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PRELIMINARY EXAMINATIONS

03 September 2020

PHYSICAL SCIENCES PAPER 2

Examiner: Mrs G Dell

Moderators: Ms T Reddy, Mr G. Morris

Time: 3 hours

Marks: 200

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 18 pages, with 9 questions, an answer sheet and a data sheet of 3 pages (i–iii). Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Start each question on a new page.
6. Show your working in all calculations.
7. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
8. Where appropriate express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.

Question 1 Multiple Choice Questions

Answer these questions on the Answer Sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 Given the chemical reaction: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$. The correct set of molar masses (in $\text{g}\cdot\text{mol}^{-1}$) of the reagents in this reaction is:

	M of N_2	M of H_2	M of NH_3
A	28	6	34
B	28	2	17
C	14	6	20
D	14	2	10

(2)

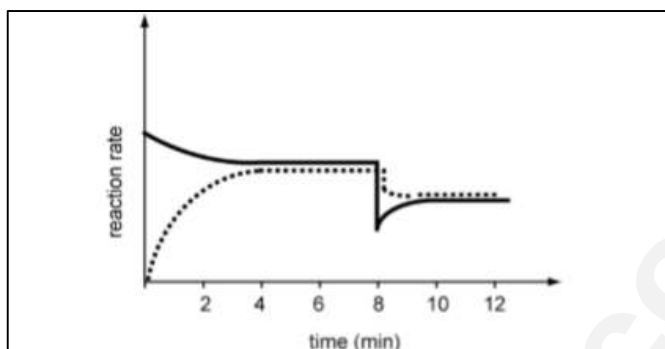
- 1.2 In a reaction $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$, 1 dm^3 of O_2 and an excess of H_2 at STP is used. The volume of H_2O formed is:

- A. $0,5\text{ dm}^3$
- B. 1 dm^3
- C. 2 dm^3
- D. $22,4\text{ dm}^3$

(2)

1.3 (Ref: Saheti Preliminary Examination P2 2019)

Consider the graph below of reaction rate for a gaseous equilibrium reaction.



Which change could NOT be responsible for the indicated change at 8 min?

- A. A decrease in pressure
- B. A decrease in temperature
- C. A decrease in concentration
- D. A decrease in volume

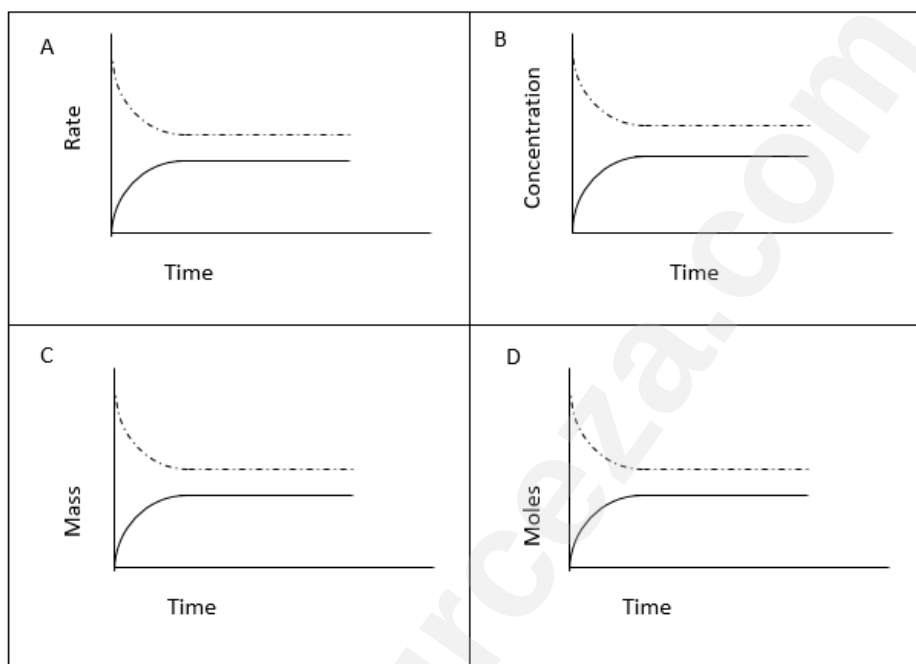
(2)

1.4 Dissolving potassium nitrate in water is an endothermic reaction. This means that:

- A. The test-tube in which this occurs will feel cold as the KNO_3 dissolves and energy is released.
- B. The test-tube in which this occurs will feel cold as the KNO_3 dissolves and energy is absorbed.
- C. The test-tube in which this occurs will feel hot as the KNO_3 dissolves and energy is released.
- D. The test-tube in which this occurs will feel hot as the KNO_3 dissolves and energy is absorbed.

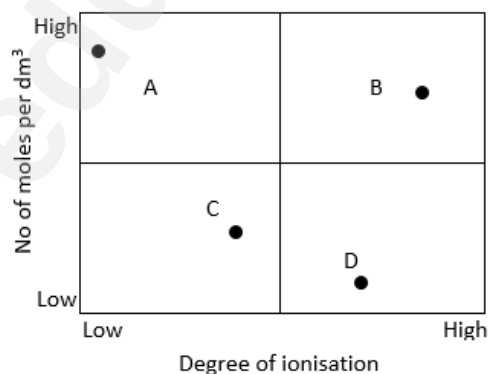
(2)

- 1.5 The following graphs are drawn to show the progress of reversible reactions. The forward reaction is represented by the dotted line and the reverse reaction is the solid line. Which graph that does not represent an equilibrium reaction?



