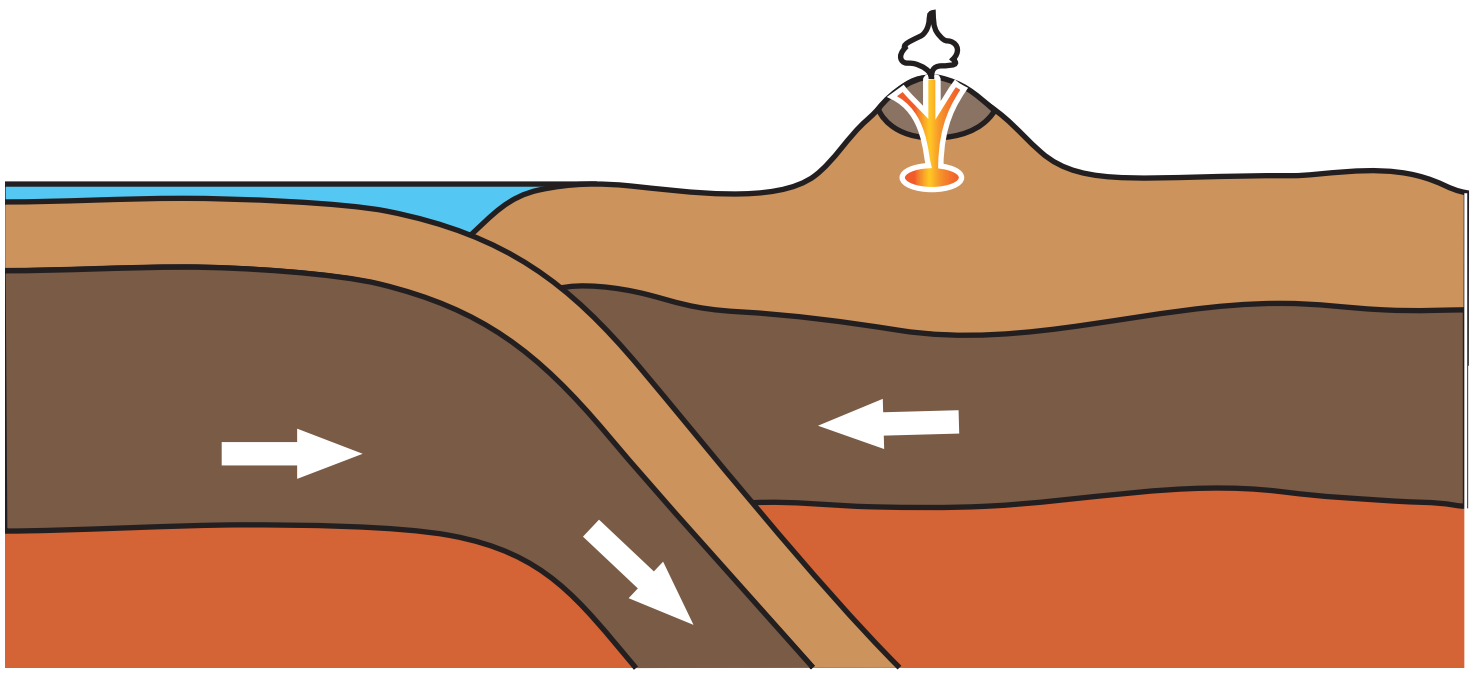


DIAGRAM 3.1



CONSTRUCTIVE

DIAGRAM 3.2



DESTRUCTIVE

TABLE 4

Particle	Number of protons	Number of electrons	Number of neutrons
W	12	12	12
X	12	12	14
Y	12	10	12
Z	11	11	12

