wjec cbac GCSE

3410UB0-1

FRIDAY, 27 MAY 2022 – 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 may 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.

INFORMATION FOR CANDIDATES

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

Question 11 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.	6	
2.	7	
3.	7	
4.	5	
5.	9	
6.	10	
7.	5	
8.	9	
9.	7	
10.	9	
11.	6	
Total	80	

Answer ALL questions.

1 (a) The table below shows the electronic structure of the elements present in potassium fluoride.

Element	Electronic structure
potassium	2,8,8,1
fluorine	2,7

DIAGRAM 1 shows the electron transfer that occurs when potassium reacts with fluorine to form potassium fluoride. The • and × symbols are outer shell electrons.

A student was asked to draw a diagram showing the electronic structures and charges on the ions formed. This is shown in DIAGRAM 2. There are TWO mistakes in the student's answer.

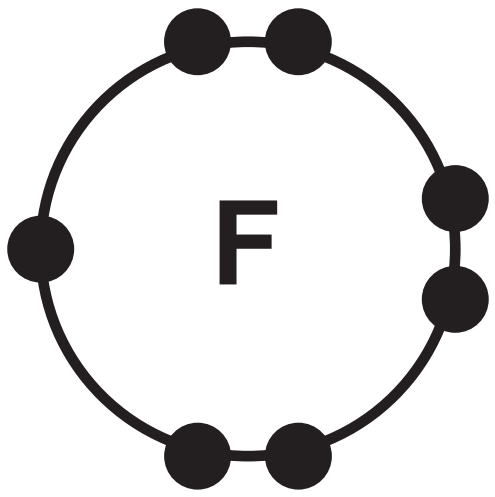
1 (a)(i) Circle the TWO mistakes in the student's answer. [2 marks]

(ii) Name the type of bonding found in potassium fluoride. [1 mark]

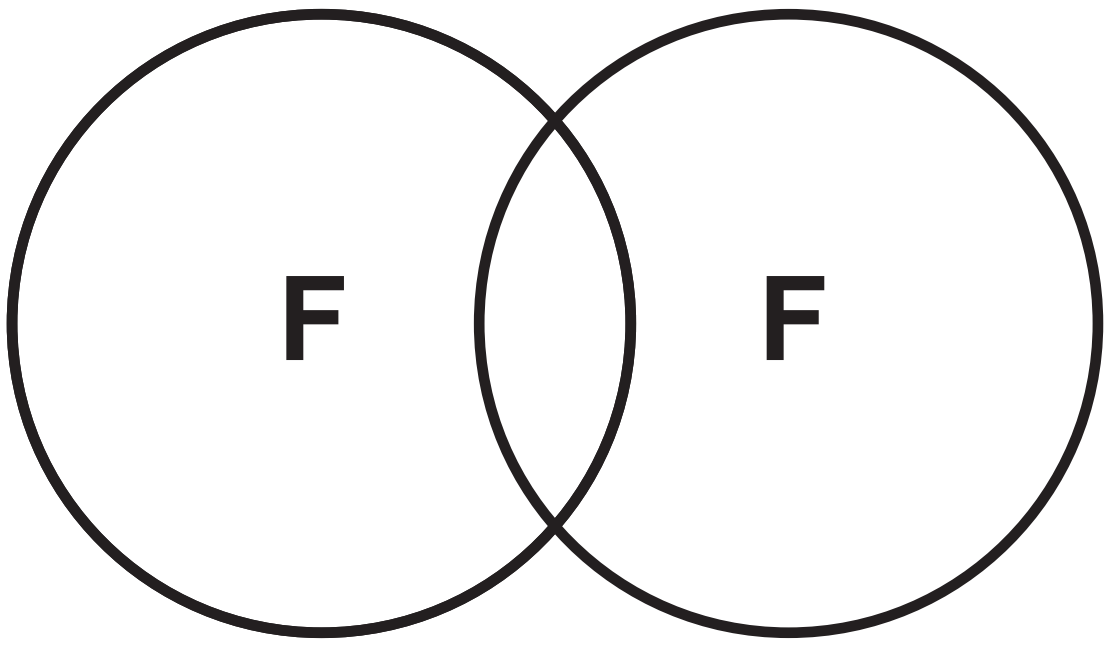
(iii) DIAGRAM 3 shows four different structures. Give the LETTER of the structure most likely to represent potassium fluoride. [1 mark]

Letter _____

1 (b) The diagram below shows the electrons in the outer shell of an atom of fluorine.



Complete the diagram to show the outer shell electrons in a molecule of fluorine. [2 marks]



6

2 (a) DIAGRAM 4 outlines the manufacture of ammonia by the Haber process.

(i) Name the raw material X. [1 mark]

(ii) The pressure used in the Haber process is 200 atm. State why a higher pressure is NOT used. [1 mark]

(iii) At 450 °C, the reaction is very slow. Iron is used in the process to speed up the reaction. Give the name for a substance used to speed up a chemical reaction. [1 mark]

2 (a)(iv)

The reaction between nitrogen and hydrogen is represented by the equation in DIAGRAM 5.

Complete the equation in DIAGRAM 6 using the key. [2 marks]

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Fertiliser	Test for positive ion	Test for negative ion
A	On adding sodium hydroxide solution and warming, a pungent smelling gas is formed which turns red litmus blue	On adding barium chloride solution a white precipitate forms
B	Lilac flame test	On adding silver nitrate solution a white precipitate forms
C	On adding sodium hydroxide solution and warming, a pungent smelling gas is formed which turns red litmus blue	On adding silver nitrate solution a white precipitate forms

2 (b) One of the main uses of ammonia is in the manufacture of fertilisers.

The table opposite shows the results obtained when tests were carried out on three different fertilisers **A**, **B** and **C**.

Give the LETTER of the fertiliser which is ammonium sulfate. [1 mark]

Letter _____

2 (c) Ammonia reacts with chlorine to form nitrogen and hydrogen chloride.

Complete the balancing of the equation for this reaction. [1 mark]

$$2NH_3 + 3Cl_2 \longrightarrow N_2 + \square\ HCl$$

7

3 (a) The list below shows part of the reactivity series.

sodium

aluminium

(carbon)

tin

copper

silver

(i) Tin is extracted from its ore by heating with carbon. Aluminium is extracted from its ore using a different method. Give the name of the method used to extract aluminium. [1 mark]

3 (a)(ii)

The equation below shows the extraction of tin from tin oxide using carbon.

Tick (✓) the box next to the correct statement. [1 mark]

- ☐ **Carbon is reduced**
- ☐ **Tin is oxidised**
- ☐ **Tin oxide is reduced**
- ☐ **Carbon dioxide is oxidised**

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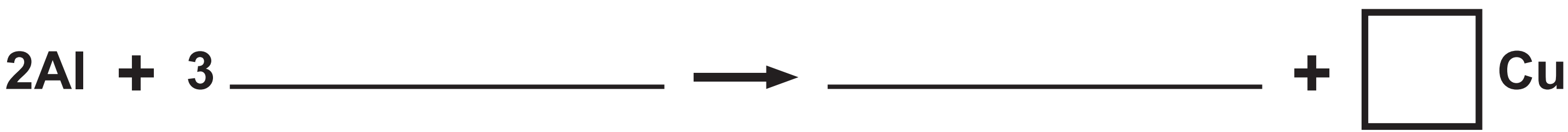

copper(II) oxide

aluminium oxide

3 (a)(iii)

When aluminium and copper(II) oxide are heated together, aluminium oxide and copper are formed.

Complete and balance the equation opposite for this reaction. [3 marks]

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A reduced the oxide of **C**

B reduced the oxide of **A**

B reduced the oxide of **C**

D reduced the oxide of **B**

3 (b) A teacher wanted to find out the position of four metals **A**, **B**, **C** and **D** in the reactivity series.

She heated each metal in turn with oxides of the other three. The results were as listed opposite.

Place the metals in order of reactivity. [2 marks]

Most reactive _____

_____

_____

Least reactive _____

7

4 The equation in DIAGRAM 7 shows the bonds which are broken and the bonds which are formed during the electrolysis of water.

(a) The total energy needed to break the bonds in the reactant is 1 856 kJ.

Calculate the energy needed to break ONE O—H bond. [2 marks]

Energy = _____ kJ

4 (b) The total energy released when the bonds in the products are formed is 1 370 kJ.

The bond energy for H—H is 436 kJ.

Calculate the energy released when making ONE O═O bond. [2 marks]

Energy = _____ kJ

4 (c) The energy profile diagram in DIAGRAM 8 shows the reaction to be endothermic. [1 mark]

On the diagram use the symbol (↕) to show the overall energy change for the reaction.

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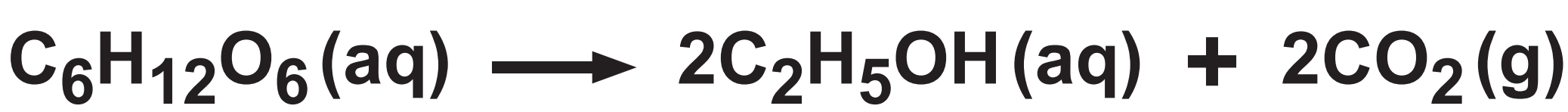
C6H12O6(aq) 2C2H5OH(aq) + 2CO2(g)

5 The chart in DIAGRAM 9 describes the laboratory preparation of ethanol from glucose solution.

The equation for the reaction occurring in process A is shown opposite.

(a)(i) Give the name of the processes A, B and C. [3 marks]

A _____

B _____

C _____

5 (a)(ii)

A teacher wanted to show that ethanol is collected in process C.

I. Tick (✓) the box next to the chemical test that the teacher would carry out to positively identify the liquid as ethanol. [1 mark]

☐ add bromine water

☐ add acidified potassium dichromate solution

☐ add silver nitrate solution

☐ add barium chloride solution

5 (a)(ii) II.

Tick (✓) the box next to the observation you would expect. [1 mark]

☐ orange to colourless

☐ orange to green

☐ green to orange

☐ colourless to green

5 (b) Alcohols can also be identified using infrared spectroscopy.

Bond	Wavenumber (cm^{-1})
C═C	1 620 to 1 670
C═O	1 650 to 1 750
C—H	2 800 to 3 100
O—H	2 500 to 3 550

(i) The structural formula and the infrared spectrum of ethanol are shown in DIAGRAMS **10A** and **10B**.

Give the LETTER of the peak that can be used to identify an alcohol. [1 mark]

Letter _____

5 (b)(ii) The structural formula and the infrared spectrum of ethanoic acid are shown in DIAGRAMS 11A and 11B.

Give the LETTER of the peak that can be used to distinguish ethanoic acid from ethanol. [1 mark]

Letter _____

5 (c) Ethanol is found in alcoholic drinks.

(i) Give ONE health problem associated with alcohol abuse over a LONG period of time. [1 mark]

(ii) Give ONE social problem associated with the excessive intake of alcohol (binge drinking) during an evening. [1 mark]

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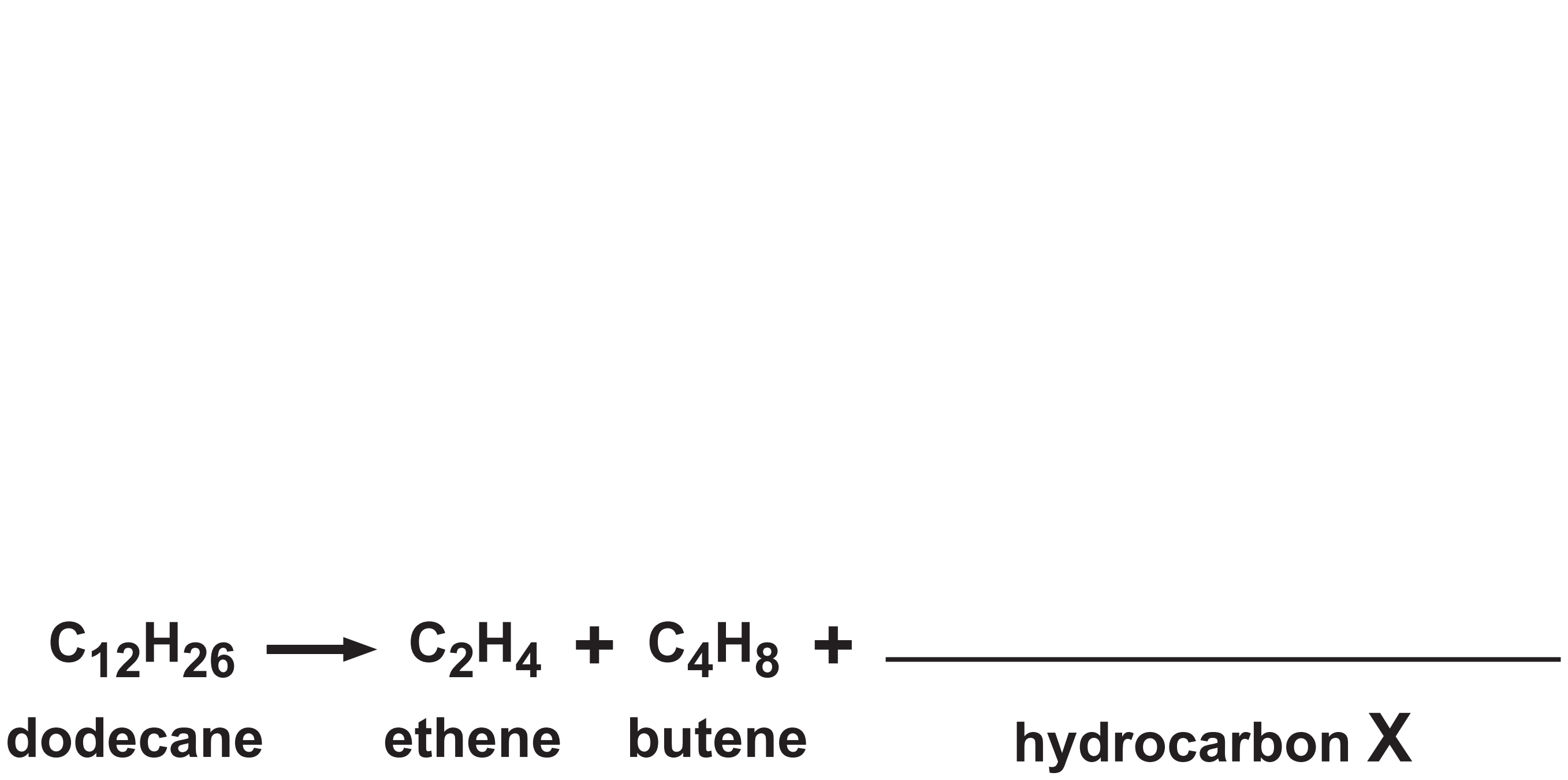

