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MICHAELHOUSE

PHYSICAL SCIENCE DEPARTMENT

A BLOCK TRIAL EXAMINATION (PAPER II – CHEMISTRY) SEPTEMBER 2020

Examiner: N. Ngcobo
Time: 3 hours

Moderator: M. Higginson
Marks: 200

PLEASE READ THE INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages, Appendix 1 (Answer Sheet) of 2 pages (i–ii) and Appendix 2 (Data Sheet) of 3 pages. Please make sure that your question paper is complete.
2. **Write your name and surname on Appendix 1 (Answer Sheet).**
3. Read the questions carefully.
4. ALL of the questions in this paper must be answered.
5. **START EACH QUESTION ON A NEW PAGE**
6. Please ensure that you number your answers as the questions are numbered in this question paper.
7. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
8. Use the data and formulae whenever necessary.
9. Show all of the necessary steps in calculations.
10. Where appropriate take your answers to 2 decimal places
11. Use of a non-programmable, non-graphical calculator is permitted.
12. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1

Answer these questions on the multiple-choice Answer Sheet on the front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter of the option that you consider to be most correct. Every question has only one correct answer.

A	☒ B	C	D
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Here the answer B has been marked.

- 1.1 A crystal lattice is an ordered arrangement of atoms, ions, or molecules in a solid material. Substances such as diamond and graphite are examples of substances arranged in a crystal lattice.

The statements below refer to the substances listed above:

- (i) All of these substances have high melting points.
- (ii) The atoms are held together by a very large number of ionic bonds.
- (iii) These substances are both allotropes of carbon.

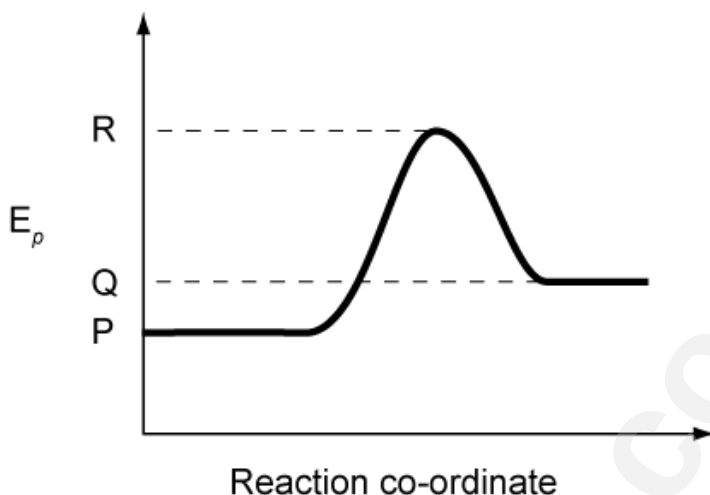
Which combination of statements true?

- A (i) and (ii) only
- B (i) and (iii) only
- C (ii) and (iii) only
- D (i), (ii) and (iii) (2)

- 1.2 Which of the following gives the number of hydrogen atoms in 6 g of NH_3 (g)?

- A
$$\frac{6,022 \times 10^{23}}{6 \times 3 \times 17}$$
- B
$$\frac{6 \times 3 \times 6,022 \times 10^{23}}{17}$$
- C
$$\frac{17 \times 6,022 \times 10^{23}}{6 \times 3}$$
- D
$$\frac{6 \times 3 \times 17}{6,022 \times 10^{23}}$$
 (2)

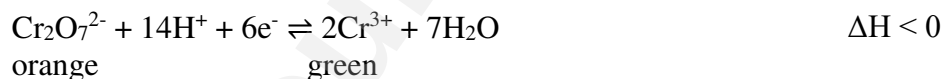
- 1.3 The graph below shows the change in potential energy (E_p) as a reaction proceeds.



Which of the following statements is true?

- A The forward reaction is endothermic
- B The activation energy for the forward reaction is represented by R
- C The activation energy for the reverse reaction is represented by Q
- D The heat of the reaction (ΔH) for the reverse reaction is represented by $Q - P$ (2)

- 1.4 The reaction represented by the equation below reaches equilibrium:



Which of the following changes will cause the colour of the equilibrium mixture to be more green than orange?