(2)

- 1.6 The grid below indicates the degree of ionisation from low to high along the horizontal axis and the moles per dm^3 from low to high along the vertical axis. Which position on the grid (A, B, C or D) will represent a weak concentrated acid?



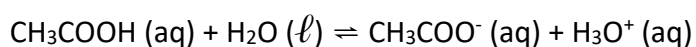
(2)

1.7 In an electroplating experiment, a jug made of cheap metal is to be silver-plated. A statement that is FALSE is:

- A. The electrolyte must contain Ag^+ ions.
- B. A pure silver rod forms the anode.
- C. The reaction is a non-spontaneous reaction.
- D. Oxidation occurs at the surface of the jug.

(2)

1.8 Acetic acid is a weak acid and forms an equilibrium in water:



Sodium acetate solution is added to the acetic acid solution. The effect on the equilibrium and the pH is:

	Equilibrium	pH
A	Shifts to left	Increases
B	Shifts to right	Increases
C	Shifts to left	Decreases
D	Shifts to right	Decreases

(2)

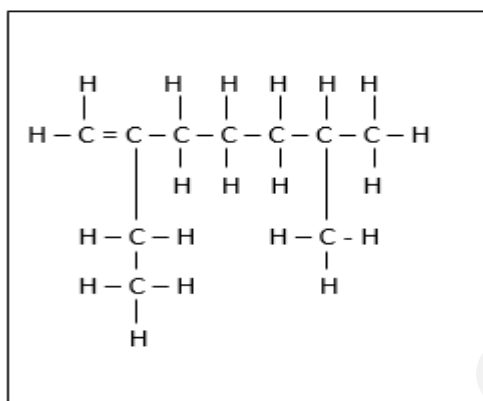
1.9 CH_3COOH is titrated against NaOH .

Your choice of indicator for the titration will be

- A. methyl red (colour changes over pH range 4,2 – 6,2)
- B. methyl orange (colour changes over pH range 3,1 – 4,4)
- C. bromothymol blue (colour changes over pH range 6,0 – 7,8)
- D. phenolphthalein (colour changes over pH range 8,3 - 10).

(2)

1.10 The IUPAC name of the organic compound shown below is:



- A. 1,6-dimethyloct-1-ene
- B. 6-ethyl, 6-methylhept-1-ene
- C. 2-ethyl, 6-methylhept-1-ene
- D. 1-methyl, 6-ethylhept-6-ene

(2)

[20]

Question 2 Bonding

2.1 Define *polar covalent bonding*. (2)

2.2 Select the appropriate formula/e from the list below. Each answer may have more than one substance that is appropriate – you need give only ONE. You may use a substance more than once.

CO₂ NH₃ Ne Ag H₂ HCl F₂ MgO SiO₂ HF Br₂ K CO

2.2.1 A molecule with pure covalent bonding. (1)

2.2.2 A substance that has an unnaturally high boiling point due to the intermolecular force called hydrogen bonding. (1)

2.2.3 A substance that conducts electricity only when it is molten. (1)

2.2.4 Only London dispersion forces exist between particles. (1)

- 2.2.5 Will form an ionic bond when exposed to chlorine gas. (1)
- 2.2.6 Forms a giant covalent structure. (1)
- 2.2.7 Has dipole-dipole inter molecular forces between particles. (1)
- 2.3 The hydrolysis of potassium bromide in water forms K^+ and Br^- ions.
- 2.3.1 Define *ionic bonding*. (2)
- 2.3.2 Explain how KBr dissolves so readily in water. (2)
- 2.3.3 Predict whether KBr will dissolve in ethanol (CH_3COOH) and if so, to what extent. Explain your reasoning. (3)
- 2.4 The table below provides information about various molecules and the boiling points of those substances.

Molecular Formula	Boiling point ($^{\circ}C$)	Geometry of molecule
SO_2	-10	Angular
CH_4	-164	Tetrahedral
CO_2	-78,5	Linear
H_2O	100	Angular

