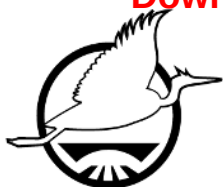




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**HeronBridge**  
COLLEGE

**PHYSICAL SCIENCE  
EXAMINATION  
PAPER 2 - CHEMISTRY**

**GRADE 12  
TIME: 3 hours**

**OCTOBER 2020  
MARKS: 200**

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**Examiner:** B. Beukes

**Moderator:** M. Janneker

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**INSTRUCTIONS**

1. This examination consists of:
  - a question paper of 17 pages;
  - an answer sheet of 2 pages; and
  - a data and formulae booklet (pages i – iii).

Please make sure that your question paper is complete.

2. Read the questions carefully.
3. It is in your own interest to write legibly and to set your work out neatly.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer. Where appropriate, express answers to TWO decimal places.

***ACKNOWLEDGMENTS : Various DBE, IGCSE, NSC and Cambridge A level papers, IEB and SQA examinations boards. St Mary's DSG 2019, Maris Stella 2015.***

**Question 1:****[2×10=20]**

Choose the most correct answer from the options presented. Each question has only ONE correct answer. Mark the answer of your choice with a cross (X) on the ANSWER SHEET that has been provided.

Answer on the answer sheet provided

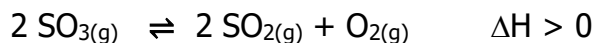
- 1.1 A molecule of propane is considered to be non-polar. Which one of the following statements best describes the reason why propane is non-polar?
- Propane only contains single covalent bonds.
  - The electronegativity difference between C and H is very small.
  - The charge distribution of electrons within the molecule is symmetrical.
  - Propane is a linear molecule.
- 1.2 Why is the boiling point of iodine monochloride,  $\text{ICl}$ , nearly  $40^\circ\text{C}$  higher than that of bromine,  $\text{Br}_2$ , although the two substances have almost the same molecular mass?
- $\text{ICl}$  is an asymmetrical molecule.
  - $\text{ICl}$  has a giant covalent structure.
  - The I - Cl bond is stronger than the Br - Br bond.
  - $\text{ICl}$  is a polar molecule.
- 1.3 The petrol additive tetraethyl-lead (IV),  $\text{Pb}(\text{C}_2\text{H}_5)_4$  has been added to petrol since 1920. The global phasing out of this additive is scheduled to be completed. When it is completely burnt in air, lead (II) oxide ( $\text{PbO}$ ), carbon dioxide, and water are formed.

How many moles of oxygen are required to burn one mole of  $\text{Pb}(\text{C}_2\text{H}_5)_4$ ? The balanced equation for this reaction is given below.



- 9,5
- 11
- 13,5
- 27

1.4 Consider the following reaction at equilibrium:



Some pure  $\text{O}_{2(g)}$  is injected into the reaction vessel at constant temperature. Once equilibrium is re-established, which of the following has a **lower value** compared to its value at the **original** equilibrium?

- A.  $K_c$  for the reaction
- B. The rate of the forward reaction
- C. The amount of  $\text{SO}_{3(g)}$  in the reaction vessel
- D. The amount of  $\text{SO}_{2(g)}$  in the reaction vessel

1.5 The following two changes were carried out separately on each of the systems listed below:

- (i) Pressure was reduced at constant temperature;
- (ii) Temperature was increased at constant pressure

Which system would give an **increase in the proportion of products** in both of these changes?

- A.  $\text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g) \quad \Delta H = + 53 \text{ kJ.mol}^{-1}$
- B.  $4\text{NH}_3(g) + 5\text{O}_2(g) \rightleftharpoons 4\text{NO}(g) + 6\text{H}_2\text{O}(g) \quad \Delta H = - 950 \text{ kJ.mol}^{-1}$
- C.  $\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \Delta H = - 92 \text{ kJ.mol}^{-1}$
- D.  $\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g) \quad \Delta H = + 57 \text{ kJ.mol}^{-1}$

1.6 Consider the hypothetical reaction  $\mathbf{A + B \rightleftharpoons C}$  for which it is given that:

$E_A$  for:  $\text{A} + \text{B} \rightarrow \text{C}$  is  $20 \text{ kJ.mol}^{-1}$

$E_A$  for:  $\text{C} \rightarrow \text{A} + \text{B}$  is  $60 \text{ kJ.mol}^{-1}$

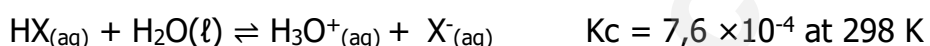
Which of the following is the value for the change in enthalpy for the reaction  $\text{A} + \text{B} \rightarrow \text{C}$ ?