- A Lowering the pH
- B Increasing the temperature
- C Decreasing the pressure
- D Adding a catalyst (2)

- 1.5 Consider solutions of equal concentration of the acids H_2CO_3 and HCl . How do the concentration of hydronium ions, $[\text{H}_3\text{O}^+]$ and the pH for the two solutions compare?

	$[\text{H}_3\text{O}^+]$	pH
A	$\text{H}_2\text{CO}_3 > \text{HCl}$	$\text{H}_2\text{CO}_3 > \text{HCl}$
B	$\text{H}_2\text{CO}_3 > \text{HCl}$	$\text{H}_2\text{CO}_3 < \text{HCl}$
C	$\text{H}_2\text{CO}_3 < \text{HCl}$	$\text{H}_2\text{CO}_3 > \text{HCl}$
D	$\text{H}_2\text{CO}_3 < \text{HCl}$	$\text{H}_2\text{CO}_3 < \text{HCl}$

(2)

1.6 Which of the following salts will decrease the pH of a sample of distilled water when dissolved in the water?

- A Na_2SO_4
 - B LiCl
 - C K_3PO_4
 - D NH_4Cl
- (2)

1.7 Iron is one of the main materials in ships. Sacrificial anodes are attached to the hull of the ship to protect the iron against corrosion.

Which of the following metals would make the best sacrificial anode?

- A Chromium
 - B Nickel
 - C Copper
 - D Tin
- (2)

1.8 An aqueous solution of sodium chloride is electrolysed by a student. What is the formula of the chemical species produced at the cathode?

- A Na^+
 - B OH^-
 - C Cl^-
 - D H_2O
- (2)

1.9 Which of the following organic compounds is a chain isomer of pentan-1-ol?

- A pentan-2-ol
 - B 2,2-dimethylpropan-1-ol
 - C ethyl propanoate
 - D methylbut-2-ene
- (2)

1.10 Which of the following molecules is least polar?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - B $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
 - C CHCOOCH_3
 - D $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CHOHCH}_3$
- (2)

[20]

QUESTION 2

2.1 Consider the table below showing the melting points of three solid oxide compounds.

	Substance	Melting point (°C)
A	Li_2O	1438
B	SnO_2	1630
C	SiO_2	1710

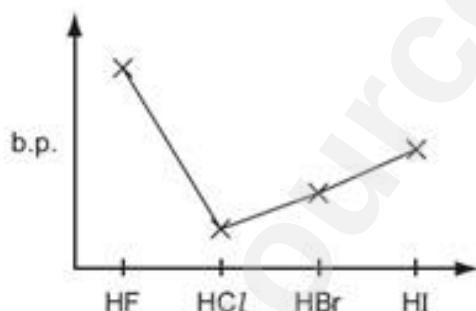
2.1.1 Define an *ionic bond*. (2)

2.1.2 Explain why solid Li_2O does not conduct electricity? (2)

2.1.3 Name the intramolecular bond found in SiO_2 (1)

2.1.4 Explain why SiO_2 has such a high melting point compared to the other compounds. (2)

2.2 The graph below shows the trend in boiling points of hydrogen halides.



2.2.1 Looking at the compounds HCl , HBr and HI ; what inference can be made about the general relationship between molecule size and boiling point? (2)

2.2.2 Name the intermolecular force responsible for the relationship mentioned in 2.2.1. (1)

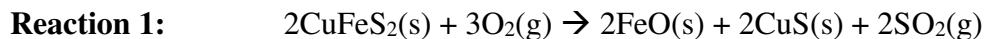
2.2.3 Name the specific type of intermolecular force found in HF but not in HCl , HBr or HI . (1)

2.2.4 State three properties of the fluorine atom that make this type of intermolecular force possible. (3)

[14]

QUESTION 3

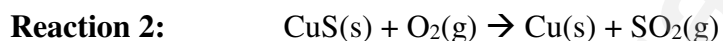
- 3.1 Copper is obtained from chalcopyrite CuFeS_2 , which is one of the most important ores in the extraction of copper. 77,8 g of chalcopyrite are reacted with oxygen according to the following balanced chemical equation:



- 3.1.1 Calculate the number of moles present in 77,8 g of chalcopyrite. (3)

- 3.1.2 Use Reaction 1 to calculate the mass of copper sulphide formed when 77,8 g of chalcopyrite is reacted. (4)

In a separate reaction vessel, the copper sulphide formed in Reaction 1 is then reacted with 26 g of oxygen gas at standard temperature and pressure as shown in Reaction 2. The balanced chemical equation is shown below:



- 3.1.3 Determine **by calculation**, which reactant is limiting. (4)

- 3.1.4 What volume of sulphur dioxide gas is produced during reaction 2? (3)

- 3.2 A student dissolves solid sodium bicarbonate (NaHCO_3) in water to make a solution.

