wjec cbac

GCSE

3410UB0-1

THURSDAY, 16 MAY 2019 – 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

____

Other Names

____

Centre Number

____

Candidate Number

0______________________________

ADDITIONAL MATERIALS

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

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 on the previous page.

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 7(c) 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 as a separate insert.

Answer ALL questions.

1 Study the diagram opposite.

A student investigated the temperature rise during a neutralisation reaction.

continued on the following page

1 The student put 25.0 cm^3 of sodium hydroxide solution and 5 drops of universal indicator into a polystyrene cup and recorded the temperature of the alkali. After 10 seconds the student added 25.0 cm^3 of dilute hydrochloric acid to the alkali and recorded the temperature every 5 seconds for another 30 seconds. Graph A opposite shows the results obtained.

(a)(i) Use the graph to find the maximum temperature rise during the reaction. [1]

Temperature rise = ____________________ °C

1 (a)(ii)

The energy given out can be calculated using the formula shown opposite.

Calculate the energy given out during the reaction.
[2]

Energy given out = ______________________ J

1 (a)(iii)

The temperature of the contents in the cup was recorded after 2 hours.

Give the final temperature reading you would expect. Give the reason for your answer. [1]

Final temperature ____________________ °C

Reason

____

____

____

____

1 (b) **The student repeated the experiment using 25.0 cm^3 of ethanoic acid of the same concentration as the hydrochloric acid.**

The table opposite shows the results obtained.

Plot the results on the grid opposite page 4.

Draw a suitable line. Label your graph B. [2]

(c) **Use the graphs to state which of the two acids is the stronger – hydrochloric acid or ethanoic acid.**

Give the reason for your choice. [1]

Acid ______________________________

Reason

____

____

____

____

1 (d) The temperature rises in both experiments were much LOWER than expected. The student suggested that using a temperature sensor instead of a thermometer would give temperature rises closer to the expected values.

(i) State why using a temperature sensor would still give a lower than expected temperature rise. [1]

1 (d)(ii)

What improvement to the apparatus would you suggest to the student to obtain temperature rises closer to the expected values? [1]

9

2 **The diagram opposite shows three reactions which are used to prepare soluble salts.**

(a)(i) Name compound A. [1]

____

(ii) Give the names of blue solution B and gas C formed in reaction 3. [2]

blue solution B ______________________________

gas C ______________________________

(b) Write the balanced symbol equation for reaction 1. [2]

____

2 (c) Reaction 1 was repeated using magnesium instead of zinc.

Explain the difference, if any, that you would expect to see. [2]

7

3 **The tables opposite show the molecular formulae of some alkanes and alkenes.**

(a) **The general formula for the alkene family is C_nH_{2n}.**

Give the general formula for the alkane family. **[1]**

____

(b) **When alkanes and alkenes completely burn in air they form the same two products.**

Give the chemical formulae for both products. **[1]**

______________ **and** ______________

3 (c) Draw the structural formula for propene. [1]

(d) Bromine water is used to distinguish alkenes from alkanes. Describe the colour CHANGE seen when bromine water is added to an alkene. [1]

4

4 (a) **The diagram opposite shows apparatus that can be used for the electrolysis of sodium chloride solution.**

(i) **Explain why hydrogen, and NOT sodium, is formed at the cathode. [1]**

____

____

____

____

____

____

(ii) **Complete the electrode equation for the reaction at the anode. [1]**

$2Cl^- \longrightarrow Cl_2 + $ ____________

4 (a)(iii)

Explain why the universal indicator turns purple during electrolysis. [2]

4 (b) **The diagram opposite shows the electrolysis of copper(II) sulfate solution.**

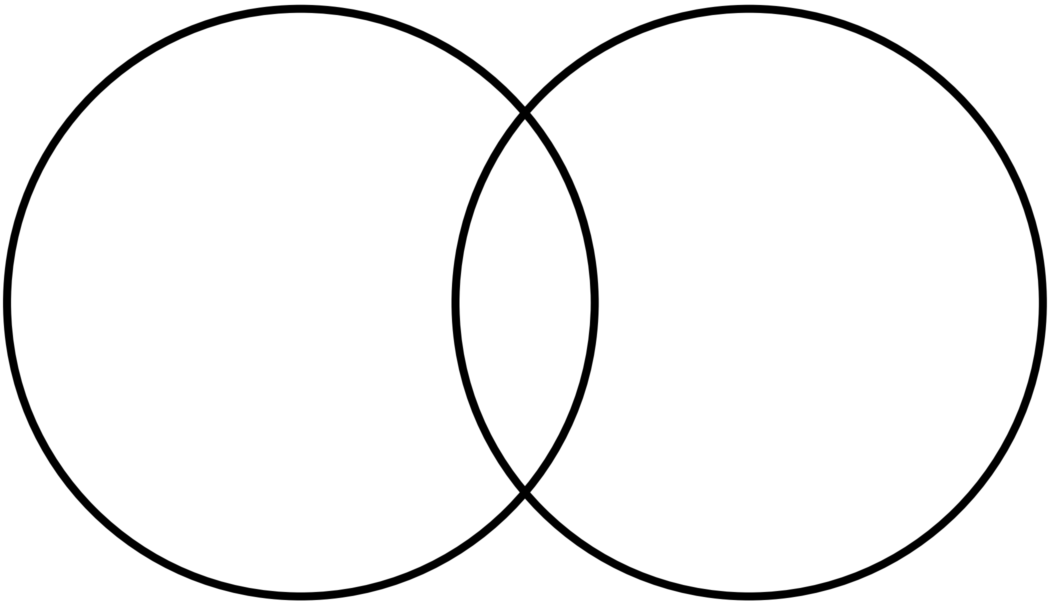
(i) **Explain, using the reaction occurring at the cathode, the meaning of the term reduction.** **[1]**

(ii) **Over time the electrolyte turns from blue to colourless. State the change you would make to the apparatus so that the electrolyte remains blue during the process.**

Give a reason for your answer. **[2]**

4 (b)(iii)

The electronic structure of oxygen is (2,6). Complete the diagram showing the outer shell electrons in an oxygen molecule, O_2. [2]



9

5 **Study the diagram opposite.**

(a) Smart materials are used to make the frames and lenses of certain spectacles.

Give the names of the different types of smart material used. Describe the unusual property of each. [2]

Frames

Lenses

5 (b) **Titanium dioxide has been used in sun creams for decades. Sun screens available today use nano-scale titanium dioxide particles. Some people believe using creams containing nano-particles is unsafe.**

(i) **Give the advantage of using nano-scale titanium dioxide particles rather than larger titanium dioxide particles to make sun screens. [1]**

5 (b)(ii)

Explain why some people are concerned about the use of nano-scale titanium dioxide particles in sun screens. [2]

5 (b)(iii)

APPROXIMATELY how many times bigger are common titanium dioxide particles (3×10^{-7} m) than nano-scale titanium dioxide particles (2.5×10^{-10} m)? [2]

Answer = ______________________________

7

6 (a) **Study the diagram opposite.**

Iron is extracted from its ore in the blast furnace.

Use information from the diagram and your knowledge to answer parts (i) and (ii).

(i) **Write a balanced symbol equation for reaction 2. [2]**

(ii) **Describe the two-stage process to form slag. [3]**

6 (b) **Iron(III) oxide reacts with dilute hydrochloric acid forming iron(III) chloride and water.**

(i) **Balance the symbol equation for this reaction on the opposite page. [1]**

(ii) **Sodium hydroxide solution can be used to detect the presence of aqueous iron(III) ions.**

The symbol equation below represents the reaction occurring between solutions of sodium hydroxide and iron(III) chloride.

$$3NaOH(aq) + FeCl_3(aq) \longrightarrow 3NaCl(aq) + Fe(OH)_3(s)$$

Write the IONIC equation for the formation of the precipitate. [2]

____

____

6 (c) Study the diagram opposite.

STEEL MANUFACTURE IN THE UK

One of the major steelmaking processes used today in the UK is the Basic Oxygen Furnace, BOF. The raw materials for the BOF are cast iron from a blast furnace and scrap steel.
Oxygen (>99.5% pure) is "blown" into the BOF at supersonic speed. The impurities are oxidised producing great quantities of heat which melts the scrap steel.

Steel can be described in general terms as iron containing small amounts of carbon, to make it tougher and more ductile. There are many types of steel, each with its own specific chemical composition and properties to meet the needs of the many different applications.

continued on the following page

FIGURE 1 opposite shows the relationships between the carbon content of steel and its ductility, tensile strength and hardness.

