GCSE

3410UB0-1

MONDAY, 22 MAY 2023 – MORNING

CHEMISTRY – Unit 2:

Chemical Bonding, Application of Chemical Reactions and Organic Chemistry
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 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.

Question 6(a) 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.	**9**	
2.	**11**	
3.	**9**	
4.	**7**	
5.	**11**	
6.	**8**	
7.	**9**	
8.	**10**	
9.	**6**	
Total	**80**	

Answer ALL questions.

1 (a) A student made some copper(II) sulfate crystals by reacting copper(II) carbonate powder with sulfuric acid using the following method.

Stage 1 **Measure 50 cm^3 of sulfuric acid into a beaker.**

Stage 2 **Add copper(II) carbonate powder, one spatula at a time, until all the acid has reacted.**

Stage 3 **Filter the mixture.**

Stage 4 **Obtain crystals from the solution.**

1 (a)(i) State how you would carry out Stage 4 to get the largest possible crystals. [1 mark]

1 (a)(ii) Crystals of copper(II) sulfate could also be made using copper(II) oxide powder instead of copper(II) carbonate powder. State and explain how the observations in Stage 2 would be different. [2 marks]

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$$CuO + H_2SO_4 \longrightarrow \underline{\qquad\qquad\qquad} + \underline{\qquad\qquad\qquad}$$

1 (a)(iii) On the opposite page, complete the symbol equation for the reaction between copper(II) oxide and sulfuric acid. Copper(II) sulfate is one of the products. [2 marks]

(b) DIAGRAM 1.1 in the separate diagram booklet shows an energy profile for a reaction.

(i) In TABLE 1.2 in the separate diagram booklet, give the LETTER that represents each part of the energy profile. [2 marks]

1 (b)(ii) Give the meaning of the term activation energy. [1 mark]

1 (b)(iii)

State how the energy profile shows that this is an exothermic reaction.
[1 mark]

9

2 (a) Crude oil is separated into mixtures of hydrocarbon compounds in the process of fractional distillation. Many of these fractions are used as fuels. This process is shown in DIAGRAM 2.1 in the separate diagram booklet.

(i) Name the changes of state happening at X and at Y. [1 mark]

X _____

Y _____

2 (a)(ii) Explain why different fractions are formed at different levels. [2 marks]

2 (a)(iii) A hydrocarbon fuel was burned and used to heat 100 g of water. The water temperature rose from 18.5 °C to 38.2 °C.

Use the equation below to calculate the amount of energy released by this fuel. Give your answer to TWO significant figures. [3 marks]

$$\text{energy (J)} = \text{mass of water (g)} \times 4.2 \times \text{temperature rise (°C)}$$

Energy = _____ J

2 (b) The products of fractional distillation can undergo a process called cracking to produce smaller, more useful hydrocarbons.

(i) Complete the equation for the cracking of $C_{16}H_{34}$. [1 mark]

$$C_{16}H_{34} \longrightarrow C_8H_{18} + \underline{\qquad\qquad} + C_2H_4$$

(ii) State the TWO conditions used for cracking. [1 mark]

2 (b)(iii)

The molecule with the formula C_2H_4 is an unsaturated hydrocarbon.

Give the meaning of the term unsaturated. [1 mark]

2 (b)(iv)

State why there is a high demand for each of the following products of the cracking reaction. [2 marks]

octane / C_8H_{18}

ethene / C_2H_4

11

3 (a) TABLE 3.1 in the separate diagram booklet shows information about some organic compounds.

(i) COMPLETE THE TABLE. [3 marks]

(ii) The molecular mass of an alkene is 98. Give the molecular formula of this alkene. [1 mark]

A_r(C) = 12 A_r(H) = 1

Molecular formula _____

3 (b) Polyvinyl chloride (PVC) is formed from a monomer, shown in DIAGRAM 3.2 in the separate diagram booklet, in a polymerisation reaction.

Complete the equation for the polymerisation reaction in DIAGRAM 3.3 in the separate diagram booklet. [2 marks]

(c) A student was asked to draw structures for isomers with the molecular formula C_4H_8.

She drew the diagrams in DIAGRAM 3.4 in the separate diagram booklet. CIRCLE ALL the CORRECT structures. [2 marks]

3 (d) Pent-2-ene reacts with bromine water in a similar manner to ethene.

The equation for the reaction of pent-2-ene with bromine is shown in DIAGRAM 3.5 in the separate diagram booklet. Complete the equation by drawing the structure of the product. [1 mark]

9

4 (a) TABLE 4.1 in the separate diagram booklet shows the results of an experiment in which zinc and lead powders were added separately to solutions of sodium chloride and iron(II) chloride.

Use the results to place the four metals in order of reactivity. [1 mark]

Most reactive _____

_____

Least reactive _____

4 (b) A student investigated metal reactivity using a different method.

He added 10.0 g of magnesium powder in 2.0 g portions to 50 cm^3 of zinc chloride solution and recorded the temperature of the mixture after each addition. He repeated the experiment with aluminium powder and again with copper powder.

The results for magnesium powder are shown in TABLE 4.2 in the separate diagram booklet.

The results for aluminium and copper have been plotted on GRAPH 4.3 in the separate diagram booklet.