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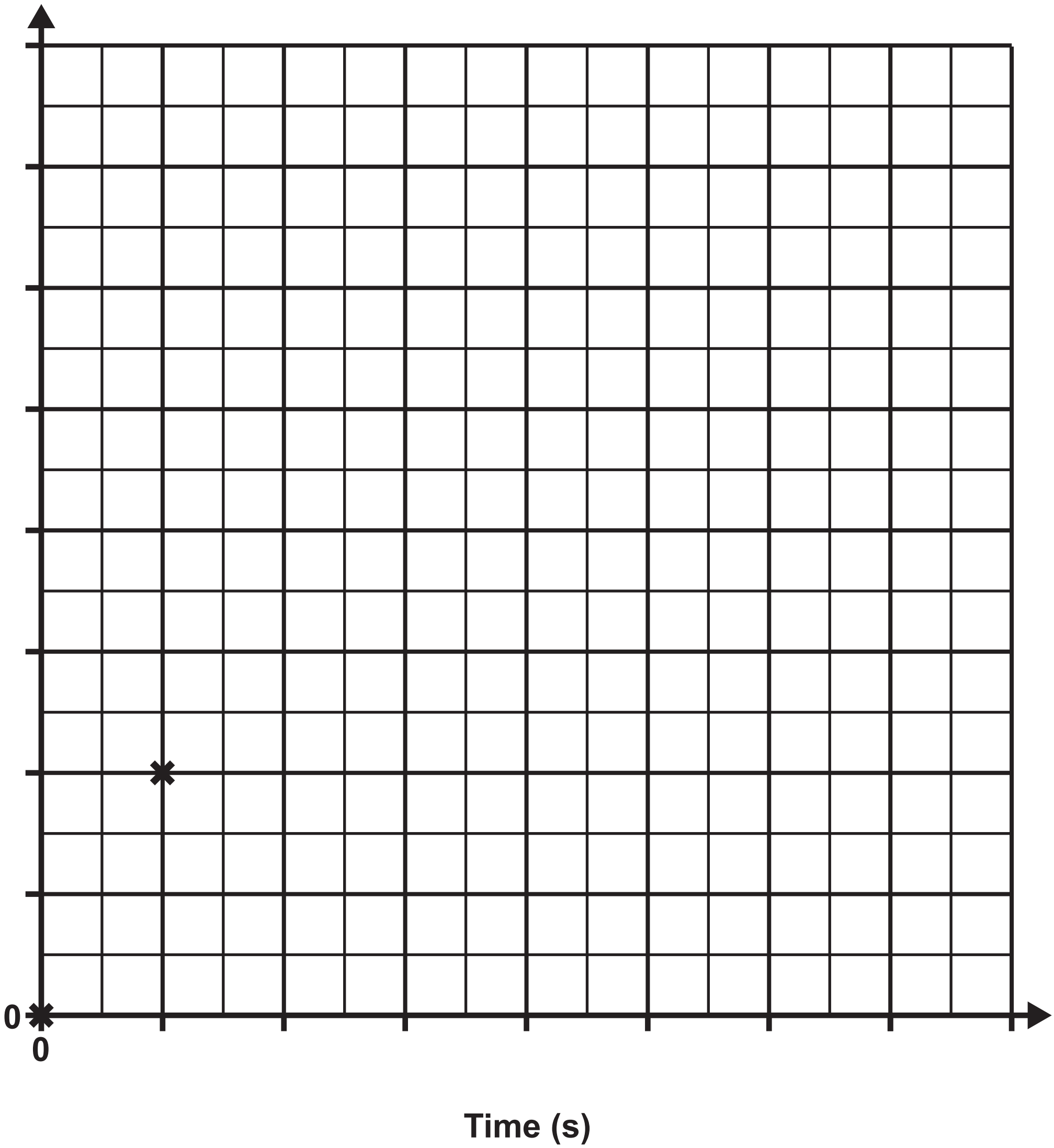
TURN OVER

TABLE 5.1

Time (s)	Volume of hydrogen (cm^3)
0	0
20	20
40	37
60	50
80	60
100	66
120	69
140	70
160	70

