wjec cbac GCSE

3410UA0-1

FRIDAY, 16 JUNE 2023 – 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 examination paper you will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Data Booklet.

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 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.

(Turn over)

INFORMATION FOR CANDIDATES

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

The assessment of the quality of extended response (QER) will take place in Question 6(a).

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.	**9**	
2.	**11**	
3.	**9**	
4.	**8**	
5.	**5**	
6.	**9**	
7.	**12**	
8.	**9**	
9.	**8**	
Total	**80**	

Answer ALL questions.

1 (a) DIAGRAM 1.1 in the separate diagram booklet shows an outline of part of the Periodic Table.

The letters shown are NOT the chemical symbols of the elements.

Choose LETTERS from the diagram to complete TABLE 1.2 in the separate diagram booklet. [4 marks]

1 (b) DIAGRAM 1.3 in the separate diagram booklet shows the electronic structure of an element in the Periodic Table.

Draw a diagram in the space below to show the electronic structure of the element which lies directly ABOVE it. [1 mark]

1 (c) TABLE 1.4 in the separate diagram booklet shows information about atoms X, Y and Z.

(i) Complete the table. [3 marks]

(ii) <u>UNDERLINE</u> the term used to describe atoms Y and Z. [1 mark]

ions inert insoluble isotopes

9

2 (a) TABLE 2.1 in the separate diagram booklet shows information about some Group 1 elements.

Use the information in the table to answer parts (i) and (ii).

(i) State the information which explains why the elements have similar chemical properties. [1 mark]

(ii) State which PROPERTY has a value which does NOT fit the trend down the group. [1 mark]

2 (b) The flow diagram in DIAGRAM 2.2 in the separate diagram booklet shows some reactions of sodium.

(i) State how REACTION 1 is prevented when storing sodium in the laboratory. [1 mark]

(ii) Give the names of alkaline solution A and gas B. [2 marks]

and

2 (b)(iii) Name the Group 1 metal which would react LEAST violently with water. [1 mark]

(iv) Complete the symbol equation for REACTION 3. [1 mark]

$$2Na + F_2 \longrightarrow 2 \underline{\qquad\qquad}$$

2 (c) Sodium fluoride is added to some UK public water supplies to reduce tooth decay in children.

In America sodium hexafluorosilicate, Na_2SiF_6, is more commonly used. The relative formula mass of sodium hexafluorosilicate is 188.

(i) Calculate the percentage of fluorine in sodium hexafluorosilicate.
[2 marks]

$A_r(F) = 19$ $M_r(Na_2SiF_6) = 188$

Percentage = _____ %

2 (c)(ii) State an ETHICAL reason why some people oppose the fluoridation of water supplies. [1 mark]

(iii) Apart from water supplies, state the most commonly used source of fluoride to reduce tooth decay. [1 mark]

3 (a) DIAGRAMS 3.1 and 3.2 in the separate diagram booklet show two methods used to separate mixtures.

(i) I. Name the changes of state happening in apparatus A and apparatus B when water is separated from salt in Method 1. [2 marks]

Apparatus A

Apparatus B

II. Name this method of separation. [1 mark]

3 (a)(ii) Explain how an orange dye is separated into a red spot and a yellow spot on the filter paper in Method 2. [2 marks]

3 (b) GRAPH 3.3 in the separate diagram booklet shows the solubility of potassium nitrate at different temperatures.

Use the information in the graph to answer parts (i) and (ii).

(i) 60 g of potassium nitrate was added to 100 g of water at 30 °C. After stirring the mixture some of the potassium nitrate did not dissolve.

Calculate the mass of potassium nitrate which did NOT dissolve.
[1 mark]

Mass = _____ g

3 (b)(ii) On cooling a saturated solution of potassium nitrate containing 100 g of water from 55 °C to a lower temperature, 36 g of solid was formed.

Determine the temperature to which the solution was cooled.

Show your working. [3 marks]

Temperature = _____ °C

9

4 (a) The flow diagram in DIAGRAM 4.1 in the separate diagram booklet shows the reactions necessary to make slaked lime (calcium hydroxide) from a marble chip (calcium carbonate).

(i) In REACTION 1, one compound breaks down when heated to form two products.

Complete the name of this type of reaction. [1 mark]

thermal _____

4 (a)(ii) Give TWO observations you would expect to make as REACTION 2 happens. [2 marks]

1 _____

_____

2 _____

_____

(iii) Complete the symbol equation for the reaction between calcium oxide and water in REACTION 2. [1 mark]

_____ + H_2O ⟶ _____

4 (b)(i)

The relative formula mass of calcium hydroxide is 74.

Calculate the number of moles of calcium hydroxide in 2.96 g. [2 marks]

Number of moles = _____ mol

4 (b)(ii) Explain why calcium hydroxide is used to treat some soils. [2 marks]

8

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TURN OVER

$$Ca(HCO_3)_2 + \underline{\qquad\qquad} \longrightarrow CaCO_3 + 2NaHCO_3$$

5 Temporary hard water is caused by the presence of dissolved calcium hydrogencarbonate, $Ca(HCO_3)_2$.

TABLE 5.1 in the separate diagram booklet shows three different methods of removing temporary hardness from water.

(a) Complete the symbol equation on the opposite page for the reaction taking place in Method 1. [1 mark]

(b) <u>UNDERLINE</u> the ratio of calcium ions to sodium ions exchanged in Method 3. [1 mark]

2 : 1 1 : 1 1 : 2 2 : 2

5 (c) Give the number of the method which does NOT form limescale. Give the reason for your answer. [2 marks]

Number _____

Reason

5 (d) Tick (✓) the box next to the name of a compound that causes permanent hardness when dissolved in water. [1 mark]

☐ calcium sulfate

☐ potassium sulfate

☐ magnesium hydrogencarbonate

☐ sodium sulfate

☐
5

6 (a) TABLE 6.1 in the separate diagram booklet shows the approximate percentages of some gases found in the Earth's ORIGINAL atmosphere and the Earth's atmosphere TODAY.

Explain how the changes to these gases have taken place over geological time. [6 marks QER]

continue answer on next page

continue answer on next page

(Turn over)

6 (b) Use the information on this page and in GRAPH 6.2 and GRAPH 6.3 in the separate diagram booklet to answer parts (i)–(iii).

Do Volcanoes Cause Global Warming?

Volcanoes release vast amounts of greenhouse gases, such as carbon dioxide, which contribute to global warming. GRAPH 6.2 shows the effect of four volcanic eruptions on the mean atmospheric temperature.

question continues

6 (b) continued

Erupting volcanoes also emit large quantities of sulfur dioxide into the atmosphere. Unlike carbon dioxide, sulfur dioxide increases the reflection of radiation from the Sun back into space, which cools the Earth's atmosphere. GRAPH 6.3 in the separate diagram booklet shows the effect of the same four large volcanic eruptions on the percentage of solar radiation reaching the Earth's surface. The graph also shows the change in carbon dioxide levels in the atmosphere over the same time period.