(i) Plot the results for magnesium on the grid of GRAPH 4.3. Draw a suitable line. [3 marks]

4 (b)(ii) State the conclusions that can be drawn about the reactivities of magnesium, aluminium, copper and zinc. Give your reasoning. [3 marks]

(Turn over)

5 (a)(i)

Draw a dot and cross diagram to show the bonding in a carbon dioxide molecule. [2 marks]

carbon (2,4) oxygen (2,6)

5 (a)(ii) Explain why carbon dioxide has a low boiling point. [2 marks]

5 (b)(i)

Draw a diagram to show the electronic changes that take place during the formation of magnesium oxide. Include the charges on the ions formed. [2 marks]

magnesium (2,8,2) oxygen (2,6)

5 (b)(ii) Explain why magnesium oxide has a higher melting point than sodium chloride. [2 marks]

5 (b)(iii)

Sodium chloride is produced by the reaction of sodium with chlorine.

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$

In a reaction using 0.080 mol of sodium, 4.12 g of sodium chloride was produced.

Calculate the percentage yield of this reaction. [3 marks]

$A_r(Na) = 23$ $A_r(Cl) = 35.5$

Percentage yield = _____ **%**

11

(Turn over)

6 (a) X, Y and Z are solutions of ethanoic acid, hydrochloric acid and sodium chloride, BUT NOT NECESSARILY IN THAT ORDER. Reactions of X, Y and Z with magnesium gave the results shown in TABLE 6.1 in the separate diagram booklet.

Use TABLE 6.1 to identify X, Y and Z, giving your reasoning. Explain the results recorded and include equations to support your answer. [6 marks QER]

continue on the next page (Turn over)

continue on the next page (Turn over)

6 (b) State how adding sodium hydroxide solution allows solutions containing iron(II) and iron(III) ions to be identified. Give the observations made for both solutions. [2 marks]

7 (a) The formation of ammonia can be represented by the equation in DIAGRAM 7.1 in the separate diagram booklet.

- The total amount of energy released in making the bonds in the products is 2340 kJ

- The total amount of energy released in making the bonds in the products is 94 kJ MORE THAN the total energy used in breaking the bonds in the reactants

- The amount of energy used to break the N≡N bond is 941 kJ

Use this information to calculate the energy used to break ONE H—H bond. [3 marks]

Answer on the next page.

Energy = _____ kJ

7 (b) The Haber process used to make ammonia is usually carried out at a temperature of around 400 °C. Explain why this is the optimum temperature. [2 marks]

A higher temperature is not used because

A lower temperature is not used because

7 (c) Ammonia is used in the production of fertilisers such as ammonium nitrate.

Give the balanced symbol equation for the reaction between nitric acid and ammonia to form ammonium nitrate. [2 marks]

7 (d) Eutrophication is a problem caused by fertilisers being washed into waterways leading to overgrowth of plants. Describe how eutrophication leads to the death of aquatic organisms. [2 marks]

8 (a) According to the Journal of the British Dental Association, the increase in consumption of fruit juices and other acidic drinks is believed to be one of the leading causes of dental erosion in children and adolescents.

Many fruit juice drinks contain more than one type of acid. Citric acid can be used as a natural preservative and provides a sour taste. Ascorbic acid (vitamin C) is a water-soluble vitamin that must be consumed regularly to ensure proper body function. Citrus fruits, as well as tomatoes and other fresh vegetables, are good sources of vitamin C.

TABLE 8.1 in the separate diagram booklet shows information about the content of different fruit juice drinks.

8 (a)(i)

Tick (✓) the TWO conclusions that can be drawn from the information. [2 marks]

☐ as pH increases, citric acid content decreases and sugar content increases

☐ as acidity decreases, ascorbic acid content decreases and water content decreases

☐ tomatoes are a good source of vitamin C and citric acid

☐ citrus fruits contain ascorbic acid and a natural preservative

8 (a)(ii) USE INFORMATION FROM TABLE 8.1 to suggest why citric acid content has a much greater effect on the pH than ascorbic acid content. [1 mark]

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H2SO4 + 2NaOH ⟶ Na2SO4 + 2H2O

8 (b) The concentration of a solution of sodium hydroxide can be determined by titrating with sulfuric acid. The equation for the reaction is shown on the opposite page.

(i) Give the IONIC equation for the formation of water in any neutralisation reaction. Include state symbols. [2 marks]

8 (b)(ii)

21.0 cm^3 of sulfuric acid with a concentration of 0.350 mol/dm^3 neutralised 25.0 cm^3 of the sodium hydroxide solution.

I. Calculate the number of moles of sulfuric acid used in the reaction. [1 mark]

Number of moles = _____ mol

8 (b)(ii)

II. Calculate the concentration of the sodium hydroxide solution. [2 marks]

Concentration = _____ mol/dm^3

8(b)(iii)

During a similar titration reaction, 0.36 g of water was produced. Calculate the number of MOLECULES of water produced in this reaction. Give your answer in STANDARD FORM. [2 marks]

A_r(H) = 1 A_r(O) = 16

Avogadro's constant = 6.0×10^{23}

Number of molecules = _____

10

9 Aluminium metal is produced industrially using electrolysis, due to the relatively high stability of aluminium oxide.

The overall equation for the reaction is

$$2Al_2O_3 \longrightarrow 4Al + 3O_2$$

(a) Describe, in terms of electrons, the reduction and oxidation occurring during the electrolysis. [2 marks]

9 (b)(i) Aluminium ore contains 36% aluminium oxide, Al_2O_3.

