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TRINITYHOUSE HIGH SCHOOL LITTLE FALLS
PHYSICAL SCIENCE: PAPER 2
GRADE 12
PRELIMINARY EXAMINATION
13 SEPTEMBER 2018

Time: 3 hours

Total: 200 marks

Examiner: Mr D Du Toit

Moderator: Mr D Brown

Name: _____

Acknowledgements: Kearsney College 2015 and Maris Stella 2015

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. This paper consists of:
 - a) a question paper of 16 pages
 - b) a data and formulae sheet
 - c) an ANSWER BOOKLET
 - d) a separate ANSWER SHEET
2. Answer ALL the questions in the ANSWER BOOKLET. Answer **Question 1** and **Question 3.4.1** of the separate ANSWER SHEET.
3. Read questions carefully.
4. Question 1 consists of 10 multiple choice questions. There is only one correct answer to each question. The questions are answered on the separate ANSWER SHEET. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D
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 Here the answer C has been marked
5. Use the data and formulae sheet whenever necessary.
6. Start each question on a new page.
7. Show your working in all calculations.
8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
9. Where appropriate, express answers to TWO decimal places.
10. It is in your own interest to write legibly and set out your work neatly.

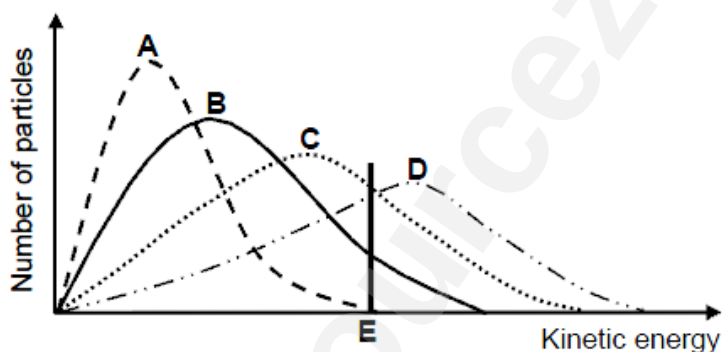
QUESTION 1 MULTIPLE-CHOICE QUESTIONS

Answer the following multiple-choice questions on your separate ANSWER SHEET. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

1.1 The chemical formula of ammonium dichromate is:

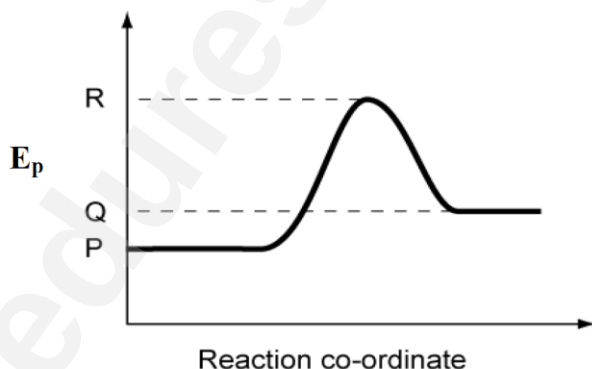
- A. $(\text{NH}_4)_3\text{Cr}_2\text{O}_7$
- B. $\text{NH}_4\text{Cr}_2\text{O}_7$
- C. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
- D. $\text{NH}_4(\text{Cr}_2\text{O}_7)_2$ (2)

1.2 The Maxwell-Boltzmann energy distribution curves below show the number of particles as a function of their kinetic energy for a reaction at four different temperatures. The activation energy is represented as E. Which ONE of these curves (A, B, C or D) represents the reaction with the highest rate?



(2)

1.3 The graph below represents the energy involved in a particular reaction.



Which one of the following statements is correct?

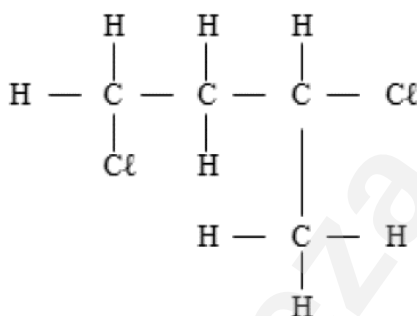
- A. The forward reaction is exothermic
- B. The heat of the reaction for the forward reaction is given by $Q - P$
- C. The activation energy for the forward reaction is given by $R - Q$
- D. The activation energy for the reverse reaction is given by $R - P$ (2)

1.8 Which of the following is the strongest reducing agent?

- A. Zn
- B. Cu
- C. Al
- D. Mg

(2)

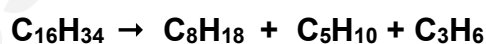
1.9 What is the correct IUPAC name of the following compound?



