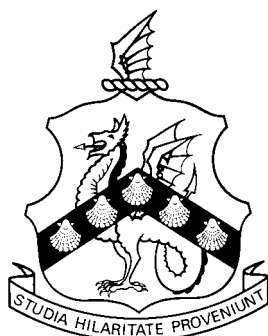




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KINGSWOOD COLLEGE

PHYSICAL SCIENCES

PAPER 2

GRADE 12

19 September 2022

Examiner: G. Makoni

Moderator: D. Price & J. Gumede

Time: 3 hours

Total: 200 marks

Name: _____

Grade 12: _____

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - a write-on question booklet with 22 pages, pages 21 and 22 have extra space that can be used if more writing pages are needed. Make sure your answers on these pages are correctly numbered.
 - Page 1 to 22 is a booklet, while insert of page i, ii and iii is a coloured data and formulae sheet.Make sure that your question paper is complete before starting.
2. Write your full name clearly in the space provided above on this page.
3. There are 7 questions.
4. Answer **all** the questions in the spaces provided.
5. Use the data and formulae sheet whenever necessary.
6. All numerical values must be to 2 decimal places unless otherwise instructed.
7. Read the questions carefully.
8. Aluminium and chlorine are written as Al and Cl, respectively, in chemical equations.

DO NOT TURN THIS PAGE OVER UNTIL THE INVIGILATOR TELLS YOU TO

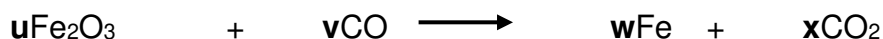
Question 1 (20 marks)

Question 1 consists of several multiple-choice questions, each with four (4) possible answers (A to D). Choose the letter which represents the best answer and mark it with an X in the answer grid below. There is only one possible answer for each question.

Answer grid for question 1

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

- 1.1 The unbalanced key reaction in the blast furnace during the extraction of iron from iron ore is given below with **u**, **v**, **w** and **x** used to balance it:



The values of **u**, **v**, **w** and **x** are:

	u	v	w	x
A	0	1	2	1
B	0	3	2	3
C	1	3	2	3
D	2	6	4	4

[2]

- 1.2 Priyanka decided to prepare 500 ml standard solution of 0.15 mol.dm^{-3} ethanoic acid using concentrated glacial ethanoic acid of concentration of 17.4 mol.dm^{-3} . Calculate the volume of glacial ethanoic acid that she must dilute with distilled water to make her standard solution.

A. 4.31 cm^3 **B.** 17.24 cm^3 **C.** 1.31 cm^3 **D.** 0.04 dm^3 [2]

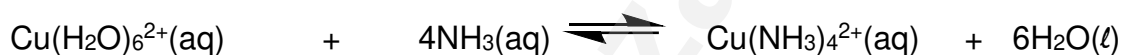
- 1.3 Which one of the following is **not** a necessary condition for the formation of hydrogen bonds to exist in a given substance?

- A. Hydrogen must be bonded to a small atom
- B. Hydrogen must be bonded to a metal
- C. Hydrogen must be bonded to an atom with a high electronegativity
- D. Hydrogen must be bonded to an atom with at least one lone pair. [2]

1.4 Which of the following statements are true?

- I. For an exothermic reaction, $\Delta H \geq 0$
 - II. During an exothermic reaction the temperature of the reaction mixture increases initially.
 - III. In an exothermic reaction the chemical potential energy of the products will be less than the chemical potential energy of the reactants.
- A. All three are correct.
 B. I and II only are correct.
 C. II only is correct.
 D. II and III are correct. [2]

1.5 The balanced chemical equation below refers to the reaction between hydrated copper (II) ions reacting with ammonia solution:



A few drops of concentrated NH_3 were added to the system that is in equilibrium. Which answer correctly shows the stress and the system's response to the stress?