Calculate the mass of aluminium oxide in 500 tonnes of the ore.
[1 mark]

Mass = _____ tonnes

(Turn over)

9 (b)(ii)

Calculate the mass of aluminium metal that could be produced from this mass of aluminium oxide.
[3 marks]

A_r(Al) = 27 A_r(O) = 16

Mass = _____ tonnes

6

END OF PAPER

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

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MONDAY, 22 MAY 2023 – MORNING

CHEMISTRY – Unit 2:

Chemical Bonding, Application of Chemical Reactions and Organic Chemistry
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

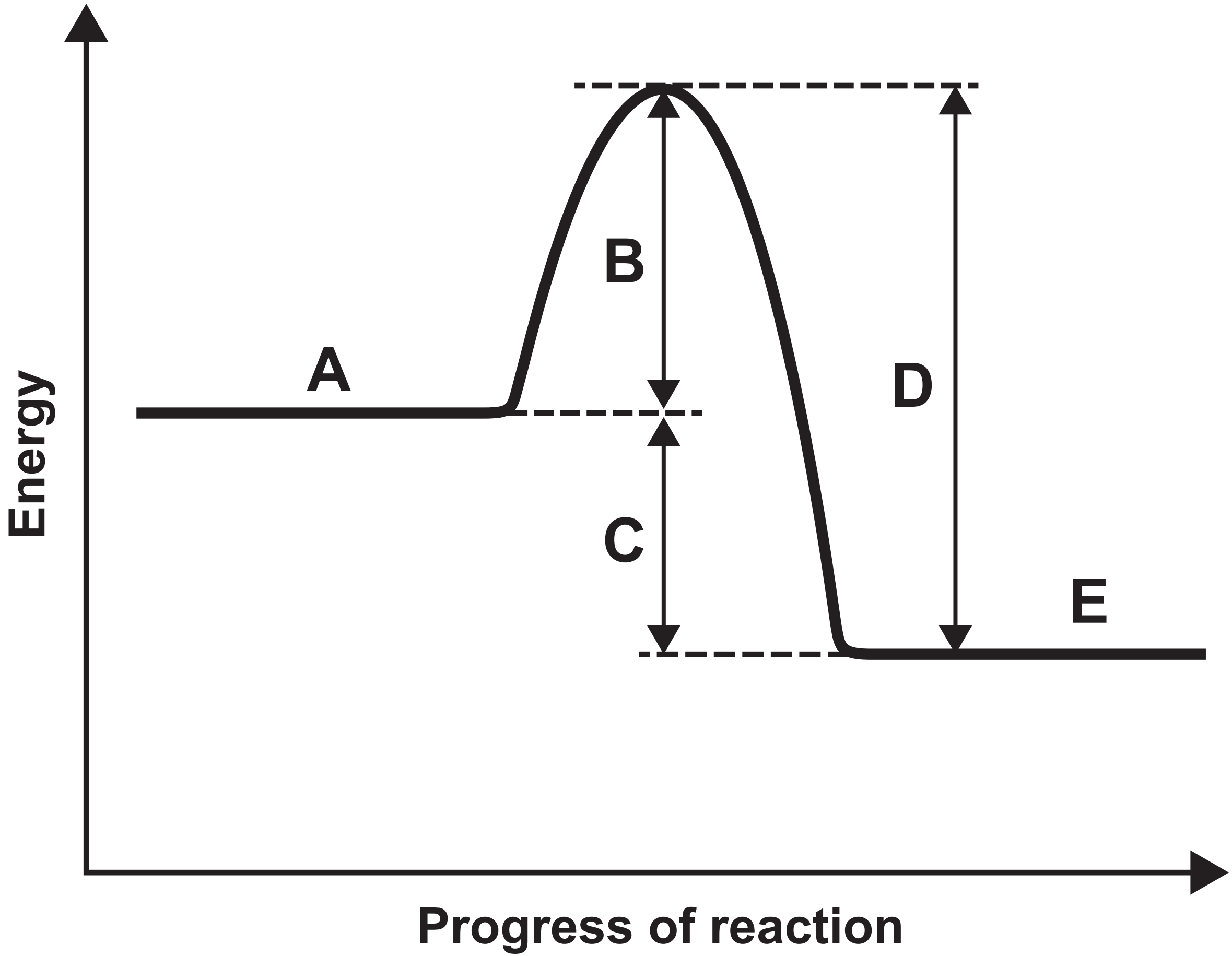

TABLE 1.2

Part of the energy profile	Letter
energy change for the reaction	_____
energy of the reactants	_____
activation energy of the reaction	_____

