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PHYSICAL SCIENCES

PAPER 2

GRADE 12

23 September 2019

KINGSWOOD COLLEGE

Examiner: G. Makoni

Moderator: D. Price

Time: 3 hours

Total: 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:

- A question paper with 12 printed pages and 2 blank page (page 10 and 12)
- A separate 4 page data sheet printed on coloured paper (Already detached from question paper).
- An answer sheet for question 1 on page 11 and for question 3.5.3 and 3.5.5 (graph paper on pages 13 and 14 respectively remember to detach and insert into the answer booklet.

Make sure that your question paper is complete before starting.

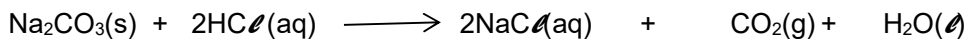
2. Write your full name clearly on your answer sheets.
3. There are 7 questions.
4. Answer **all** the questions in the answer booklet provided. Begin each question on a new page and leave 1 line between each part of a question.
5. Use the data and formulae whenever necessary.
6. Read the questions carefully and where calculations are involved leave your final answer to 2 decimal places unless stated otherwise in the question.
7. Write in black or dark blue pen. (Diagrams and graphs should be drawn in pencil).
8. It is in your interest to write legibly and to set your work out neatly.

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

Question 1

The following questions are multiple choice and each consists of 4 possible answers **A – D**, choose the letter that represents the best answer and mark it on the grid given on page 11.

1.1 Consider the following equation:



Which substance in the reaction above is in solution?

- A. Na_2CO_3
 - B. NaCl
 - C. CO_2
 - D. H_2O
- (2)

1.2 The name of K_2SO_3 is

- A. Potassium sulphate
 - B. Dipotassium sulphite
 - C. Dipotassium sulphate
 - D. Potassium sulphite
- (2)

1.3 The number of molecules in 11g of carbon dioxide is

- A. 0.25
 - B. 1.51×10^{-23}
 - C. 1.51×10^{23}
 - D. 2.50×10^{23}
- (2)

1.4 A *solvent* can be defined as

- A. A homogeneous mixture of solution and solute.
 - B. Amount of solute per unit volume of solution.
 - C. A substance that is dissolved in the solution.
 - D. A substance in which another substance is dissolved, forming a solution.
- (2)

1.5 Which of the following compounds has a polar covalent bond?

- A. Carbon dioxide
 - B. Sodium chloride
 - C. PH_3
 - D. Chlorine
- (2)

1.6 Which letter has the correct set of information about a hypothetical reaction?

	ΔH	Energy changes occurring	Temperature changes occurring	Reaction type
A	$\Delta H < 0$	Chemical potential energy converted to thermal energy	Temperature rises to maximum before dropping	Exothermic
B	$\Delta H < 0$	Thermal energy converted to chemical potential energy	Temperature rises to maximum before dropping	Exothermic
C	$\Delta H < 0$	Chemical potential energy converted to thermal energy	Temperature drops to minimum before rising	Endothermic
D	$\Delta H < 0$	Thermal energy converted to chemical potential energy	Temperature drops to minimum before rising	Endothermic

(2)

1.7 An *open system* in chemistry can be defined as

- A. One in which mass is conserved in a system but energy can enter or leave the system freely
- B. One in which mass is not conserved and energy cannot enter or leave the system freely
- C. One in which energy can be exchanged but matter cannot be exchanged between the system and its environment.
- D. One in which both energy and matter can be exchanged between the system and its surrounding.

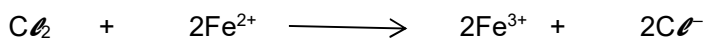
(2)

1.8 Which of the following substance is **not** amphoteric?

- A. H_2O
- B. HCO_3^-
- C. CO_3^{2-}
- D. HSO_4^-

(2)

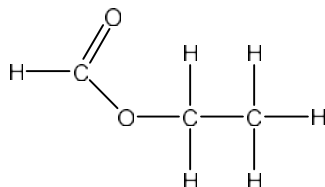
1.9 Which of the following cell notation is correct for the reaction below:



- A. $\text{Pt} | \text{C}\ell^- | \text{C}\ell_2 || \text{Fe}^{2+}, \text{Fe}^{3+} | \text{Pt}$
 B. $\text{Pt} | \text{C}\ell_2 | \text{C}\ell^- || \text{Fe}^{2+}, \text{Fe}^{3+} | \text{Pt}$
 C. $\text{Pt} | \text{C}\ell^- | \text{C}\ell_2 || \text{Fe}^{3+}, \text{Fe}^{2+} | \text{Pt}$
 D. $\text{Pt} | \text{C}\ell_2 | \text{C}\ell^- || \text{Fe}^{3+}, \text{Fe}^{2+} | \text{Pt}$