DUCTILITY is a material's ability to be pulled into a wire.

TENSILE STRENGTH is a measurement of the force required to pull something such as wire to the point where it breaks.

HARDNESS is a measure of how resistant a material is to permanent shape change when a compressive force is applied.

FIGURE 2 opposite shows the percentage of carbon in various alloys of iron.

6 (c)(i)

Tick (✓) the box next to the statement which best describes one way that production costs are reduced. [1]

high purity oxygen is used ☐

impurities are oxidised forming heat ☐

oxygen is blasted in at supersonic speed ☐

scrap steel is used in the process ☐

6 (c)(ii)

Tick (✓) the box next to the statement which best describes the effect of increasing the percentage of carbon in steel from 0 % to 0.45 %. [1]

ductility increases, hardness increases ☐

tensile strength increases, ductility increases ☐

ductility decreases, tensile strength increases ☐

hardness increases, tensile strength decreases ☐

6 (c)(iii)

A steel manufacturer wants to design an alloy with a high tensile strength but low ductility.

Tick (✓) the box next to the approximate value for the percentage of carbon that should be included. **[1]**

0.2 ☐

0.6 ☐

1.0 ☐

1.5 ☐

6 (c)(iv)

Name the alloy which is the most easily pulled into a wire and withstands the least compressive force.
[1]

____

12

7 The flow diagram opposite outlines the manufacture of ammonia by the Haber Process followed by the production of ammonium sulfate by neutralisation.

(a) Explain the choice of temperature used in the Haber Process and the reason why a catalyst is used. [3]

7 (b) **Powdered ammonium sulfate is industrially formed by spraying sulfuric acid into a reaction chamber filled with ammonia gas.**

The exothermic reaction that occurs evaporates all water present in the system, forming a powdery salt.

Write a balanced symbol equation for this reaction. [2]

7 (c) In the laboratory ammonium sulfate is prepared by reacting ammonium hydroxide solution with dilute sulfuric acid.

Describe the titration method for making pure crystals of ammonium sulfate in the laboratory.

Explain each stage of your method. [6 QER]

11

8 **Methanol, ethanol and butanol all belong to the homologous series of alcohols.**

(a) **The table opposite shows information about two different methods for the manufacture of ethanol.**

Use the information in the table and your knowledge to answer the following question.

Explain TWO advantages and TWO disadvantages of method A compared with method B. [4]

Advantages

1. ____

____

____

____

2. ____

____

____

____

continued on the following page

Disadvantages

1. ____

____

____

____

2. ____

____

____

____

8 (b) **Ethanol is found in alcoholic drinks. Alcoholic drinks turn sour when left exposed to air because ethanol is oxidised to ethanoic acid and water.**

Complete the balanced symbol equation for this reaction. [1]

$C_2H_5OH + O_2 \longrightarrow$ ______________________________

8 (c) **Methanol readily burns in air. The diagram opposite shows the bonds which are broken and the bonds which are formed during the combustion of methanol.**

Some relevant bond energies are shown in the table.

Bond	Bond energy (kJ)
C — H	413
C — O	358
C ═ O	805
O — H	464

8 (c)(i)

The total energy needed to break all the bonds in the reactants is 5616 kJ. The energy needed to break the bonds in one molecule of methanol is 2061 kJ.

Use this information to calculate the amount of energy needed to break ONE O═O bond. [2]

Energy needed = ____________________________ kJ

8 (c)(ii)

Calculate the total energy released when all the bonds in the products are formed. [2]

Energy released = ______________________ kJ

The burning of methanol gives out heat and is said to be exothermic. Use the total energy value 5616 kJ and your answer to part (ii) to show that this is correct. [1]

8 (c)(iv)

On the axes opposite draw the energy profile for the combustion of methanol and use the symbol (↕) to show the activation energy for the reaction. [1]

8 (d) Butanol has the molecular formula C_4H_9OH.

It has four positional isomers, **A**, **B**, **C** and **D** shown opposite.

Give the LETTER of the isomer corresponding to each of the names in the table. [2]

Name	Isomer
butan-1-ol	
butan-2-ol	
2-methylpropan-1-ol	
2-methylpropan-2-ol	

13

9 (a) **A student carries out a series of chemical tests on solutions of three unknown compounds, A, B and C.**

Her results are recorded in the table opposite.

Use the information provided to give the CHEMICAL NAME for each of the compounds. **[3]**

Compound A ______________________________

Compound B ______________________________

Compound C ______________________________

9 (b) **A technician wants to prepare 250 cm^3 of a 0.25 mol / dm^3 solution of lead nitrate, $Pb(NO_3)_2$.**

(i) **Calculate the number of moles of lead nitrate required to make the solution. [2]**

Number of moles = ____________________ mol

9 (b)(ii)

Calculate the mass of solid lead nitrate that should be dissolved to make the solution. [2]

A_r(Pb) = 207 A_r(O) = 16 A_r(N) = 14

Mass = ______________________ g

9 (b)(iii)

The only electronic balance available to the technician has a precision of ± 0.01 g.

Exactly how much lead nitrate should the technician weigh out to ensure that the concentration of the solution is as close as possible to 0.25 mol / dm^3? [1]

Mass ______________________________ g

8

END OF PAPER

QUESTION NUMBER	ADDITIONAL PAGE, IF REQUIRED. WRITE THE QUESTION NUMBER(S) IN THE LEFT-HAND MARGIN.

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For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1	9	
2	7	
3	4	
4	9	
5	7	
6	12	
7	11	
8	13	
9	8	
Total	80	

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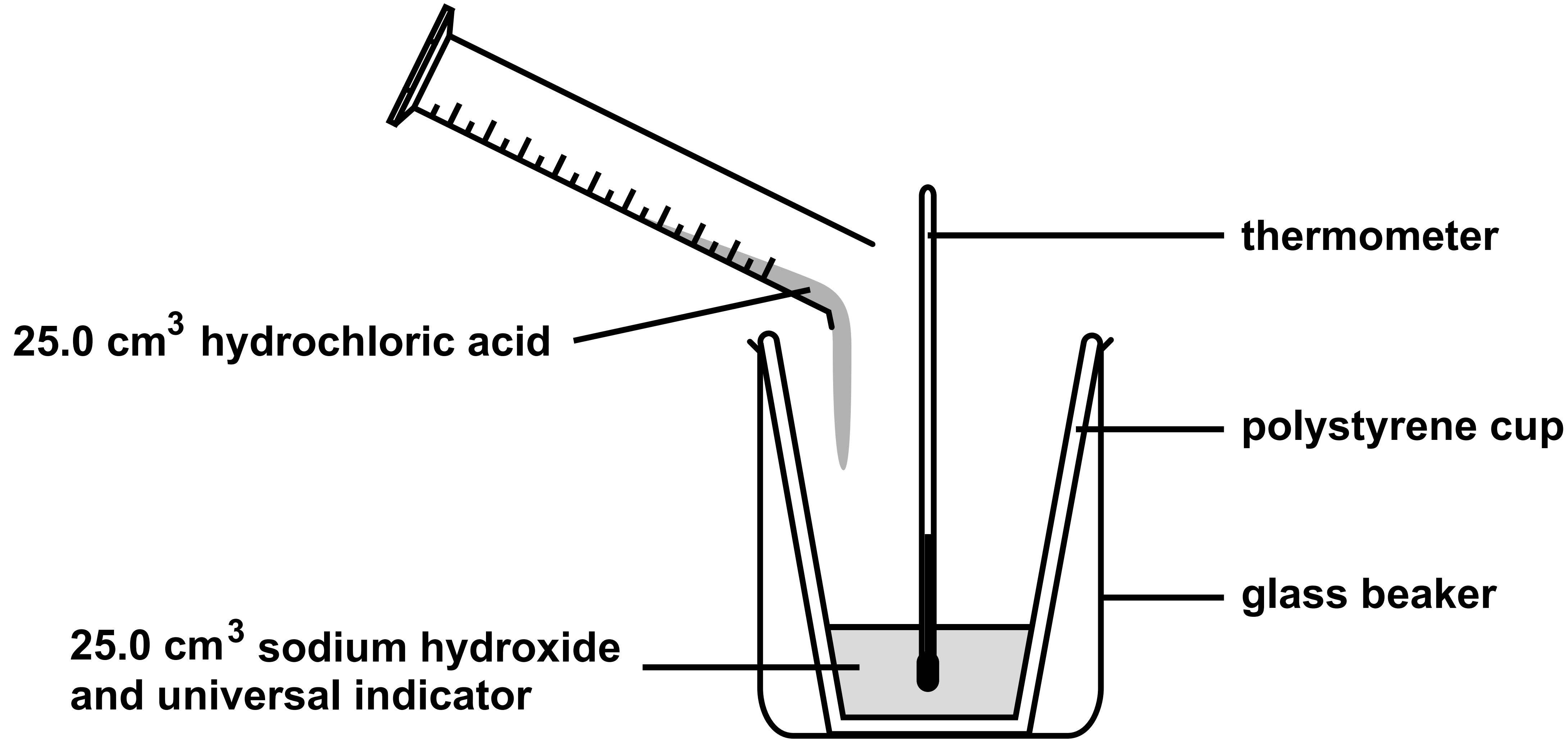
Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