DIAGRAM 2.1

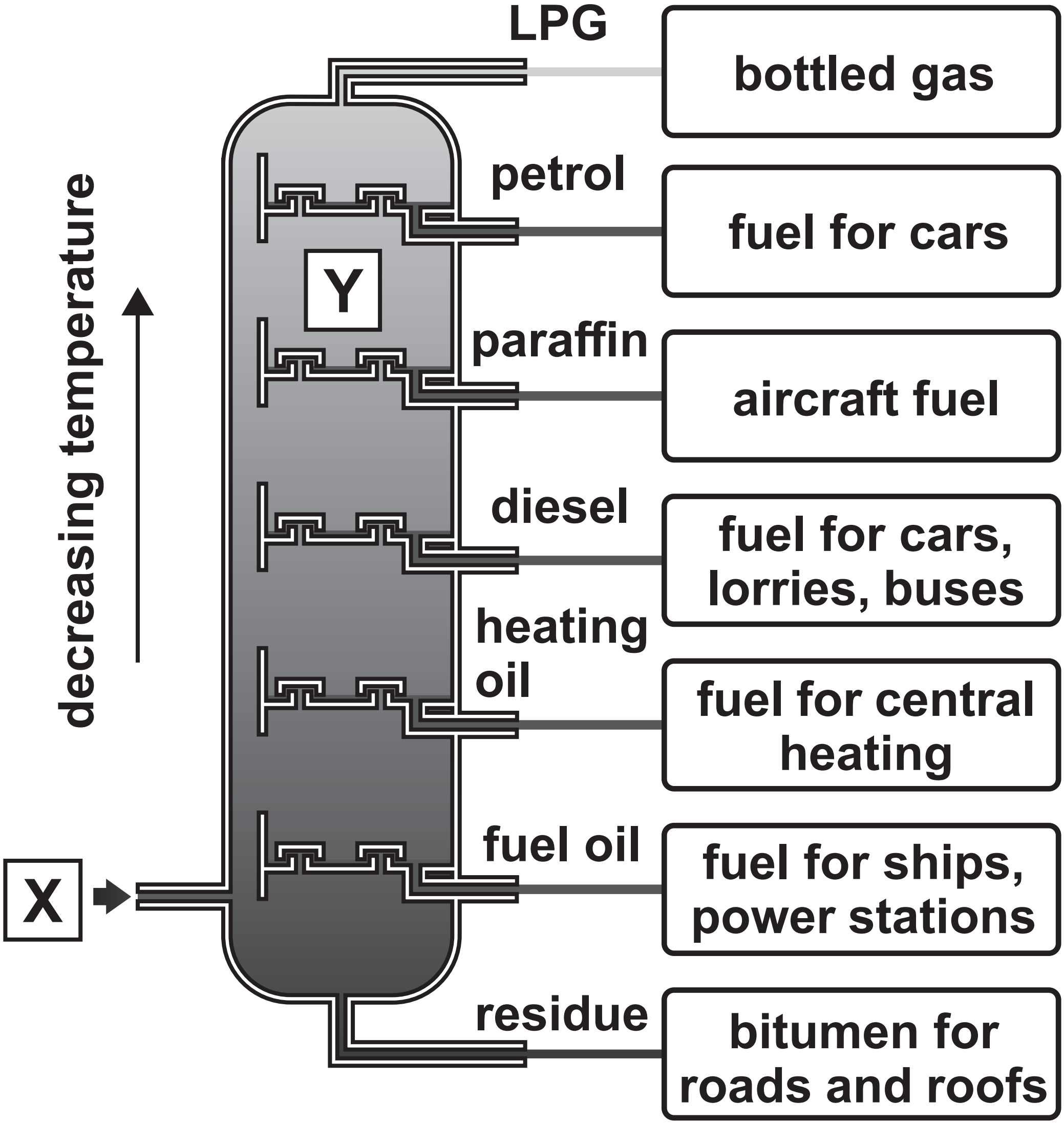
LPG
bottled gas
petrol
fuel for cars
Y
paraffin
aircraft fuel
diesel
fuel for cars, lorries, buses
heating oil
fuel for central heating
fuel oil
fuel for ships, power stations
residue
bitumen for roads and roofs
decreasing temperature
X

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TABLE 3.1

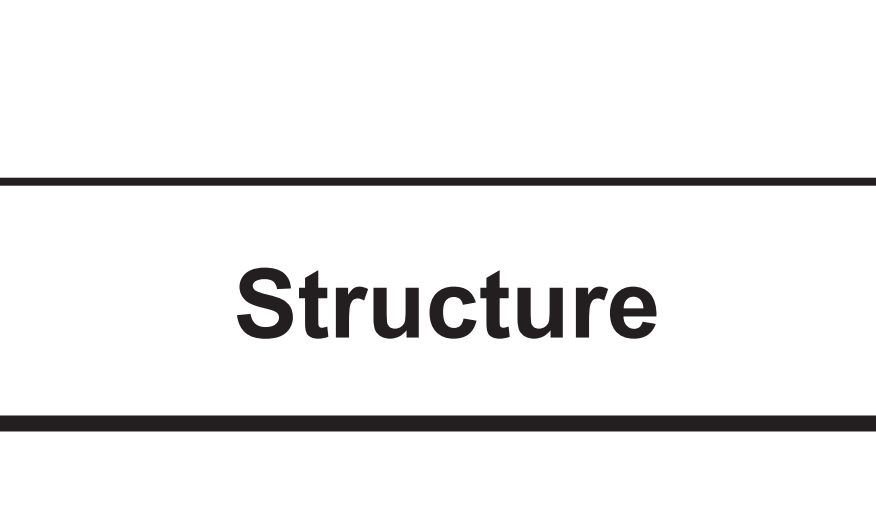
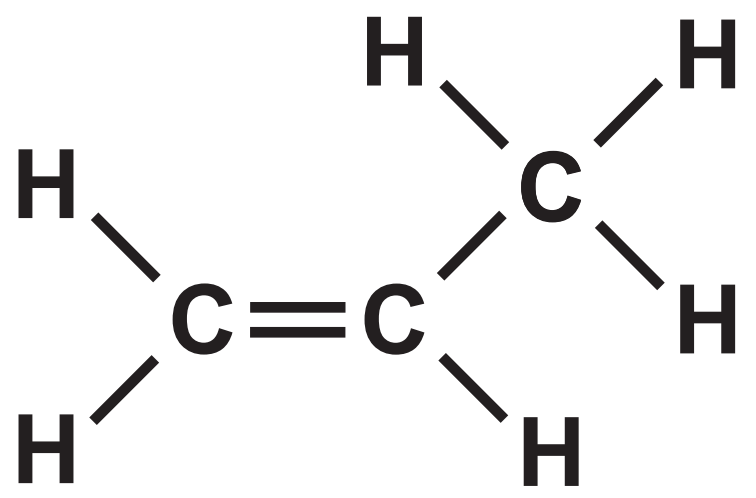
Name	Molecular formula	Structure	Homologous series
ethanol	C_2H_5OH		alcohols
ethanoic acid	CH_3COOH		_____
_____	C_3H_6		alkenes