- A.  $+20 \text{ kJ.mol}^{-1}$
- B.  $-40 \text{ kJ.mol}^{-1}$
- C.  $+40 \text{ kJ.mol}^{-1}$
- D.  $-60 \text{ kJ.mol}^{-1}$

- 1.7 An electrochemical (voltaic) cell which operates at 25 °C is represented by  $\text{Cu}_{(s)} / \text{Cu}^{2+}_{(aq)} (1 \text{ mol.dm}^{-3}) // \text{M}^{2+}_{(aq)} (1 \text{ mol.dm}^{-3}) / \text{M}_{(s)}$  where M is an unknown metal. A voltmeter connected across the electrodes reads 0,44 V. The standard electrode potential, in volts, for M /  $\text{M}^{2+}$  is;

- A. +0,78
- B. +0,10
- C. - 0,14
- D. - 0,10

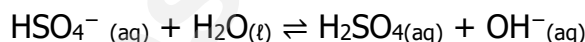
- 1.8 A weak acid, HX, ionizes as shown in the equation:



X<sup>-</sup> ions are removed from the solution at 298 K. What is the effect on K<sub>c</sub> and the pH of the solution?

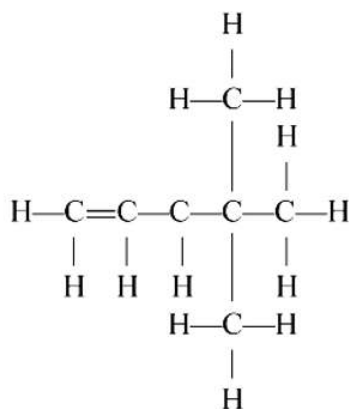
|    | K <sub>c</sub> | pH        |
|----|----------------|-----------|
| A. | Increase       | Increase  |
| B. | No effect      | Decrease  |
| C. | No effect      | No effect |
| D. | Decrease       | No effect |

- 1.9 The **hydrogen sulphate ion** *can act as both an acid and a base*. It reacts with water, according to the following balanced equation:



- A. H<sub>2</sub>O acts as a base in the above reaction.
- B. HSO<sub>4</sub><sup>-</sup> acts as a base in the above reaction.
- C. HSO<sub>4</sub><sup>-</sup> (aq) acts as an acid in the above reaction.
- D. HSO<sub>4</sub><sup>-</sup> (aq) acts as both an acid and base in the above reaction.

1.10 The correct IUPAC name for the molecule given below is:



- A. 4,4-dimethylpent-1-ene
- B. 4,4-dimethylpentene
- C. 2,2-dimethylpentene
- D. 2,2-dimethylpent-4-ene

**Question 2:**

The rate at which calcium carbonate reacts with *excess* hydrochloric acid is investigated by timing the amount of gas liberated.

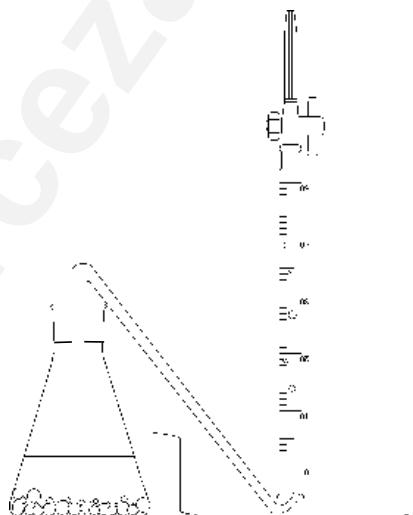
- 2.1 Write a balanced equation for the reaction of calcium carbonate with hydrochloric acid. (2)

In a first experiment (A), 50 cm<sup>3</sup> of 0,1 mol.dm<sup>-3</sup> HCl at 20 °C is added to 0,15 g of CaCO<sub>3</sub> chips.

- 2.2 Prove by calculation that the hydrochloric acid is in excess and determine by how many moles it is in excess. (5)

The results obtained are given in the table below:

| <b>Table 1: Data for Experiment A</b> |                                              |
|---------------------------------------|----------------------------------------------|
| Time (s)                              | Volume of CO <sub>2</sub> (cm <sup>3</sup> ) |
| 0                                     | 0                                            |
| 10                                    | 16.5                                         |
| 16                                    | 23.5                                         |
| 24                                    | 29.3                                         |
| 40                                    | 33.6                                         |
| 60                                    | 33.6                                         |