- A. 2,4-dichloro-2-methylpropane
- B. 1,3-dichloro-3-methylpropane
- C. 1,3-dichlorobutane
- D. 2,4-dichlorobutane

(2)

1.10 The reaction represented by the equation below takes place in the presence of a catalyst.



This reaction is an example of:

- A. addition
- B. cracking
- C. elimination
- D. combustion

(2)

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QUESTION 2 CHEMICAL BONDING

The table below shows the melting points and the heat energies needed to melt certain substances.

Substance	I ₂	NaCl	HF	HCl	HI
Melting point (K)	387	1074	190	158	222
Heat energy for melting (kJ/mol)	7,9	28,9	3,9	2,0	2,9

2.1 Define the following terms:

2.1.1 *Intramolecular bond* (2)

2.1.2 *Intermolecular force* (2)

2.2 Consider hydrogen fluoride.

2.2.1 Name the intermolecular force found between HF molecules. (1)

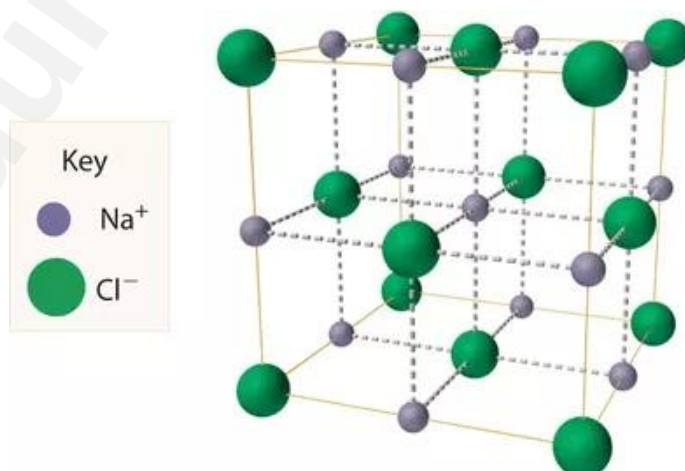
2.2.2 Provide the specific name for the intramolecular bond found in HF. (2)

2.3 Consider an iodine crystal (I₂).

2.3.1 Name the specific bond between atoms in a crystal of iodine. (2)

2.3.2 Explain, using evidence from their relative atomic masses, why hydrogen iodide requires more heat energy to melt than hydrogen chloride. (4)

2.3.3 Explain why the heat energy required to melt sodium chloride is large by referring to the image below. (3)



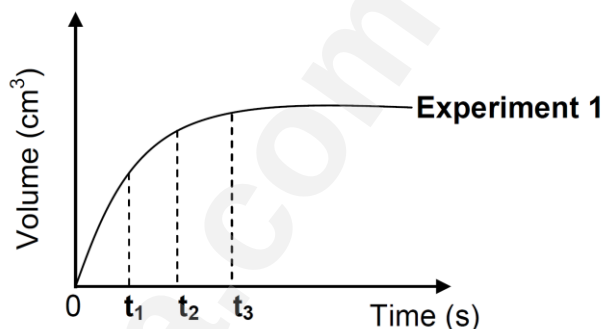
Source: <http://physicsopenlab.org> accessed on 11 August 2018

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QUESTION 3 REACTION RATES & ENERGY OF REACTIONS

Dilute HCl , indicated in the table below, react with EXCESS zinc in each of the three experiments to produce hydrogen gas. The zinc is completely covered with the acid in each experiment. The volume of hydrogen gas produced is measured in each experiment. The graph below was obtained for **Experiment 1**.

Experiment	Dilute acid
1	100 cm^3 of 0,1 mol.dm^{-3} of HCl
2	50 cm^3 of 0,01 mol.dm^{-3} of HCl
3	100 cm^3 of 0,2 mol.dm^{-3} of HCl