DIAGRAM 3.2

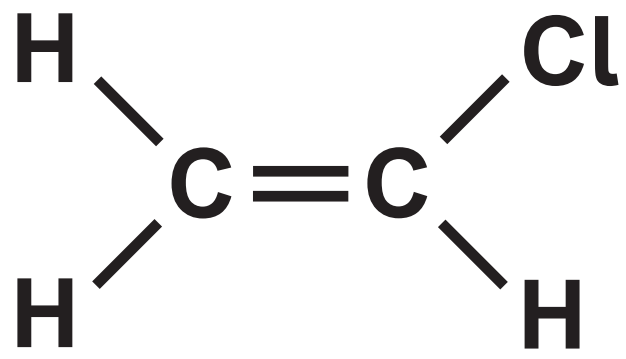


DIAGRAM 3.3

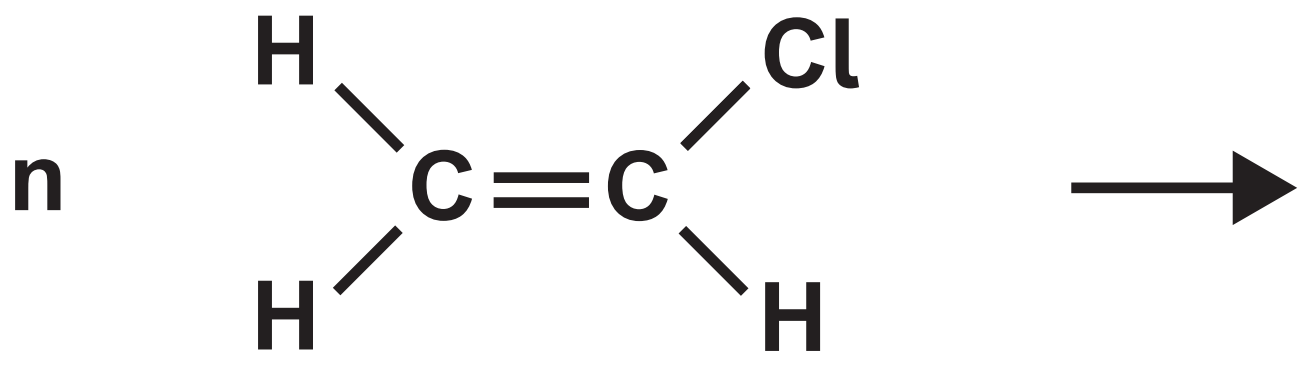
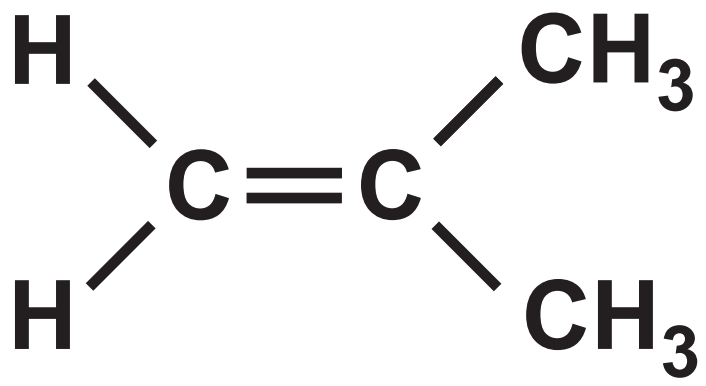