$C_{12}H_{26}$ → C_2H_4 + C_4H_8 +
dodecane
ethene
butene
hydrocarbon X

6 (a) Kerosene is one of the fractions separated during the fractional distillation of crude oil.

Kerosene contains dodecane, $C_{12}H_{26}$. Dodecane undergoes a further process **A** to form smaller, more useful hydrocarbons, ethene, butene and one molecule of hydrocarbon **X**.

(i) Name process **A**. [1 mark]

_____

_____

(ii) Complete the equation opposite for this reaction. [1 mark]

6 (b) C_4H_8 has three isomers.
DIAGRAM 12 shows two of the three isomers.

The third isomer is methylpropene.
Draw its structure in the box in the diagram booklet. [1 mark]

6 (c)(i) Polyethene is made from ethene by addition polymerisation. Draw the structure of the repeating unit for polyethene in DIAGRAM 13. [1 mark]

(ii) The presence of the double bond in ethene can be confirmed using bromine water.

I. Complete the equation for the reaction between ethene and bromine in DIAGRAM 14. [1 mark]

II. Tick (✓) the box next to the name of the product formed. [1 mark]

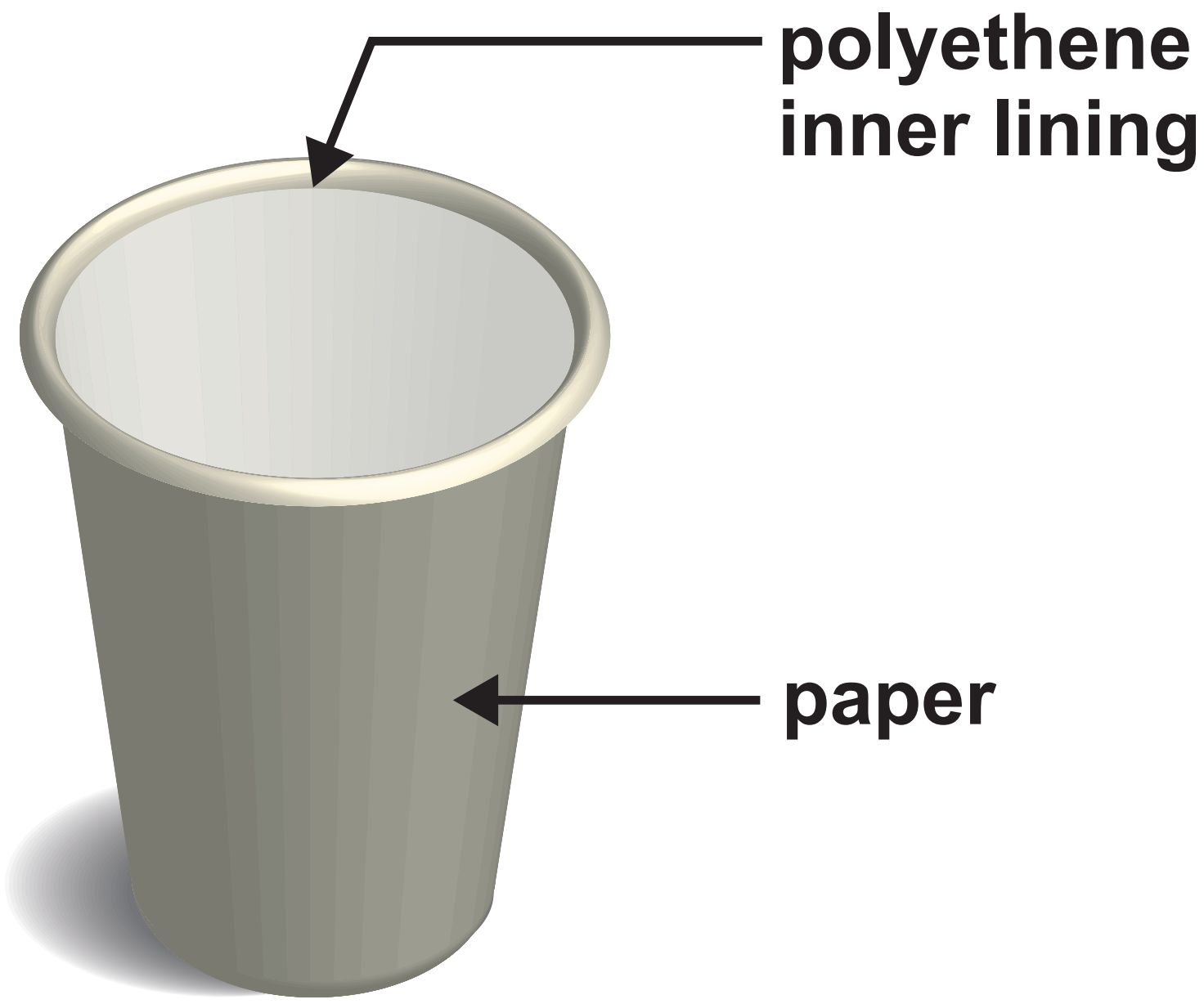
☐ 1,2-dibromoethene

☐ 1,1-dibromoethane

☐ 1,2-dibromoethane

☐ 1,1-dibromoethene

6 (d) In the UK, around 3 billion disposable coffee cups are used every year. Each paper coffee cup is lined with polyethene which is impossible to remove at a recycling plant. If the automated machine that sorts waste at a recycling centre detects a plastic lining, it rejects the cup sending it to general household waste.



6 (d)(i) Most general household waste is disposed of in landfill sites.

Apart from using landfill sites, give the OTHER disposal method of general household waste. State an environmental problem associated with the method. [2 marks]

Method

Problem

6 (d)(ii) Recycling helps to conserve raw materials. Name the raw material used to make polyethene. Give the main reason why it is important to conserve this raw material. [2 marks]

Raw material

Main reason

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Stage 1 $2CH_4 + O_2 \rightleftharpoons 2CO + 4H_2$

Stage 2 $CO + 2H_2 \rightleftharpoons CH_3OH$

7 Scientists make ‘new fuel’ discovery

Methanol is vital in manufacturing a wide range of fuels and chemicals. Methanol is produced from methane found in natural gas. At the moment methane is condensed into liquid natural gas at the site where it is extracted and transported in pressurised containers.

Traditionally, methanol is created by converting methane into hydrogen and carbon monoxide molecules at high temperature, then rearranging the atoms in a different order in a second highly pressurised process. The current two-stage process is very energy intensive, as it burns a lot of fossil fuel to achieve high temperatures (see opposite).

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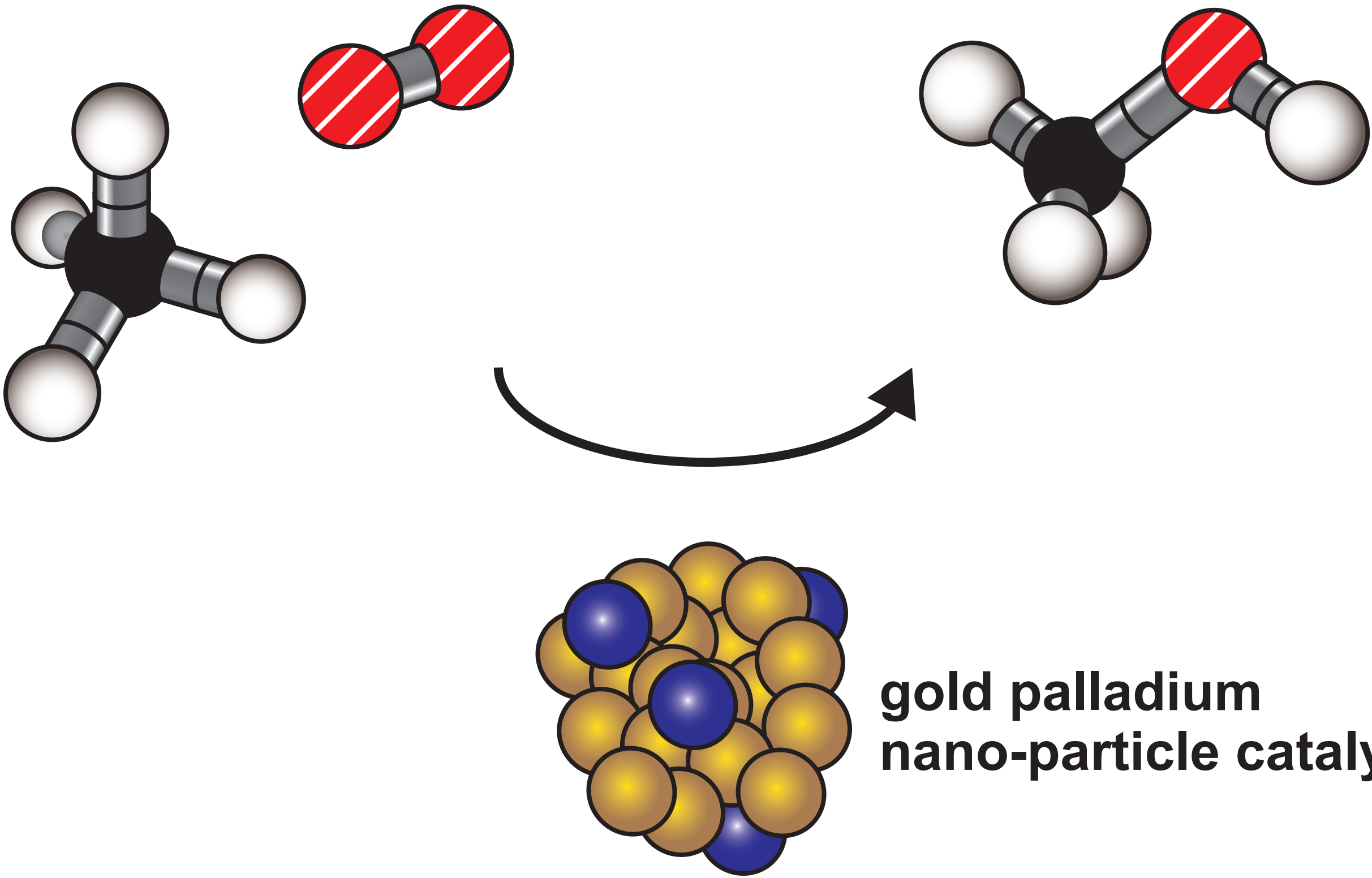

gold palladium
nano-particle catalyst

7 (continued)

Scientists have discovered a new way of creating greener and cheaper methanol from methane using gold palladium nano-particles to initiate a one-stage chemical reaction that can be done at temperatures no higher than 50 °C. In this new process the gold palladium nano-particles act as a catalyst enabling methane and oxygen to combine, forming methanol in a single stage reaction.

The discovery opens up the prospect of easily converting methane into methanol at the site where the methane is extracted, so that methanol can be transported as a liquid at atmospheric pressure.