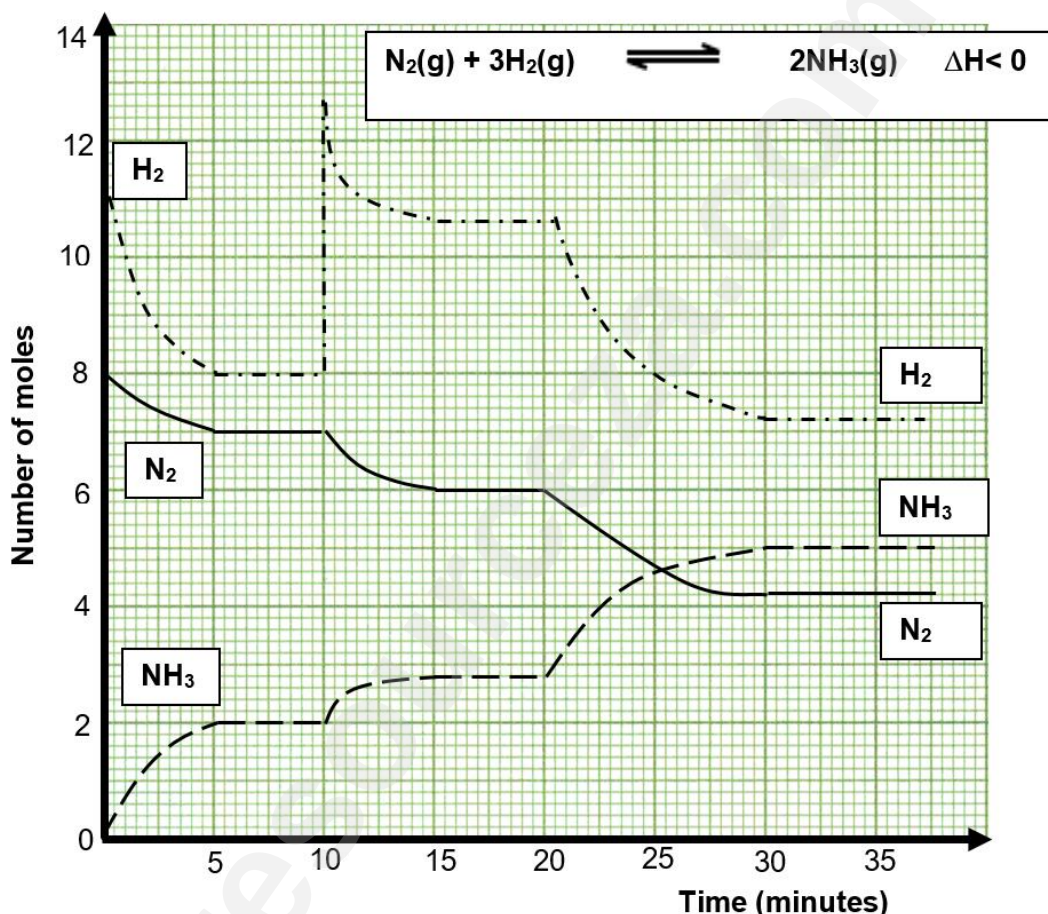


- 3.1 Name the apparatus that can be used to measure the volume of hydrogen gas released over time. (1)
- 3.2 At which time (t_1 , t_2 or t_3) is the:
- 3.2.1 reaction rate the highest? (1)
- 3.2.2 mass of zinc present in the flask the smallest? (1)
- 3.3 In which time interval, **between t_1 and t_2** OR **between t_2 and t_3** , does the largest volume of hydrogen gas form per second? (1)
- 3.4 The above graph for Experiment 1 has been replicated for you on the ANSWER SHEET.
- 3.4.1 On this graph sketch the graphs that will be obtained for **Experiments 2 and 3**. Clearly label the two graphs as **Experiment 2** and **Experiment 3**. (4)
- 3.4.2 Explain the shape of the graph drawn for **Experiment 3** in question 3.4.1 by referring to the collision theory. (4)
- 3.5 Consider the HCl solution for **Experiment 3**.
- 3.5.1 Write a balanced equation for the reaction between hydrochloric acid (HCl) and zinc (Zn). Ignore phase indicators. (3)
- 3.5.2 Calculate the number of moles of HCl present in experiment 3. (3)
- 3.5.3 Calculate the minimum mass of zinc needed in experiment 3 for the zinc to be considered 'in excess'. (3)

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QUESTION 4 CHEMICAL EQUILIBRIUM

- 4.1 In the Haber Process 8 mol of N_2 gas and 11 mol of H_2 gas is introduced into a container of volume 10 l at a temperature of 450°C , to form ammonia. The container is sealed immediately after the gases are added. The graph below represents the changes in the number of moles of the gases in the reaction vessel over a period of 35 minutes.