6 (b)(i)

Tick (✓) the box next to the statement which best describes the effect of volcanic eruptions on the overall level of carbon dioxide in the atmosphere. [1 mark]

☐ No significant impact on the overall level of carbon dioxide

☐ A significant increase in the level of carbon dioxide

☐ A significant decrease in the level of carbon dioxide

6 (b)(ii)

Tick (✓) the box next to the statement which best describes the effect that volcanic eruptions have on the mean atmospheric temperature. [1 mark]

☐ Mean atmospheric temperature decreases

☐ Mean atmospheric temperature increases

☐ No effect on the mean atmospheric temperature

6 (b)(iii)

Tick (✓) the box next to the statement which best explains the change in solar radiation reaching the Earth's surface after volcanic eruptions.
[1 mark]

☐ Solar radiation decreases because it is reflected by sulfur dioxide

☐ Solar radiation increases because it is absorbed by carbon dioxide

☐ Solar radiation increases because it is absorbed by carbon dioxide and sulfur dioxide

☐ Solar radiation decreases because it reacts with sulfur dioxide forming sulfuric acid

9

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CaCO3(s) + 2HCl(aq) CaCl2(aq) + CO2(g) + H2O(l)

7 Chalk is a form of calcium carbonate, $CaCO_3$.

A student carried out an experiment to investigate the rate of reaction between POWDERED chalk and EXCESS dilute hydrochloric acid at 20 °C.

The equation on the opposite page shows that chalk reacts with dilute hydrochloric acid forming carbon dioxide gas.

DIAGRAM 7.1 in the separate diagram booklet shows the apparatus used.

(a) State the purpose of the cotton wool. [1 mark]

7 (b) The student recorded the mass of the flask and contents every 10 seconds for 70 seconds.

Describe what the student must do to calculate the mass of carbon dioxide formed in the first 10 seconds.

[1 mark]

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TURN OVER

7 (c) Look at GRAPH 7.2 in the separate diagram booklet. Line A shows the mass of carbon dioxide formed against time.

A tangent to line A has been drawn at 23 s.

Use the tangent and the equation below to calculate the rate of reaction at 23 s.

Show your working on the opposite page. Give your answer to TWO significant figures. [3 marks]

$$\text{rate} = \frac{\text{change in mass}}{\text{change in time}}$$

Rate = _____ g/s

7 (d) The student repeated the experiment using the SAME mass of chalk powder as the original experiment but a DIFFERENT CONCENTRATION of acid.

TABLE 7.3 in the separate diagram booklet shows the mass of carbon dioxide formed.

(i) Plot the results from the table on GRAPH 7.2 in the separate diagram booklet and draw a suitable line.

Label this line B. [3 marks]

7 (d)(ii) Use particle theory to explain why the rate of this reaction is lower than that in the original experiment. [3 marks]

7 (e) Sketch on GRAPH 7.2 in the separate diagram booklet the curve you would expect if the experiment was repeated using the ORIGINAL acid and TWICE the mass of chalk. Assume that the acid is still in excess.

Label this line C. [1 mark]

12

8 (a) TABLE 8.1 in the separate diagram booklet shows information about some Group 7 elements.

(i) State how the radius of the atom changes down Group 7. [1 mark]

8 (a)(ii) Explain in terms of electronic structure why the reactivity of the elements decreases down Group 7. [2 marks]

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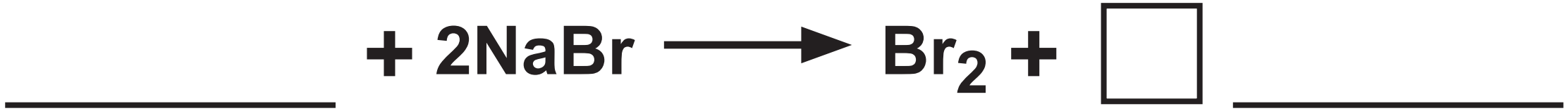
+ 2NaBr
Br2 +

8 (b) Sea water contains sodium bromide, which is the raw material for the production of bromine.

Between 1953 and 2004 bromine, Br_2, was manufactured from sea water at a chemical plant in Amlwch, Anglesey.

Sea water was treated with chlorine, which converts sodium bromide into bromine.

On the opposite page, complete the balanced equation for the reaction between chlorine and sodium bromide. [3 marks]

8 (c) 4.47 g of copper bromide was found to contain 1.27 g of copper.

(i) Calculate the mass of bromine in 4.47 g of the copper bromide. [1 mark]

Mass = _____ g

8 (c)(ii)

Calculate the simplest formula of the copper bromide.

You MUST show your working.
[2 marks]

A_r(Br) = 80 A_r(Cu) = 63.5

Simplest formula _____

9

9 (a) A student tested compounds **A**, **B** and **C** to identify them.

Her observations are recorded in TABLES **9.1**, **9.2** and **9.3** in the separate diagram booklet.

(i) Use your knowledge of the tests for ions to complete the tables for compounds **B** and **C**. [3 marks]

(ii) Write the chemical formula for compound **A**. [1 mark]

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☐ $Na^+(aq) + NO_3^-(aq) \longrightarrow AgCl(s)$

☐ $Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq)$

$\downarrow$

$NaNO_3(s) + AgCl(s)$

☐ $Ag^+(aq) + NO_3^-(aq) \longrightarrow AgNO_3(s)$

☐ $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

☐ $Ag^+(aq) + Cl^-(aq) \longrightarrow NaNO_3(s)$

9 (b) When silver nitrate solution reacts with sodium chloride solution to produce a white precipitate the following reaction occurs.

$AgNO_3(aq) + NaCl(aq)$

↓

$NaNO_3(aq) + AgCl(s)$

Put a tick (✓) in the box on the opposite page which shows the ionic equation for the formation of the precipitate. [1 mark]

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TURN OVER

9 (c) When silver carbonate is heated it breaks down to give silver metal and carbon dioxide and oxygen gas.

$$2Ag_2CO_3 \longrightarrow 4Ag + 2CO_2 + O_2$$

Calculate the mass of silver that would be produced from heating 13.8 g of silver carbonate. [3 marks]

$M_r(Ag_2CO_3) = 276$ $A_r(Ag) = 108$

Space for working on the opposite page

Mass = g

8

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 _____

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DIAGRAM 1.1

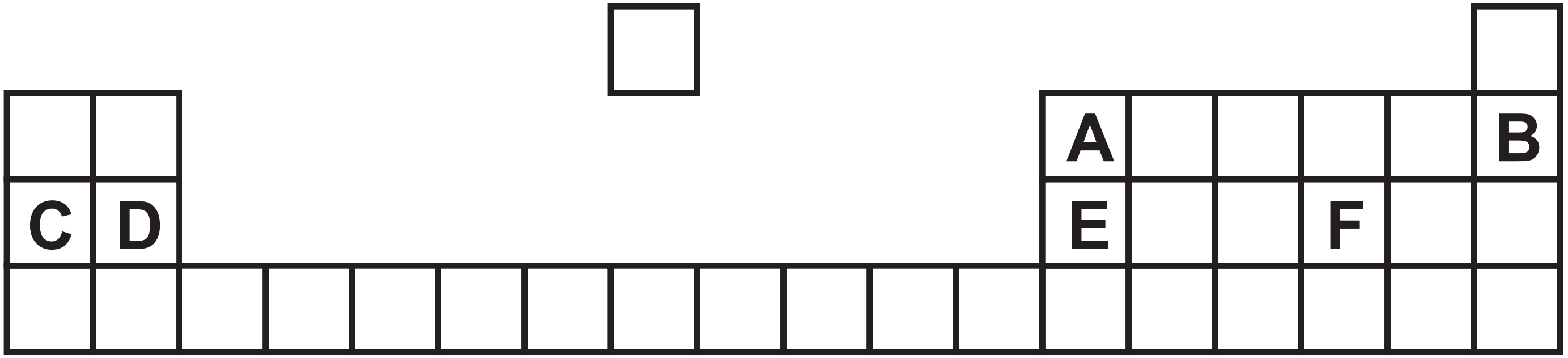

TABLE 1.2

	Letter
The element in Group 3 and Period 2	_____
The element which has 10 protons in its nucleus	_____
The element with the electronic structure 2,8,6	_____
The element which forms a 2+ ion	_____