GRAPH 5.2



FLOW DIAGRAM 6

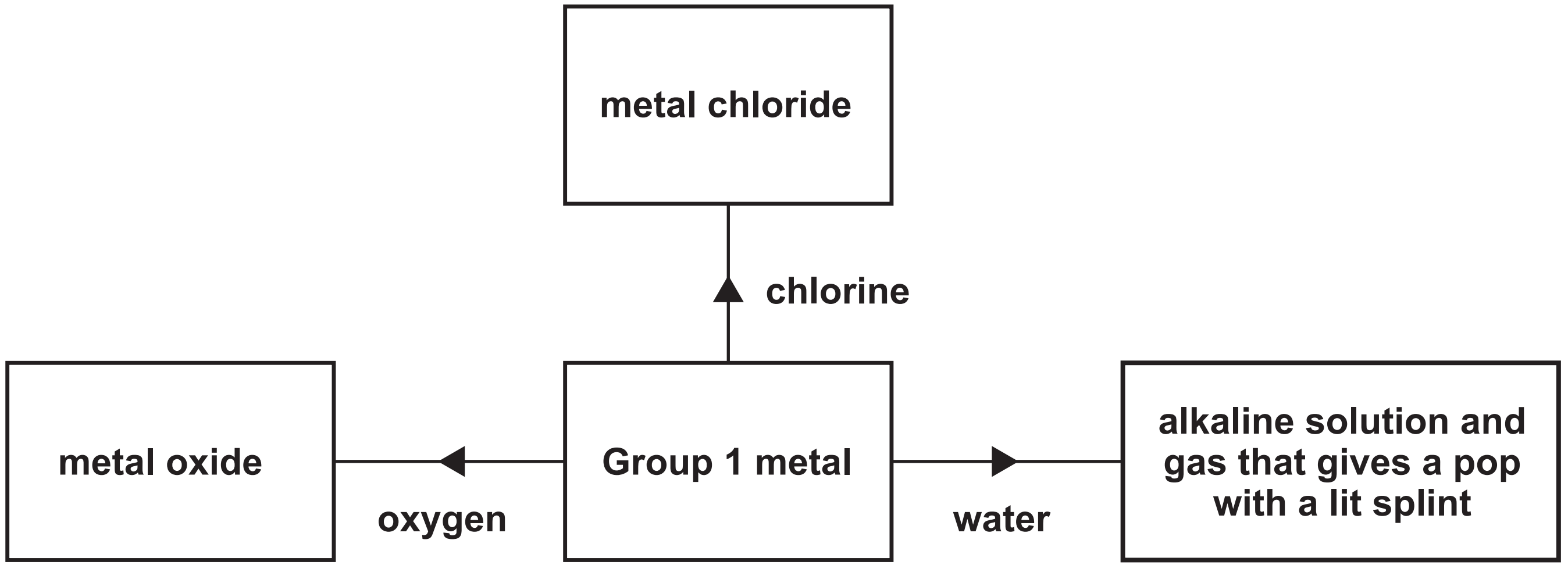


TABLE 7.1

Group 0 gas	Atomic radius (pm)
He	31
Ne	38
Ar	71
Kr	88
Xe	108
Rn	120

TABLE 7.2

Xenon compound	Oxidation state of xenon	Melting point (°C)
XeF_2	+2	129
XeF_4	+4	117
XeF_6	+6	49

TABLE 7.3

Krypton compound	Oxidation state of krypton	Melting point (°C)
$KrCl_2$	+2	98
$KrCl_4$	+4	80
$KrCl_6$	+6	

TABLE 8

Halogen	Halide solution
chlorine	sodium chloride
bromine	sodium bromide
iodine	sodium iodide

FLOW DIAGRAM 9

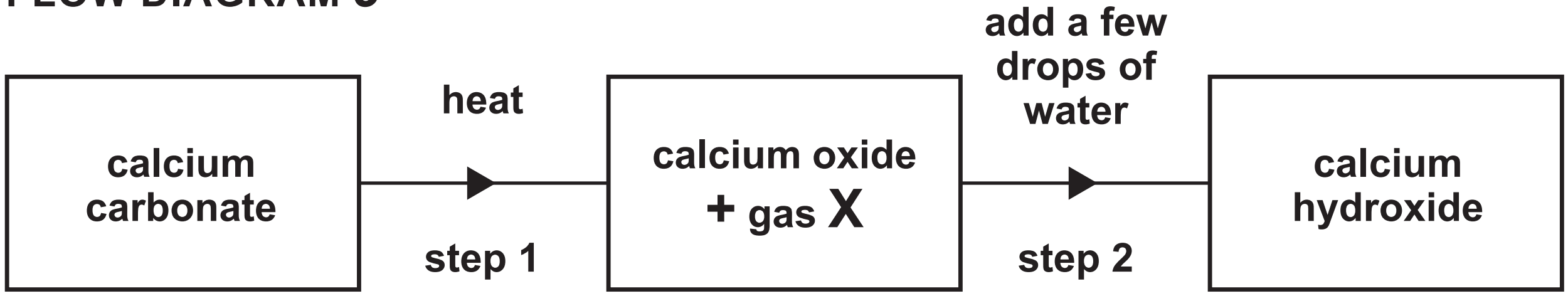


TABLE 10.1

Water sample	Volume of soap solution needed (cm^3)		
	Before boiling	After boiling	After washing soda
A	8	2	2
B	12	12	2
C	2	2	2
D	9	6	2