- 4.1.1 Use figures from the graph to determine the equilibrium **concentrations** of H_2 , N_2 and NH_3 at a time of 8 minutes. (3)
- 4.1.2 State *Le Chatelier's principle*. (2)
- 4.1.3 Identify the change (stress) which was introduced to the reaction at 10 minutes and explain the subsequent changes in the number of moles of all substances immediately after 10 minutes. (4)
- 4.1.4 At a time of 20 minutes a further change was made to the equilibrium mixture, which brought about a permanent change to the equilibrium constant, K_c . Explain the change that must have been made AND state how this change would have affected the equilibrium constant. (2)

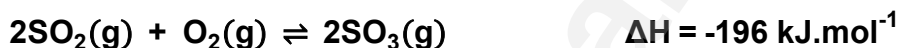
- 4.2 0,1 mol of hydrogen and 0,1 mol of iodine gas are sealed in a 1 litre container and allowed to react to form hydrogen iodide. The reaction is allowed to reach equilibrium at 488°C. At this equilibrium it is found that there is 0,05 mol of hydrogen iodide in the container.

4.2.1 Write a balanced chemical equation for the above reaction. Ignore phase indicators. (3)

4.2.2 Calculate the value of equilibrium constant (K_c) at 488°C. (6)

4.2.3 Explain what can be deduced from the value of the equilibrium constant. (1)

- 4.3 The Contact Process is an industrial process for the manufacture of sulfuric acid. In this process, sulfur dioxide is reacted with oxygen to form sulfur trioxide according to the following balanced equation:



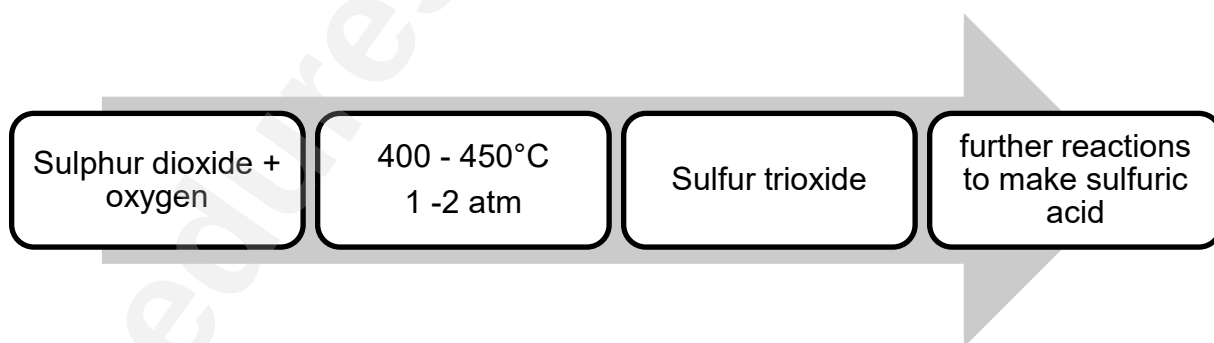
4.3.1 Define *yield*. (2)

4.3.2 Refer the above chemical equation for the reaction of SO_2 and O_2 . What conditions are necessary to increase the yield of SO_3 for each of the following? State either HIGH or LOW.

4.3.2.1 temperature (1)

4.3.2.2 pressure (1)

Sulfur trioxide is used as the base for other reactions to make sulfuric acid. A flow diagram for the entire process including the industrial conditions for the above reaction is shown below.



- 4.3.3 Refer to flow diagram above. Explain the industrial conditions for the reaction of sulfur dioxide with oxygen as mentioned in the flow diagram. Refer to economic and safety considerations and the possible compromises that need to be made to manufacture sulfur trioxide in your explanation. (4)

QUESTION 5 ACIDS & BASES

- 5.1 Propanoic acid ($\text{C}_2\text{H}_5\text{COOH}$) occurs naturally in Swiss cheese in a concentration that can be as high as 1%. The sodium and calcium salts of propanoic acid are food additives used in processed cheeses to slow down the formation of moulds.

The following table of indicator colours might be useful in the questions that follow.

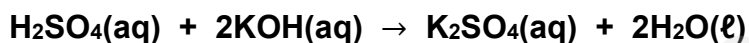
Indicator	More acidic colour	More basic colour	pH range of colour change
Bromothymol blue	Yellow	Blue	6,0 – 7,7
Phenolphthalein	Colourless	Pink	8,3 – 10,0
Methyl orange	Red	Yellow	3,2 – 4,4

- 5.1.1 Classify propanoic acid as a *monoprotic* or *polyprotic* acid. (1)
- 5.1.2 Sodium propanoate is made by the reaction of sodium hydroxide with propanoic acid. Write a balanced equation for this reaction. (2)
- 5.1.3 Define the term *hydrolysis of a salt*. (2)
- 5.1.4 Fully explain which indicator should be used for the titration of sodium hydroxide and propanoic acid by referring to possible hydrolysis reactions. (5)
- 5.2 The table below shows the ionisation constants for two acids.