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DIAGRAM 1.3

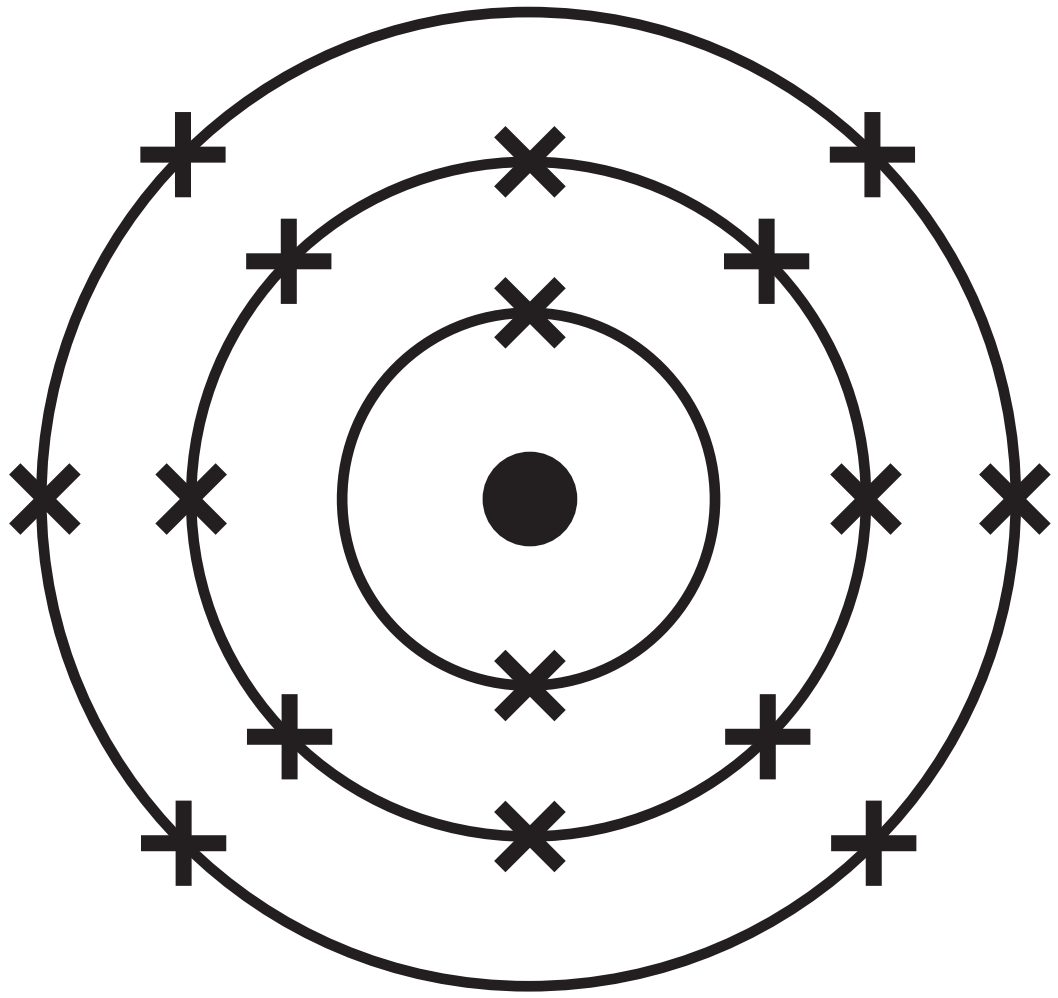

TABLE 1.4

Atom	Symbol	Number of protons	Number of neutrons	Number of electrons
X	$^{31}_{15}X$	_____	16	15
Y	$^{39}_{19}Y$	19	_____	19
Z	$^{40}_{19}Z$	19	21	_____

TABLE 2.1

Element	Relative atomic mass	Number of electrons in the outer shell	Melting point (°C)	Boiling point (°C)	Density (g/cm^3)
lithium	7	1	180	1 342	0.53
sodium	23	1	98	883	0.97
potassium	39	1	63	759	0.89
rubidium	85	1	39	688	1.53
caesium	134	1	29	671	1.93

DIAGRAM 2.2

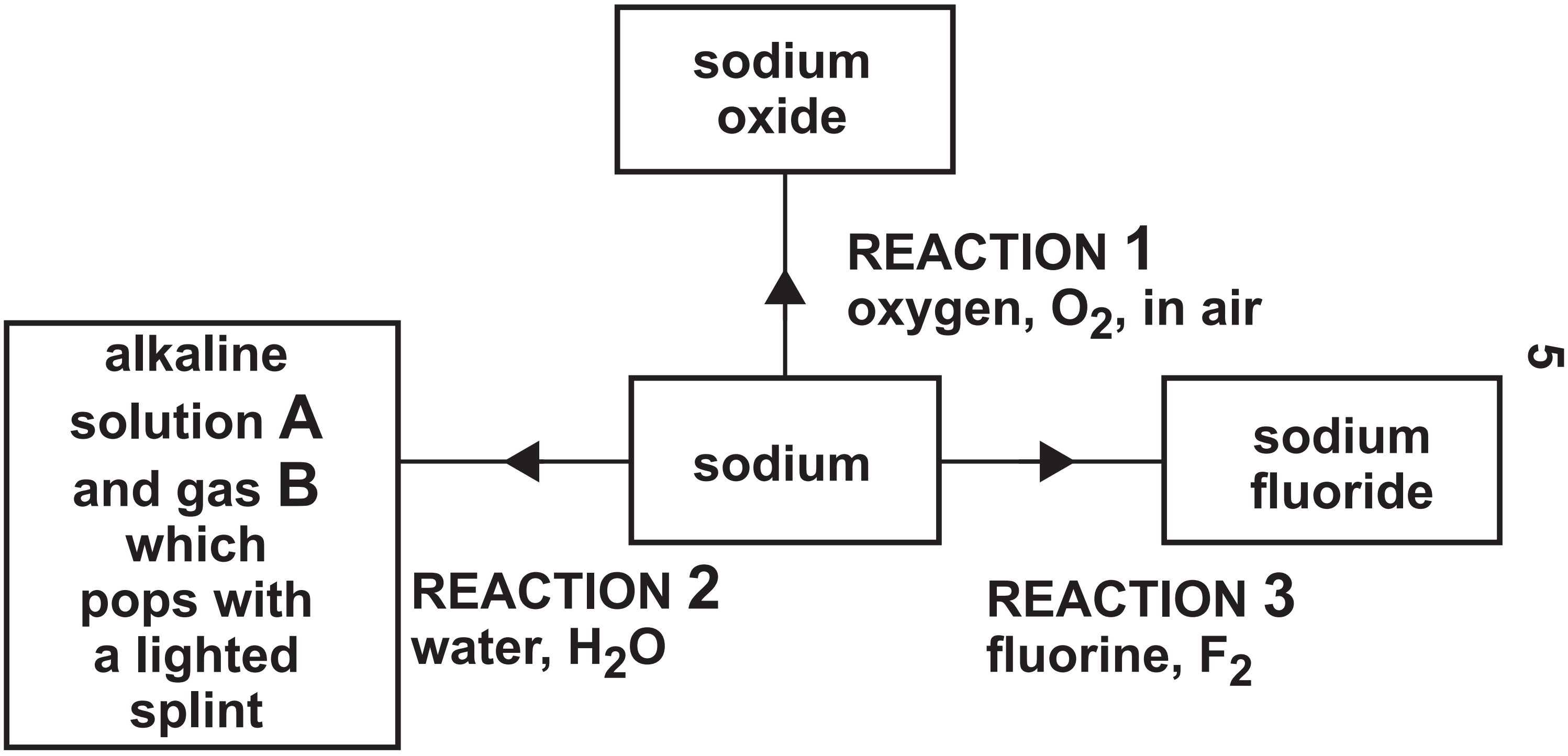
sodium oxide
REACTION 1
oxygen, O_2, in air
alkaline solution A and gas B which pops with a lighted splint
sodium
sodium fluoride
REACTION 2
water, H_2O
REACTION 3
fluorine, F_2