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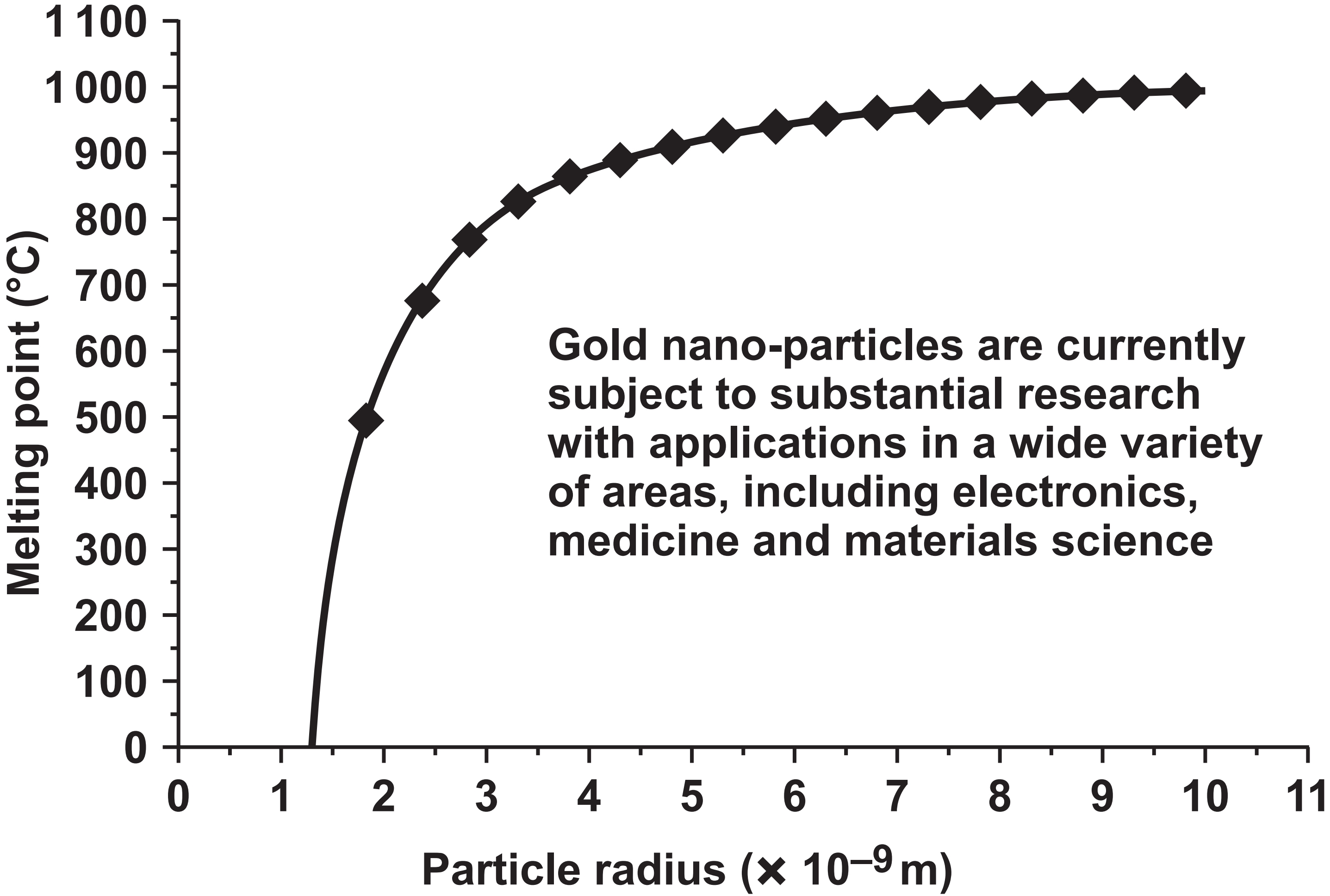
1 100
1 000
900
800
700
600
500
400
300
200
100
0
Melting point (°C)
0
1
2
3
4
5
6
7
8
9
10
11
Particle radius (× 10⁻⁹ m)
Gold nano-particles are currently subject to substantial research with applications in a wide variety of areas, including electronics, medicine and materials science

7 (continued)

Nano-particles have very different and unique properties from their bulk form.

Bulk gold

- shiny
- always gold colour
- inert
- conducts electricity
- melting point 1 064 °C

Gold nano-particles

- found in a range of colours (100 nm purple; 20 nm red; 1 nm yellow)
- never gold colour
- very good catalysts
- semi-conductors
- range of melting points

(Turn over)

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2CH4 +

7 (a) Tick (✓) the box next to the TWO statements which support the opinion that the new method is more ENVIRONMENTALLY FRIENDLY. [2 marks]

- ☐ It is cheaper than the traditional method
- ☐ It uses less energy
- ☐ It reduces carbon dioxide emissions
- ☐ It uses gold nano-particles
- ☐ It uses more fuel

(b) Complete the balanced equation on the opposite page for the NEW method of converting methane to methanol. [2 marks]

7 (c) Tick (✓) the box next to the TRUE statement. [1 mark]

☐ The melting points of gold nano-particles and bulk gold are the same

☐ Gold nano-particles have a fixed melting point value

☐ Smaller gold nano-particles have higher melting points than larger gold nano-particles

☐ The melting point of gold nano-particles depends on their size

5

8 **Mountaineers often choose an ethanol burner when hiking in extremely cold conditions.**

ethanol burner

A group of students was asked to investigate how the mass of ethanol burned is related to the amount of energy given out.

Four students each burned a different mass of ethanol and recorded the temperature rise of 250 g of water. DIAGRAM 15 shows the apparatus used by each of the students. They used their results to calculate the energy given out.

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Student	Mass of ethanol burned (g)	Energy given out ($J \times 10^4$)
A	1.1	2.2
B	1.8	3.6
C	2.9	5.8
D	4.2	8.4

Formula for question 8 (a)

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

8 (continued)

The table opposite shows the students' results.

(a) The temperature rise can be calculated using the formula opposite.

Use this formula to calculate the temperature rise recorded by student D. [2 marks]

Temperature rise = _____ °C

(b) Plot the energy given out against mass of ethanol burned on DIAGRAM 16 and draw a suitable line. [3 marks]

8 (c) Describe the relationship between the mass of ethanol burned and the energy given out. [2 marks]

8 (d) All the recorded temperature rises were LOWER than expected.

Explain ONE piece of advice you would give the students to resolve this problem. [2 marks]

9

9 Transition metals have the ability to form ions with different charges. Iron and copper are transition metals.

(a) A teacher carried out a series of reactions to show that iron can form Fe^{2+} and Fe^{3+} ions. This is shown in DIAGRAM 17.

(i) State what you would expect to SEE during the reactions that shows iron is a transition metal. [1 mark]

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Fe + 2
FeCl2

9 (a)(ii)

In REACTION 2, iron reacts with iron(III) chloride forming iron(II) chloride, $FeCl_2$.

I. Complete and balance the equation for this reaction on the opposite page. [2 marks]

II. Explain the meaning of the term **oxidation** in relation to REACTION 2. [2 marks]

9 (b) Name the reagent used to identify copper(II) ions in solution. Give the observation expected. [2 marks]

Reagent

Observation

7

10 (a) Some household cleaners are a concentrated solution of ammonia.

To determine the concentration of an ammonia solution, 10.0 cm^3 of a household cleaner was titrated with dilute sulfuric acid of concentration 1.5 mol/dm^3.

The end-point was determined by using the indicator methyl orange.

The procedure was repeated three times and the mean volume of dilute sulfuric acid needed to neutralise 10.0 cm^3 of the ammonia solution was found to be 12.0 cm^3.

(Turn over)

10 (a)(i) Use the equation below to calculate the number of moles of sulfuric acid in 12.0 cm^3 of the 1.5 mol/dm^3 solution. [2 marks]

$$\text{concentration} = \frac{\text{number of moles}}{\text{volume}}$$

Number of moles of sulfuric acid = _____ mol

10 (a)(ii) Ammonia solution reacts with sulfuric acid according to the equation below.

Use the equation for the reaction to find the number of moles of ammonia in 10.0 cm^3 of the household cleaner. [1 mark]

Number of moles of ammonia = _____ mol

10 (a)(iii) Calculate the concentration of ammonia in mol / dm^3. [2 marks]

Concentration of ammonia = _____ mol / dm^3

10 (b)

DIAGRAM 18 shows two reactions of dilute hydrochloric acid.

(i) Predict the temperature change if dilute ethanoic acid, CH_3COOH, is added to sodium hydroxide instead of dilute hydrochloric acid. Give the reason for your answer. [2 marks]

(ii) A salt is formed when ethanoic acid is added to copper(II) carbonate.

I. Give the name of the salt. [1 mark]

10 (b)(ii) II.

The negative ion present in the salt is CH_3COO^-.

Underline the correct formula of the salt. [1 mark]

$Cu(CH_3COO)_2$

$CuCH_3COO$

Cu_2CH_3COO

$Cu_2(CH_3COO)_2$

9

11 **DIAGRAM 19 shows the laboratory apparatus that can be used to model the manufacture of aqueous sodium hydroxide (NaOH), chlorine (Cl_2) and hydrogen (H_2) from aqueous sodium chloride, NaCl.**

Aqueous sodium chloride contains the ions Na^+, Cl^-, OH^- and H^+.

Explain, in terms of ions, the formation of each of the THREE products. Include equations to support your answer.
[6 marks QER]

continue on next page

(Turn over)

continue on next page

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6

END OF PAPER

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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		

GCSE

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HIGHER TIER

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

Diagram Booklet

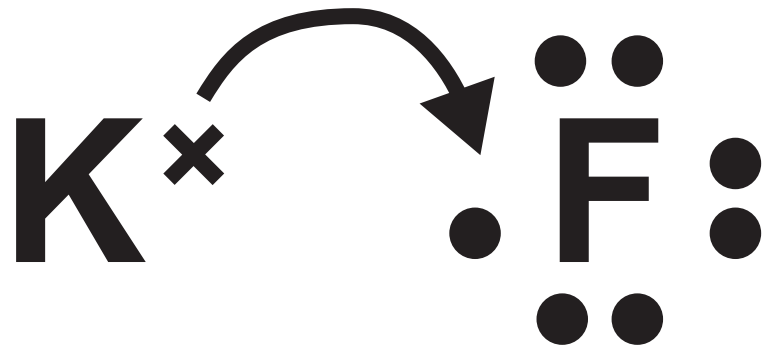
Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

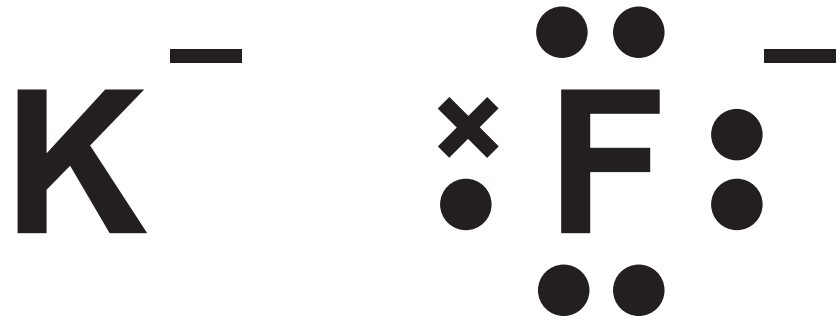
DIAGRAM 1



(2,8,8,1) (2,7)

DIAGRAM 2

Student's answer



(2,8,8) (2,8,8)

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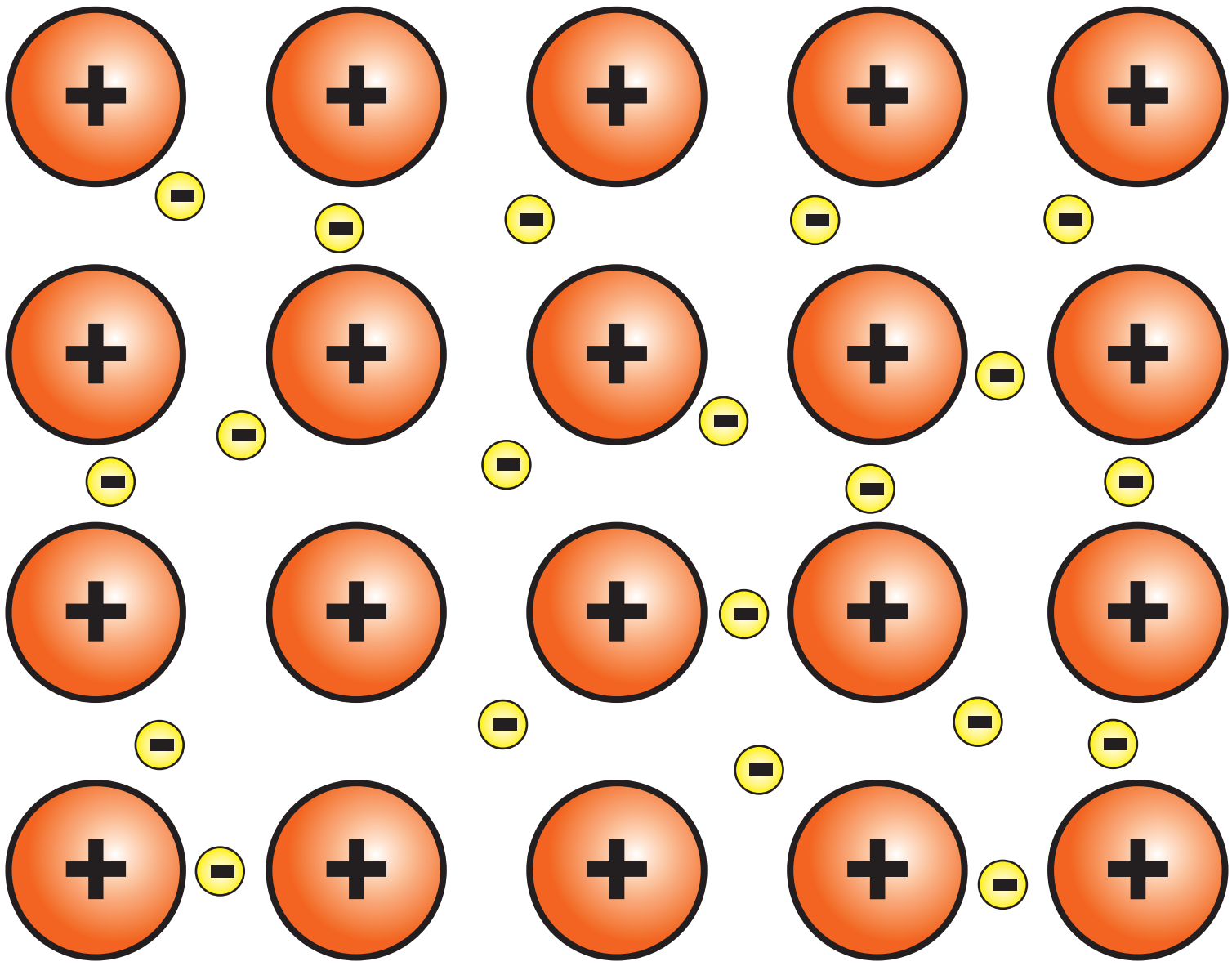
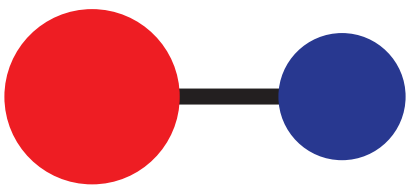
DIAGRAM 3