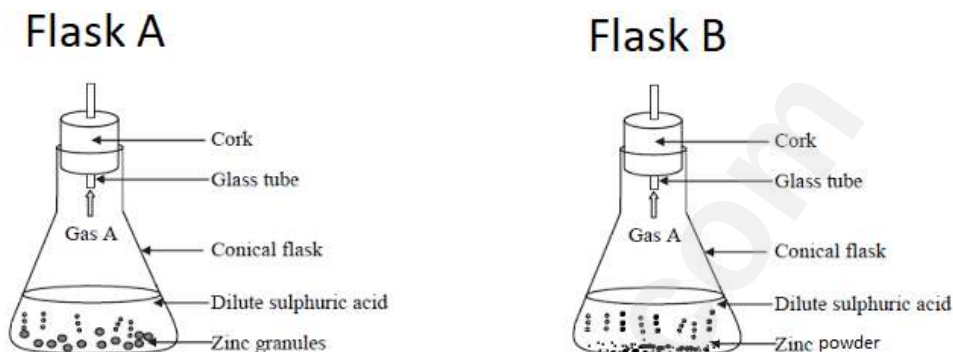
- 3.2.1 Define *concentration*. (2)

- 3.2.2 Calculate the mass of sodium bicarbonate required to make a 250 cm^3 solution of concentration $0,02 \text{ mol.dm}^{-3}$. (4)

[20]

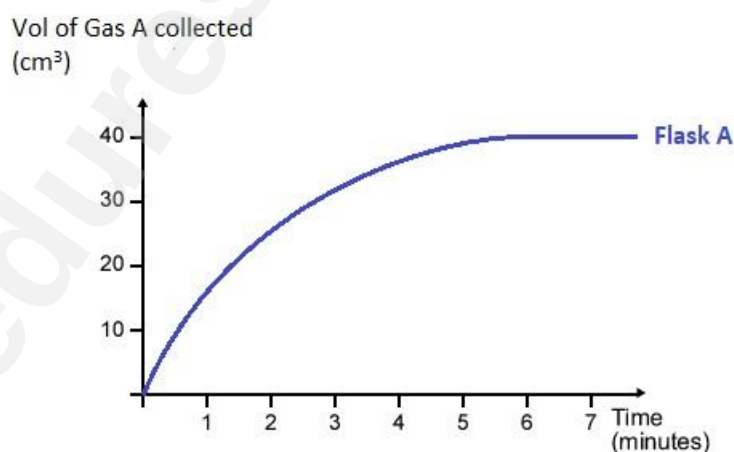
QUESTION 4

- 4.1 A student wants to investigate how the surface area of reactants influences the rate of reaction between zinc and excess dilute sulphuric acid. He sets up two conical flasks as shown in the diagram below. He records the volume of Gas A collected.



- 4.1.1 Provide a suitable hypothesis for this investigation. (2)
- 4.1.2 Write a balanced chemical equation for the reaction between zinc and sulphuric acid. (2)
- 4.1.3 For this investigation, identify:
- the independent variable (1)
 - the dependent variable (1)
 - two controlled variables (2)
- 4.1.4 Apart from collecting Gas A, what other method could the student use to measure the rate of this reaction? (2)

The following graph represents the students results:



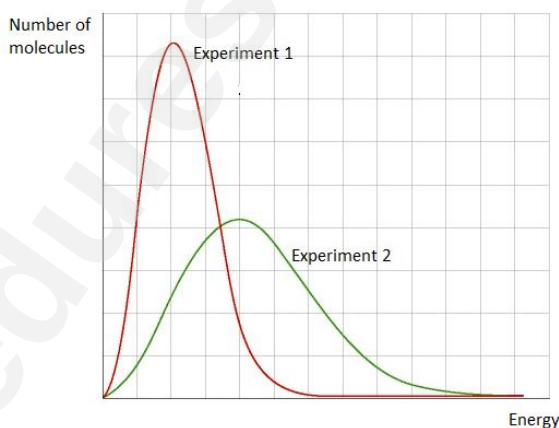
- 4.1.5 On the axes provided in your answer sheet, sketch the graph that represents the results from Flask B. (2)

- 4.2 In a separate experiment, the student uses the reaction between zinc and sulphuric acid to investigate the effect of concentration on the rate of reaction. In the first experiment, 10 g of zinc powder is added to 50 cm³ of a 0,05 mol.dm⁻³ solution of sulphuric acid. The time taken to collect 15 cm³ of Gas A is recorded.