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DIAGRAM 3.1 – Method 1

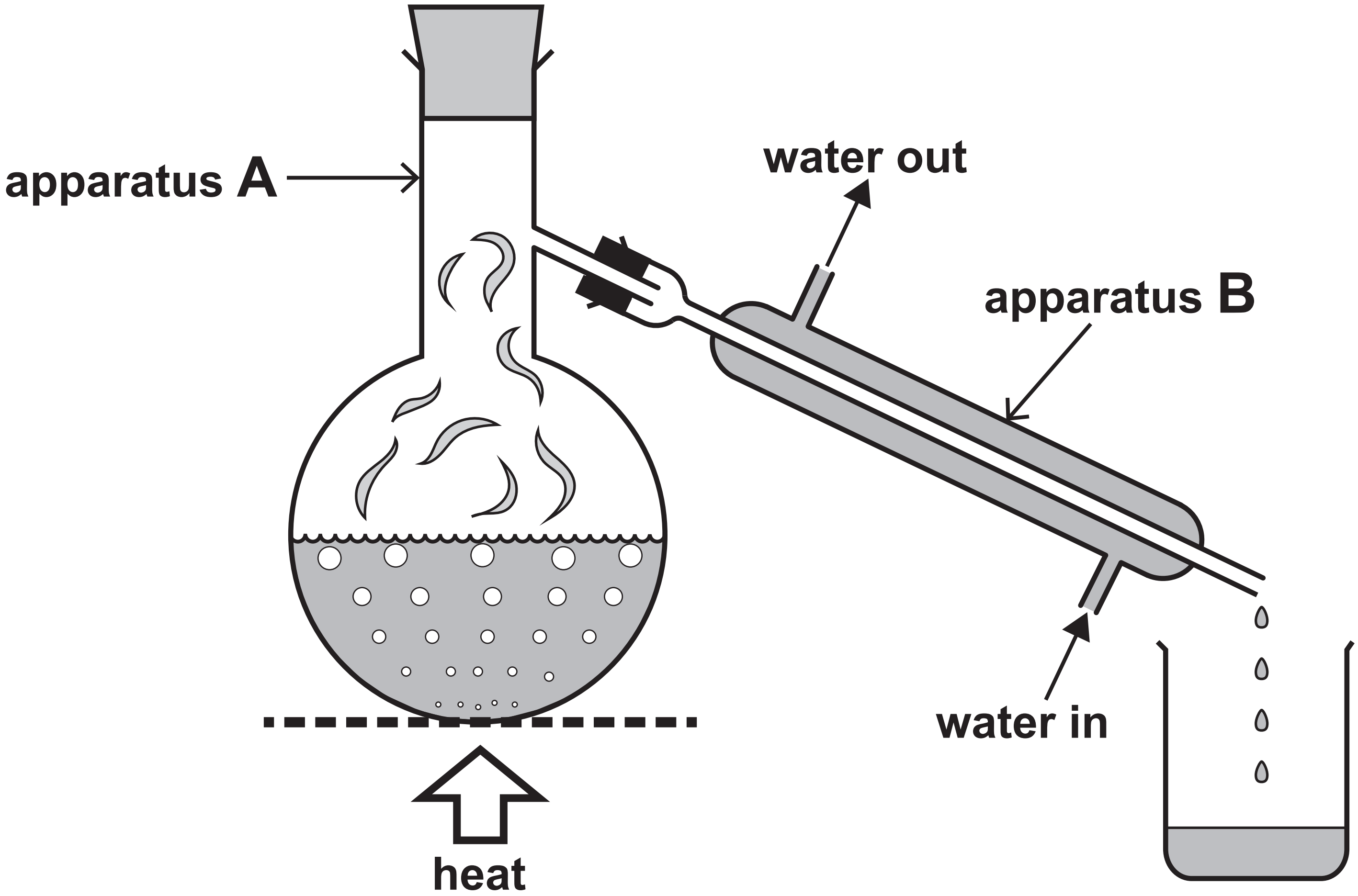
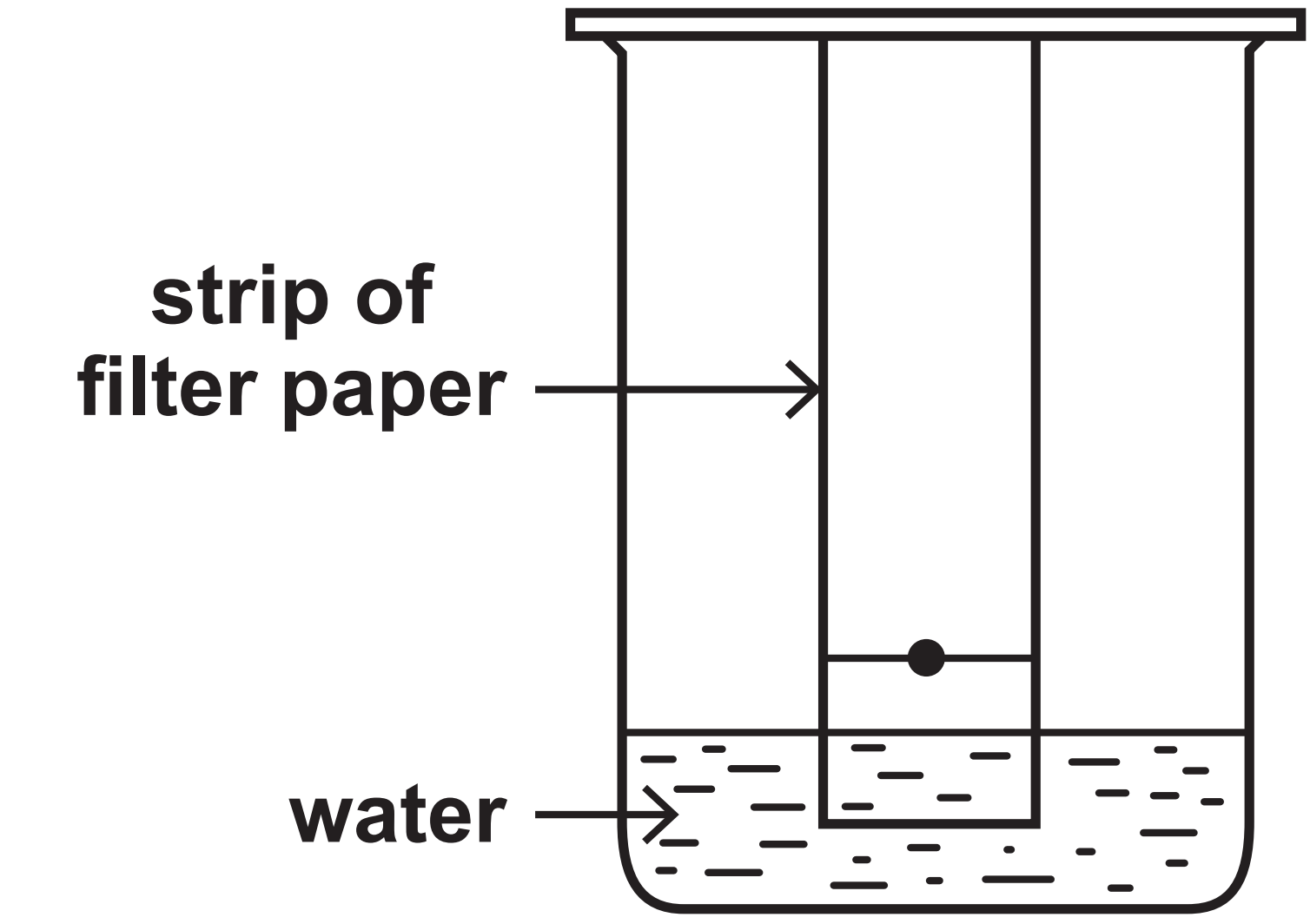