A

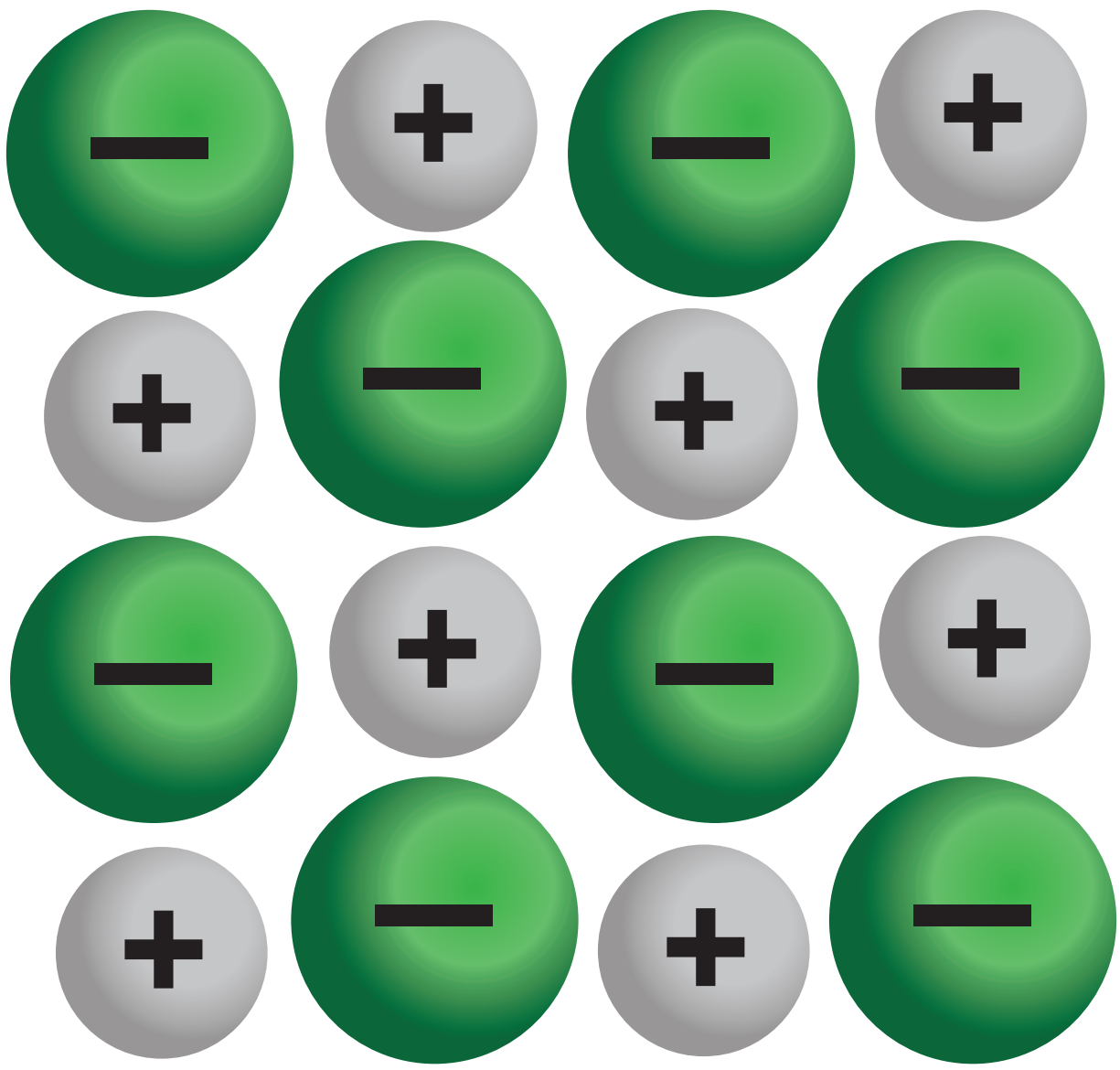


B



3

C



D

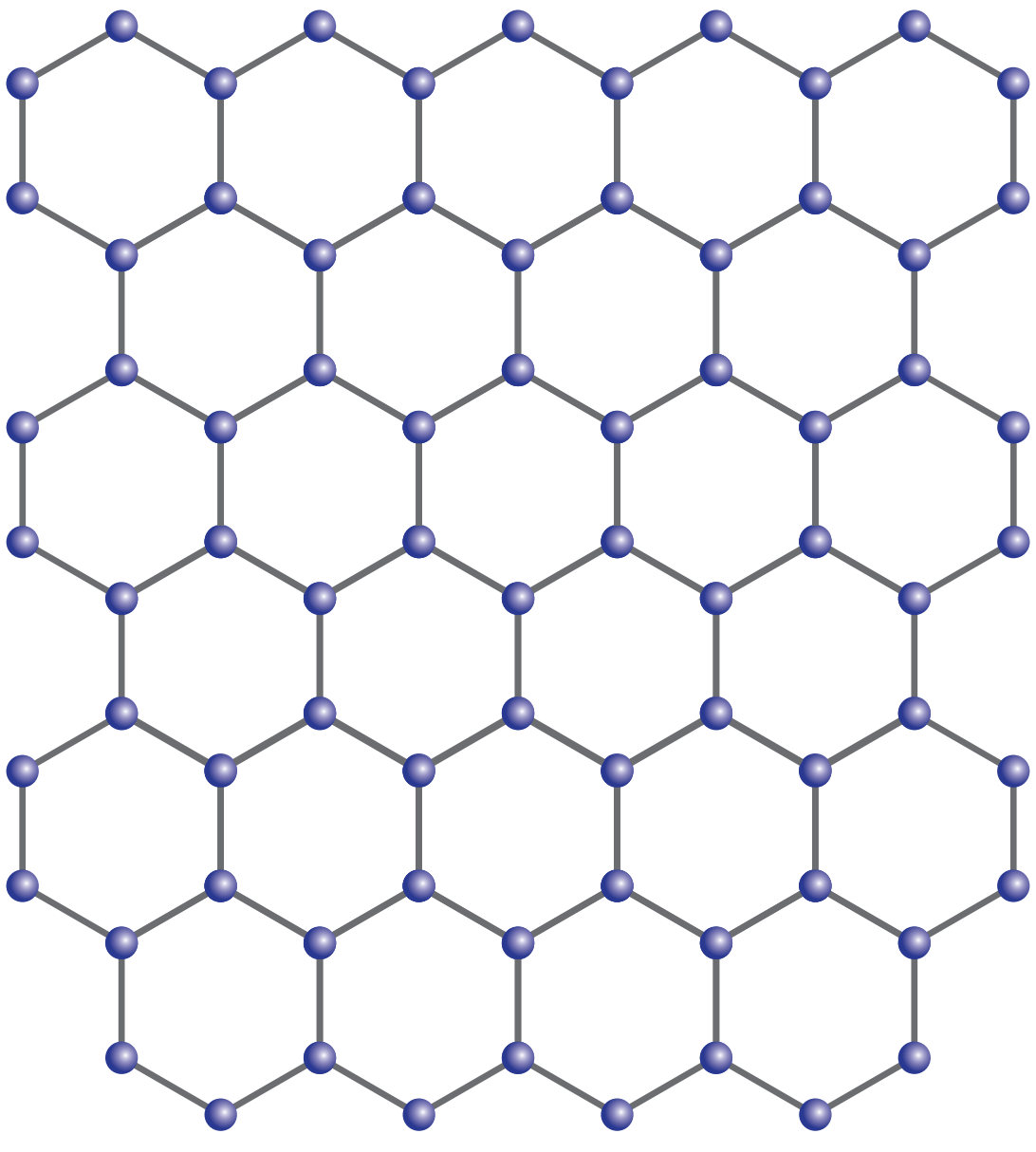


DIAGRAM 4

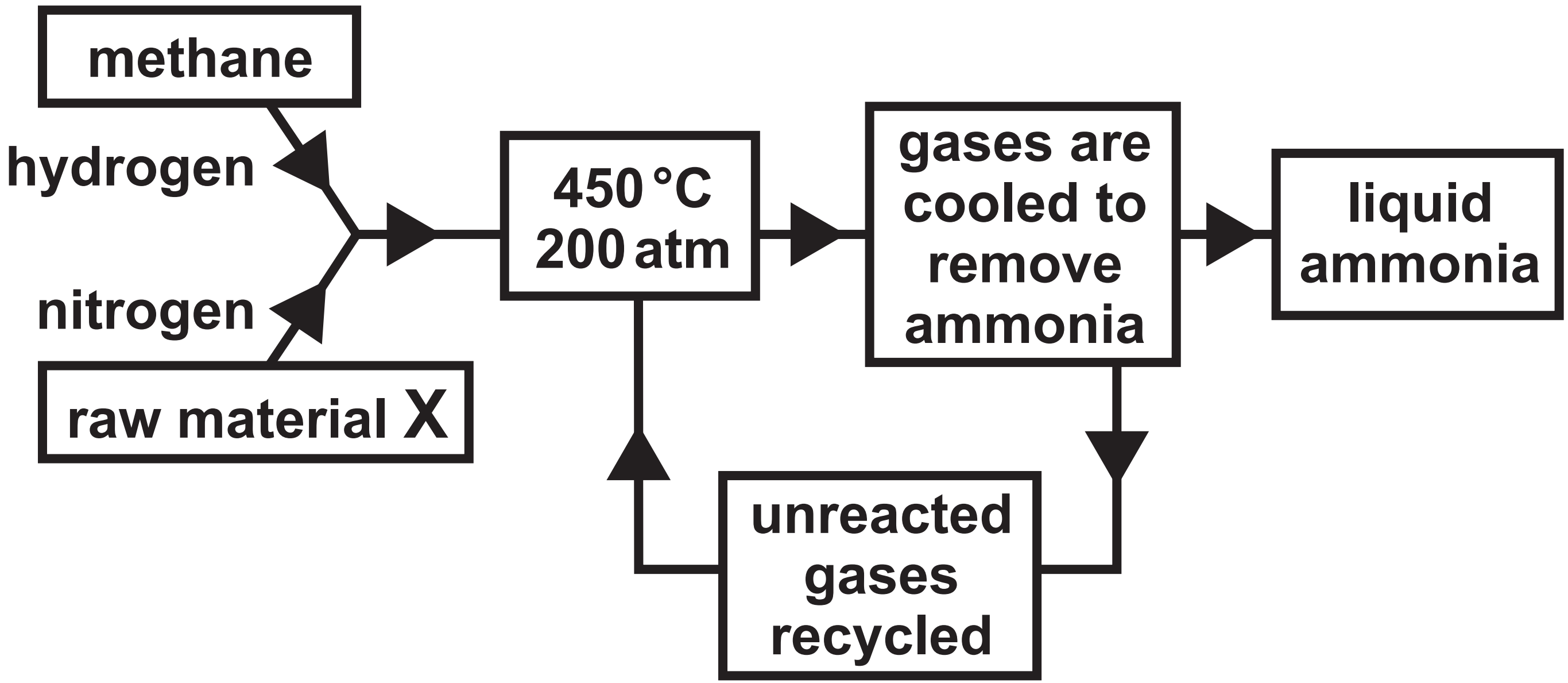
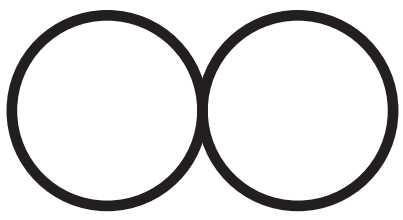

methane
hydrogen
nitrogen
raw material X
450 °C
200 atm
gases are cooled to remove ammonia
liquid ammonia
unreacted gases recycled