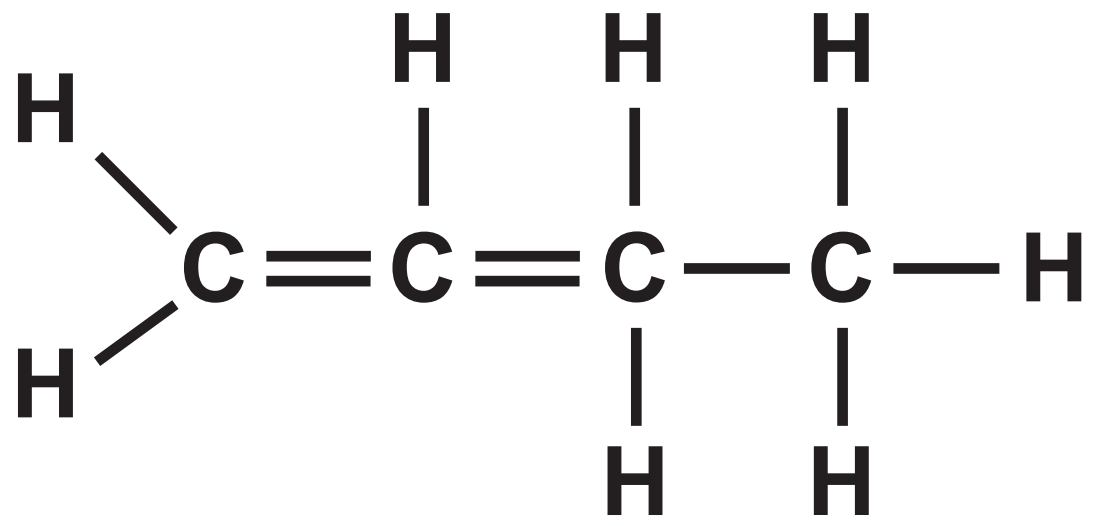
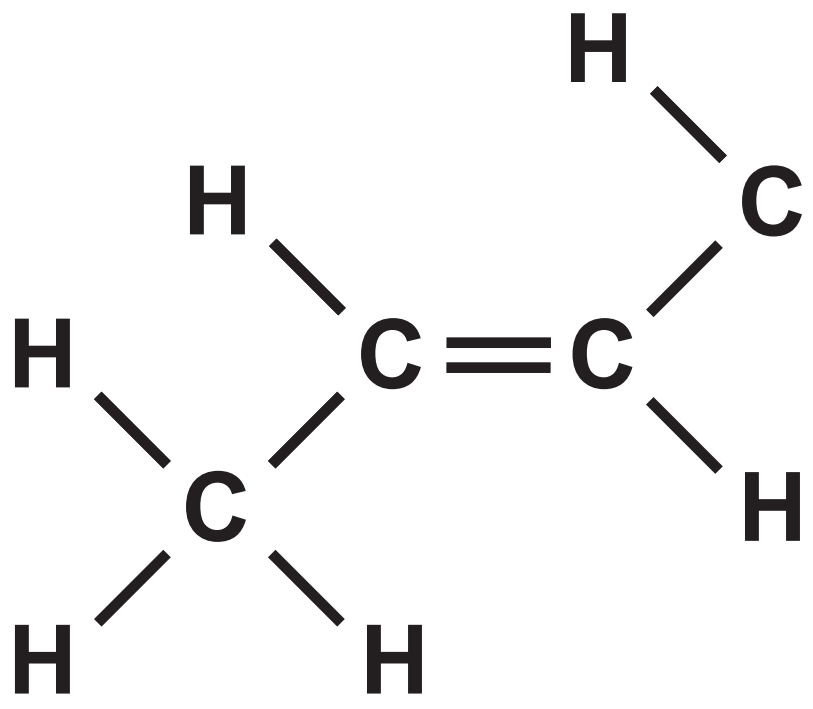
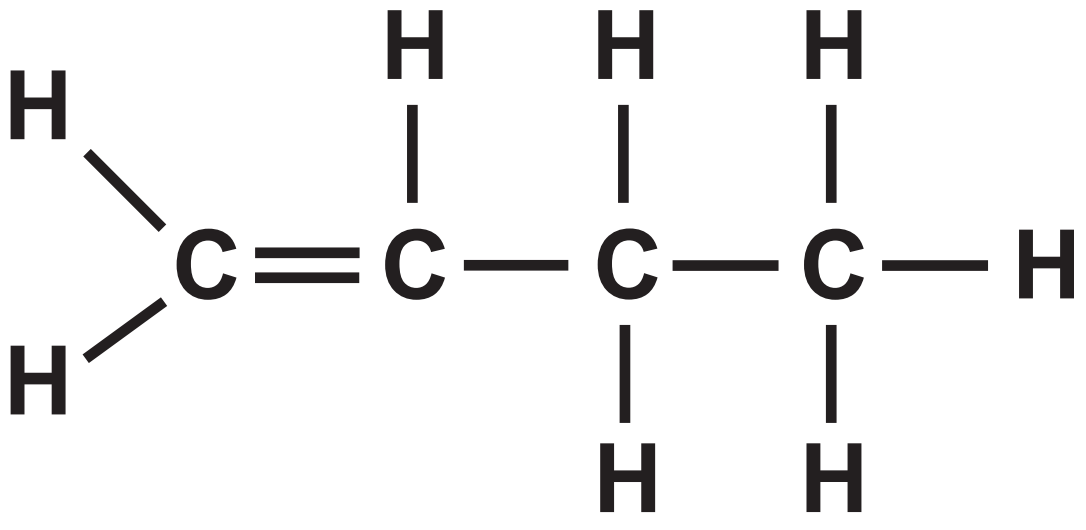