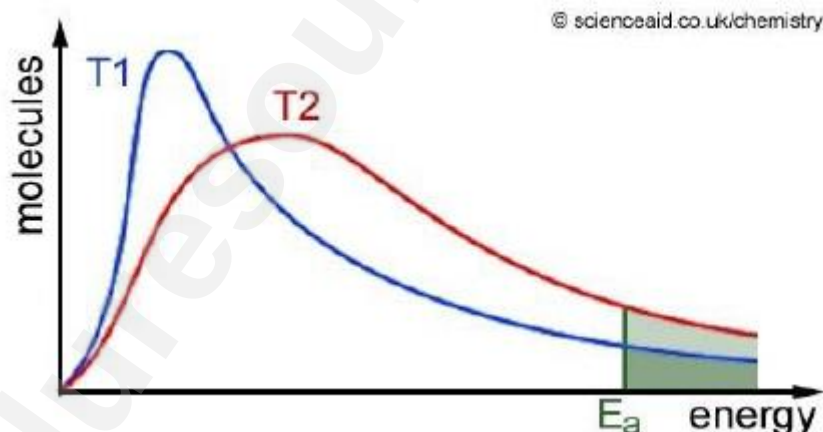


- 2.3 The CO<sub>2</sub> can be collected as shown by the downward displacement of water because it does not dissolve in water. With reference to specific intermolecular forces, explain why CO<sub>2</sub> does not dissolve in water. (2)
- 2.4 Calculate the average rate of the reaction in cm<sup>3</sup>.s<sup>-1</sup> for the time interval 10 to 24 seconds. (3)
- 2.5 Plot a graph of volume of CO<sub>2</sub> against time for Experiment A on the graph paper provided on the ANSWER SHEET. Label this graph A. (6)

Thereafter, several further experiments were conducted, each time changing some of the variables to investigate their effect on the reaction rate. The table below shows the reaction conditions for each of the experiments.

| Table 2: Reaction conditions for five experiments |                                   |                                               |                                 |                                           |                                |
|---------------------------------------------------|-----------------------------------|-----------------------------------------------|---------------------------------|-------------------------------------------|--------------------------------|
| Experiment                                        | Mass of $\text{CaCO}_3(\text{g})$ | Concentration of HCl ( $\text{mol.dm}^{-3}$ ) | Volume of HCl ( $\text{cm}^3$ ) | Temperature of HCl ( $^{\circ}\text{C}$ ) | State of solid $\text{CaCO}_3$ |
| A                                                 | 0.15                              | 0.1                                           | 50                              | 20                                        | Chips                          |
| B                                                 | 0.075                             | 0.1                                           | 50                              | 20                                        | Powder                         |
| C                                                 | 0.15                              | 0.1                                           | 70                              | 20                                        | Chips                          |
| D                                                 | 0.050                             | 0.1                                           | 50                              | 10                                        | Chips                          |

- 2.6 On your graph paper, sketch the graph that you would expect to obtain for Experiments B, C and D. Label each graph clearly. (6)
- 2.7 Define a *catalyst*. (2)
- 2.8 The Maxwell-Boltzmann distribution curve is given below:



- 2.8.1 At which temperature  $T_1$  or  $T_2$ , would the reaction be at a higher temperature? (1)
- 2.8.2 Explain using collision theory why an increase in **temperature will** increase the rate of the reaction. (4)
- [31]

**Question 3:**

Ammonia can be commercially produced via the Haber process.

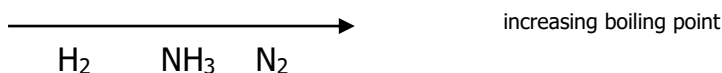
- 3.1 1,5 moles of hydrogen gas and 1 mole of nitrogen gas were pumped into an empty 200 cm<sup>3</sup> container at a temperature of 120°C, which is then sealed. The following equilibrium was established in the container:



Analysis of the equilibrium mixture showed that 1,2 mol of H<sub>2</sub> **was used up** to reach equilibrium.

- 3.1.1 Define *concentration*. (2)
- 3.1.2 Calculate the concentration of the nitrogen gas in the 200 cm<sup>3</sup> container at 120°C once equilibrium had been reached. (4)
- 3.1.3 Calculate the equilibrium constant at 120°C. (5)
- 3.1.4 State *Le Chatelier's Principle*. (2)
- 3.1.5 When the pressure in the container is **decreased** at constant temperature, what is the effect on the amount of N<sub>2</sub>? Write only INCREASES, DECREASES or STAYS THE SAME. (1)
- 3.1.6 Explain your answer to 3.1.5. (3)
- 3.1.7 When the concentration of N<sub>2</sub> (g) is increased, and equilibrium is re-established, what is the effect on K<sub>c</sub>? The temperature remains constant. Write only INCREASES, DECREASES or STAYS THE SAME. (1)
- 3.1.8 State the specific type of bonding that occurs **within** a molecule of ammonia. (2)
- 3.1.9 Define an *intermolecular force*. (2)

- 3.1.10 All the substances in the reaction above are gases at room temperature. According to the trend that the strength of intermolecular forces increases with increasing molecular mass, it would be expected that the boiling points in increasing order would be as follows:

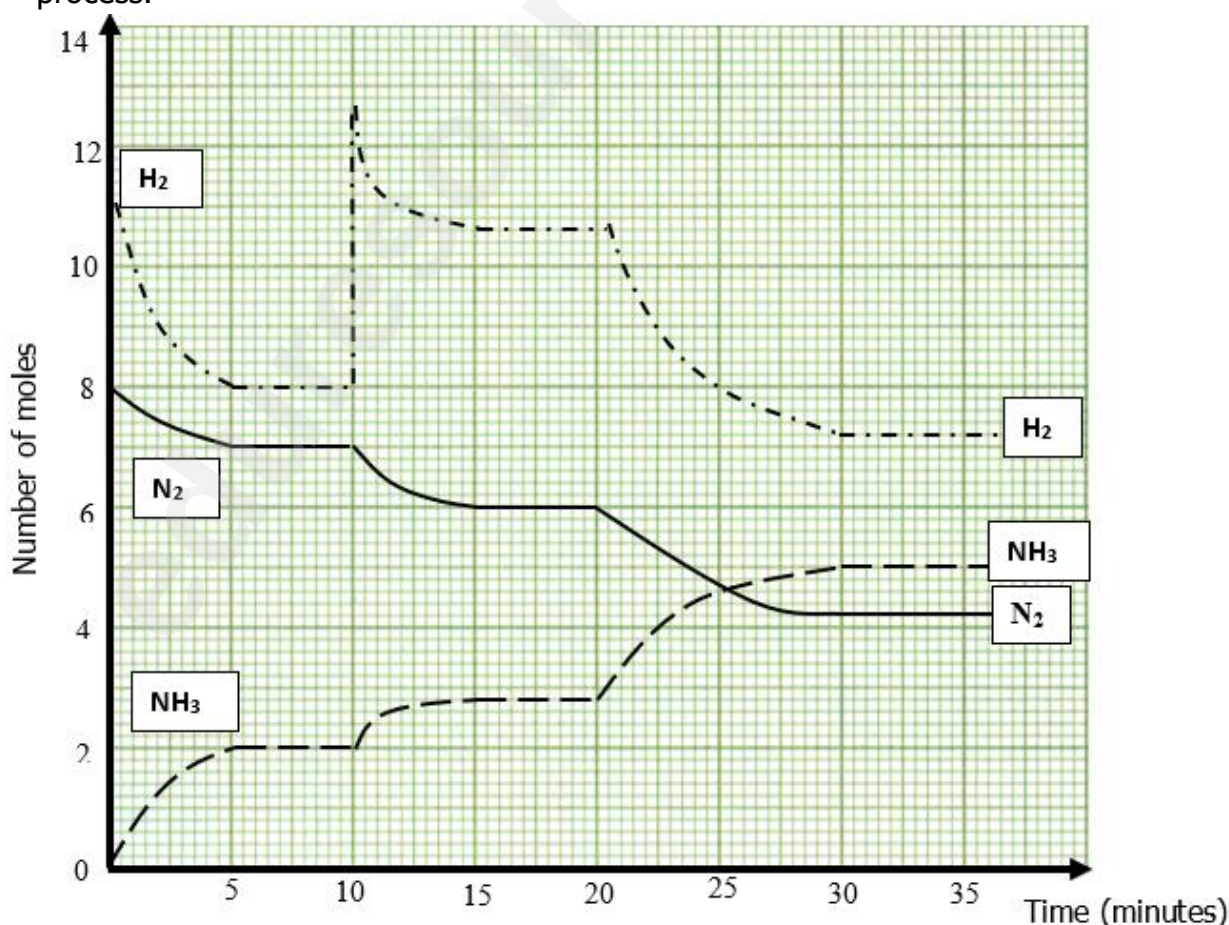


However, the table below gives the actual boiling points of these substances:

| Substance | Boiling point (°C) |
|-----------|--------------------|
| Hydrogen  | -252               |
| Nitrogen  | -196               |
| Ammonia   | -33                |

Use your knowledge of intermolecular forces to explain why the boiling point of ammonia does not follow the expected trend. (4)

- 3.2 The graph below illustrates the change in moles of nitrogen, hydrogen and ammonia over a period of time during a different application of the Haber process.



- 3.2.1 Identify the change that was made to the equilibrium mixture at a time of 10 minutes? (1)
- 3.2.2 Explain why the number of moles of the various gases changed as they did after the change at 10 minutes was made. (2)
- 3.2.3 At a time of 20 minutes a further change was made to the equilibrium mixture which brought about a permanent change in the equilibrium constant,  $K_c$ . **State and explain** the change that must have been made and state how this change would have affected the equilibrium constant (*increase or decrease*). (4)
- [33]**

#### **Question 4:**

Calcium hydroxide is a weak base. 2 g of impure  $\text{Ca}(\text{OH})_2$  is dissolved in water to make a solution of volume  $250 \text{ cm}^3$ .