DIAGRAM 5

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

DIAGRAM 6

Key:



nitrogen gas, N_2

hydrogen gas, H_2

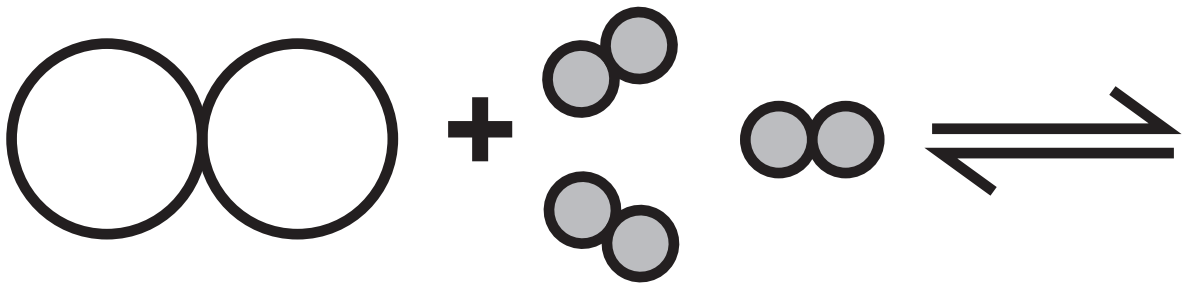


DIAGRAM 7

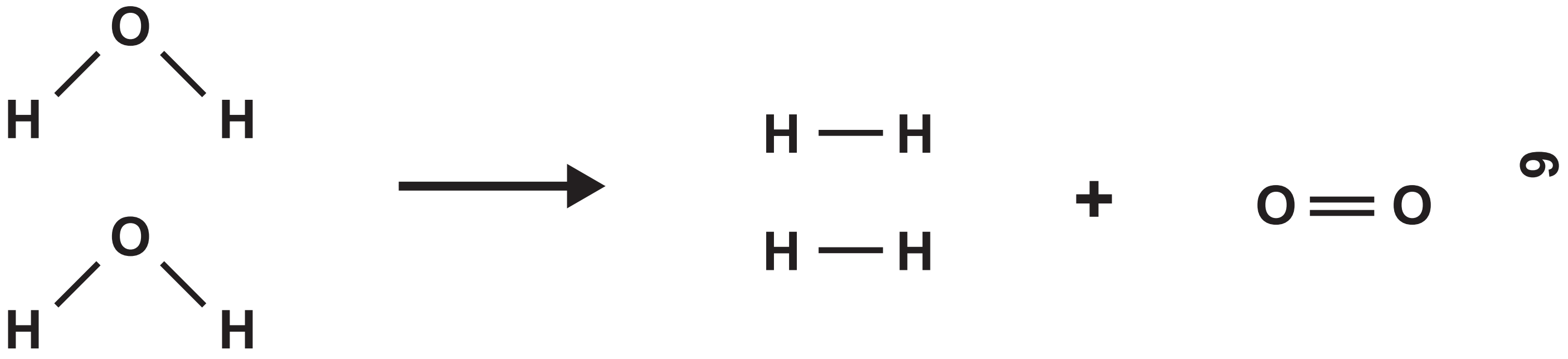
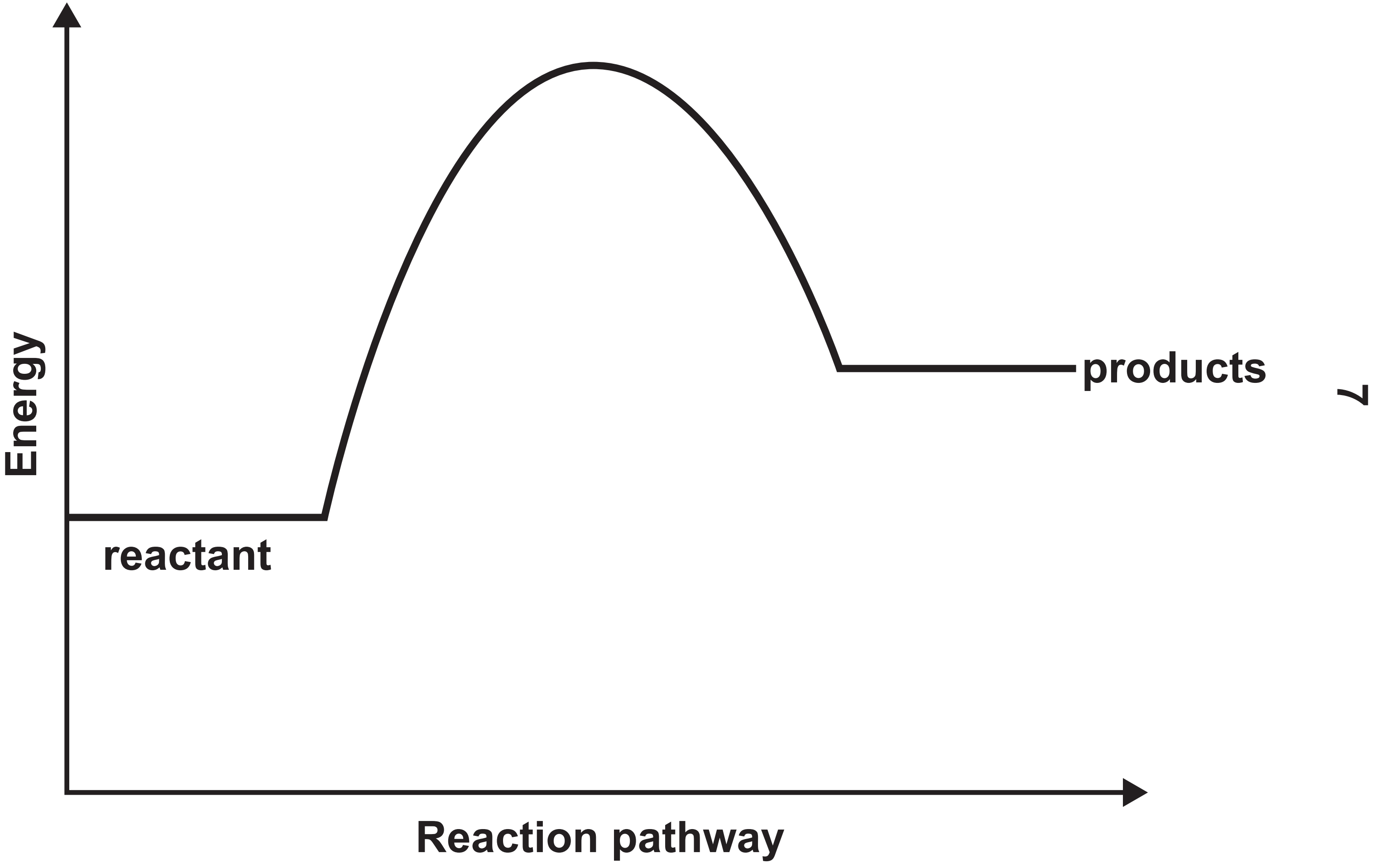
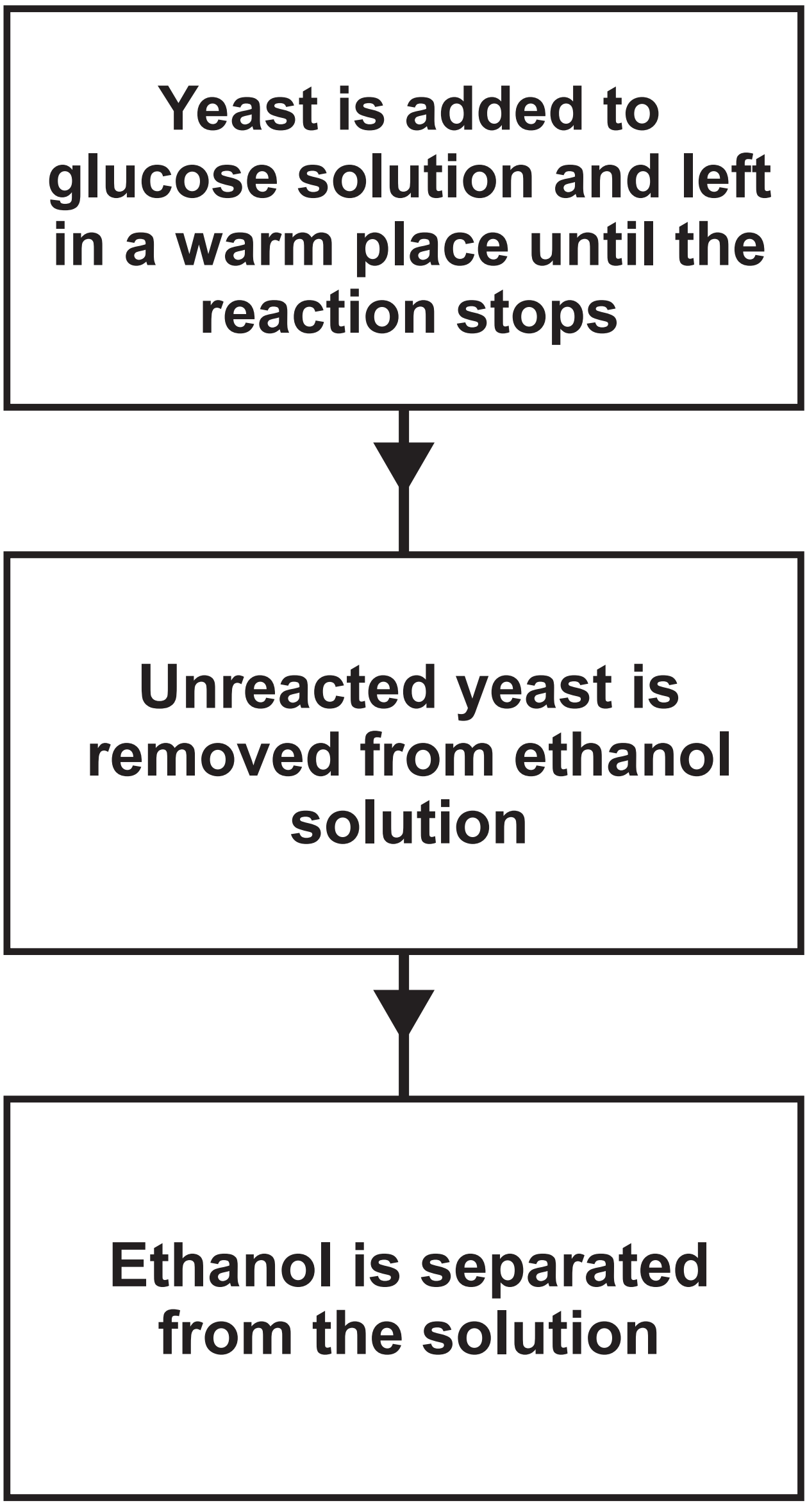


DIAGRAM 8



7

DIAGRAM 9


Process A
Yeast is added to glucose solution and left in a warm place until the reaction stops
Process B
Unreacted yeast is removed from ethanol solution
Process C
Ethanol is separated from the solution