	Stress	Response
A	Increase in pH	Forward reaction favoured to lower the pH
B	Increase in pH	Backward reaction favoured to lower pH
C	Decrease in pH	Forward reaction favoured to increase pH
D	Increase in concentration of NH_3	Forward reaction favoured to increase K_c value

[2]

1.6 Water was added to $0.2 \text{ mol} \cdot \text{dm}^{-3} \text{ HNO}_3$. Which one of the following shows the change in strength, concentration and pH of the acid?

	Strength	Concentration	pH
A	Remains the same	Remains the same	Remains the same
B	Increases	Increases	increases
C	Remains the same	Decreases	increases
D	Decreases	Decreases	decreases

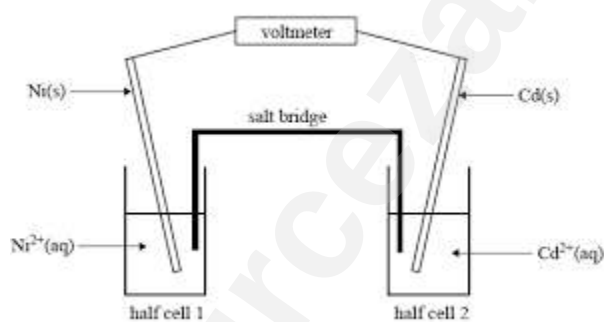
[2]

1.7 An *electrolyte* can be defined as:

- A. A substance that can conduct electricity by forming free ions when molten or dissolved in solution.
- B. A substance that conducts electricity by releasing free electrons when molten or dissolved in solution.
- C. A solid that transfers charge from an external circuit to a solution.
- D. A substance that transfers electrons from a solution to an external circuit.

[2]

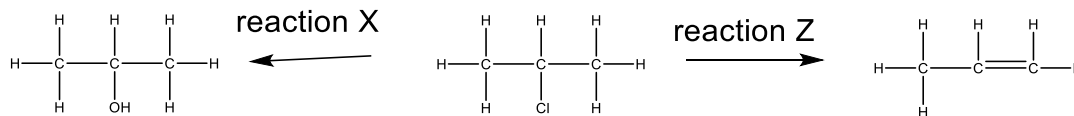
1.8 The diagram below shows a Nickel (Ni) – Cadmium (Cd) electrochemical cell. Which set of information is correct about the cell?



	Reducing agent	E^0_{cell}	Cell notation
A	Cd	+0.15	$\text{Cd} \text{Cd}^{2+} \text{Ni}^{2+} \text{Ni}$
B	Cd^{2+}	+0.15	$\text{Cd} \text{Cd}^{2+} \text{Ni}^{2+} \text{Ni}$
C	Ni^{2+}	-0.15	$\text{Cd} \text{Cd}^{2+} \text{Ni}^{2+} \text{Ni}$
D	Ni	-0.15	$\text{Cd} \text{Cd}^{2+} \text{Ni}^{2+} \text{Ni}$

[2]

Study the following reaction scheme and refer to it in answering question 1.9 and 1.10



1.9 Which set of information is correct about the reaction X and reaction Z?

	General type of reaction	Specific type of reaction
A	Reaction X is elimination	Reaction Z is dehydrohalogenation
B	Reaction Z is addition	Reaction X is hydration
C	Reaction X is substitution	Reaction Z is dehydrogenation
D	Reaction Z is elimination	Reaction Z is dehydrohalogenation

[2]

1.10 Which of the following set of information is correct about the reactions?

	Reaction condition	By-products of reaction
A	Reaction X is heated under reflux in aqueous alkali	Reaction X by-product is $\text{C}_2\text{H}_5\text{Cl}$
B	Reaction Z is heated under reflux in aqueous alkali	By-product for reaction Z is HCl
C	Reaction X is in hot concentrated NaOH in ethanol	By-products for reaction X is HCl
D	Reaction Z is in hot concentrated NaOH in ethanol	Reaction Z by-product is $\text{C}_2\text{H}_5\text{Cl}$

[2]

Question 2 (29 marks)