(2)

1.10 Which reagents and reaction conditions can best be used to produce:



	Reagents	Reaction conditions
A	$\text{CH}_3\text{OH} + \text{CH}_3\text{COOH}$	$\text{H}_2\text{SO}_4(\text{l}) + \text{heat}$
B	$\text{CH}_3\text{C}\ell + \text{CH}_3\text{COOH}$	$\text{H}_2\text{SO}_4(\text{l}) + \text{heat}$
C	$\text{HCO}_2\text{H} + \text{CH}_3\text{CH}_2\text{OH}$	$\text{Al}_2\text{O}_3 + \text{heat}$
D	$\text{HCO}_2\text{H} + \text{CH}_3\text{CH}_2\text{OH}$	$\text{H}_2\text{SO}_4(\text{l}) + \text{heat}$

(2)

[20 marks]

Question 2

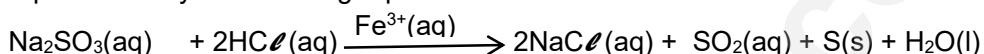
- 2.1 When **chlorine** gas is bubbled in hot **sodium hydroxide** solution it reacts to produce a mixture of **sodium chlorate, sodium chloride and water**. This is an example of a chemical change. Represent this chemical change using a balanced chemical equation with symbols and state (phase) symbols. (4)
- 2.2 Define the following terms:
- 2.2.1 *Intramolecular bond* (1)
- 2.2.2 *Electronegativity*. (2)
- 2.3 With the aid of Lewis diagrams describe in detail the intramolecular bonding in:
- 2.3.1 Chlorine (2)
- 2.3.2 Sodium chloride (3)
- 2.3.3 Water (2)
- 2.4 Sodium chloride is a solid at room temperature and pressure whereas chlorine is a gas and water is a liquid under the same conditions.
- 2.4.1 Define the term *intermolecular forces* (1)
- 2.4.2 Explain, using intermolecular forces, in detail why the three substances have different states at room temperature and pressure. (5)

- 2.4.3 With the help of a sketch diagram describe the intermolecular forces in sodium chloride solution. (4)
- 2.4.4 Explain briefly why solid sodium chloride does not conduct electricity whereas sodium chloride solution conducts electricity. (2)

[26 marks]

Question 3

During their Matric Chemistry practical investigation Ernest and Chad collaborated in their investigation on how temperature as well as concentration affects the rate of the reaction between sodium thiosulphate and hydrochloric acid. The reaction, catalysed by Fe^{3+} , is represented by the following equation:



- 3.1 Define the term *reaction rate*. (1)
- 3.2 Suggest with a reason a suitable method that Ernest and Chad could use to follow or measure the reaction rate. (1)
- 3.3 Will the method you suggested in 3.2 give the average or instantaneous reaction rate? Explain your answer. (3)
- 3.4 With the aid of a labelled Maxwell-Boltzmann distribution curve explain the effect they expected temperature to have on the reaction rate. (4)
- 3.5 They were provided with HCl of concentration $2 \text{ mol}\cdot\text{dm}^{-3}$, Fe^{3+} of concentration $0.1 \text{ mol}\cdot\text{dm}^{-3}$ and $\text{Na}_2\text{S}_2\text{O}_3$ of concentration $1 \text{ mol}\cdot\text{dm}^{-3}$. During the investigation they mixed 45 cm^3 of Na_2SO_3 , 45 cm^3 of HCl and 10 cm^3 of Fe^{3+} . The table below shows some of their results:

Exp No	Concentration of HCl (M)	Concentration of Na_2SO_3 (M)	Concentration of Fe^{3+} (M)	Time taken for reaction to be complete (s)	Reaction rate (10^{-2}s^{-1})
1	2.00	1.00	0.00	20.8	
2	1.75	0.80	0.10	16.2	
3	1.50	0.80	0.10	18.0	
4	1.25	0.80	0.10	19.21	
5	1.00	0.80	0.10	20.3	
6	0.75	0.80	0.10	22.1	
7	2.00	1.00	0.10	14.3	
8	2.00	0.80	0.10	15.3	

- 3.5.1 Which **two** experiments could they use to deduce the effect of the catalyst on the reaction rate? Explain your answer. (2)