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TURN OVER

DIAGRAM 10A

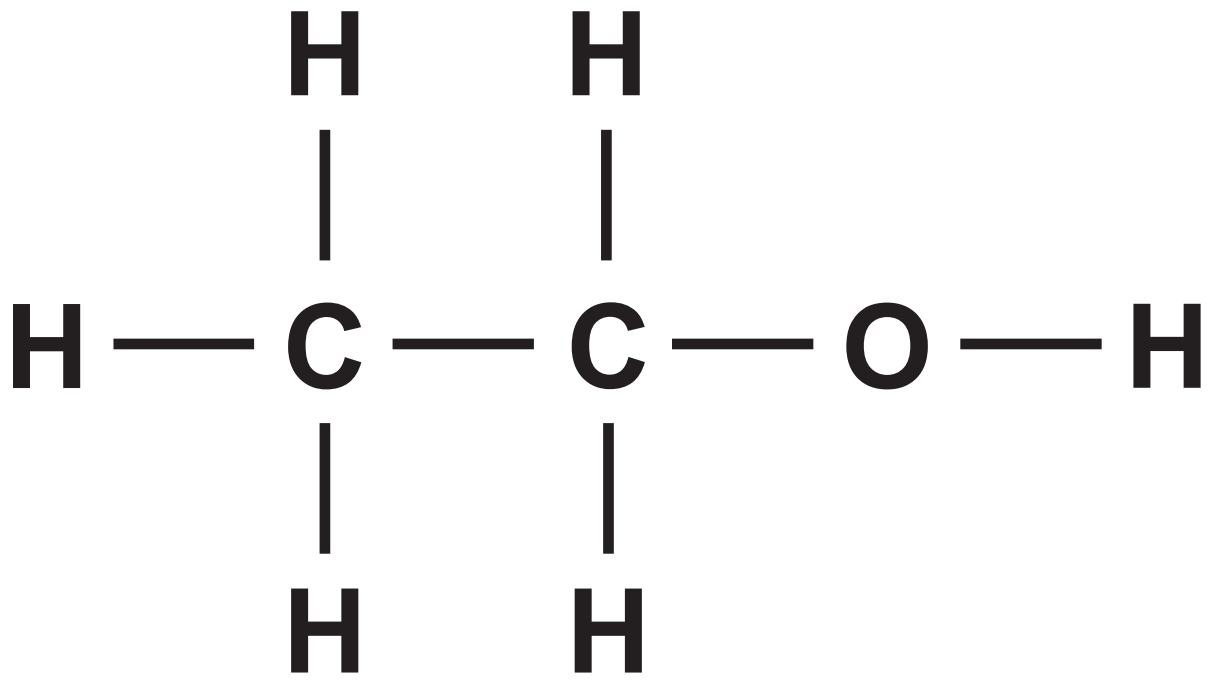
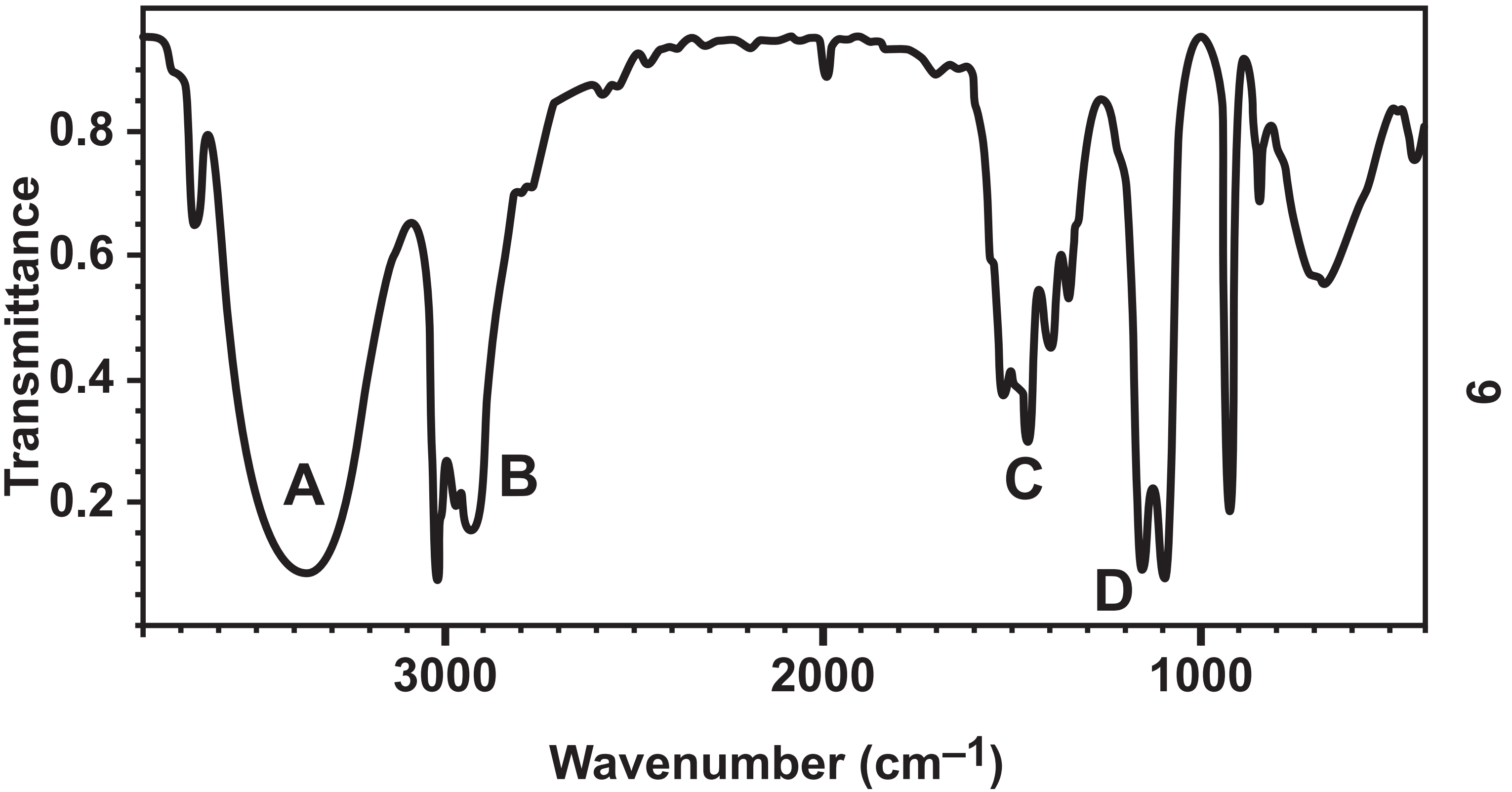


DIAGRAM 10B


Transmittance
0.8
0.6
0.4
0.2
A
B
C
D
3000
2000
1000
Wavenumber (cm−1)
6

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TURN OVER

DIAGRAM 11A

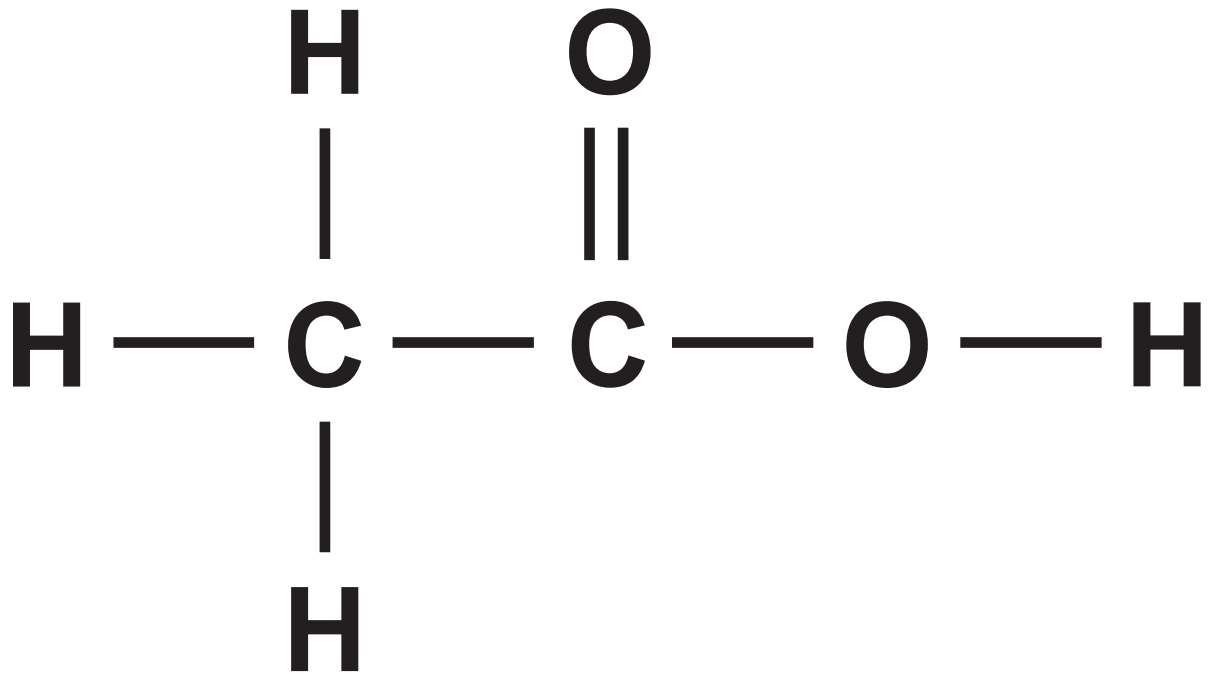
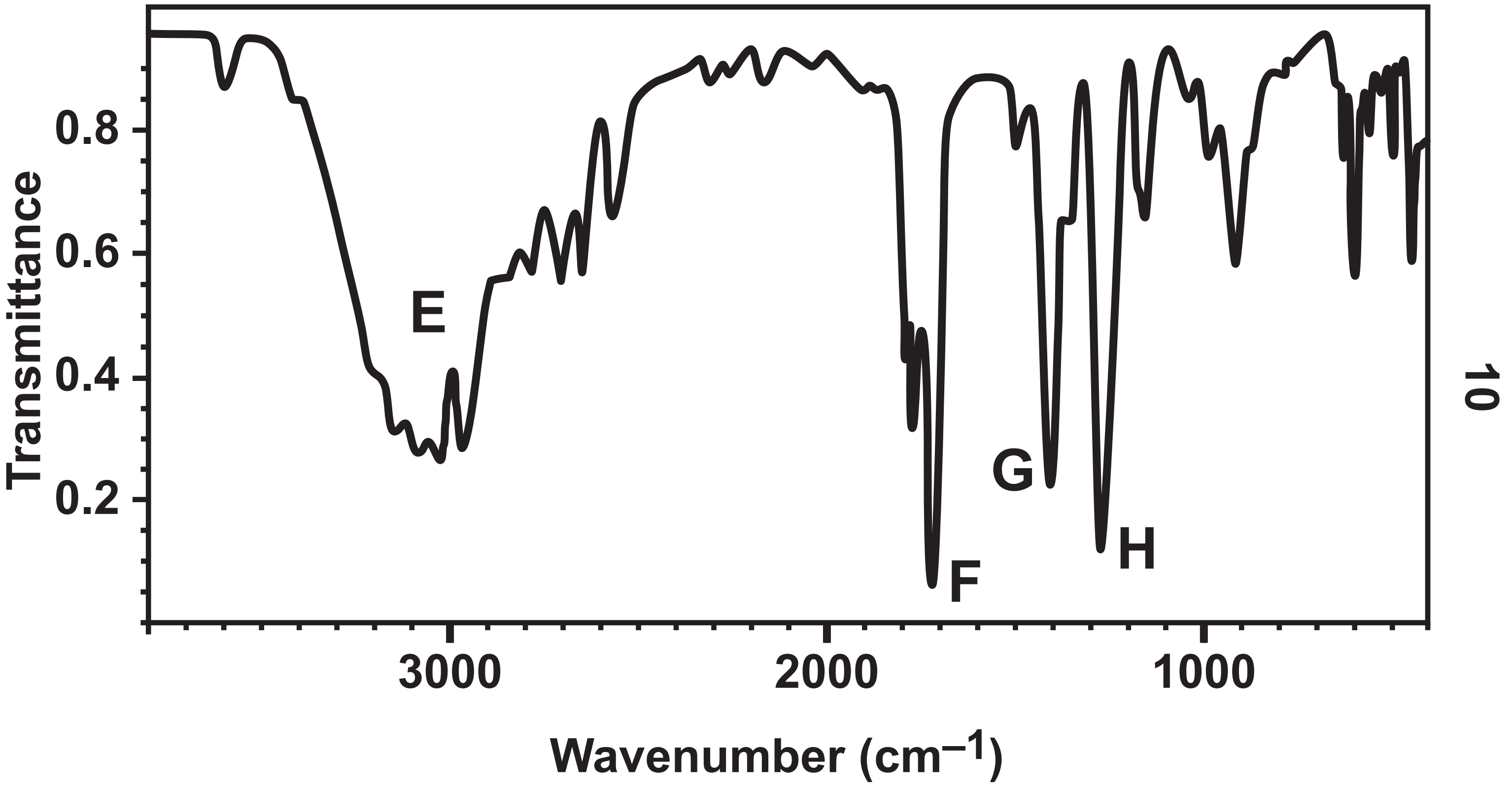


DIAGRAM 11B


Transmittance
0.8
0.6
0.4
0.2
E
F
G
H
3000
2000
1000
Wavenumber (cm^{-1})