2.1 Carefully study the diagrams below and then answer the questions that follow:

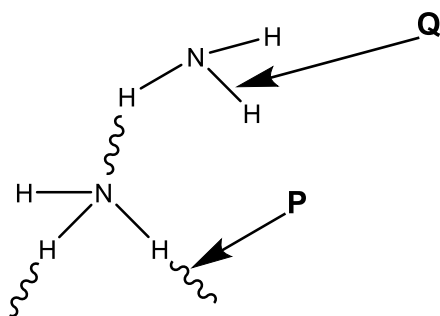


Diagram 1

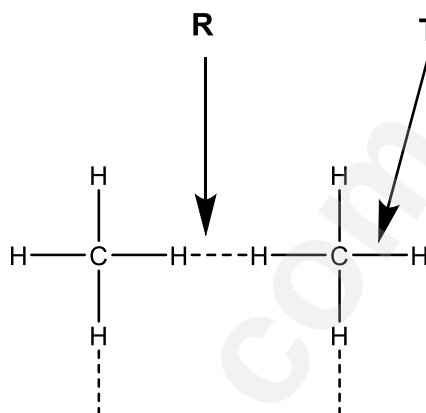


Diagram 2

2.1.1 Write down the names of the compounds represented in

a) Diagram 1 _____ [1]

b) Diagram 2 _____ [1]

2.1.2 State with a reason/justification what is represented by the letter:

a) **Q** _____

 _____ [3]

b) **R** _____

 _____ [3]

2.1.3 Explain in detail the origin of the part labelled **R** in diagram 2. [3]

2.1.4 The substance in diagram 1, when dissolved in water actually reacts with water. Before it reacts with water it is a poor conductor of electricity, but after dissolving in water it conducts electricity.

a) Write down a balanced chemical equation (think carefully about the chemistry involved) for the dissolving/reacting with water, include phase/state symbols. [4]

b) Explain in detail why the substance in diagram 1 does not conduct electricity before it dissolves/reacts with water. [4]

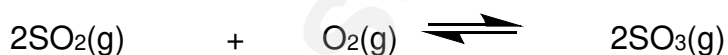
2.2 Ethanol can be used as a fuel, when this is done the ethanol reacts with oxygen. In the presence of limited oxygen, the products of the reaction are carbon monoxide and water. In one such case, Luke used 50 ml of ethanol to light up his room during load shedding. Assume 1 ml of ethanol has a mass of 1 gram for this question.

2.2.1 Write a balanced chemical equation for this reaction when ethanol reacts with limited oxygen. [4]

- 2.2.2 Deduce by calculation the volume of oxygen that must be used in-order to produce carbon monoxide in this reaction. [6]

Question 3 (27 marks)

- 3.1 One of the key reactions in the manufacture of sulphuric acid is called the Contact process and is shown below:



This reaction is catalysed by a V_2O_5 catalyst. The **rate of this reaction** and the **yield** of this reaction is thought to determine the viability of the manufacture of sulphuric acid.

- 3.1.1 Define the following terms as used above:

a) *Rate of reaction:* [2]

b) *Yield:* _____

[2]

c) Catalyst: _____

[2]

3.1.2 This reaction is followed by an increase in temperature when it occurs.

a) State with a reason whether the reaction as it is written is endothermic, exothermic or none of the two.

[3]

b) In the space below, draw a labelled sketch of potential energy profile graph for the reaction.

[5]

c) In the graph above use a dotted line to show how the catalyst affects the rate of the reaction. Explain your answer.