DIAGRAM 3.4


H
CH3
C
C
H
CH3


H
H
H
H
C
C
C
C
H
H
H
H
H


H
H
H
C
C
H
C
H
H


H
H
H
H
C
C
C
C
H
H
H
H

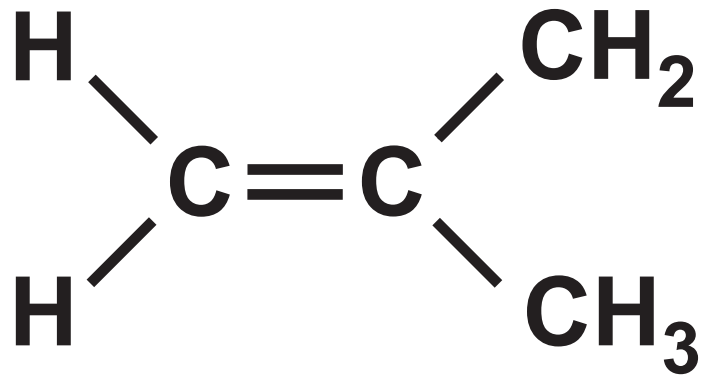

H
CH2
C
C
H
CH3

DIAGRAM 3.5

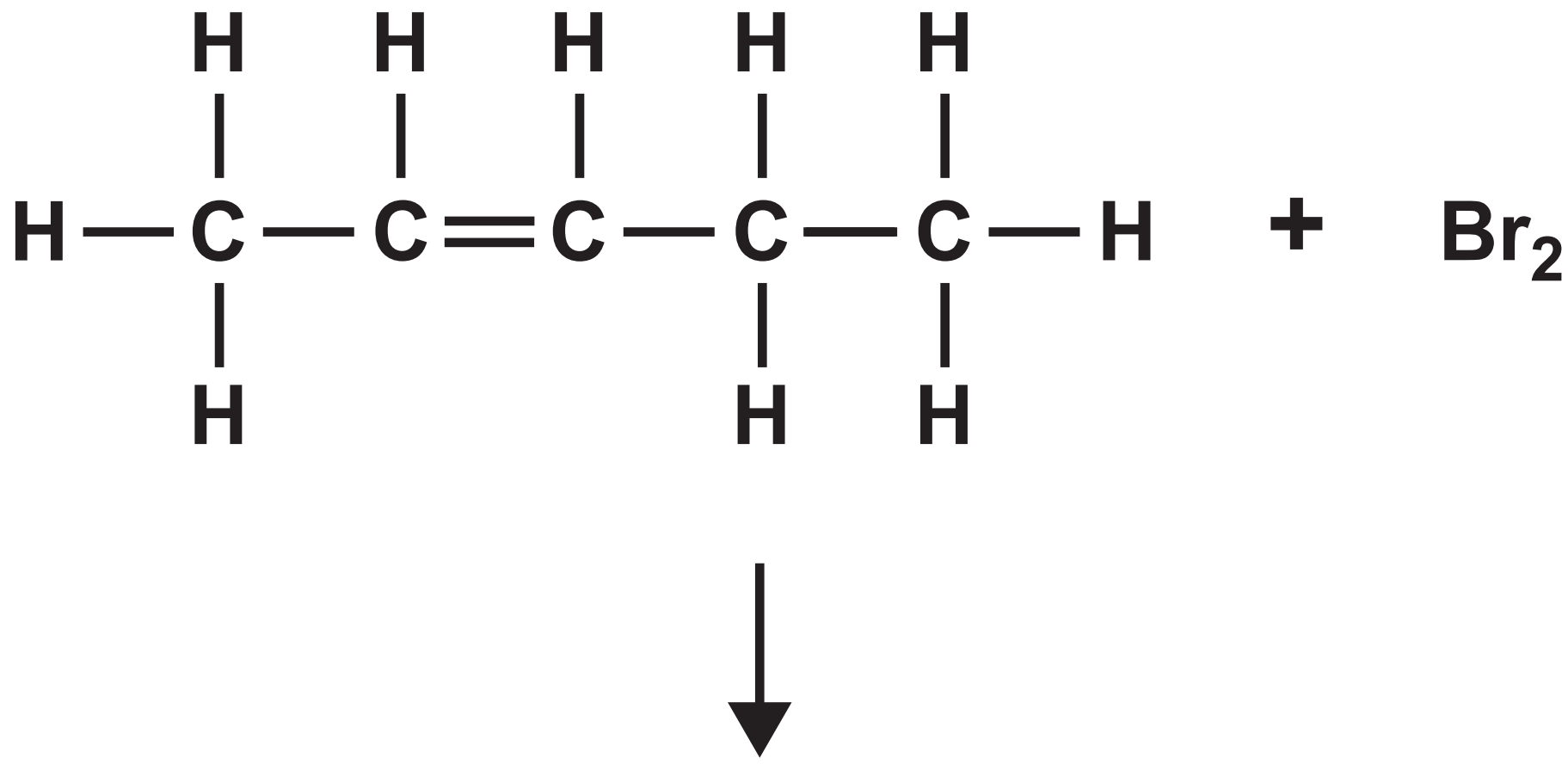


TABLE 4.1

	Sodium chloride solution	Iron(II) chloride solution
zinc	no change	colour change
lead	no change	no change

TABLE 4.2

Mass of magnesium powder added (g)	Temperature (°C)
0	21.0
2.0	23.2
4.0	25.1
6.0	27.5
8.0	29.7
10.0	31.6