DIAGRAM 3.2 – Method 2



GRAPH 3.3

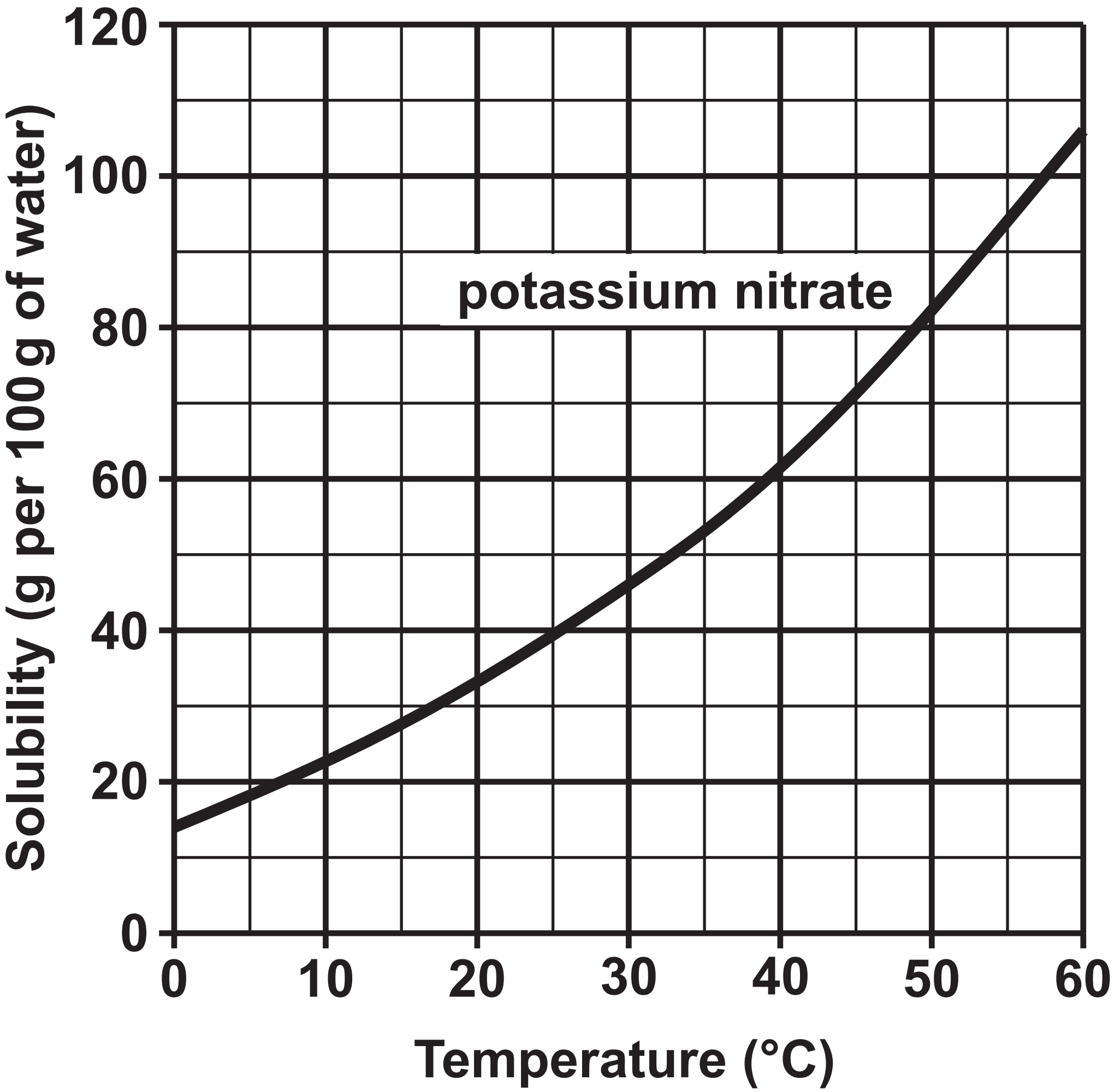

120
100
80
60
40
20
0
Solubility (g per 100 g of water)
potassium nitrate
0
10
20
30
40
50
60
Temperature (°C)