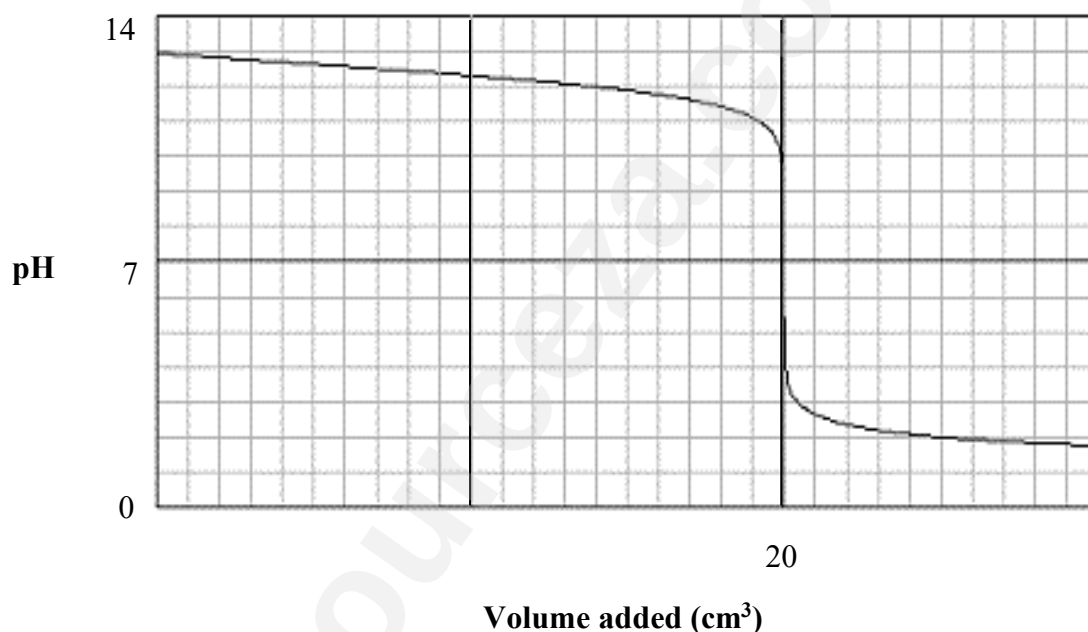
Name	Formula	K_a
Nitrous acid	HNO_2	$4,5 \times 10^{-4}$
Nitric acid	HNO_3	?

- 5.2.1 Will the ionisation constant for nitric acid be GREATER THAN, LESS THAN or EQUAL to that of nitrous acid? Explain. (3)
- 5.2.2 Which of these acids (if any) will have a lower electric conductivity? Explain. (assume that the concentration of both of acids is the same)(2)
- 5.2.3 Write a balanced chemical equation for the reaction of nitric acid with calcium carbonate. Ignore phase indicators. (3)

- 5.3 A different titration of a standard solution of sulfuric acid, H_2SO_4 (concentration $0,4 \text{ mol}\cdot\text{dm}^{-3}$), and a potassium hydroxide, KOH , solution of unknown concentration was performed in the lab. Bromothymol blue was used for the titration. A 30 ml sample was pipetted for this titration. The balanced chemical equation for the reaction between sulfuric acid and potassium hydroxide is shown below.



The titration curve (graph of pH versus volume of acid or base added) shown below was obtained.