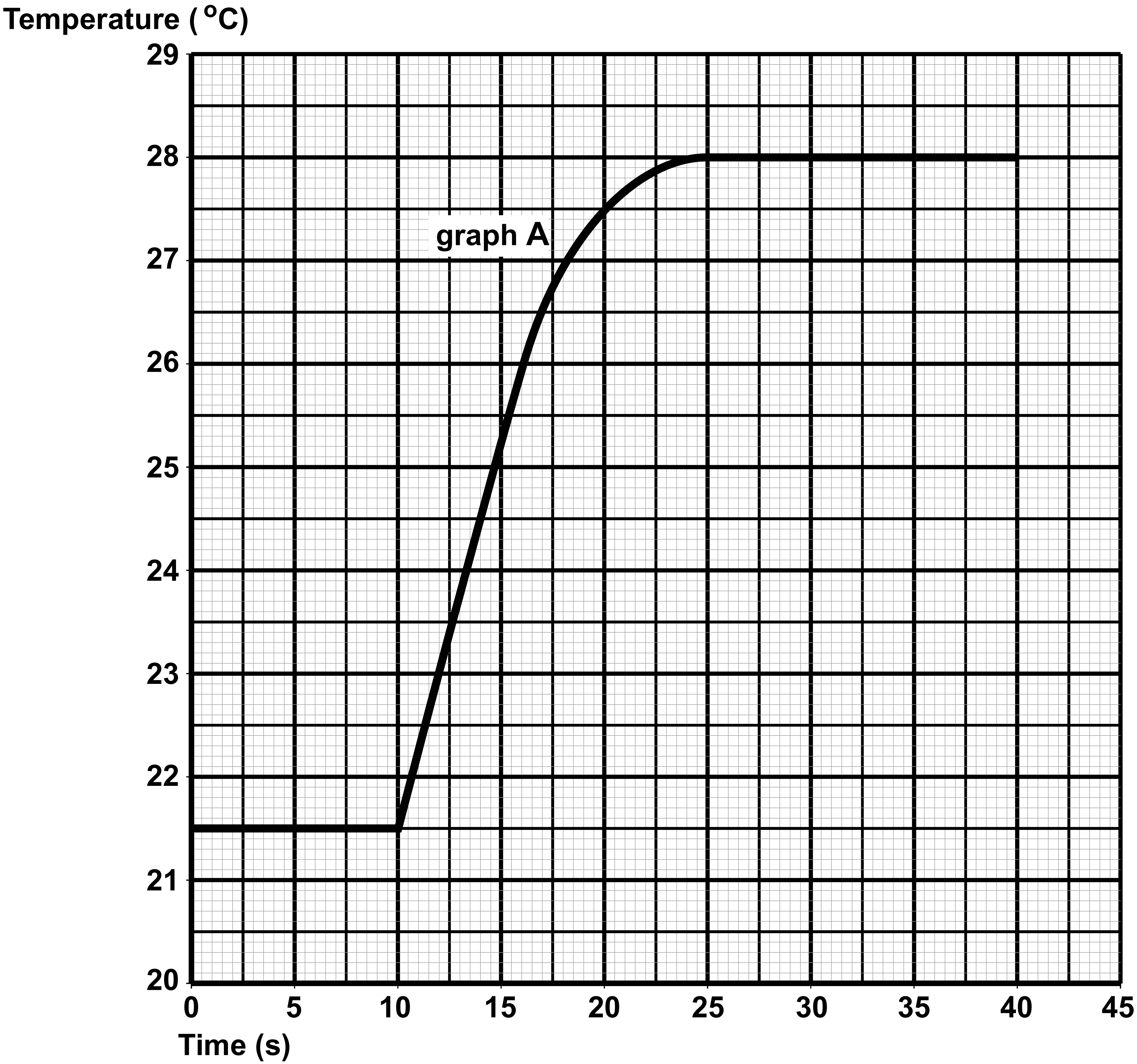
HIGHER TIER

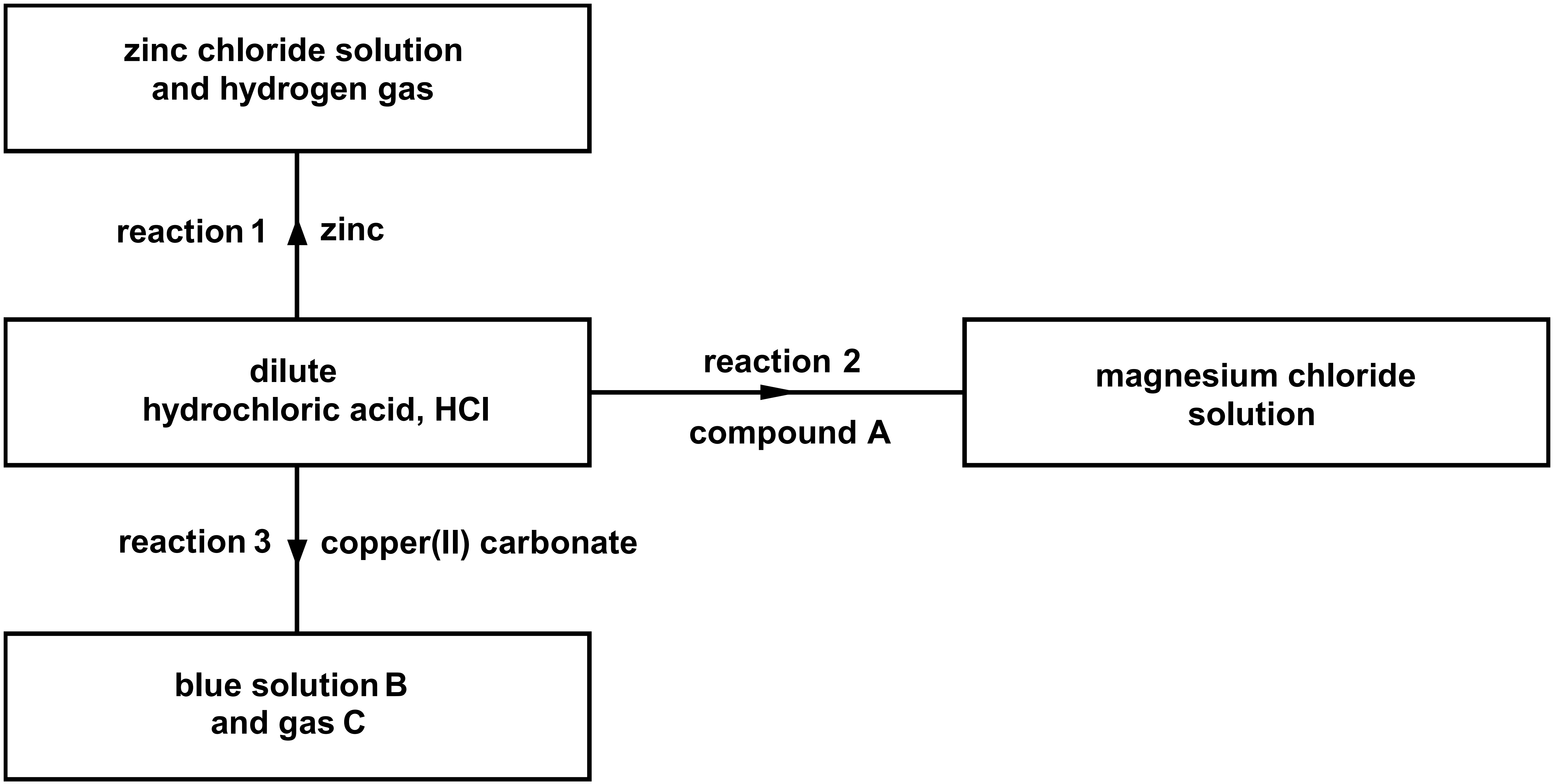
INSERT

Time (s)	0	5	10	15	20	25	30	35	40
Temperature (°C)	21.5	21.5	21.5	24.0	26.0	26.9	27.0	27.0	27.0


thermometer
25.0 cm3 hydrochloric acid
polystyrene cup
glass beaker
25.0 cm3 sodium hydroxide and universal indicator