[3]

3.2 Explain how each of the following factors affect the rate of a reaction:

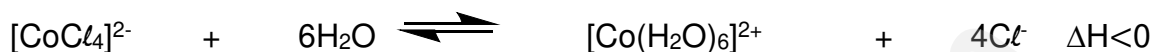
3.2.1 Particle size

[4]

3.2.2 Temperature (use of a Maxwell-Boltzmann distribution is expected) [6]

Question 4 (28 marks)

4.1 One of the chemical tests of water is to use cobalt (II) chloride. In the absence of water cobalt (II) chloride exists as a **blue solution** due to $[\text{CoCl}_4]^{2-}$ complex, when water is present the Cl^- is replaced by water to form the **pink** complex of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ as shown in the equation below:



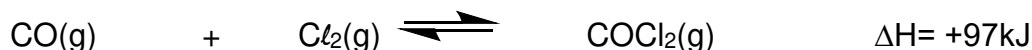
4.1.1 State *Le Châtelier's principle* [2]

4.1.2 Explain in detail what will be observed when the system, which is originally in equilibrium, is heated. [4]

4.1.3 a) What will be **observed** when Cl^- concentration is decreased? [1]

b) How does this affect the value of the equilibrium constant K_c ? Explain your answer [3]

4.2 3 moles of CO , 2 moles of Cl_2 and 0 moles of COCl_2 were placed in a **closed system** at a temperature of 45°C in the presence of catalyst. The **equilibrium constant** is 0.1 and the total volume of the container is 2 dm^3 . The chemical equation for the reaction is:



4.2.1 Define *closed system* [2]

4.2.2 Write down an expression of K_c for the reaction. [2]

4.2.3 Deduce by calculation the concentrations of the mixture when equilibrium is achieved. [6]

4.2.4 During a class discussion on the reaction above, Morgan said “*When the catalyst was added the rate of the forward reaction increased so that the equilibrium constant increased.*” Do you agree with Morgan? Comment on your answer. [4]

- 4.2.5 Leah and Nana got into an argument about the effect of increasing temperature on the system which was initially in equilibrium. Leah had this to say; “*Increasing the temperature increases the rate of the forward reaction and lowers the rate of the backward reaction, therefore favouring the forward reaction and increasing the value of K_c* ”. On the other hand, Nana was convinced that the rate of the backward reaction stays the same.

Assess with justifications the argument between Leah and Nana. [4]

Question 5 (33 marks)

- 5.1 H_2SO_3 ionises as a **weak diprotic acid**.

5.1.1 Define the terms:

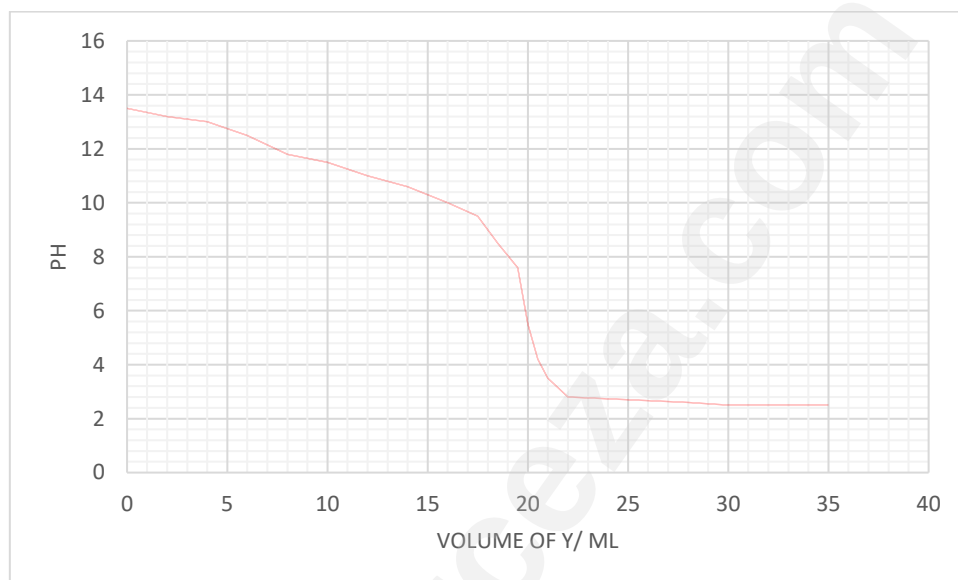
a) *Ionisation* [2]

b) *Weak acid* [2]

5.1.2 Write down the name of H_2SO_3 [2]

5.1.3 With the help of a relevant equation explain the meaning of diprotic [5]

- 5.2 Taryn and Hakim decided to carry out a titration between NH_3 solution and a dibasic acid, H_2X . They used the new pH meter with permission from the laboratory assistant. The acid and base were labelled either X or Y. They obtained the results shown in the graph below after titrating Y against 25.00 ml of X of concentration 0.15 mol.dm^{-3} .