- 4.1 Define a *weak base*. (2)
- 4.2 Write an equation to show the dissociation of  $\text{Ca}(\text{OH})_2$ . (3)

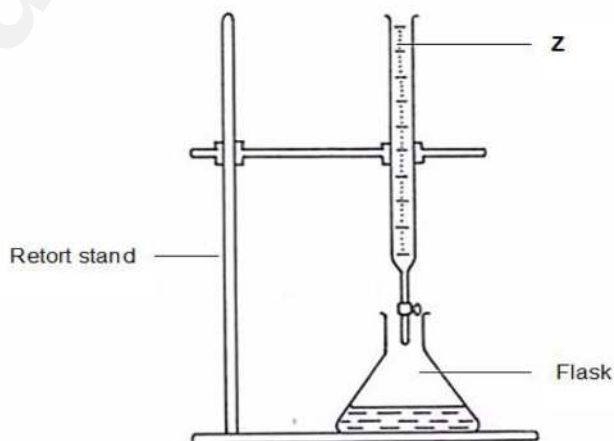
$50 \text{ cm}^3$  of the impure  $\text{Ca}(\text{OH})_2$  solution is now titrated against a standard solution of ethanoic acid.

The reaction equation is given below:



- 4.3 Give a reason why ethanoic acid is regarded as a *monoprotic acid*. (1)

The following apparatus was used:



4.4 Write down the NAME of the apparatus labelled Z. (1)

40 cm<sup>3</sup> of the 0,1 mol.dm<sup>-3</sup> ethanoic acid solution is needed for neutralisation.

4.5 Calculate the percentage purity of the Ca(OH)<sub>2</sub> used. (6)

4.6 Define *hydrolysis*. (2)

4.7 Determine which ion/s of the salt produced by this neutralisation (a weak acid and a weak base) will undergo hydrolysis by using the appropriate hydrolysis equation/s. (2)

4.8 Will the pH at the end of this titration be **EQUAL TO 7, GREATER THAN 7** or **SMALLER THAN 7**? Explain. (3)

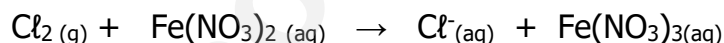
4.9 The pH of a solution of ethanoic acid of concentration 0,01 mol.dm<sup>-3</sup> is 2,87. The pH of a solution of hydrochloric acid of the same concentration is 1,0.

Explain why the pH values differ even though the concentrations are the same.

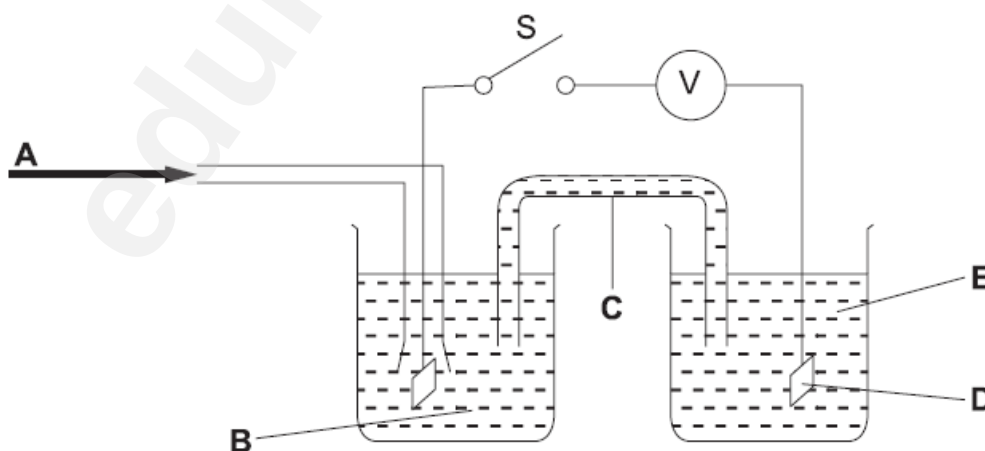
(3)  
[23]

### Question 5:

Chlorine gas and iron (II) nitrate react together in aqueous solution as follows:



The diagram below shows the apparatus that could be set up to produce electricity. The two electrodes are made of an inert metal. The switch is closed.



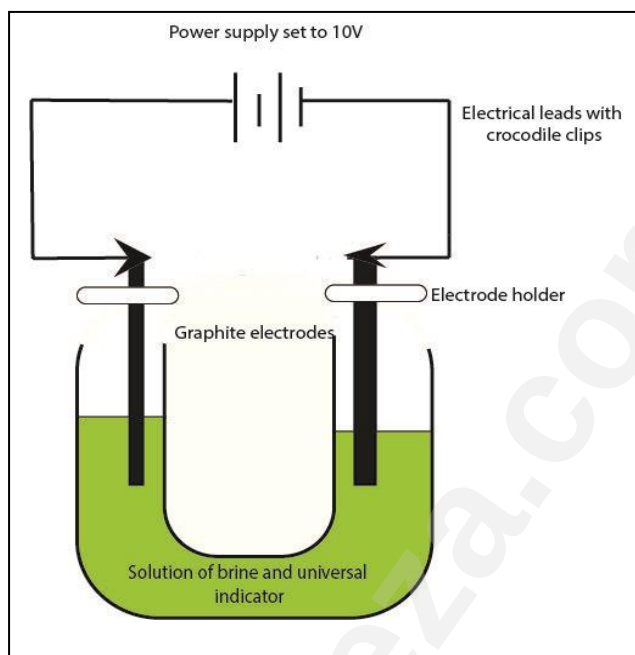
5.1 Define a *redox reaction*. (2)