The experiment is then repeated four times with different concentrations of sulphuric acid being used. The results obtained are shown in the table below.

Experiment	Concentration of sulphuric acid (mol.dm ⁻³)	Time (s)	Time ⁻¹ (x 10 ⁻²) (s ⁻¹)
1	0,05	67	1,5
2	0,10	32	3,1
3	0,15	23	(a)
4	0,20	16	(b)
5	0,25	13	7.7

- 4.2.1 Calculate the values of the average rate of: Experiment 3 and 4:
 a) Experiment 3 (1)
 b) Experiment 4 (1)
- 4.2.2 Draw a graph of the inverse of time (Time⁻¹) versus concentration of sulphuric acid used on the GRAPH SHEET provided. (6)
- 4.2.3 Write down a conclusion for this investigation. (2)
- 4.3 The Maxwell Boltzmann distribution curves below show the distribution of molecular energies for the reaction between zinc and sulphuric acid at two different temperatures.



How did the temperature change from Experiment 1 to Experiment 2?
 Write only INCREASED/DECREASED or STAYED THE SAME.

(1)
 [23]

QUESTION 5

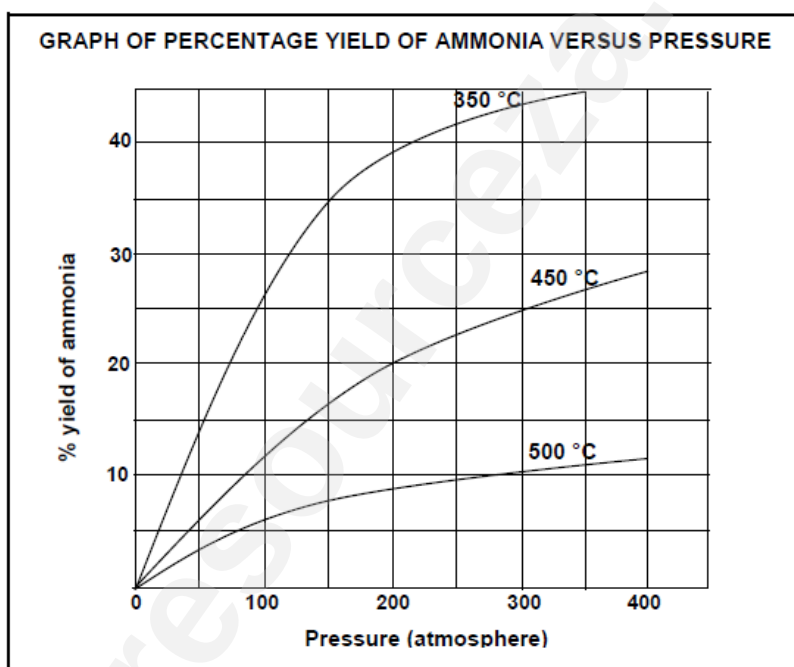
The balanced chemical equation below represents the reaction used in the Haber process to produce ammonia.



During the industrial production of ammonia, the ammonia gas is removed from the reaction vessel as soon as it is formed.

5.1 Give one advantage of removing the ammonia gas as soon as it forms. (1)

The following graph shows the percentage yield of ammonia at different temperatures and pressures.