TABLE 10.2

Water sample	Volume of soap solution needed (cm^3)		
	Before boiling	After boiling	After washing soda
A	5	1	1
B	8	6	1
C	1	1	1
D	7	4	1

GCSE

3410UA0-1

THURSDAY, 13 JUNE 2024 – MORNING

CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources

HIGHER TIER

Data Booklet

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS	
Name	Formula
aluminium	Al^{3+}
ammonium	NH_4^+
barium	Ba^{2+}
calcium	Ca^{2+}
copper(II)	Cu^{2+}
hydrogen	H^+
iron(II)	Fe^{2+}
iron(III)	Fe^{3+}
lithium	Li^+
magnesium	Mg^{2+}
nickel	Ni^{2+}
potassium	K^+
silver	Ag^+
sodium	Na^+
zinc	Zn^{2+}

NEGATIVE IONS	
Name	Formula
bromide	Br^-
carbonate	CO_3^{2-}
chloride	Cl^-
fluoride	F^-
hydroxide	OH^-
iodide	I^-
nitrate	NO_3^-
oxide	O^{2-}
sulfate	SO_4^{2-}

THE PERIODIC TABLE

KEY

A_r	relative atomic mass
Sym	symbol
Z	atomic number

1	2	GROUP										3	4	5	6	7	0
								1 H 1									4 He 2
7 Li 3	9 Be 4											11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
23 Na 11	24 Mg 12											27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
39 K 19	40 Ca 20	45 Sc 21	48 Ti 22	51 V 23	52 Cr 24	55 Mn 25	56 Fe 26	59 Co 27	59 Ni 28	63.5 Cu 29	65 Zn 30	70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
86 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	179 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	210 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

THE PERIODIC TABLE

PERIODIC TABLE – KEY
ATOMIC NUMBER – SYMBOL – NAME

1	H – Hydrogen
2	He – Helium
3	Li – Lithium
4	Be – Beryllium
5	B – Boron
6	C – Carbon
7	N – Nitrogen
8	O – Oxygen
9	F – Fluorine
10	Ne – Neon
11	Na – Sodium
12	Mg – Magnesium
13	Al – Aluminium
14	Si – Silicon
15	P – Phosphorus
16	S – Sulfur
17	Cl – Chlorine
18	Ar – Argon
19	K – Potassium
20	Ca – Calcium
21	Sc – Scandium
22	Ti – Titanium
23	V – Vanadium
24	Cr – Chromium
25	Mn – Manganese
26	Fe – Iron
27	Co – Cobalt
28	Ni – Nickel
29	Cu – Copper
30	Zn – Zinc
31	Ga – Gallium
32	Ge – Germanium
33	As – Arsenic

34	Se – Selenium
35	Br – Bromine
36	Kr – Krypton
37	Rb – Rubidium
38	Sr – Strontium
39	Y – Yttrium
40	Zr – Zirconium
41	Nb – Niobium
42	Mo – Molybdenum
43	Tc – Technetium
44	Ru – Ruthenium
45	Rh – Rhodium
46	Pd – Palladium
47	Ag – Silver
48	Cd – Cadmium
49	In – Indium
50	Sn – Tin
51	Sb – Antimony
52	Te – Tellurium
53	I – Iodine
54	Xe – Xenon
55	Cs – Caesium
56	Ba – Barium
57	La – Lanthanum
72	Hf – Hafnium
73	Ta – Tantalum
74	W – Tungsten
75	Re – Rhenium
76	Os – Osmium
77	Ir – Iridium
78	Pt – Platinum
79	Au – Gold
80	Hg – Mercury

81	Tl – Thallium
82	Pb – Lead
83	Bi – Bismuth
84	Po – Polonium
85	At – Astatine
86	Rn – Radon
87	Fr – Francium
88	Ra – Radium
89	Ac – Actinium