- 5.2 Identify substance **A**. (1)
- 5.3 Explain why a platinum electrode would be needed in the half cell B. (2)
- 5.4 Identify the component **C**. (1)
- 5.5 Is electrode **D** the cathode or the anode? (1)
- 5.6 Identify the anion in the reaction that is present in solution **E** at the start of the reaction. (1)
- 5.7 If the switch **S** is closed, use the Table of Standard Electrode Potentials to write down:
- 5.7.1 the oxidation half reaction. (2)
- 5.7.2 the reduction half reaction. (2)
- 5.7.3 the overall balanced ionic cell reaction. (2)
- 5.8 Write down the cell notation for this cell, including all conditions but **not** phase indicators. (5)
- 5.9 Calculate the initial reading on the voltmeter under standard conditions. (3)
- 5.10  $\text{Fe}^{2+}$  is added to solution E, explain *how* and *why* this would affect the reading on the voltmeter. (3)
- 5.11 Suggest TWO change that could be made to the *construction* of the cell which would increase the maximum current the cell could deliver. (2)

**[27]**

**Question 6:**

6.1 The following apparatus is set up in a school laboratory:



The **universal indicator** changes from green ( $\sim$  pH 7 for the salt solution) to blue-purple at a pH  $>$  7 or from green to red at a pH  $<$  7.

The students make the following observations:

- bubbles of gas are noticed at each electrode.
- At one electrode the indicator turns red initially and is then bleached to colourless. At the other electrode, the indicator turns purple. The remainder of the solution stays green.

6.1.1 Define an *electrolyte*. (2)

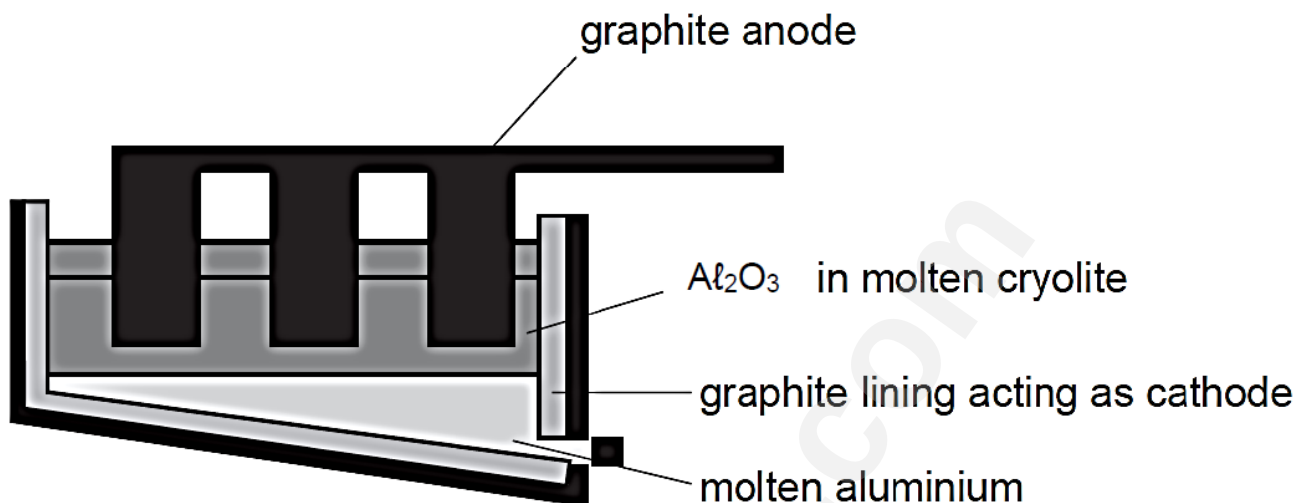
6.1.2 Write a half reaction for the observation occurring at the cathode. (2)

6.1.3 In reality, this cell could never be used in the chlor-alkali industry. Suggest ONE reason why. (2)

6.1.4 Explain why is it important to keep the brine solution concentrated? (2)

6.2 The diaphragm and mercury cells are able to produce good quality sodium hydroxide (particularly the mercury cell) yet the **membrane cell** technology is by far the most widely used in the chlor-alkali industry today. Suggest TWO reasons the membrane cell has advantages over the diaphragm and mercury cells. (2)