GRAPH 4.3

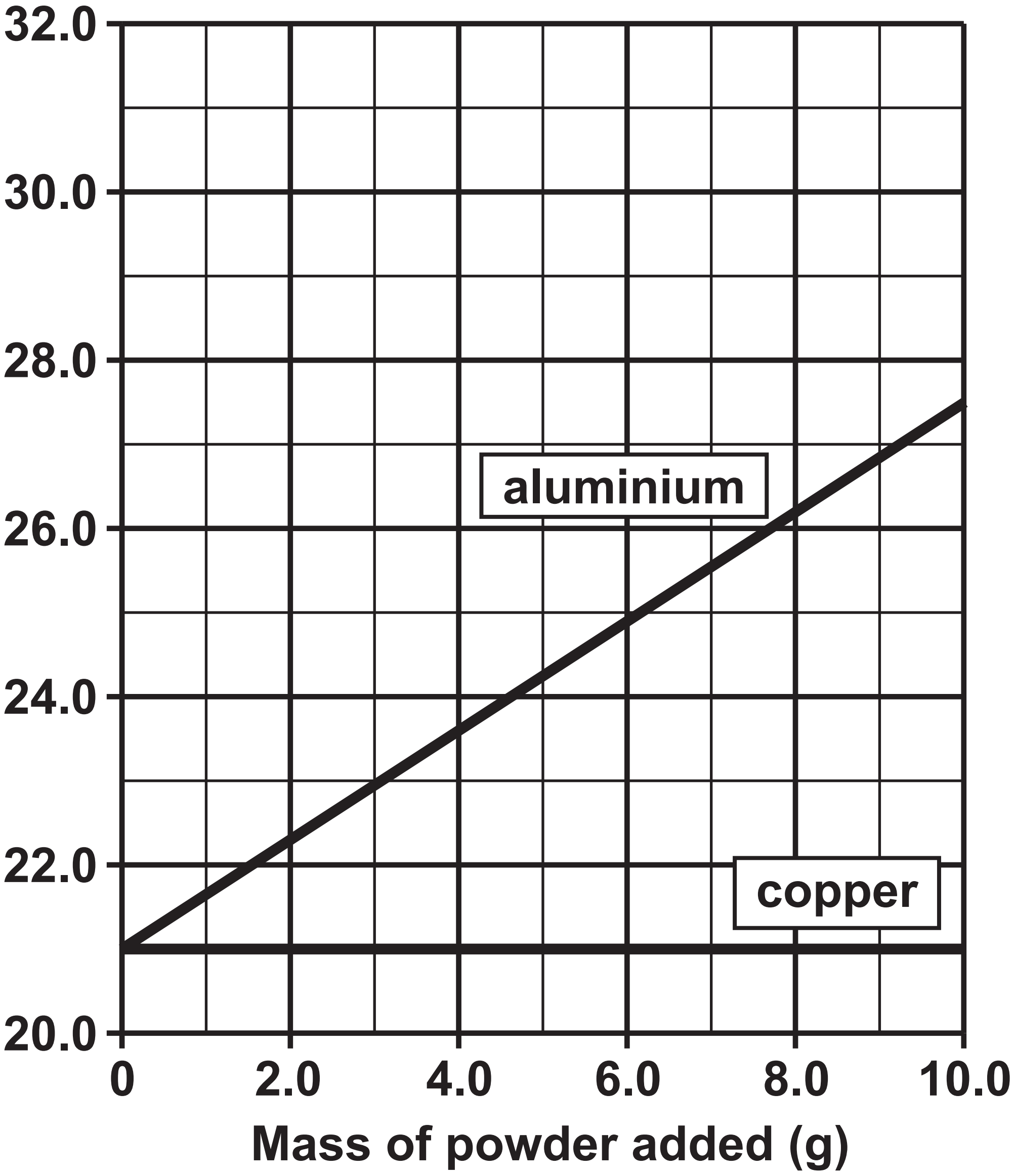

Temperature (°C)
32.0
30.0
28.0
26.0
24.0
22.0
20.0
aluminium
copper
0
2.0
4.0
6.0
8.0
10.0
Mass of powder added (g)

TABLE 6.1

Solution	Reaction with magnesium
X	rapid fizzing, salt formed, temperature increase of 18 °C
Y	no reaction
Z	slow fizzing, salt formed, temperature increase of 11 °C

DIAGRAM 7.1

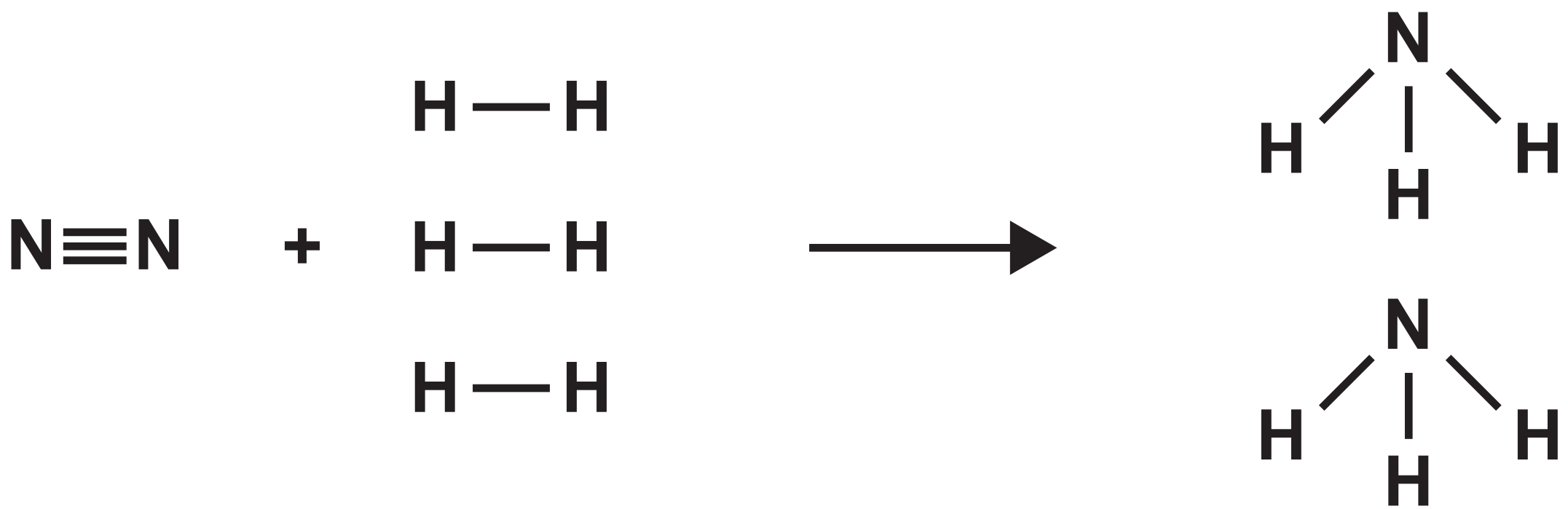


TABLE 8.1

Fruit juice drink	pH	Water (%)	Citric acid (%)	Ascorbic acid (mg / 100 g)	Sugar (%)
lime	2.2	76.4	4.80	29	1.68
lemon	2.4	81.3	4.60	53	1.80
grapefruit	3.0	90.3	1.35	38	2.34
orange	3.6	87.4	0.96	50	4.85
tangerine	3.8	85.7	0.74	31	7.89

GCSE

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MONDAY, 22 MAY 2023 – MORNING

CHEMISTRY – Unit 2:

Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

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	KEY A_r — relative atomic mass Sym — symbol Z — atomic number						
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						

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		