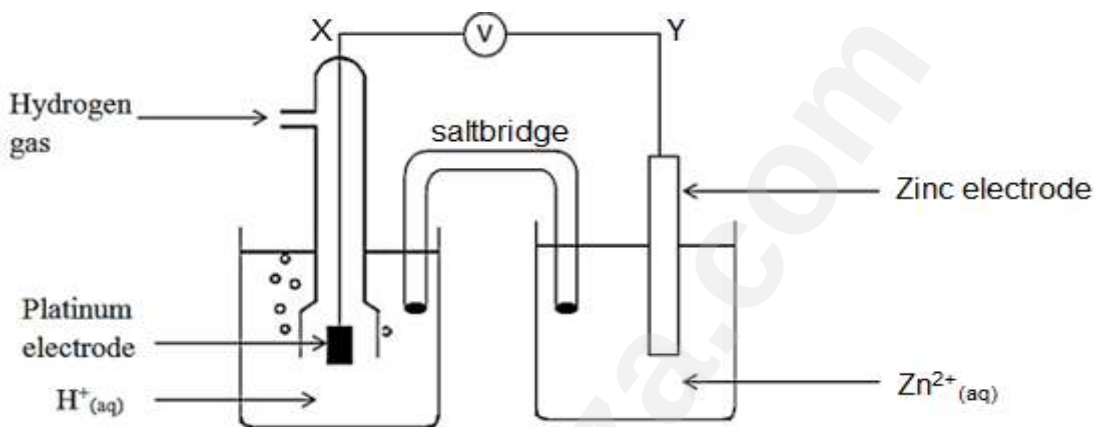


- 5.3.1 Write the balanced equation showing the complete ionisation of sulfuric acid in water. Ignore phase indicators. Assume that sulfuric acid fully ionises in solution, i.e. both deprotonations occur fully. (3)
- 5.3.2 Calculate the concentration of hydroxide ions in the standard solution of sulfuric acid at 25°C . (3)
- 5.3.3 Identify which solution was added using the burette. (1)
- 5.3.4 Calculate concentration of the potassium hydroxide solution. (4)

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QUESTION 6 ELECTROCHEMISTRY

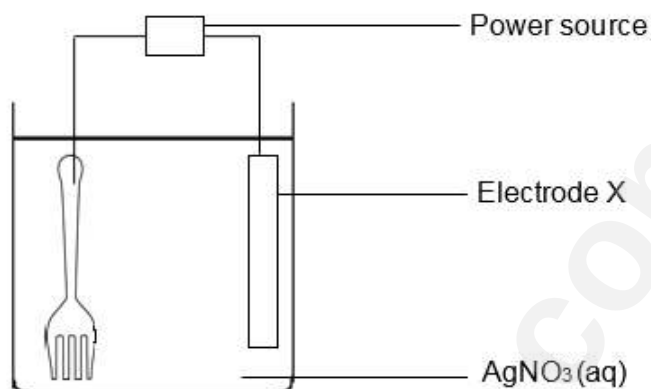
- 6.1 A standard electrochemical cell is set up by connecting a standard hydrogen reference electrode (SHE) as one half-cell to a Zn/Zn^{2+} half-cell. A voltmeter is connected across the cells which are connected as shown in the diagram below.



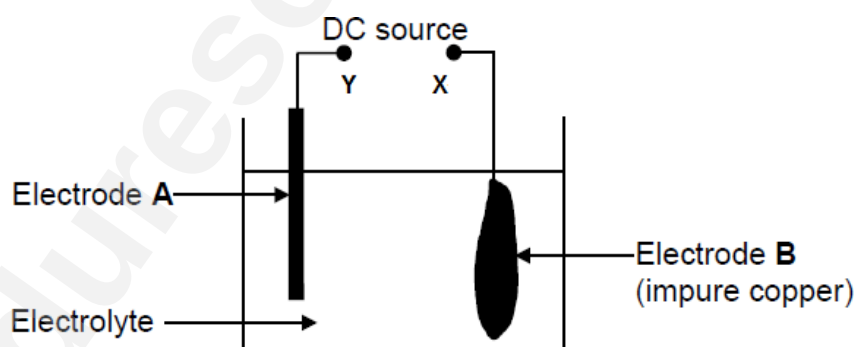
When the half-cells are connected, the voltmeter initially measures a potential difference, $E^\ominus$, of $-0,76 \text{ V}$.

- 6.1.1 Give the net-cell reaction for this electrochemical cell. No phase indicators are required. (2)
- 6.1.2 Give ONE purpose of the salt bridge. (1)
- 6.1.3 In which direction is the current flowing in the external circuit? Only write from **X to Y** or **Y to X**. (1)
- 6.1.4 Write down the chemical formula of a suitable electrolyte that can be used in the zinc half- cell. (2)
- 6.1.5 What is the meaning of the negative value of $E^\ominus$? (2)
- 6.1.6 Two of the three standard conditions used in this galvanic cell would be a temperature of 25°C and an electrolyte concentration of $1 \text{ mol}\cdot\text{dm}^{-3}$. State the third condition. (1)
- 6.1.7 Give the cell notation for the cell as it is connected as shown in the diagram above. Include all phase indicators. (3)
- 6.1.8 Why is it necessary that these conditions be standardised? (3)

- 6.2 A silver-plated cutlery set is not worth that much since it is only a cheap metal alloy that has been plated with silver. Electrochemical technicians can use the simplified electrolytic cell shown below to electroplate silver onto a cheap metal alloy fork.