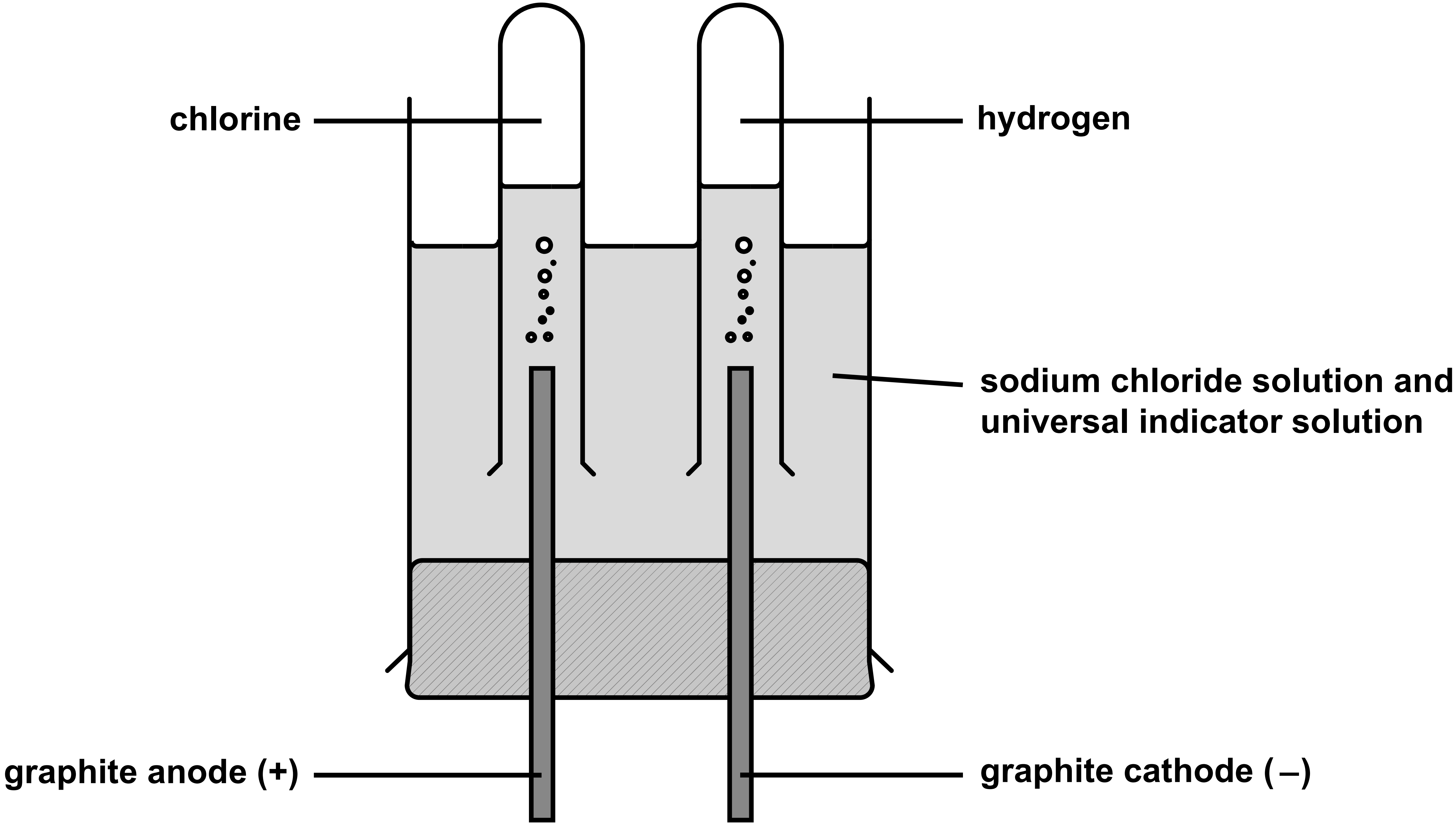
energy given out = TOTAL volume of reaction mixture × 4.2 × temperature rise

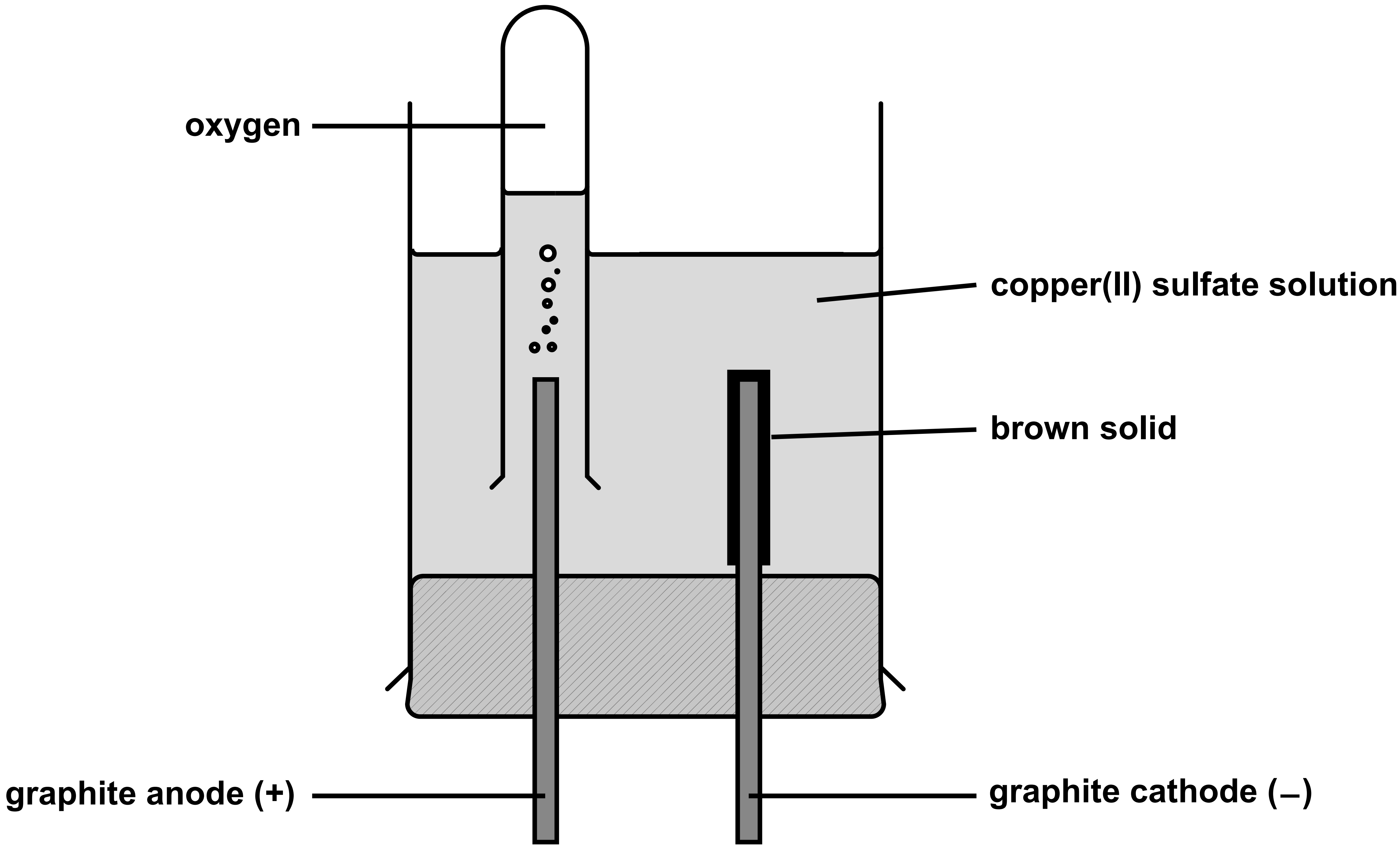

Temperature (°C)
29
28
27
26
25
24
23
22
21
20
graph A
0
5
10
15
20
25
30
35
40
45
Time (s)


zinc chloride solution and hydrogen gas
reaction 1
zinc
dilute hydrochloric acid, HCl
reaction 2
compound A
magnesium chloride solution
reaction 3
copper(II) carbonate
blue solution B and gas C