5.2 Write down the percentage yield of ammonia at a temperature of 350 °C and a pressure of 150 atmospheres. (1)

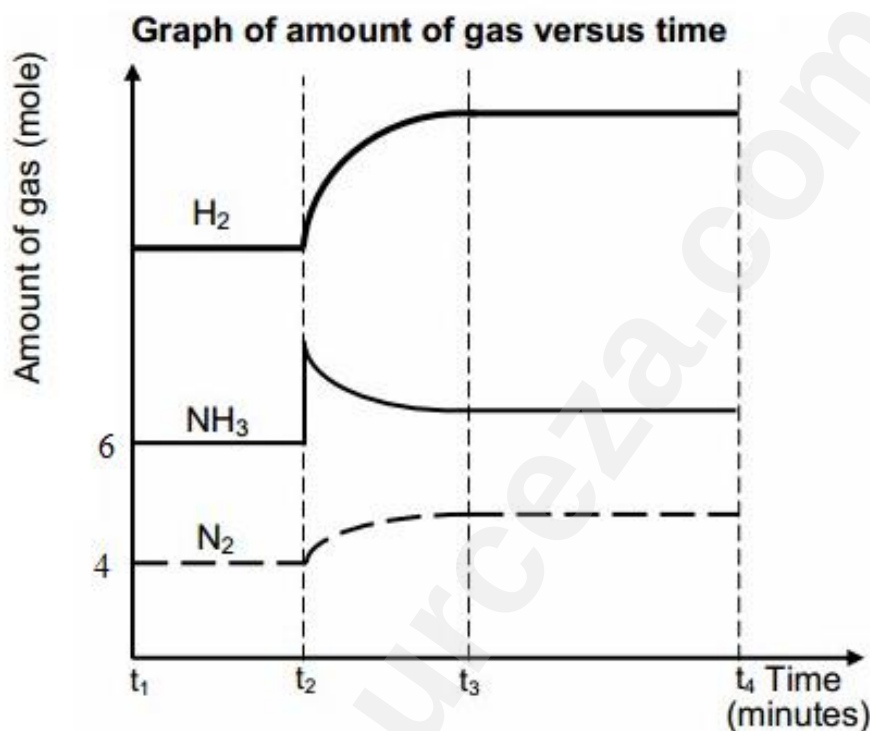
5.3 By referring to Le Chatelier's principle, explain the following observations:

5.3.1 For a given pressure, the yield of ammonia gas at 500 °C is lower than the yield at 350 °C. (3)

5.3.2 For a given temperature, the yield of ammonia gas at 350 atmospheres is higher than the yield at 100 atmospheres. (2)

- 5.4 A chemical engineer produces ammonia gas at a smaller scale in a closed container. The volume of the container remains constant at 5 dm^3 . The concentrations of each gas were tracked over time and the following graph (not to scale) was obtained.

At time t_1 , the temperature is 450°C and the equilibrium constant is 0.7.

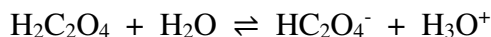


- 5.4.1 Define a *closed system* (2)
- 5.4.2 Identify the stress that occurred at time t_1 . (1)
- 5.4.3 Use Le Chatelier's principle to explain the changes seen in the graph between times t_2 and t_3 . (3)
- 5.4.4 Write down the expression for the equilibrium constant (K_c) for this reaction. (2)
- 5.4.5 Calculate the concentration of $\text{H}_2(\text{g})$ that was in the container at time t_1 . (6)
- [21]**

QUESTION 6

Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) is an organic acid that is used commonly as a household cleaner. Oxalic acid has a K_a value of 5.5×10^{-2} .

6.1 Oxalic acid ionises in water according to the following balanced equation:



6.1.1 Define an *acid* according to the Brønsted-Lowry theory. (2)

6.1.2 Classify oxalic acid as a WEAK or STRONG acid. Give a reason for your answer. (2)

6.1.3 Write the expression for the ionisation constant (K_a) for the ionisation of oxalic acid. (2)

6.1.4 If the initial concentration of oxalic acid is $0,4 \text{ mol}\cdot\text{dm}^{-3}$, calculate the concentration of hydronium (H_3O^+) at equilibrium. (6)

6.2 A student prepares 500 cm^3 of a $0,4 \text{ mol}\cdot\text{dm}^{-3}$ solution of oxalic acid at 25°C . The student then titrates the oxalic acid with a sodium hydroxide solution. The neutralisation reaction is represented by the balanced chemical equation below.