- 6.2.1 State the type of energy conversion that occurs in this type of cell. (2)
- 6.2.2 Write down the reduction half reaction. (2)
- 6.2.3 Calculate the mass of silver that is plated onto the fork if a current of 900 mA runs for 10 minutes. (6)
- 6.2.4 Explain why it is not possible to electroplate the above fork with aluminium by using an aqueous solution of aluminium ions. (2)
- 6.3 The simplified diagram below represents an electrochemical cell used for the purification of copper.



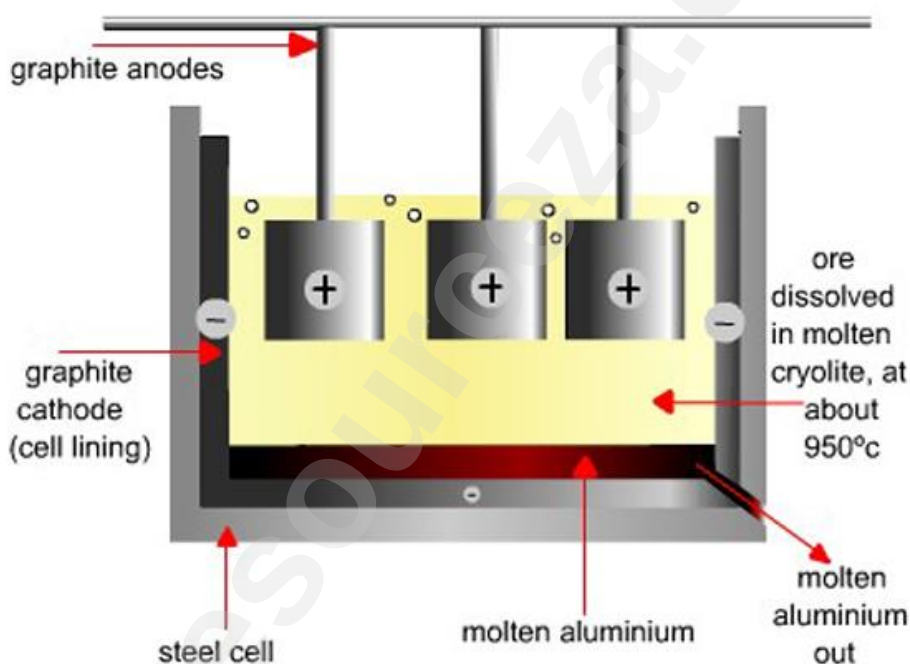
- 6.3.1 Which electrode (A or B) is the anode? (1)
- 6.3.2 What is the polarity of the DC-source at X? (Only write positive or negative). (1)

Due to small amounts of chromium impurities in the impure copper, the electrolyte becomes contaminated with Cr^{3+} ions.

6.3.3 Will the contamination of Cr^{3+} ions in the solution affect the purity of copper obtained during the process. Explain your answer by referring to the Table of Standard Reduction Potentials. (3)

6.3.4 After the purification of the impure copper was completed, it was found that $2,85 \times 10^{-2}$ moles of copper were formed. The initial mass of electrode B was 2,0 g. Calculate the percentage of copper that was initially present in electrode B. (4)

6.4 Below is a schematic diagram of the Hall-Herault Cell used in the extraction of aluminium metal from its ore bauxite (mainly aluminium oxide).



6.4.1 Give the chemical formula for aluminium oxide. (1)

6.4.2 Explain why the ore is dissolved in molten cryolite before undergoing electrolysis. (2)

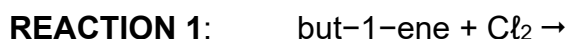
6.4.3 The anodes and cathode of this cell are made of graphite. By referring to the structure of graphite, explain ONE reason why it is a suitable substance to use in this cell. (2)

6.4.4 A gas is released as a by-product of this reaction. Give the reaction that produces this gas and describe its effect on the environment and on the cell itself. (3)

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QUESTION 7 ORGANIC CHEMISTRY (1)

But-1-ene, an unsaturated hydrocarbon, and compound X, a saturated hydrocarbon, both react with chlorine, as represented by the incomplete equations below:

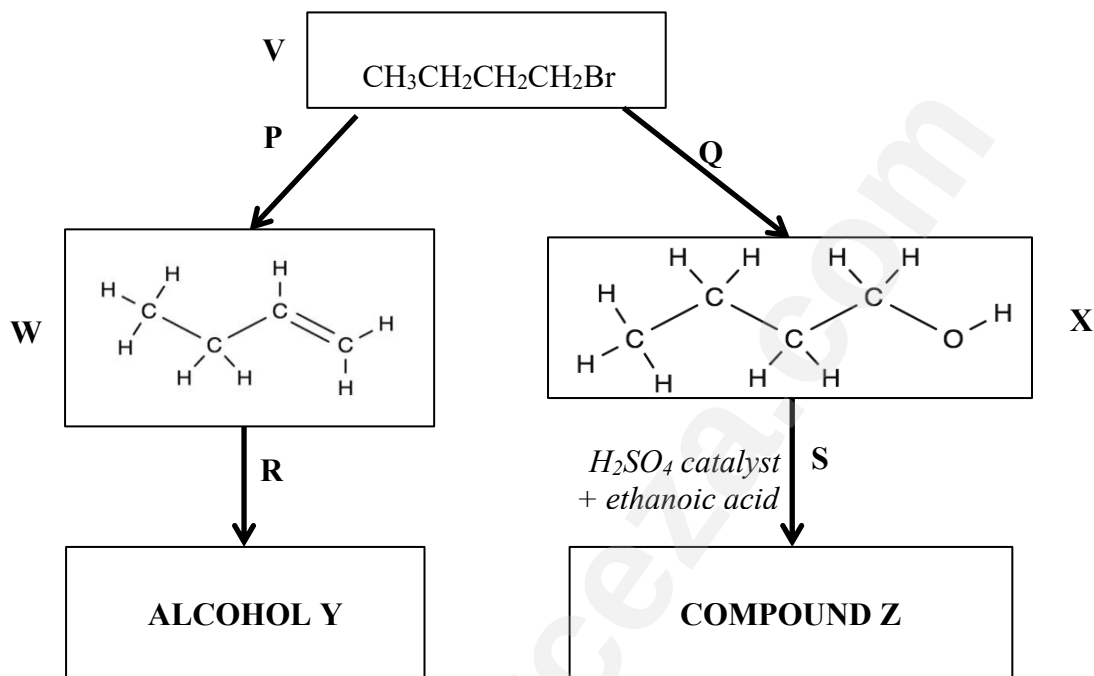


- 7.1 Define *homologous series*. (2)
- 7.2 To which homologous series does the hydrocarbon in **reaction 1** belong? (1)
- 7.3 Explain what is meant by the term “unsaturated”. (2)
- 7.4 Describe a test that can be performed to confirm that but-1-ene is unsaturated. (3)
- 7.5 Identify the **general type** of reaction that occurs in:
- 7.5.1 **Reaction 1** (1)
- 7.5.2 **Reaction 2** (1)
- 7.6 Write down the **structural formula** of the product formed in **Reaction 1**. (2)
- 7.7 What reaction condition is necessary for **reaction 2** to take place? (1)
- 7.8 Write down the IUPAC name of **reactant X**. (1)
- 7.9 Write down the name or formula of **product Y**. (1)
- 7.10 2-chloropropane is then heated under reflux (about 70°C) in the presence of a **concentrated** solution of NaOH in an ethanol solvent.
- 7.10.1 Identify the **general type** and **specific name** of the reaction that occurs under the conditions listed above. (2)
- 7.10.2 Write down the IUPAC name of the organic product formed in the reaction identified in Question 7.10.1 above. (2)
- 7.10.3 Use structural formulae to write a balanced equation for the reaction that takes place when 2-chloropropane reacts with a **dilute** sodium hydroxide solution. (4)

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QUESTION 8 ORGANIC CHEMISTRY (2)

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



- 8.1 Define the term *functional group*. (2)
- 8.2 Name the functional group in **compound X**. (1)
- 8.3 Identify the **general type** of reaction occurring in **reaction Q**. (1)
- 8.4 Give the **specific name** of **reaction R**. (1)
- 8.5 Write the IUPAC name of **alcohol Y**. (2)
- 8.6 Give the **specific name** of **reaction S**. (1)
- 8.7 What is the IUPAC name for **compound Z**? (2)
- 8.8 Define the term *isomer*. (2)
- 8.9 Using condensed structural formula give the functional isomer of **compound Z**. (2)
- 8.10 Using structural formula, draw a structural isomer of **compound W** and classify the type of structural isomer you have drawn. (3)
- 8.11 Name the reaction that would occur if **reaction S** were done without the ethanoic acid. (1)

[18]**200 marks**