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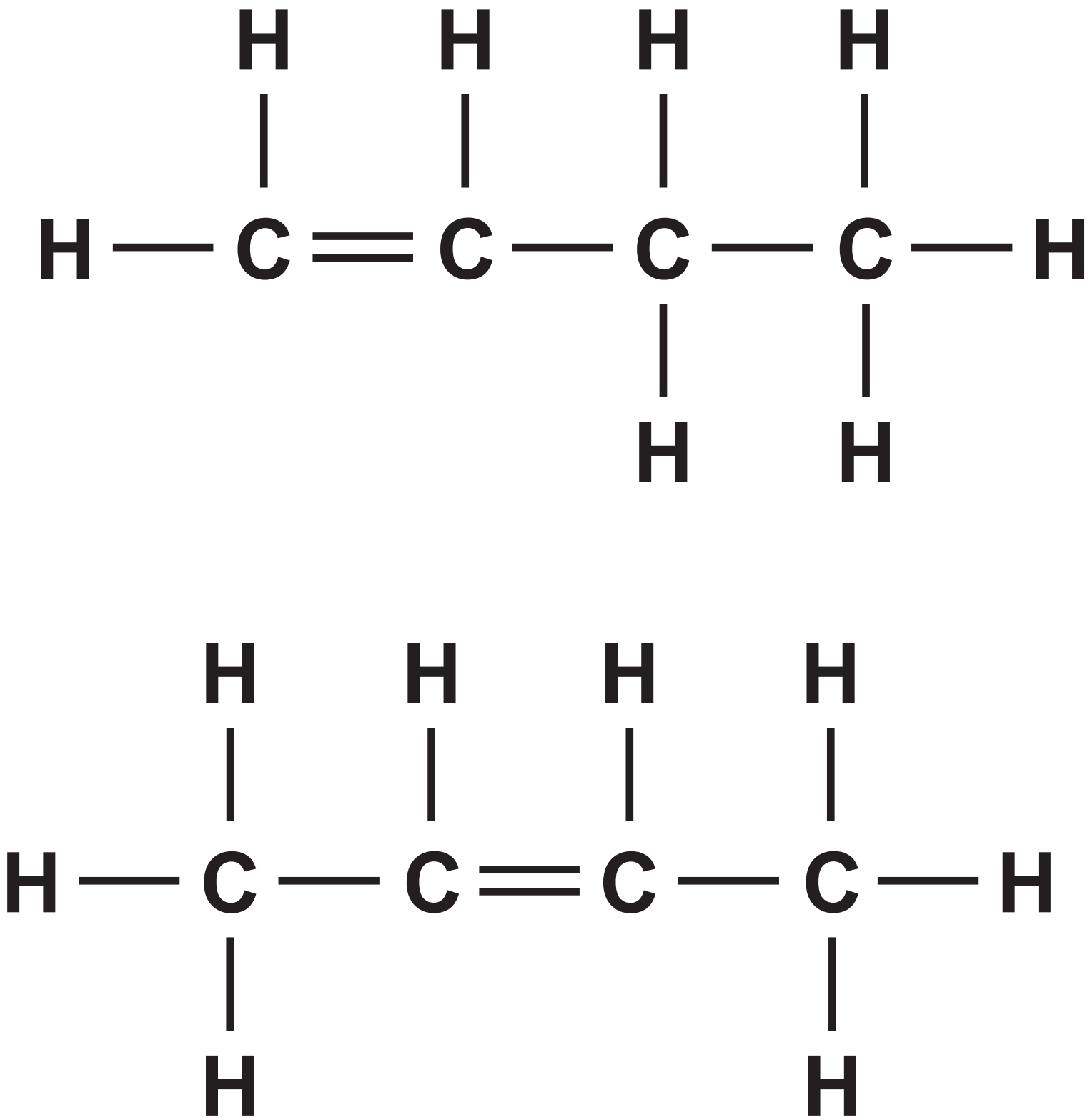
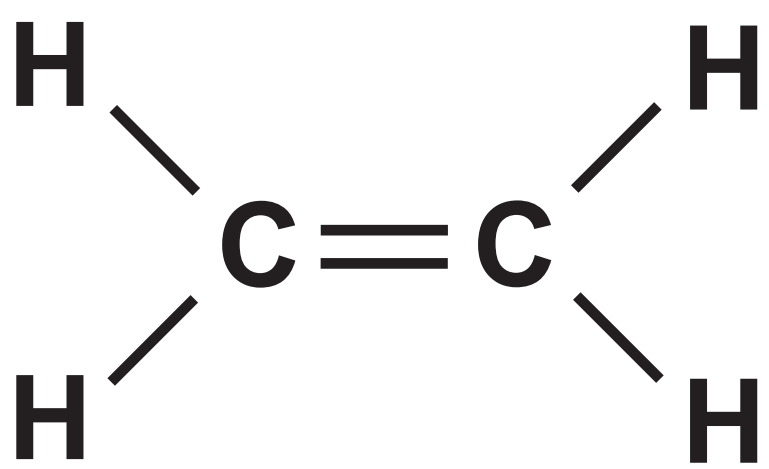
TURN OVER

DIAGRAM 12



Your answer to question 6 (b)

DIAGRAM 13



ethene

repeating unit for polyethene

DIAGRAM 14

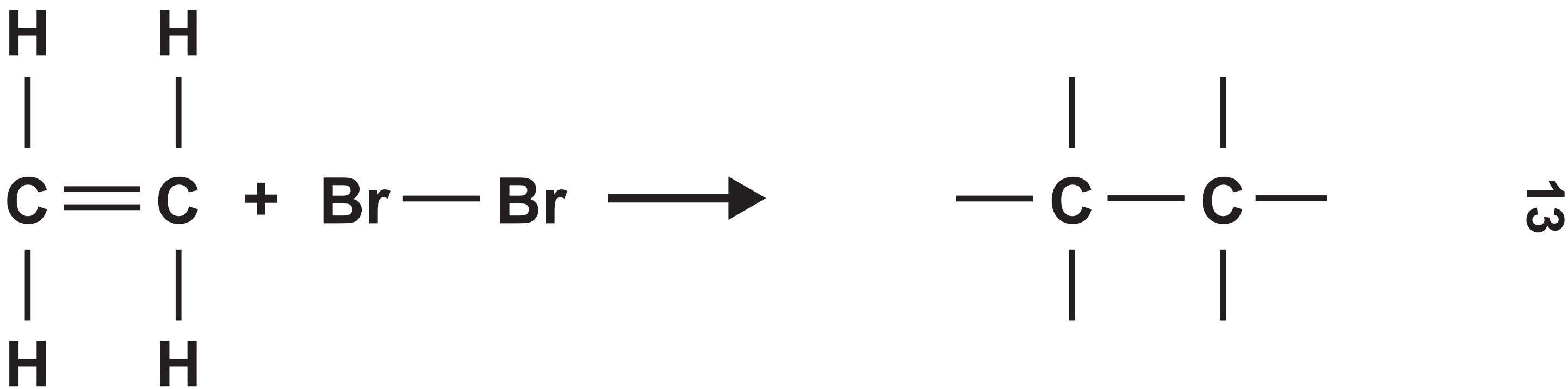


DIAGRAM 15

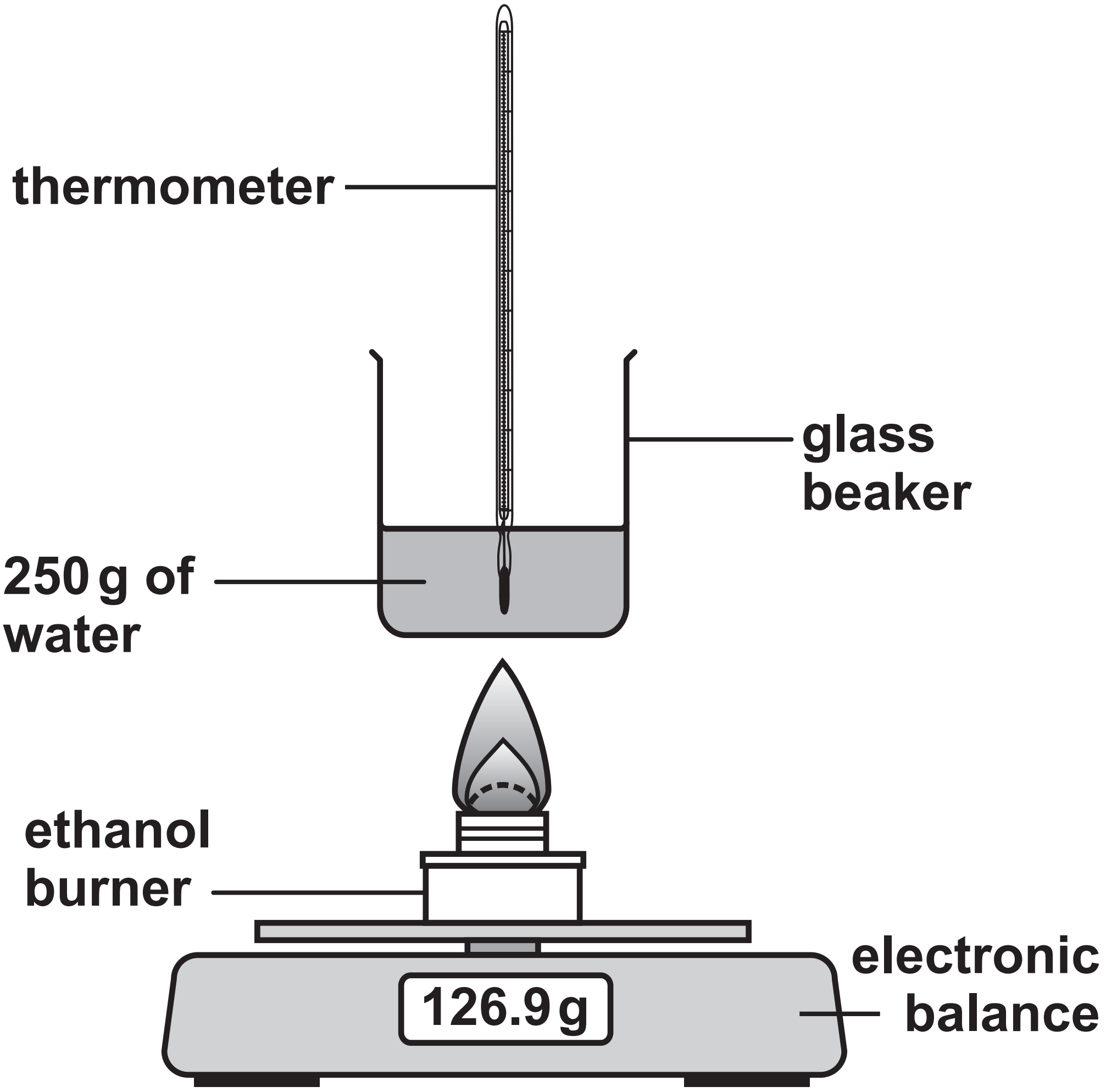

thermometer
glass beaker
250 g of water
ethanol burner
126.9 g
electronic balance

DIAGRAM 16

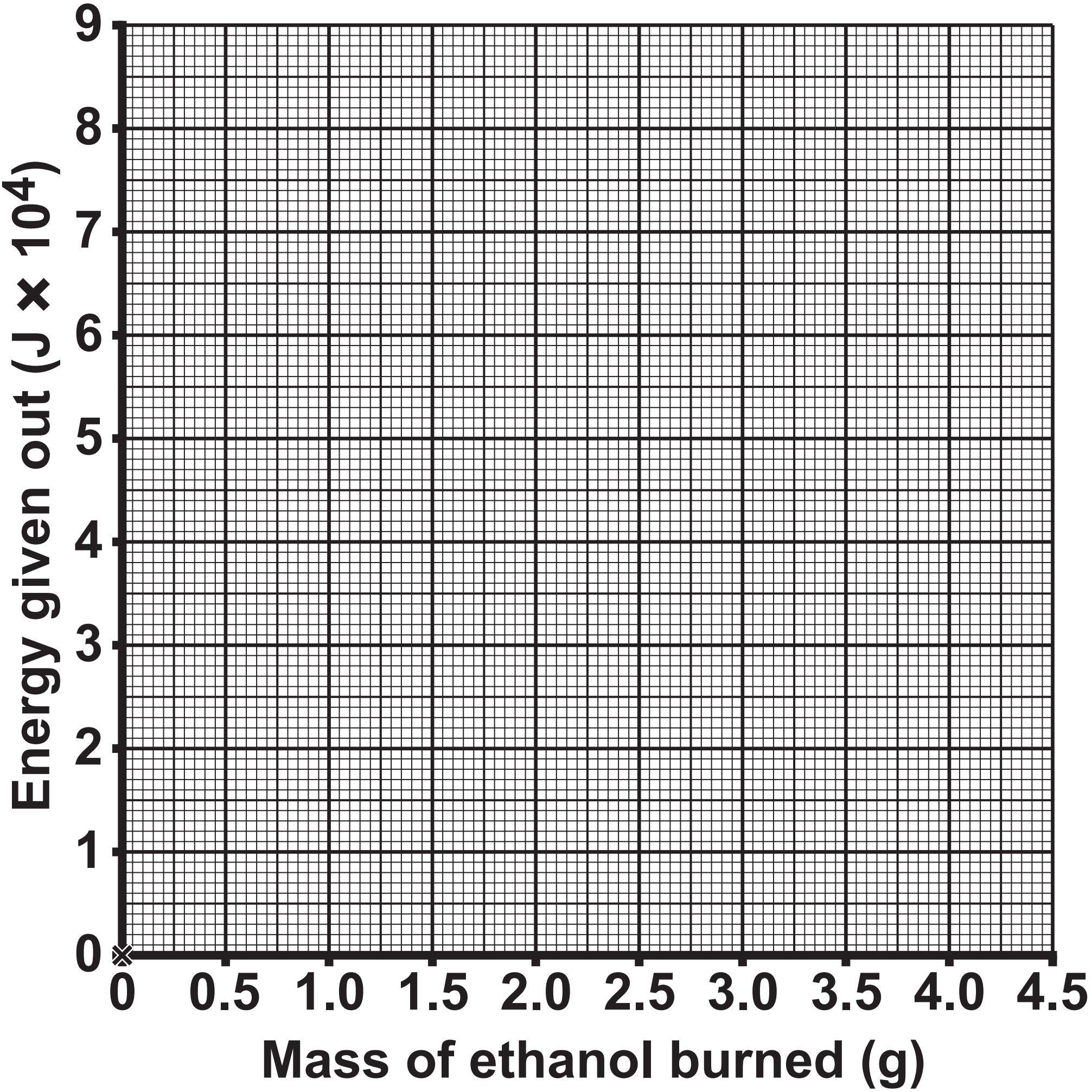

Energy given out (J x 10⁴)
9
8
7
6
5
4
3
2
1
0
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Mass of ethanol burned (g)