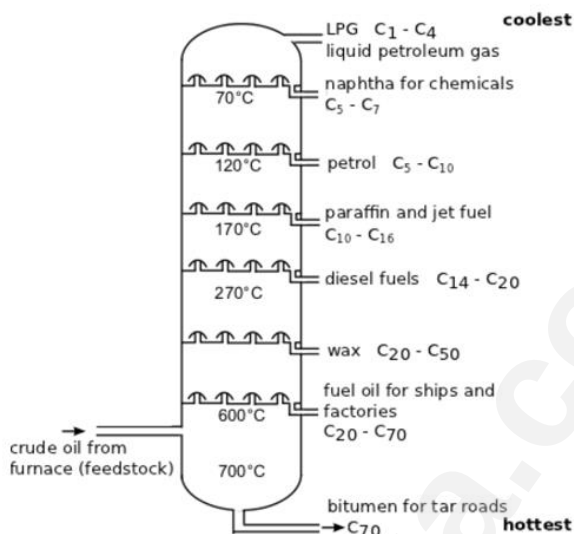
- 6.3 The apparatus shown below is used in the Hall-Heroult electrolytic process for the extraction of aluminium from alumina ( $\text{Al}_2\text{O}_3$ ). The melting point of alumina is  $2000^\circ\text{C}$ , and the melting point of aluminium metal is  $660^\circ\text{C}$ .



- 6.3.1 Suggest one advantage of using molten cryolite in this cell. (1)
- 6.3.2 Explain by referring to the structure of graphite, how it is able to conduct electricity and thereby make a suitable electrode. (2)
- 6.3.3 Why is it important that the alumina-cryolite mixture be kept at a high temperature (of  $\pm 900^\circ\text{C}$ )? (2)
- 6.3.4 13,5 g of aluminium is required to make one aluminium cold drink can. Calculate the time taken, IN HOURS, to make one aluminium can if a current of 10 A is passed through the molten alumina. (6)
- [21]**

**Question 7:**

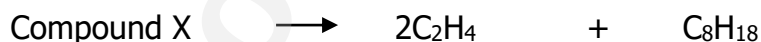
7.1 Crude oil is a mixture of hydrocarbons. The diagram below shows a method of separating crude oil.



Most of the compounds in crude oil are saturated hydrocarbons.

7.1.1 Define a *saturated* compound. (2)

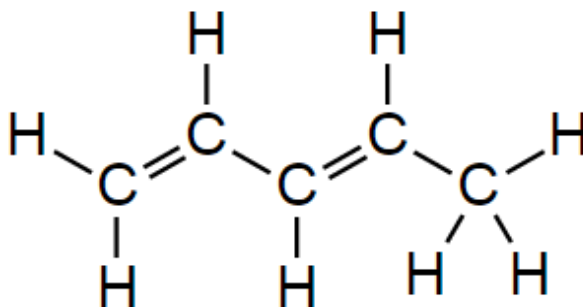
$C_8H_{18}$  can be formed through the cracking of compound X. The incomplete chemical equation for this cracking process is:



7.1.2 Write down the molecular formula of compound X. (2)

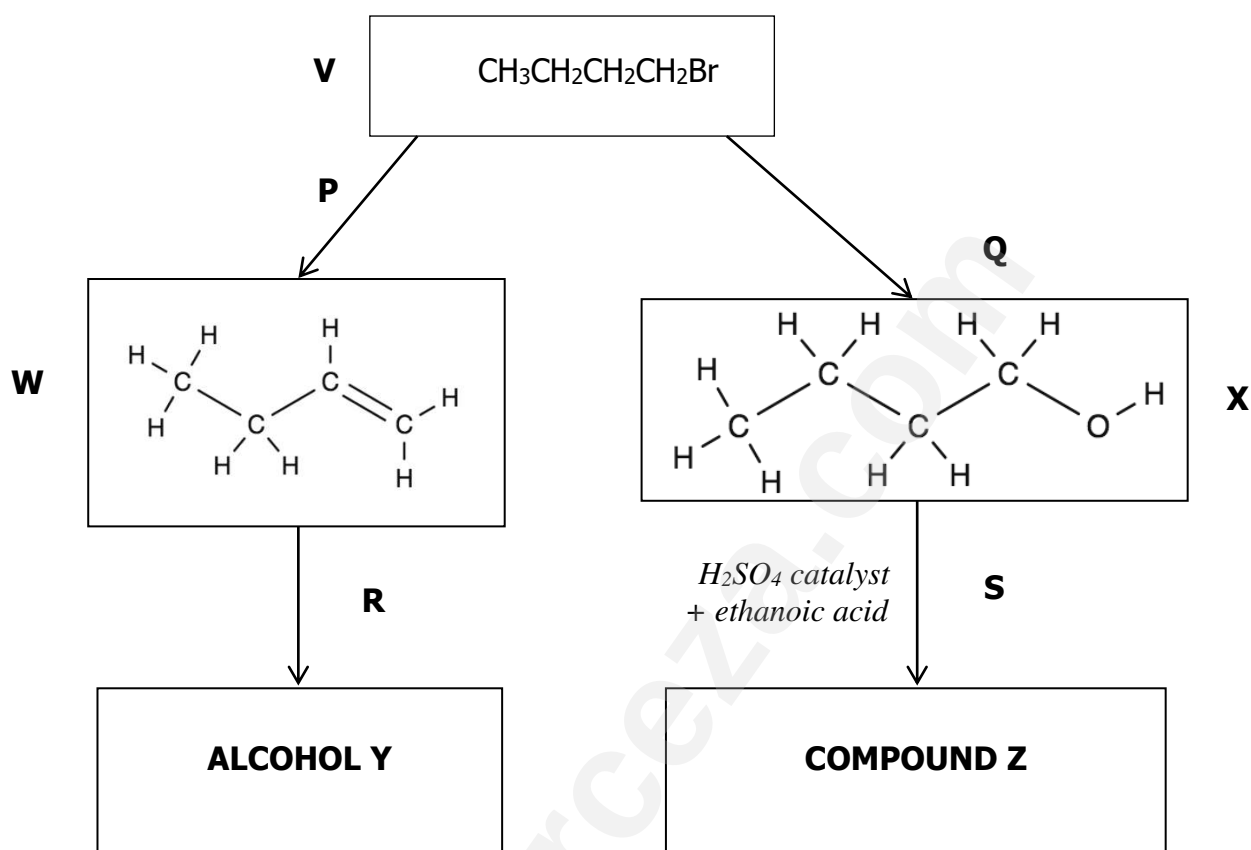
7.1.3 Out of the three compounds above, which one is most likely to be collected last, lower down in the fractional distillation column? Explain your answer by referring to the intermolecular forces involved. (4)