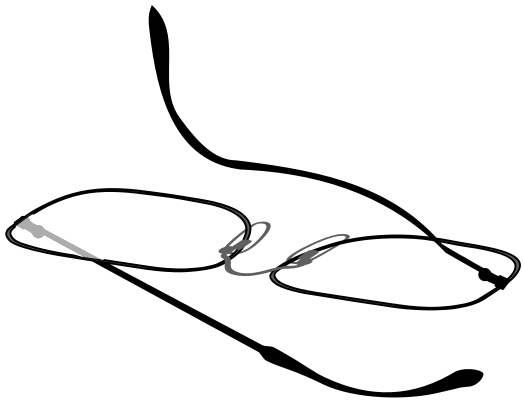
Alkanes
CH_4
C_2H_6
C_3H_8
C_4H_{10}

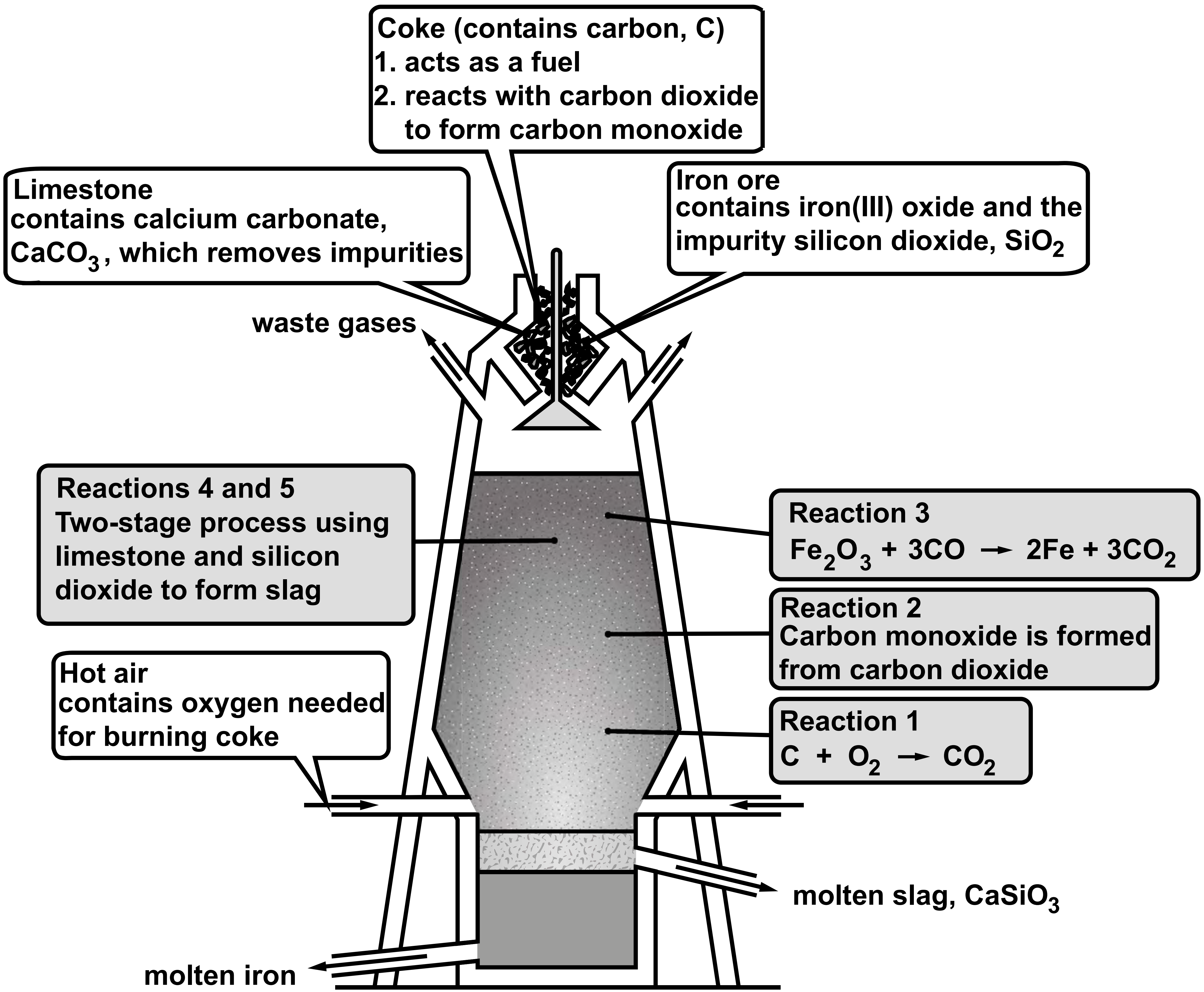
Alkenes
C_2H_4
C_3H_6


chlorine
hydrogen
sodium chloride solution and
universal indicator solution
graphite anode (+)
graphite cathode (–)



oxygen
copper(II) sulfate solution
brown solid
graphite anode (+)
graphite cathode (–)



Coke (contains carbon, C)
1. acts as a fuel
2. reacts with carbon dioxide to form carbon monoxide
Limestone
contains calcium carbonate, $CaCO_3$, which removes impurities
Iron ore
contains iron(III) oxide and the impurity silicon dioxide, SiO_2
waste gases
Reactions 4 and 5
Two-stage process using limestone and silicon dioxide to form slag
Reaction 3
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
Reaction 2
Carbon monoxide is formed from carbon dioxide
Hot air
contains oxygen needed for burning coke
Reaction 1
$C + O_2 \rightarrow CO_2$
molten slag, $CaSiO_3$
molten iron

$$Fe_2O_3(s) + \square\, HCl(aq) \longrightarrow \square\, FeCl_3(aq) + \square\, H_2O(l)$$