- 3.5.2 Explain using a labelled reaction profile (progress) diagram how a catalyst alters the rate of a reaction. (5)
- 3.5.3 On the attached answer sheet on page 13 calculate and fill in the values of $1/t$ which represent reaction rate. **Note the units in the column!** (2)
- 3.5.4 Which experiments in the table should they not use to deduce the effect of changing concentration of HCl on the reaction rate? Explain your answer. (2)
- 3.5.5 On the graph paper provided on page 14 use the results in the table and your calculated values to plot a graph of $1/t$ against concentration of HCl . (6)
- 3.5.6 Suggest a reason why $1/t$ was used in this graph and not t . (2)
- 3.5.7 Use your graph to deduce a mathematical relationship between $1/t$ and concentration of HCl . (2)
- 3.5.8 Use your understanding of rates of reaction to draw a conclusion on the effect of concentration of HCl on the reaction rate. (2)
- 3.5.9 Explain your conclusion in 3.5.8 using your understanding of factors affecting rates of reaction. (2)
- 3.5.10 For experiment 4 in the table deduce by calculation the volume of $2 \text{ mol} \cdot \text{dm}^{-3}$ HCl they diluted to make 45 cm^3 of $1.25 \text{ mol} \cdot \text{dm}^{-3}$ HCl . (3)

[37 marks]

Question 4

- 4.1 Explain the meaning of dynamic equilibrium. (2)
- 4.2 State the condition necessary for chemical equilibrium to be achieved. (1)
- 4.3 The reaction that takes place in the Contact process, which is catalysed by V_2O_5 , is shown below:
- $$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \xrightleftharpoons{\text{V}_2\text{O}_5} 2\text{SO}_3(\text{g}) \quad \Delta H < 0$$
- 4.3.1 Write down an expression of K_c for the reverse reaction. (2)
- 4.3.2 State *Le Chatelier's principle*. (2)
- 4.3.3 Use *Le Chatelier's principle* to explain the effect of:
- Reducing the volume of the container. (3)
 - Increasing the temperature of the system. (3)
 - Addition of V_2O_5 , the catalyst. (1)
- 4.3.4 Explain how increasing the volume of the container would affect the rate of the forward reaction as compared to that of the backward reaction. (3)
- 4.3.5 Suggest a reason why the following conditions are used industrially in the Contact process: a temperature of 450°C and a pressure of 2 atmospheres. (2)
- 4.3.6 At a temperature of 350 K, 1.5 moles of SO_2 and 0.8 moles of O_2 were placed in a 2.5 dm^3 container that had V_2O_5 and the container sealed. After equilibrium was achieved 0.4 moles of SO_3 were present in the mixture.
- Deduce the concentration of gases present at equilibrium. (5)
 - Calculate the value of K_c at 350 K. (2)

- c) How would the addition of SO_3 to the system affect the value of K_c ? Explain your answer. (2)
- 4.3.7 Assume the reaction in 4.3.6 proceeded to completion and answer the following questions:
- Deduce the limiting reagent in 4.3.6. (2)
 - Calculate the number of moles of SO_3 that would be produced. (3)
 - Define the term *yield*. (1)
 - Use the number of moles of SO_3 produced in 4.3.6 and the number of moles you calculated in 4.3.7 to deduce the percentage yield of SO_3 . (2)