6.2.1 Define the term *neutralisation*. (2)

6.2.2 If 15 cm^3 of sodium hydroxide are used to neutralise 25 cm^3 of the $0,4 \text{ dm}^3$ oxalic acid solution, then calculate the concentration of the sodium hydroxide used. (4)

6.2.3 Use a hydrolysis reaction equation to explain whether the solution at the endpoint of the titration reaction is ACIDIC, BASIC or NEUTRAL. (4)

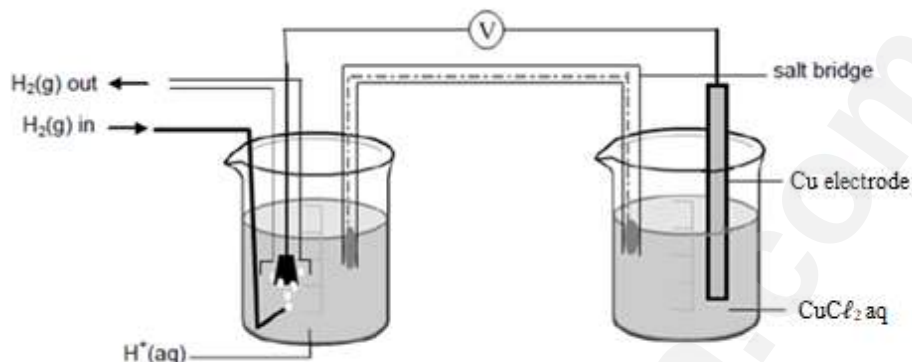
The table below shows some indicators and their pH sensitivity range.

Indicator	pH range
Phenolphthalein	8,2 – 10,0
Bromothymol blue	6,8 – 7,6
Methyl orange	4,0 – 5,6

6.2.4 Which indicator should the student use for this titration? (1)
[23]

QUESTION 7 (Adapted from Redhill School Prelim P2 2015)

The Standard Electrode Potential table which appears on your information sheet has been constructed using the apparatus shown in the diagram below. A standard hydrogen half-cell is joined by a salt bridge to a variety of half-cells. In this particular electrochemical cell the Cu/Cu^{2+} half-cell is used and is operating under standard conditions.



- 7.1 What energy transfer happens in this cell? (2)
- 7.2 List the standard conditions under which this cell operates. (3)
- 7.3 What is the significance of the standard hydrogen electrode being assigned the electrode potential of 0,00 V? (2)
- 7.4 Name the metal that is usually used as the electrode in the standard hydrogen electrode and explain why this metal is chosen? (2)
- 7.5 Hydrogen gas is bubbled through the electrolyte in the H_2/H^+ half-cell.

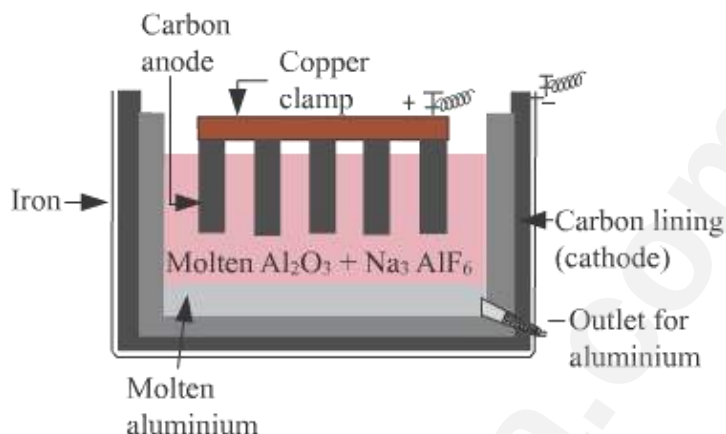
Use the table of Standard Reduction Potentials to write down the:

- 7.5.1 oxidation half reaction. (1)
- 7.5.2 reduction half reaction (1)
- 7.6 Write down the cell notation of this cell. Standard conditions need NOT be shown. (3)
- 7.7 Calculate the emf (E°_{cell}) of this cell under standard conditions. (3)
- 7.8 The surface area of the electrodes is increased. State how the following will change. State only INCREASE/DECREASE/STAYS THE SAME)
 - 7.8.1 Current delivered by the cell (1)
 - 7.8.2 E°_{cell} (1)

[19]

QUESTION 8

The cell below illustrates the production of aluminium from alumina (Al_2O_3) using the Hall-Heroult process.

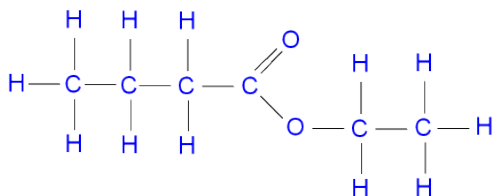


- 8.1 Write the half-reaction that is occurring at the cathode. (2)
- 8.2 What gas is produced at the anode? (2)
- 8.3 What is the function of the molten cryolite? (2)
- 8.4 Calculate the mass of aluminium in grams that will be extracted from the aluminium oxide when a current of 150 A passes through the solution for 15 minutes. (7)
- 8.5 Why is important for the alumina to be molten? (2)
- 8.6 Provide one advantage and one disadvantage of using carbon electrodes in this process. (2)

[17]

QUESTION 9

- 9.1 The structure below shows an organic compound that is used to give a pineapple flavour in sweets.