DIAGRAM 4.1

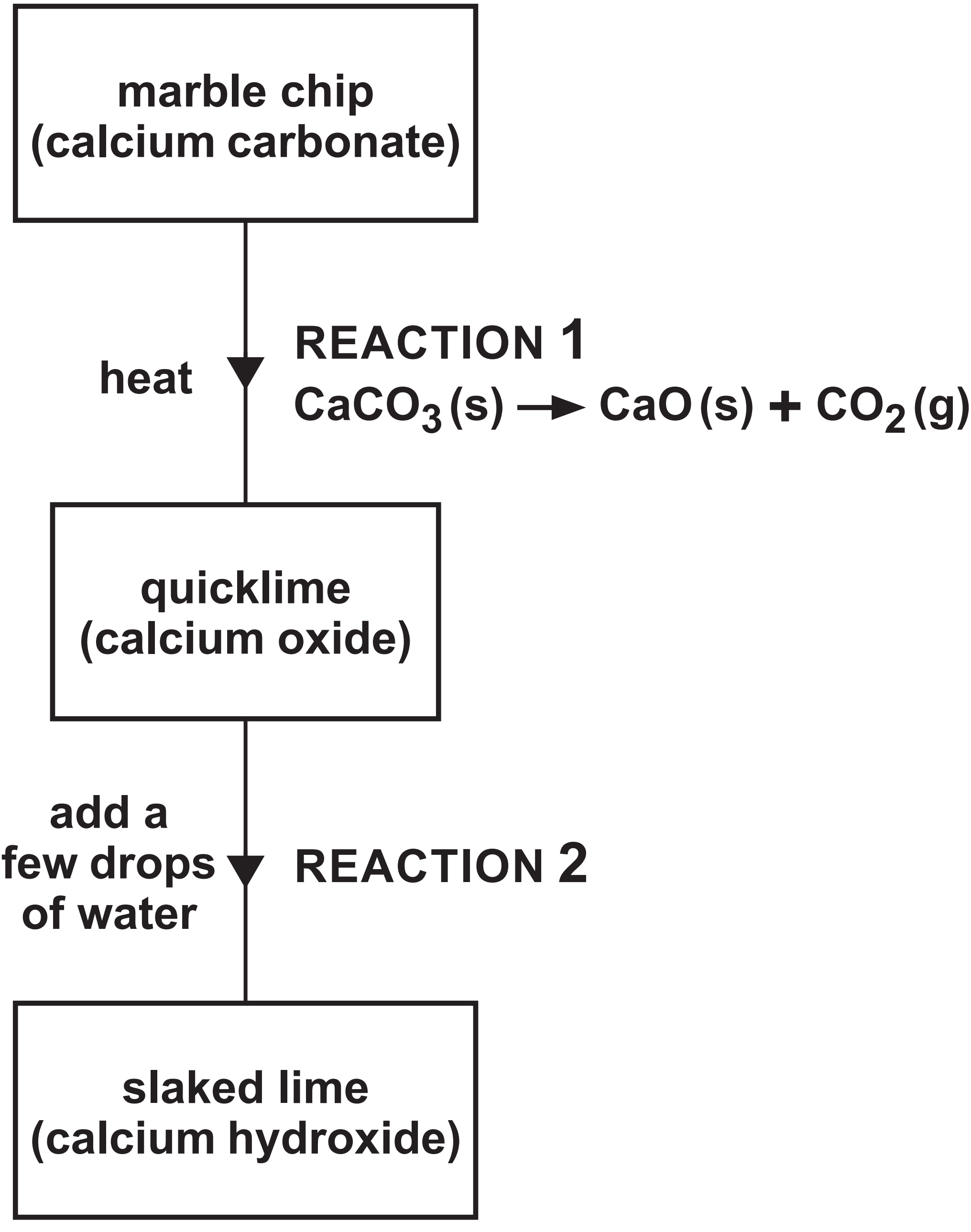

marble chip
(calcium carbonate)
heat
REACTION 1
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
quicklime
(calcium oxide)
add a
few drops
of water
REACTION 2
slaked lime
(calcium hydroxide)

TABLE 5.1

Method	Product(s) in softened water
1. Adding sodium carbonate	insoluble calcium carbonate dissolved sodium hydrogencarbonate
2. Boiling	insoluble calcium carbonate carbon dioxide
3. Passing through an ion exchange column containing Na^+ ions	dissolved sodium hydrogencarbonate

TABLE 6.1

Gas	Approximate percentage (%) of gases in the Earth's atmosphere	
	ORIGINAL	TODAY
carbon dioxide	75	0.04
water vapour	25	variable, between 1–2
oxygen	0	21

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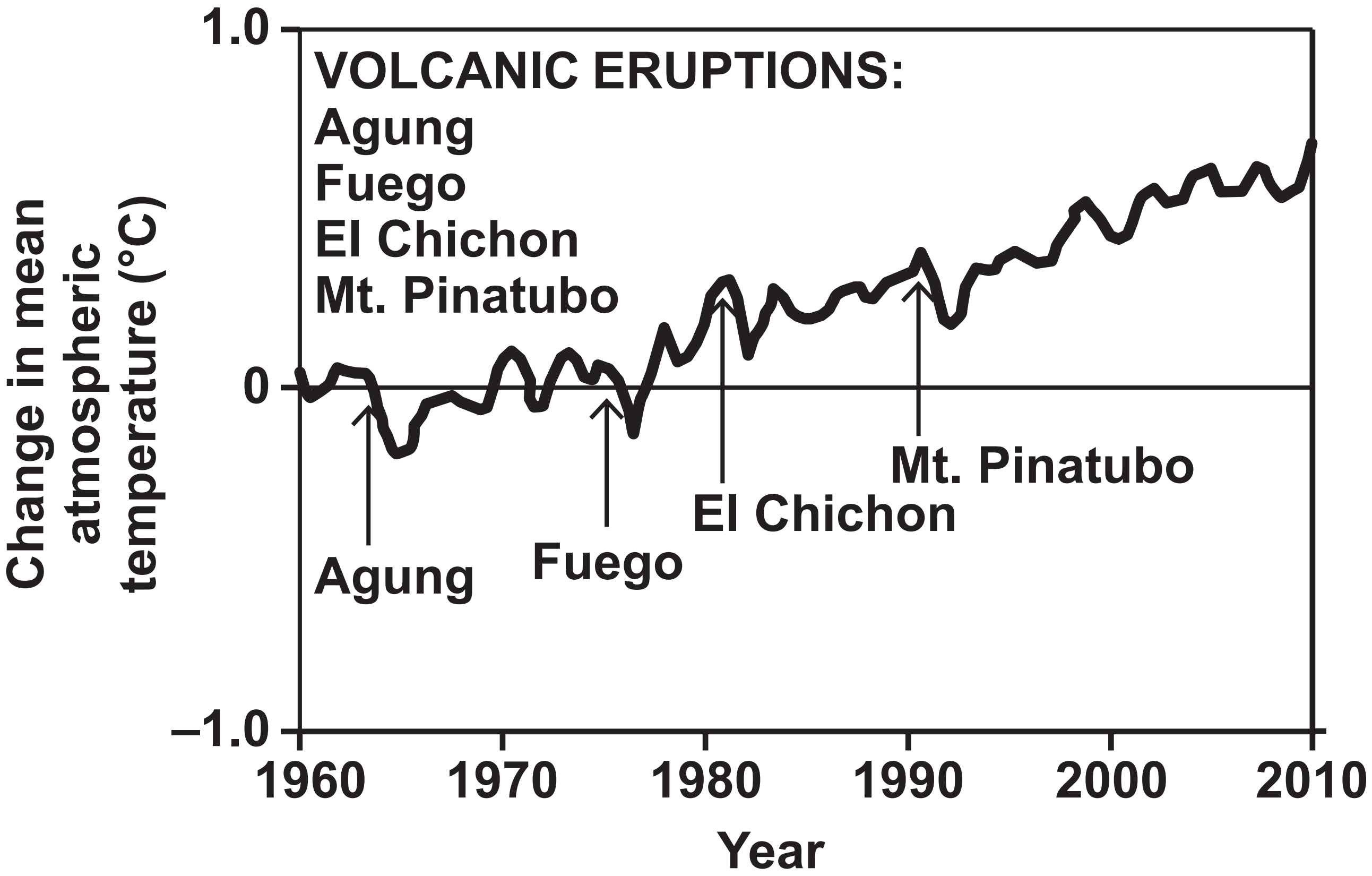
GRAPH 6.2


1.0
0
–1.0
VOLCANIC ERUPTIONS:
Agung
Fuego
El Chichon
Mt. Pinatubo
Agung
Fuego
El Chichon
Mt. Pinatubo
1960
1970
1980
1990
2000
2010
Year
Change in mean atmospheric temperature (°C)