7.1.4 Give the IUPAC name the organic molecule represented below:



(2)

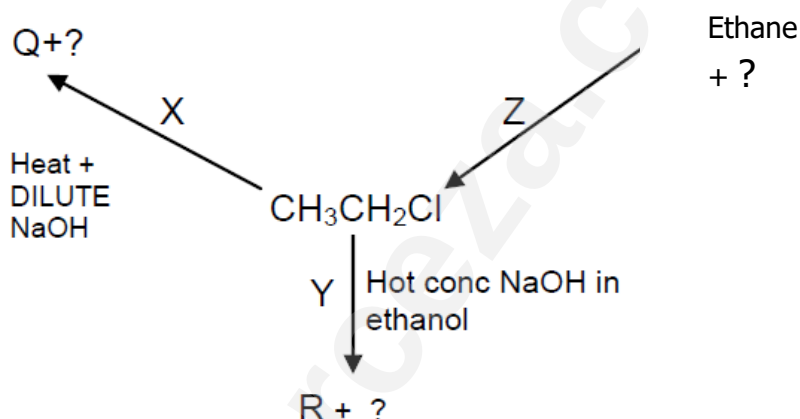
7.2 In the flow diagram below, **P**, **Q**, **R** and **S** represent different types of reactions involving compounds **V**, **W**, **X**, **Y**, and **Z**.



- 7.2.1 Define the term *functional group*. (2)
- 7.2.2 **Describe** the functional group in compound **W**. (2)
- 7.2.3 Using structural formulae, draw a structural isomer of compound **W** and classify the type of structural isomer you have drawn. (3)
- 7.2.4 Identify the **specific** type of reaction occurring in reaction **P**. (1)
- 7.2.5 Identify the **general** type of reaction occurring in reaction **R**. (1)
- 7.2.6 Give the structural formula for **ALCOHOL Y**. (2)
- 7.2.7 Identify the **general** type of reaction occurring in reaction **S**. (1)
- 7.2.8 What is the IUPAC name for **COMPOUND Z**? (2)
- 7.2.9 Write an equation for the reaction **S** that occurs by making use of structural formula. (5)

- 7.2.10 Give the name and condensed structural formula of a **functional isomer** of the organic product **Z**. (2)
- 7.2.11 Compare the viscosities of compounds **W** and **X** (assuming they were liquids). Fully explain your answer in terms of intermolecular forces. (4)
- 7.2.12 Name the **general** reaction that would occur if reaction **S** were done without the ethanoic acid. (1)

7.3 The flowchart represents various organic reactions using chloroethane. Q and R represent organic compounds that can be prepared from chloroethane by using the substances as indicated. The letters X, Y and Z represent different reaction types.



Consider reaction Z.

- 7.3.1 What **specific** type of reaction is represented by Z? (1)
- 7.3.2 State the reaction condition needed for reaction Z. (1)

Consider reaction X.

- 7.3.3 What **specific** type of reaction is represented by X? (1)
- 7.3.4 Give the IUPAC name of organic compound Q. (2)
- 7.3.5 Name the other product of reaction X. (1)

Consider reaction Y.

- 7.3.6 Give the **specific** type of reaction represented by Y. (1)
- 7.3.7 Name the organic compound R. (2)

[45]