- 9.1.1 Write down the IUPAC name for the organic compound above. (2)
- 9.1.2 What homologous series does this compound belong to? (1)
- 9.1.3 Write down the IUPAC name of the carboxylic acid used to make this compound. (2)
- 9.1.4 Using **STRUCTURAL FORMULAE**, write down the chemical equation for the formation of this compound. (4)
- 9.1.5 Write down the **CHEMICAL FORMULA** of the acid catalyst used in the reaction that forms this compound. (2)
- 9.1.6 Define the term *isomers*. (2)
- 9.1.7 Write down the IUPAC name of one positional isomer of this compound. (2)
- 9.1.8 Write down the **CONDENSED STRUCTURAL FORMULA** of the functional isomer of this compound. (2)
- 9.2 The table below shows the molar masses and boiling points of different organic compounds.

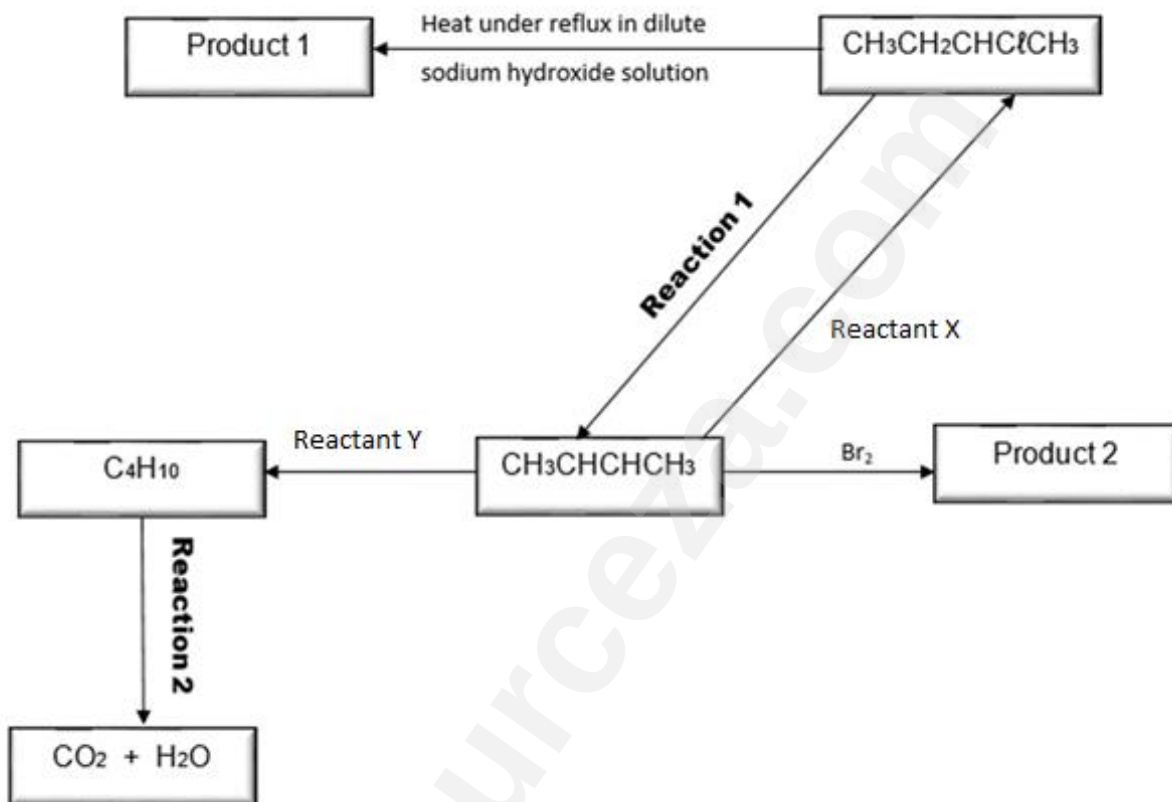
Organic Compound	Molar Mass (g/mol)	Boiling Point (°C)
Butane	58,12	-1
Pentane	75,12	36,1
Butan-1-ol	74,12	117,7
Propanoic acid	74,08	141,2