GRAPH 6.3

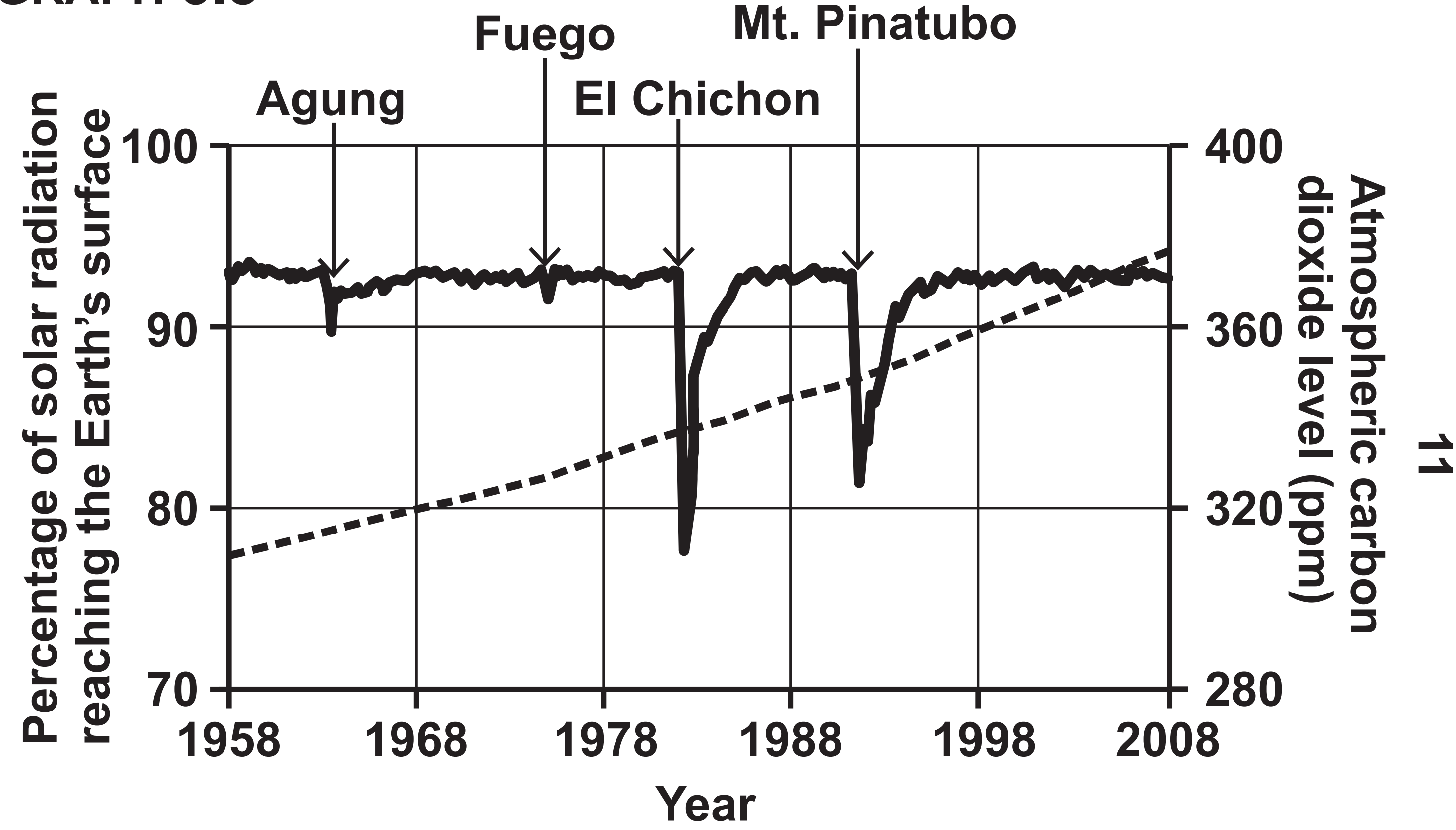
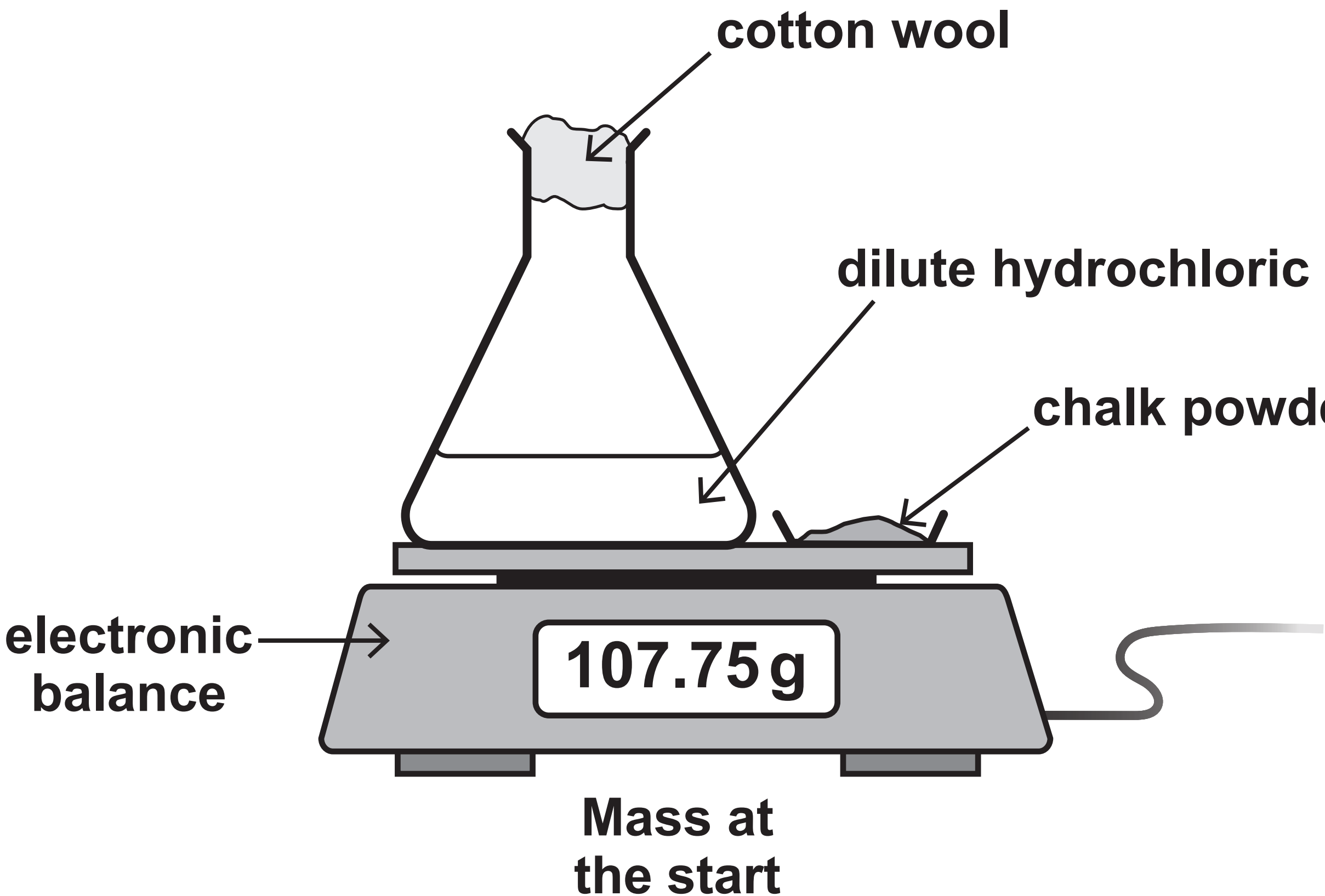