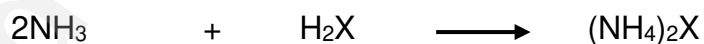


- 5.2.1 State with a reason which substance X or Y is the acid. [2]

- 5.2.2 Define the term *neutralisation* [2]

- 5.2.3 Deduce the volume of Y that is required to neutralise 25.00 ml of X. [2]

- 5.2.4 If the equation for the neutralisation is:



- Deduce by calculation the concentration of Y [5]

- 5.2.5 The table below shows the pH ranges of some indicators. Use the information to suggest with a reason a suitable indicator for the titration if they were not using a pH meter. [2]

Indicator	pH range at endpoint
Congo red	3.0 – 5.0
Bromothymol blue	6.0 – 7.6
Phenolphthalein	8.3 – 10.0

- 5.2.6 Explain the difference between the end point of an acid base titration and the equivalence point of the titration. [2]

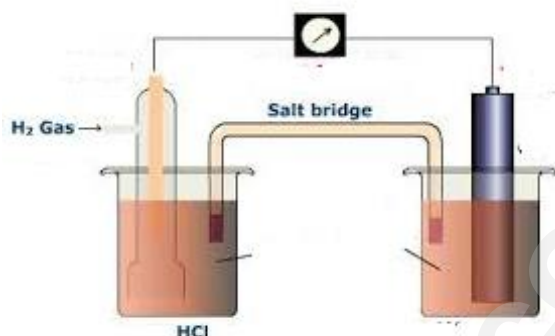
- 5.2.7 a) Is the salt $(\text{NH}_4)_2\text{X}$ neutral, acidic or basic? [1]

- b) Identify an ion in the salt which is hydrolysed and use this with the aid of an equation to explain your answer in 5.2.7 a) [4]

- 5.2.7 Suggest with a reason the identity of a suitable acid used in this titration. [2]

Question 6 (31 marks)

6.1 The diagram below shows an electrochemical cell under standard conditions:



The $E_{\text{cell}} = -1.18 \text{ V}$.

6.1.1 State with a reason which type of electrochemical cell this is. [2]

6.1.2 State the conditions that make this cell a standard cell. [3]

6.1.3 Suggest an identity of the other half cell [2]

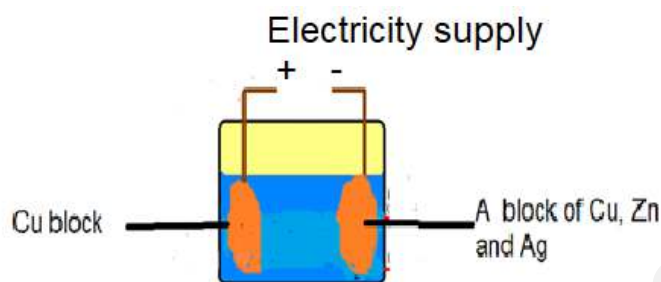
6.1.4 State with a reason which half-cell is the cathode [2]

6.1.5 Suggest a reason why the E_{cell} is negative in this cell. [2]

6.1.5 a) Suggest the chemical formula of a substance that can be used in the salt bridge [2]

b) Explain the functions of the salt bridge in detail, paying particular attention to the chemistry occurring. [4]

6.2 The diagram below shows another electrochemical cell:



The electrolyte in this cell is $\text{CuSO}_4(\text{aq})$. The block of Cu, Zn and Ag was made up mostly of Cu while there are very small amounts of Zn and Ag.