BASIC OXYGEN FURNACE

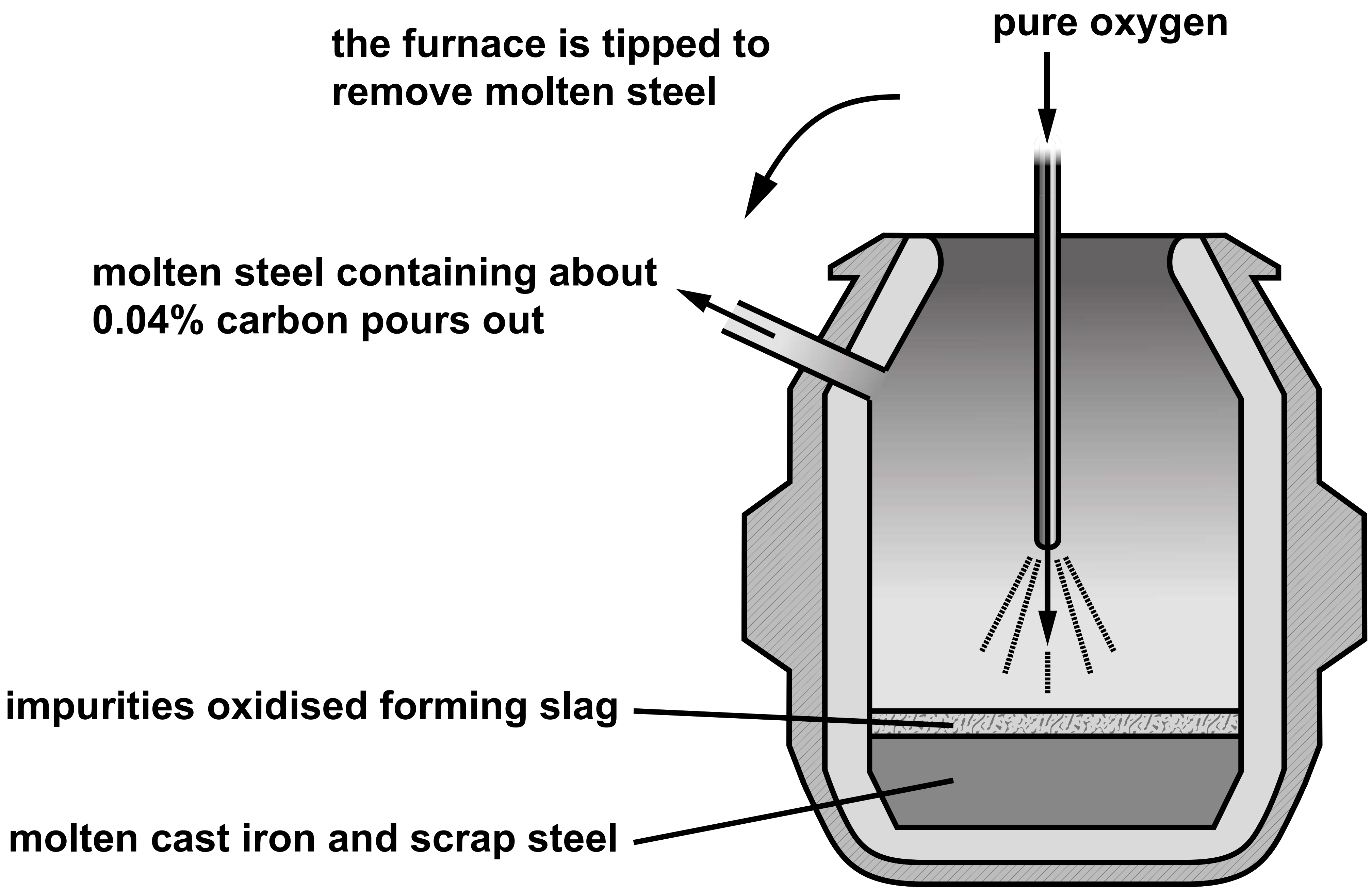


FIGURE 1

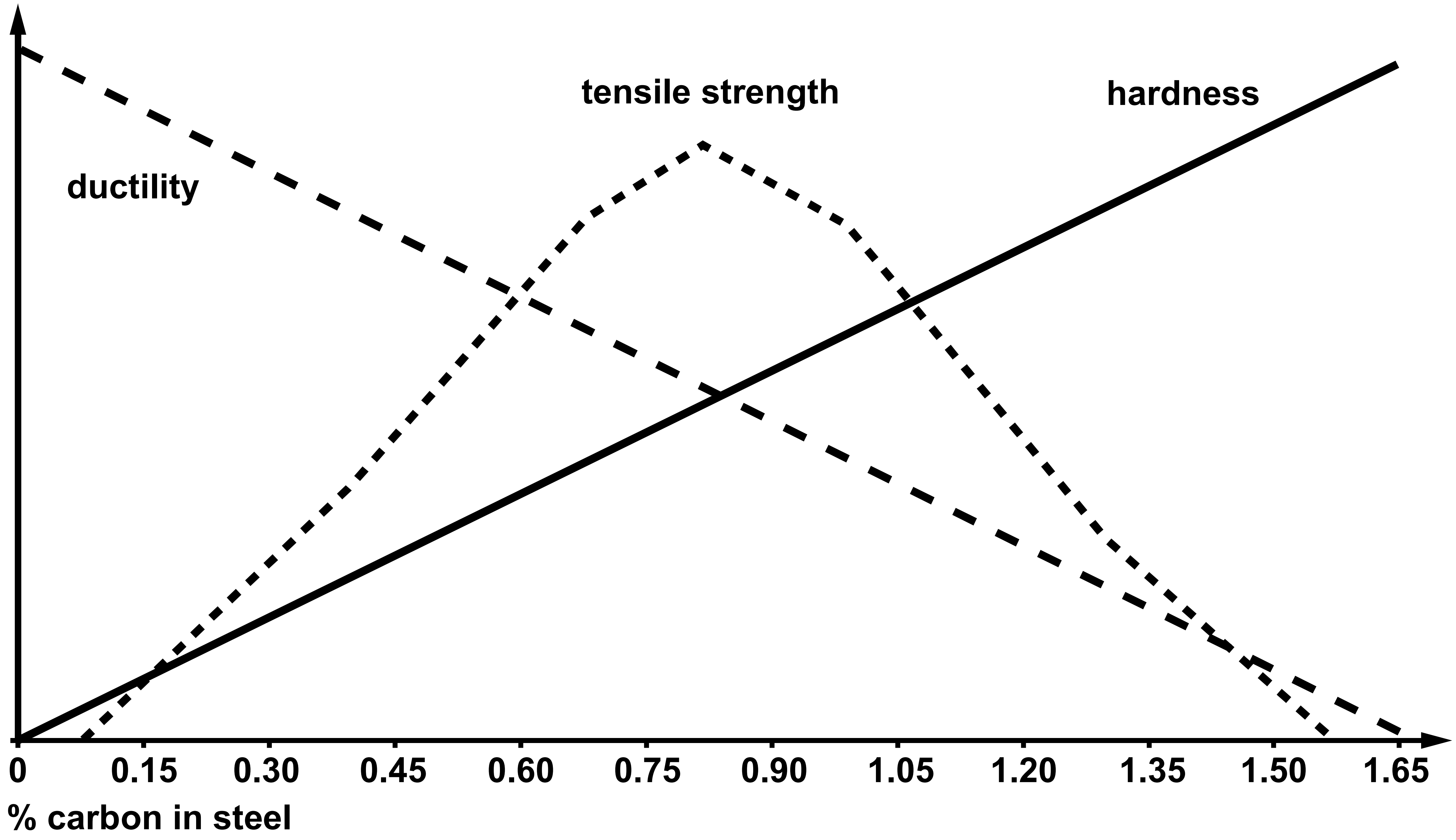
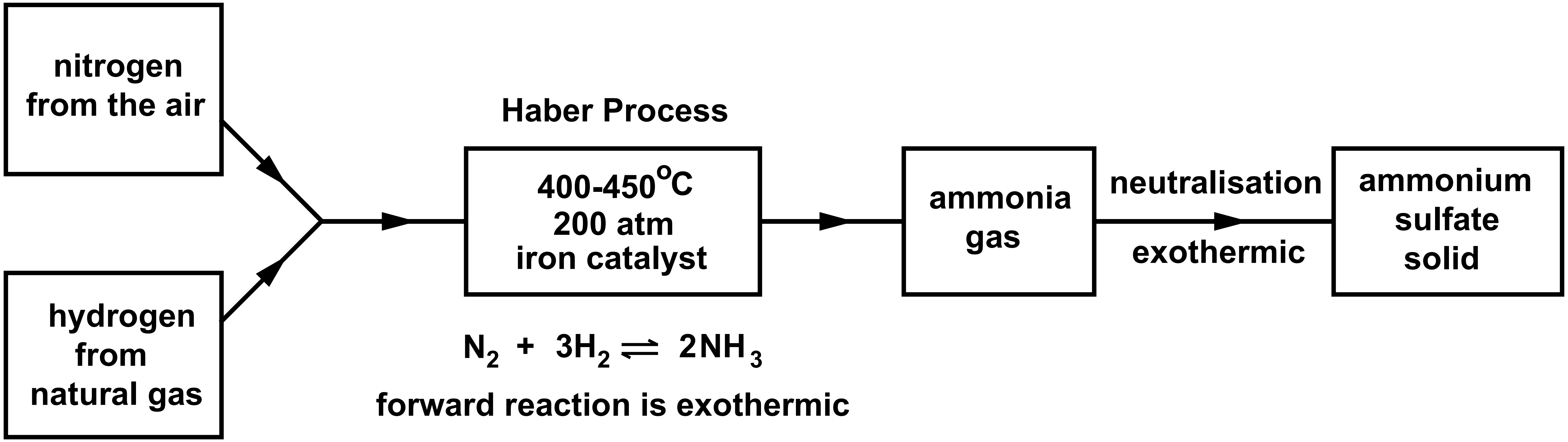
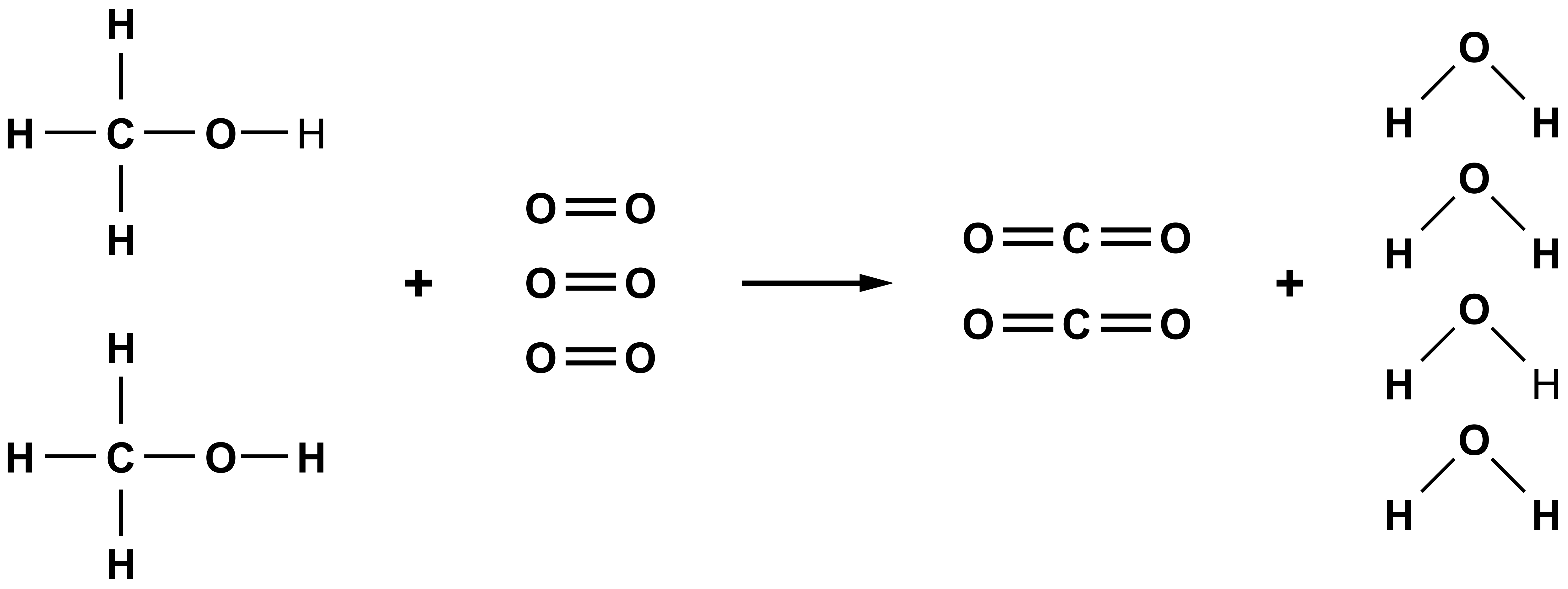