Agung
Fuego
El Chichon
Mt. Pinatubo
Percentage of solar radiation reaching the Earth's surface
100
90
80
70
Atmospheric carbon dioxide level (ppm)
400
360
320
280
1958
1968
1978
1988
1998
2008
Year
Atmospheric carbon dioxide level
Percentage of solar radiation reaching the Earth's surface

DIAGRAM 7.1



Mass at the start

GRAPH 7.2

Mass of carbon dioxide formed (g)

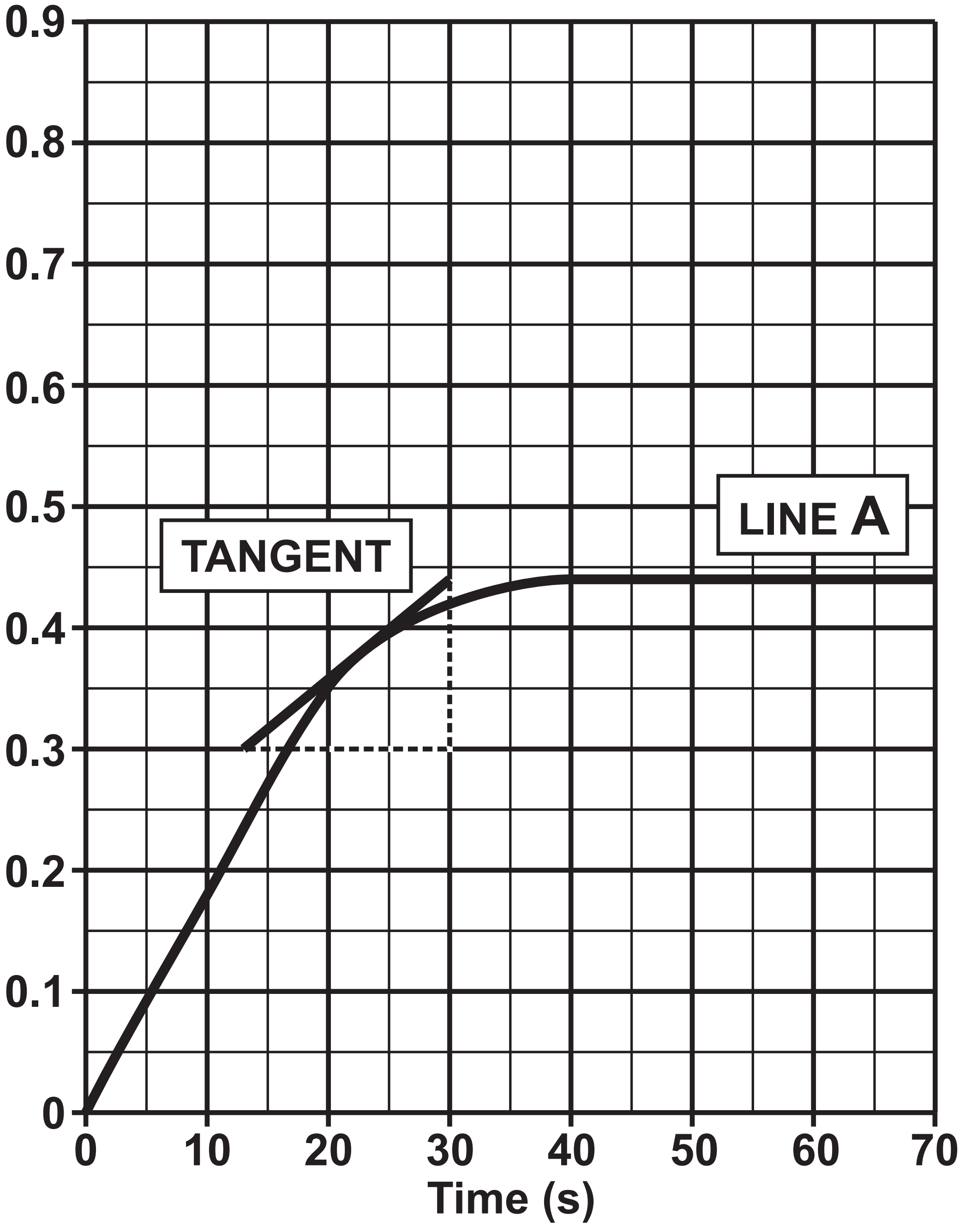


TABLE 7.3

Time (s)	0	10	20	30	40	50	60	70
Mass of carbon dioxide formed (g)	0.00	0.11	0.20	0.28	0.35	0.40	0.43	0.44

TABLE 8.1

Element	Radius of the atom (nm)	Number of electrons in outer shell
chlorine	0.099	7
bromine	0.114	7
iodine	0.133	7

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TABLE 9.1

Compound A	Observation	Ion present
Flame test	apple-green flame	barium
Add silver nitrate solution	white precipitate	chloride

TABLE 9.2

Compound B	Observation	Ion present
Flame test	lilac flame	_____
Add silver nitrate solution	cream precipitate	_____

TABLE 9.3

Compound C	Observation	Ion present
Flame test	brick-red flame	_____
Add silver nitrate solution	yellow precipitate	_____

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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

1	2	GROUP						
								1 H 1
7 Li 3	9 Be 4							
23 Na 11	24 Mg 12							
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
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
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
223 Fr 87	226 Ra 88	227 Ac 89						

KEY

A_r	relative atomic mass
Sym	symbol
Z	atomic number

3	4	5	6	7	0
					4 He 2
11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
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
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
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

THE PERIODIC TABLE

PERIODIC TABLE – KEY
ATOMIC NUMBER – SYMBOL – NAME

1	H – Hydrogen	19	K – Potassium
2	He – Helium	20	Ca – Calcium
3	Li – Lithium	21	Sc – Scandium
4	Be – Beryllium	22	Ti – Titanium
5	B – Boron	23	V – Vanadium
6	C – Carbon	24	Cr – Chromium
7	N – Nitrogen	25	Mn – Manganese
8	O – Oxygen	26	Fe – Iron
9	F – Fluorine	27	Co – Cobalt
10	Ne – Neon	28	Ni – Nickel
11	Na – Sodium	29	Cu – Copper
12	Mg – Magnesium	30	Zn – Zinc
13	Al – Aluminium	31	Ga – Gallium
14	Si – Silicon	32	Ge – Germanium
15	P – Phosphorus	33	As – Arsenic
16	S – Sulfur	34	Se – Selenium
17	Cl – Chlorine	35	Br – Bromine
18	Ar – Argon	36	Kr – Krypton

37	Rb – Rubidium	57	La – Lanthanum
38	Sr – Strontium	72	Hf – Hafnium
39	Y – Yttrium	73	Ta – Tantalum
40	Zr – Zirconium	74	W – Tungsten
41	Nb – Niobium	75	Re – Rhenium
42	Mo – Molybdenum	76	Os – Osmium
43	Tc – Technetium	77	Ir – Iridium
44	Ru – Ruthenium	78	Pt – Platinum
45	Rh – Rhodium	79	Au – Gold
46	Pd – Palladium	80	Hg – Mercury
47	Ag – Silver	81	Tl – Thallium
48	Cd – Cadmium	82	Pb – Lead
49	In – Indium	83	Bi – Bismuth
50	Sn – Tin	84	Po – Polonium
51	Sb – Antimony	85	At – Astatine
52	Te – Tellurium	86	Rn – Radon
53	I – Iodine	87	Fr – Francium
54	Xe – Xenon	88	Ra – Radium
55	Cs – Caesium	89	Ac – Actinium
56	Ba – Barium		