6.2.1 Define an *oxidising agent* [2]

6.2.2 What does the symbol (aq) stand for? [1]

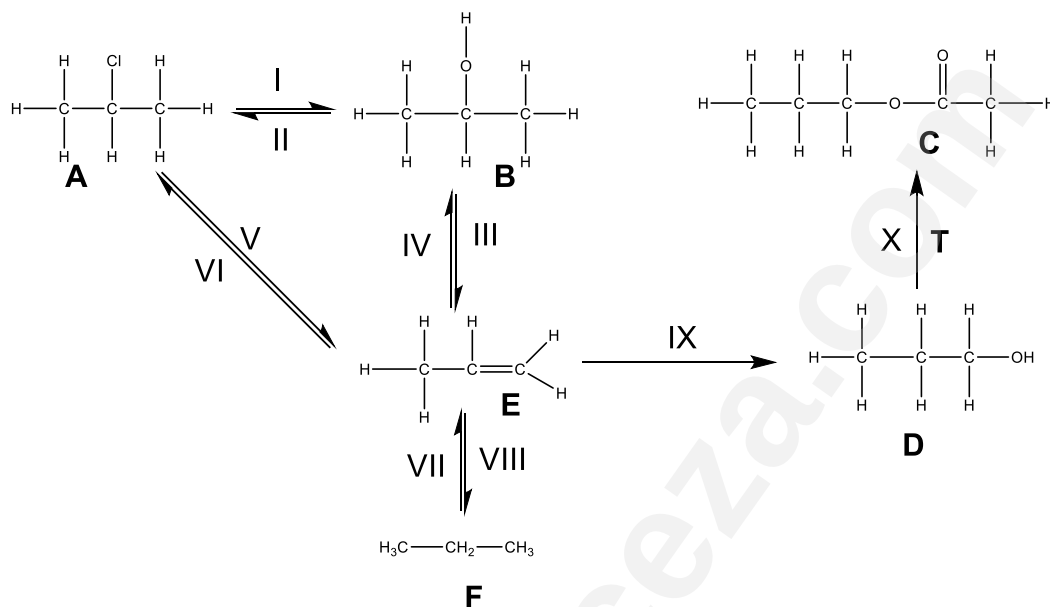
6.2.3 Write down the ion-electron equation taking place on the cathode. [2]

6.2.4 With reference to standard electrode potentials, explain the reactions that takes place on the anode over time. [6]

6.2.5 State one application of this electrochemical cell in industry, commenting on the information given in the cell during the process. [3]

Question 7 (32 marks)

Organic compounds are unique and often possess biological properties and so they are found in living organisms. Carefully study the reaction scheme of some common organic compounds that is shown below:



The organic molecules are identified by alphabetic letters in bold, while the reactions are identified by Roman numerals in normal text.

7.1 a) Define the term *saturated hydrocarbon* [2]

b) Which letter from the reaction scheme above represents a saturated hydrocarbon. [1]

7.2 a) Identify using letters the two structural isomers in the reaction scheme [2]

b) State with a reason the type of isomerism that exists between the two molecules. [2]

7.3 Write down the IUPAC names of the following molecules:

a) **A** [2]

- b) **C** _____ [2]
- 7.4 a) Define the term *functional group* [2]
- _____
- _____
- _____
- b) Write down the name of the functional group of the following molecules:
- i. **D** _____ [1]
- ii. **C** _____ [1]
- c) i. Write down the condensed formula of a branched functional isomer of molecule **C**. [3]
- _____
- _____
- ii. Write down the IUPAC name of the isomer in i. above. [2]
- _____
- _____
- 7.5 From the reaction scheme above identify using the number only reactions which correspond to:
- a) A dehydration reaction: _____ [1]
- b) A cracking reaction: _____ [1]
- 7.6 For each of the following reactions state the reaction conditions:
- a) Reaction III: _____ [2]
- b) Reaction X: _____ [3]
- _____
- 7.7 Identify with the structural formula the organic molecule **T** that is used in reaction X [2]

[3]

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