tensile strength
hardness
ductility
0
0.15
0.30
0.45
0.60
0.75
0.90
1.05
1.20
1.35
1.50
1.65
% carbon in steel

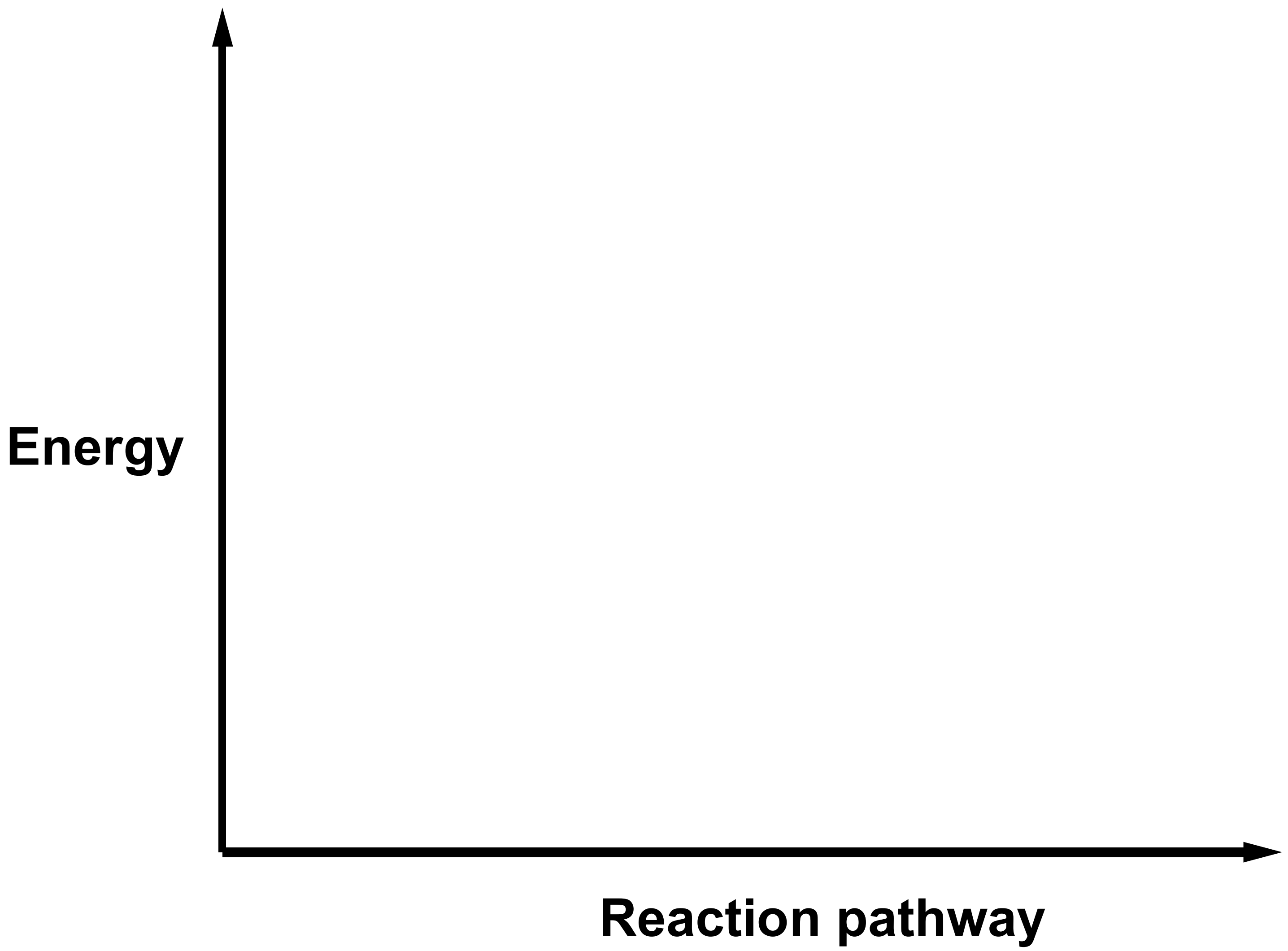
FIGURE 2

Name of alloy	Percentage of carbon
low carbon steel	0.0 – 0.6 %
medium carbon steel	0.6 – 0.8 %
high carbon steel	0.8 – 1.3 %
very high carbon steel	1.3 – 1.6 %

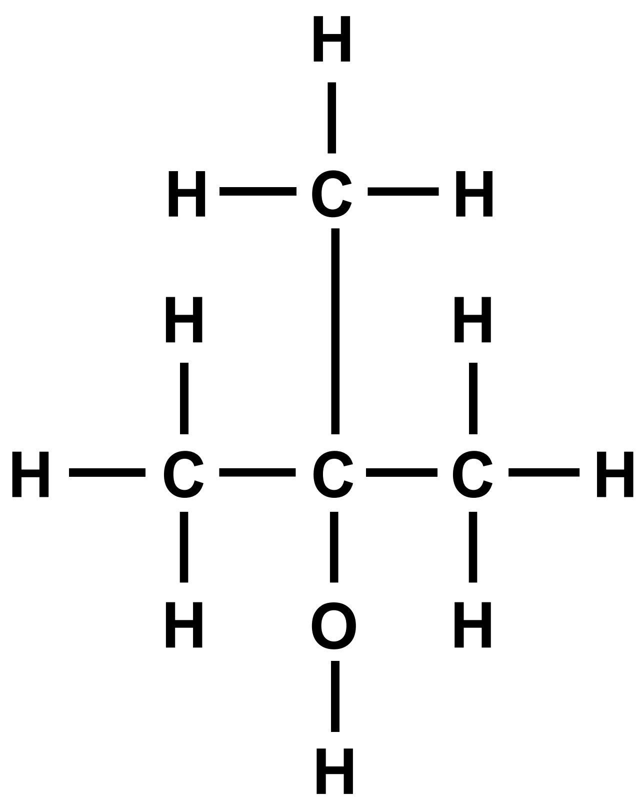

nitrogen from the air
hydrogen from natural gas
Haber Process
400-450°C
200 atm
iron catalyst
ammonia gas
neutralisation
exothermic
ammonium sulfate solid
$N_2 + 3H_2 \rightleftharpoons 2NH_3$
forward reaction is exothermic

	Method **A** fermentation	Method **B** addition reaction
Raw material	sugar from sugar cane	ethene from crude oil
Reaction	yeast catalyst $C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$	phosphoric(V) acid catalyst $C_2H_4(g) + H_2O(g) \longrightarrow C_2H_5OH(l)$
Operating pressure	1 atm	60 atm
Type of process	batch (stop-start)	continuous (runs all the time)