DIAGRAM 17

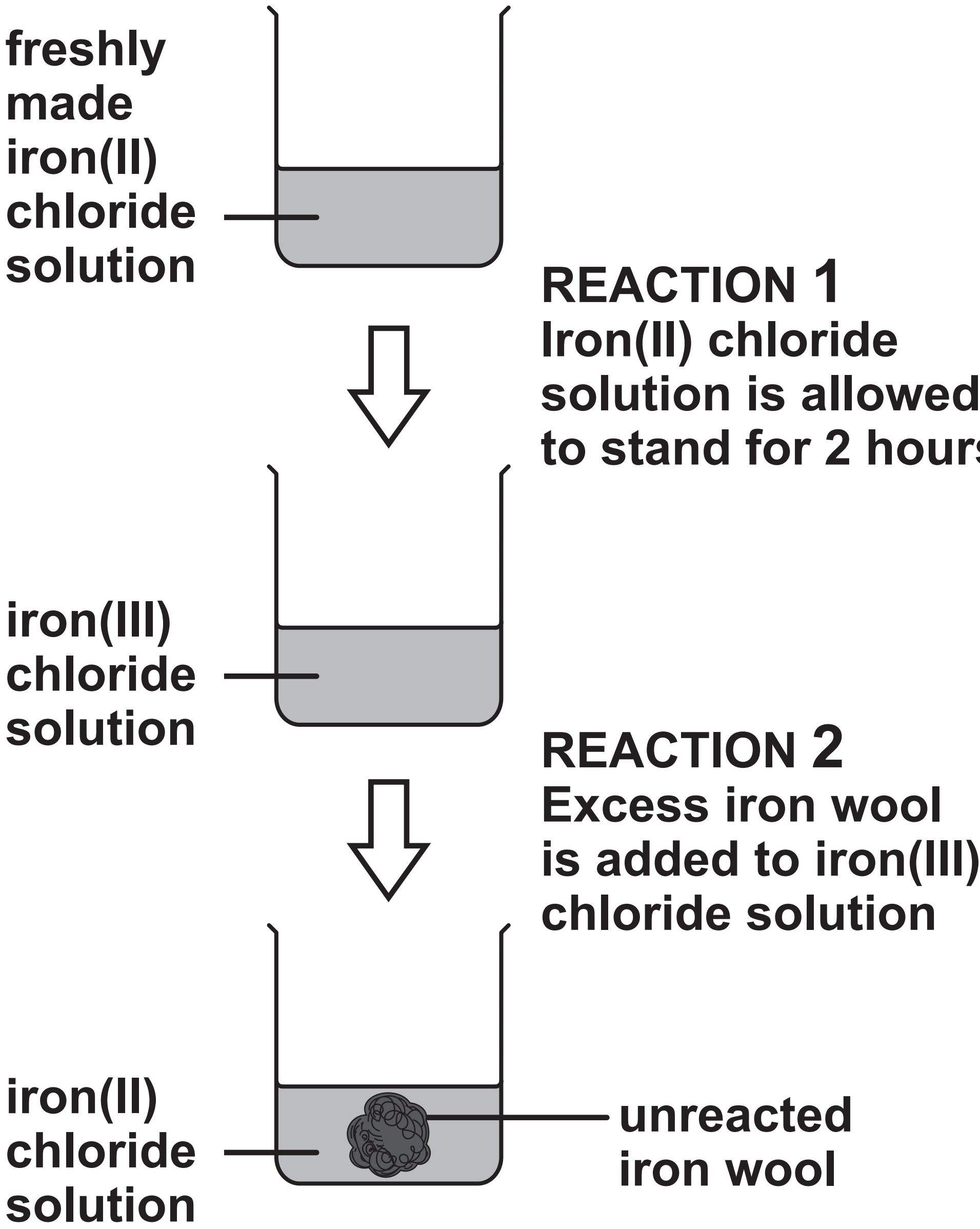

freshly made iron(II) chloride solution
REACTION 1
Iron(II) chloride solution is allowed to stand for 2 hours
iron(III) chloride solution
REACTION 2
Excess iron wool is added to iron(III) chloride solution
iron(II) chloride solution
unreacted iron wool

DIAGRAM 18

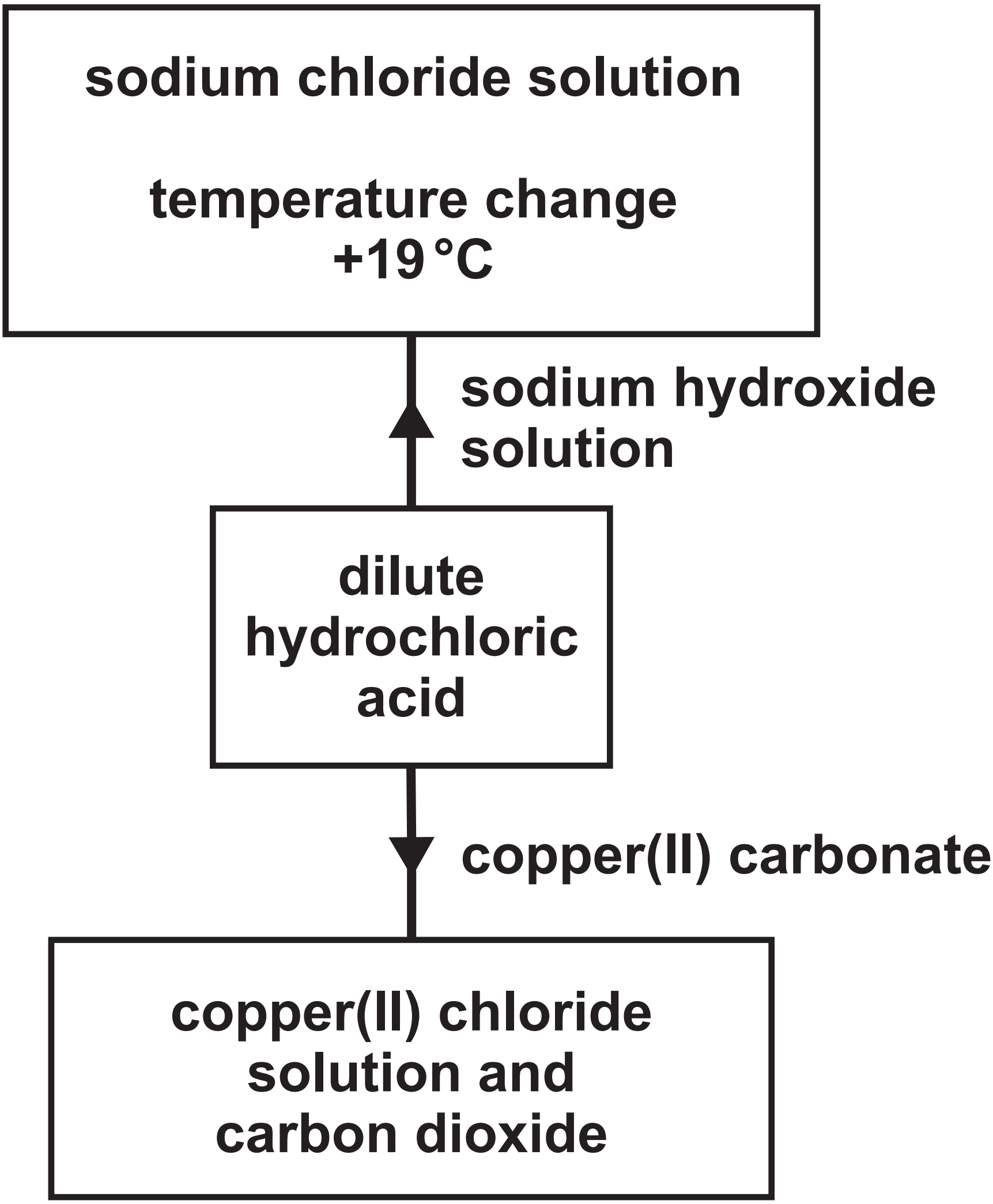
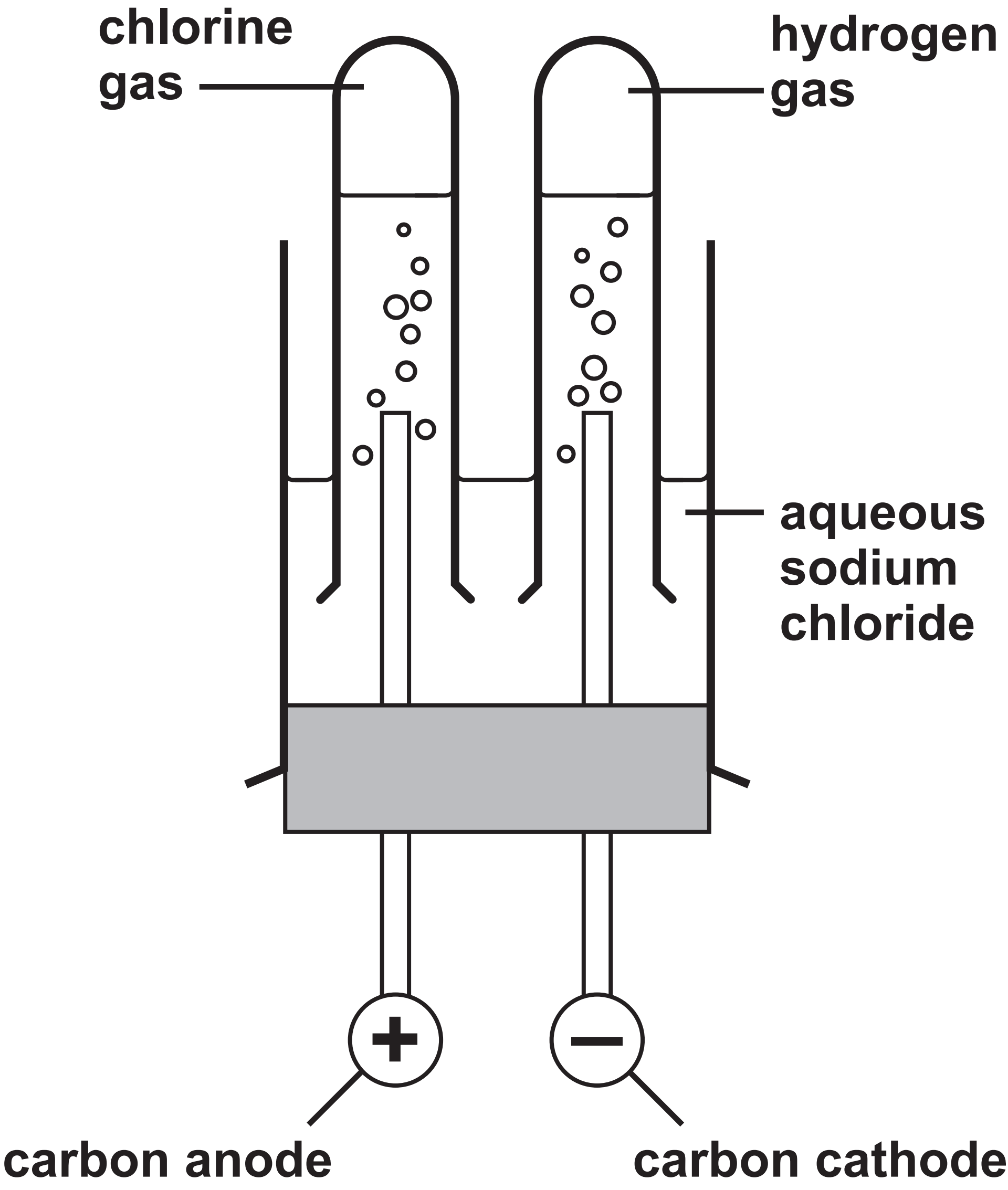

sodium chloride solution
temperature change +19 °C
sodium hydroxide solution
dilute hydrochloric acid
copper(II) carbonate
copper(II) chloride solution and carbon dioxide

DIAGRAM 19


chlorine gas
hydrogen gas
aqueous sodium chloride
carbon anode
carbon cathode