- 9.2.1 Name the predominant intermolecular forces found in butane and pentane. (1)
- 9.2.2 Explain why there is a difference in the boiling points of butane and pentane. (3)
- 9.2.3 By making reference to the relative strengths of the intermolecular forces, explain the difference between the boiling points of butan-1-ol and propanoic acid. (4)

[25]

QUESTION 10 (Adapted from Trinity House Prelim P2 2018)

Refer to the flow diagram below and answer the questions that follow:



10.1 Give the **SPECIFIC NAME** for:

10.1.1 Reaction 1. (1)

10.1.2 Reaction 2. (1)

10.2 Draw the **STRUCTURAL FORMULA** for Product 1. (2)

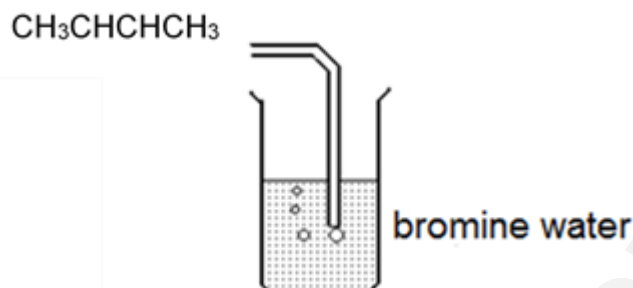
10.3 Give the reaction conditions for Reaction 1. (2)

10.4 Give the chemical formula of:

10.4.1 Reactant X. (1)

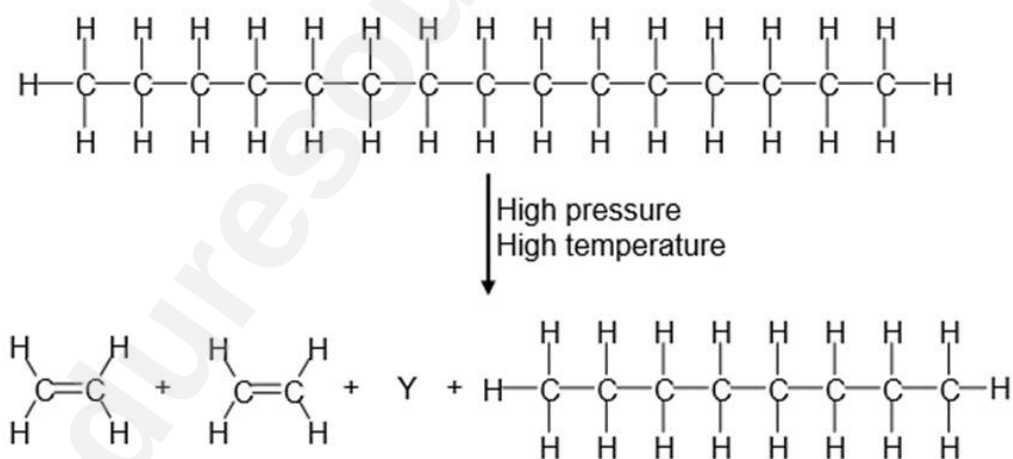
10.4.2 Reactant Y. (1)

- 10.5 $\text{CH}_3\text{CHCHCH}_3$ is reacted with bromine (Br_2) in order to form Product 2. The gas is bubbled through red-brown bromine water as shown in the diagram below.



- 10.5.1 What colour change will be observed in the beaker as the reaction proceeds? (1)
- 10.5.2 What **SPECIFIC TYPE** of organic reaction is this? (1)
- 10.5.3 Draw the **STRUCTURAL FORMULA** of Product 2. (2)
- 10.5.4 Give the IUPAC name of Product 2. (2)
- 10.6 Petrol requires the use of alkanes in the range from C_5 to C_{10} . Cracking is the process that is used to convert longer chains into shorter chains.

The diagram below illustrates one of the possible cracking reactions of $\text{C}_{15}\text{H}_{32}$



- 10.6.1 What type of cracking is taking place in the above reaction? (1)
- 10.6.2 Write down the **STRUCTURAL FORMULA** and **IUPAC NAME** for the hydrocarbon represented by Y. (3)
- [18]**

Total: 200 marks