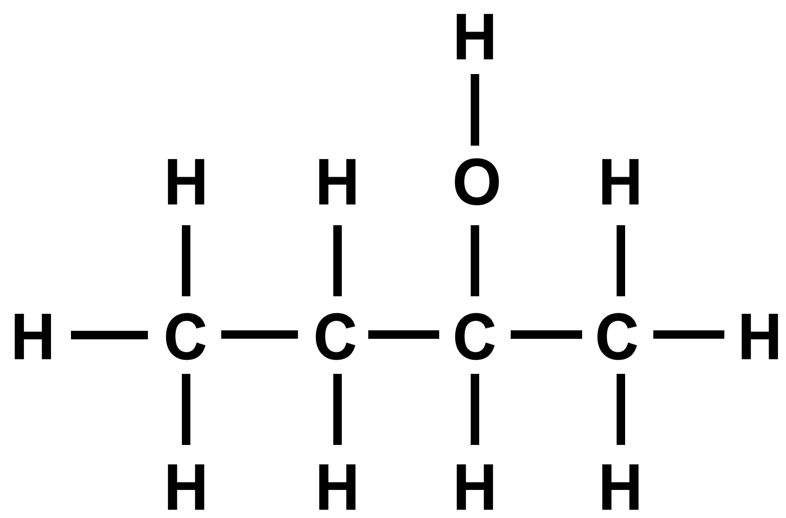



Energy
Reaction pathway

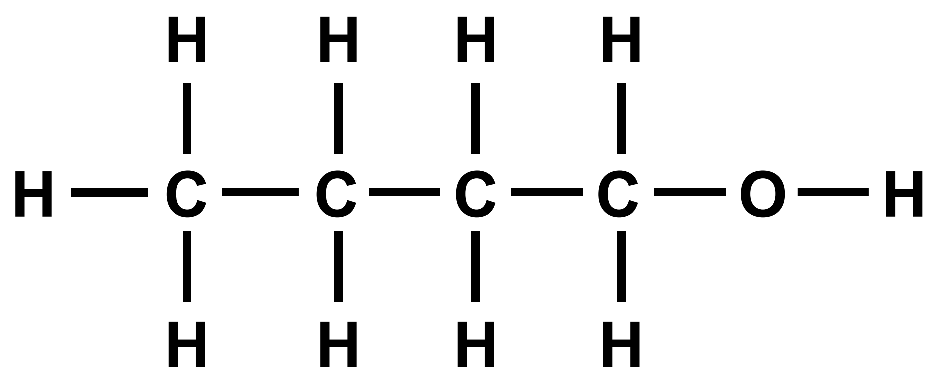
A



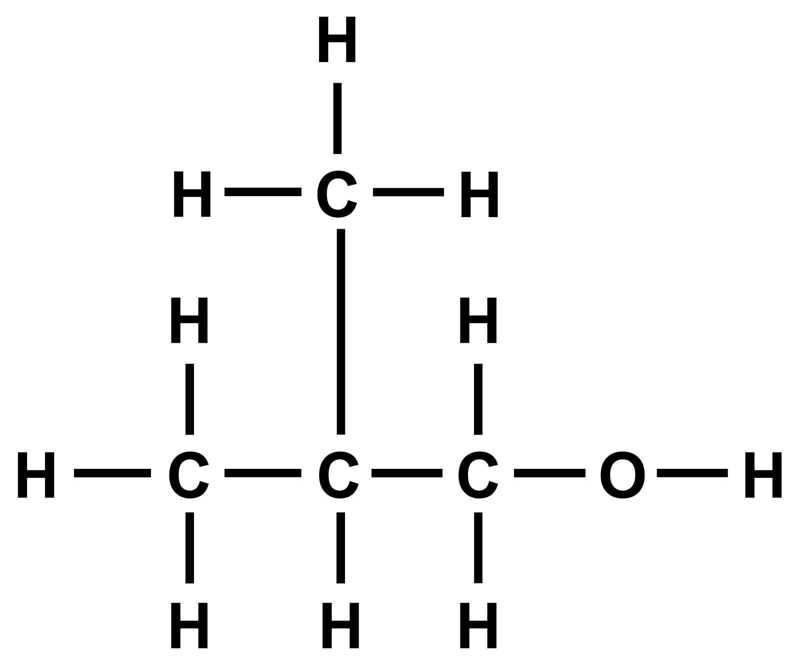
B



C



D



	A	B	C
Add dilute HCl	no reaction	fizzes	no reaction
Add $BaCl_2(aq)$	white precipitate forms	no reaction	no reaction
Add NaOH(aq)	green precipitate forms	pungent smelling gas given off, turns damp red litmus paper blue	no reaction
Add $AgNO_3(aq)$	no reaction	no reaction	cream precipitate forms
Flame test	no colour	no colour	apple-green flame

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS Name	Formula	NEGATIVE IONS Name	Formula
aluminium	Al^{3+}	bromide	Br^{-}
ammonium	NH_4^{+}	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^{-}
calcium	Ca^{2+}	fluoride	F^{-}
copper(II)	Cu^{2+}	hydroxide	OH^{-}
hydrogen	H^{+}	iodide	I^{-}
iron(II)	Fe^{2+}	nitrate	NO_3^{-}
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^{+}	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^{+}		
silver	Ag^{+}		
sodium	Na^{+}		
zinc	Zn^{2+}		

THE PERIODIC TABLE

1	2						Group					3	4	5	6	7	0
							1 H										4 He
7 Li	9 Be											11 B	12 C	14 N	16 O	19 F	20 Ne
23 Na	24 Mg											27 Al	28 Si	31 P	32 S	35.5 Cl	40 Ar
39 K	40 Ca	45 Sc	48 Ti	51 V	52 Cr	55 Mn	56 Fe	59 Co	59 Ni	63.5 Cu	65 Zn	70 Ga	73 Ge	75 As	79 Se	80 Br	84 Kr
86 Rb	88 Sr	89 Y	91 Zr	93 Nb	96 Mo	99 Tc	101 Ru	103 Rh	106 Pd	108 Ag	112 Cd	115 In	119 Sn	122 Sb	128 Te	127 I	131 Xe
133 Cs	137 Ba	139 La	179 Hf	181 Ta	184 W	186 Re	190 Os	192 Ir	195 Pt	197 Au	201 Hg	204 Tl	207 Pb	209 Bi	210 Po	210 At	222 Rn
223 Fr	226 Ra	227 Ac															

Key:

relative atomic mass → A
Symbol

PERIODIC TABLE - KEY
ATOMIC NUMBER - SYMBOL - NAME

1 H - Hydrogen	32 Ge - Germanium	77 Ir - Iridium
2 He - Helium	33 As - Arsenic	78 Pt - Platinum
3 Li - Lithium	34 Se - Selenium	79 Au - Gold
4 Be - Beryllium	35 Br - Bromine	80 Hg - Mercury
5 B - Boron	36 Kr - Krypton	81 Tl - Thallium
6 C - Carbon	37 Rb - Rubidium	82 Pb - Lead
7 N - Nitrogen	38 Sr - Strontium	83 Bi - Bismuth
8 O - Oxygen	39 Y - Yttrium	84 Po - Polonium
9 F - Fluorine	40 Zr - Zirconium	85 At - Astatine
10 Ne - Neon	41 Nb - Niobium	86 Rn - Radon
11 Na - Sodium	42 Mo - Molybdenum	87 Fr - Francium
12 Mg - Magnesium	43 Tc - Technetium	88 Ra - Radium
13 Al - Aluminium	44 Ru - Ruthenium	89 Ac - Actinium
14 Si - Silicon	45 Rh - Rhodium	
15 P - Phosphorus	46 Pd - Palladium	
16 S - Sulfur	47 Ag - Silver	
17 Cl - Chlorine	48 Cd - Cadmium	
18 Ar - Argon	49 In - Indium	
19 K - Potassium	50 Sn - Tin	
20 Ca - Calcium	51 Sb - Antimony	
21 Sc - Scandium	52 Te - Tellurium	
22 Ti - Titanium	53 I - Iodine	
23 V - Vanadium	54 Xe - Xenon	
24 Cr - Chromium	55 Cs - Caesium	
25 Mn - Manganese	56 Ba - Barium	
26 Fe - Iron	57 La - Lanthanum	
27 Co - Cobalt	72 Hf - Hafnium	
28 Ni - Nickel	73 Ta - Tantalum	
29 Cu - Copper	74 W - Tungsten	
30 Zn - Zinc	75 Re - Rhenium	
31 Ga - Gallium	76 Os - Osmium	