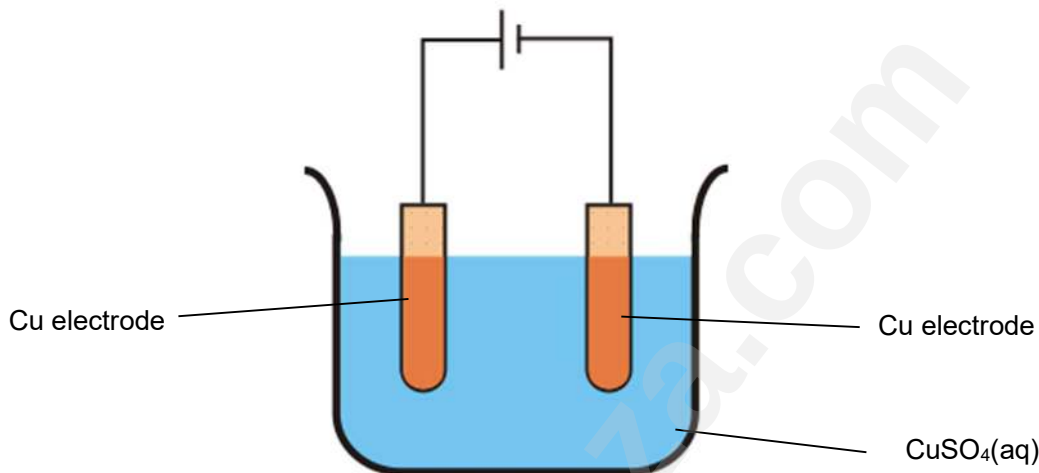
[36 marks]**Question 5**

- 5.1 Acids can be classified as strong or weak and also as concentrated or dilute.
- Define the term *weak acid*. (2)
 - State the difference between a strong acid and a concentrated acid. (2)
 - H_2SO_3 is an example of a weak diprotic. With the aid of an ionisation equation describe what the term weak diprotic mean. (4)
- 5.2 H_2SO_3 of concentration 0.25 mol.dm^{-3} was found by Ethan in the lab. On further investigation he found that it has a concentration of H_3O^+ at 25°C of 0.01. Calculate:
- Hydroxide ion concentration in this solution at 25°C . (3)
 - Deduce the concentration of the unionised H_2SO_3 in solution. (2)
 - Deduce the value of K_a for H_2SO_3 at 25°C . (4)
- 5.3 H_2SO_3 is titrated against sodium hydroxide solution to produce a salt.
- Define the term *salt*. (1)
 - Write a balanced chemical equation for the reaction occurring during the titration. (3)
 - Define *hydrolysis*. (1)
 - Write down the chemical formula of the ion that undergoes hydrolysis in the reaction in 5.3.2. (1)
 - Write down the equation for its hydrolysis reaction. (3)
 - Suggest a suitable range of pH for the salt formed during the titration. (2)

[28 marks]**Question 6**

- 6.1 Zn metal is placed in $\text{CuSO}_4(\text{aq})$ in a beaker and left in there for some time.
- With the aid of standard redox potentials state whether a spontaneous reaction will occur. Explain your answer. (2)
 - Identify with a reason which ions are spectator ions if a spontaneous reaction occurs. (2)
 - Write down the overall reaction and deduce the emf. (4)

- 6.1.4 State with a reason which half reaction was the anode. (2)
- 6.1.5 State with a reason which substance is the oxidising agent in the cell. (2)
- 6.2 Carefully study the electrochemical cell shown below which was adapted from *electrical4u.com*.

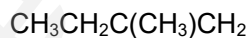


- 6.2.1 Is this cell a galvanic or electrolytic cell? Explain your answer. (3)
- 6.2.2 Write down the half reaction occurring on:
- The anode (2)
 - The cathode. (2)
- 6.2.3 The anode is replaced with one that has impure copper. The impurities are Ag (silver) and Zn (zinc).
- State with a reason the reaction that occurs on the anode first. (2)
 - Explain why Zn is not deposited on the cathode. (2)
 - State what happens to the impurities, Ag and Zn. Explain your answer. (3)

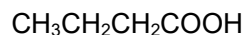
[26 marks]

Question 7

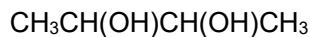
- 7.1 Consider the following organic molecules (**A – D**) and then use them to answer the questions that follow:



A



B



C



D

- 7.1.1 Using only the letters **A** to **D** choose any one compound that is a hydrocarbon. (1)
- 7.1.2 Define the term *structural isomer*. (2)

- 7.1.3 Write down the structures of the following:
- a) Full structural formula of a chain isomer of **A**. (2)
 - b) A condensed formula of a functional isomer of **B**. Also write down the IUPAC name of this isomer. (3)
- 7.1.4 Write down the IUPAC names of:
- a) **C** (2)
 - b) **D** (2)
- 7.1.5 **A** reacts with steam ($\text{H}_2\text{O}(\text{g})$) at high pressure in the presence of H_3PO_4 .
- a) Suggest the purpose of H_3PO_4 . (1)
 - b) Define the term *functional group*. State the functional group that will be present in the resultant organic compound after the reaction. (1)
 - c) Give a name to the general type of reaction that occurs. Suggest why **A** reacts in that way with steam. (2)
- 7.2 CH_3CHCH_2 reacts Br_2 at room temperature and pressure.
- 7.2.1 Write down a balanced chemical equation for the reaction. Show the structural formula of the organic product. (5)
 - 7.2.2 State the specific name of the reaction taking place. (1)
 - 7.2.3 State the observation that would be made during this reaction. (2)
 - 7.2.4 How will the boiling point of the organic product compare with that of CH_3CHCH_2 . Explain your answer. (3)

[27 marks]

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Answer sheet for question 1

- Put an X over the box which contains the letter which corresponds to the correct answer as shown below.

A	~~B~~	C	D
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- There is only one correct answer for each question.
- Remember to detach this answer sheet and put it in your answer booklet.

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

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Name: _____

Answer sheet for question 3.5.3

- Remember to insert this in your answer booklet at the end of the exam.

Exp No	Concentration of HCl /(M)	Concentration of Na_2SO_3 / (M)	Concentration of Fe^{3+} / (M)	Time taken for reaction to be complete/ (s)	Reaction rate/ (10^{-2}s^{-1})
1	2.00	1.00	0.00	20.8	
2	1.75	0.80	0.10	16.2	
3	1.50	0.80	0.10	18.0	
4	1.25	0.80	0.10	19.21	
5	1.00	0.80	0.10	20.3	
6	0.75	0.80	0.10	22.1	
7	2.00	1.00	0.10	14.3	
8	2.00	0.80	0.10	15.3	

(2)

Graph paper for question 3.5.5

- Remember to insert this into your answer booklet.