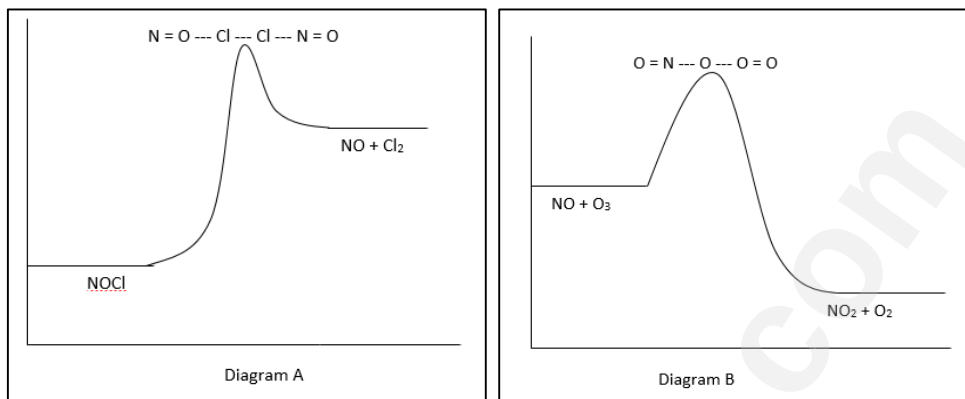
[https://web.chem.ucsb.edu/~genchem/Chem1CS03/moreinfo/trends_in_boiling_points .pdf](https://web.chem.ucsb.edu/~genchem/Chem1CS03/moreinfo/trends_in_boiling_points.pdf)

- 2.4.1 CH_4 and CO_2 have significantly lower boiling points than SO_2 and H_2O . Using the information provided and your knowledge of inter-molecular forces, explain why. (6)
- 2.4.2 Both SO_2 and H_2O are angular molecules. What makes the boiling point of H_2O so much higher than SO_2 ? (3)

[25]

Question 3

3.1 Two energy profile diagrams, drawn to similar scales, are given below:



Ref: Chemistry: Brown, Lemay, Bursten

3.1.1 Which reaction (A or B) is endothermic? (1)

3.1.2

a. Define activation energy. (2)

b. Which of the two reactions has the bigger activation energy? (1)

3.1.3 What is the activated complex in reaction B? (1)

3.1.4 Which reaction has the bigger magnitude of enthalpy, ΔH ? (1)

3.2 The chemical equation for a reaction is given:



3.2.1 In this reaction, 0,5 g of CaCO_3 is reacted with 50 ml of $0,25 \text{ mol} \cdot \text{dm}^{-3}$ HCl . Show that HCl is in excess. (4)

3.2.2 Suggest a method that could be used to monitor the progress of this reaction. (2)

3.2.3

- a. In terms of collision theory, what are the requirements for a successful reaction to occur? (2)
- b. The reaction above used a solid lump of calcium carbonate. It took 128 s to reach conclusion. The same amount of calcium carbonate was crushed to powder and then reacted with HCl . Would the reaction rate **INCREASE** or **DECREASE**? Explain your answer using collision theory arguments. (4)
- c. What other factors could be changed to control the time of the reaction? (2)

[20]

Question 4 https://www.qcaa.qld.edu.au/downloads/senior/snr_chemistry_07_as_sa_equal.pdf

4.1 Why is a chemical equilibrium considered to be dynamic? (2)

4.2 In the reaction below, the ions of potassium dichromate (an orange crystalline solid dissolved in water, K_2CrO_7) and potassium chromate (a yellow crystalline solid dissolved in water, $KCrO_4$) are in equilibrium. In both cases it is the anions that are coloured.

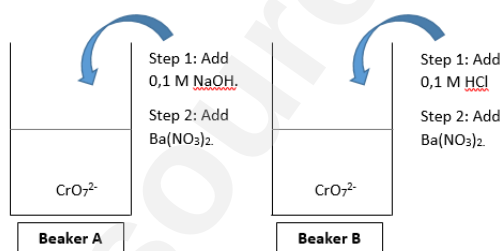


Orange

Yellow

An experiment was carried out in two steps:

Step 1: Equal amounts of dichromate solution were placed in 2 beakers, labelled A and B. To beaker A, 20 ml of $0,1 \text{ mol.dm}^{-3}$ NaOH was added. To beaker B, 20 ml of $0,1 \text{ mol.dm}^{-3}$ HCl was added.



http://faculty.uml.edu/james_hall/84124/19.htm

4.2.1

a. Write the equilibrium constant expression for the reaction. (2)

b. If the reaction temperature is increased, how will the K_c value change? Write **INCREASE/DECREASE/STAY CONSTANT**. (1)

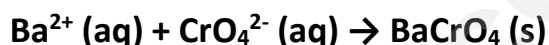
4.2.2 State Le Chatelier's Principle. (2)

4.2.3 Predict the predominant colour you will observe in Beaker A when the NaOH is added. Explain your prediction referring to Le Chatelier's principle. (4)

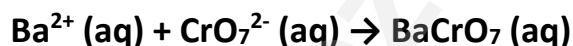
4.2.4 Predict the predominant colour you will observe in Beaker B when the HCl is added. Explain your prediction. (4)

4.2.5 **Step 2** of the experiment: Equal amounts of a solution of barium nitrate are added to each beaker.

When CrO_4^{2-} reacts with Ba^{2+} , insoluble BaCrO_4 forms according to the reaction:



When CrO_7^{2-} reacts with Ba^{2+} , soluble BaCrO_7 forms according to the reaction:



- What is a precipitate? (1)
- Predict which beaker (A or B) will form more precipitate? (2)
- Establish a relationship between pH and the amount of precipitate and the clarity of the solution in the beakers. (6)

[24]

Question 5

5.1 Define the terms:

5.1.1 Polyprotic acid. (1)

5.1.2 Conjugate base. (1)

5.2 Consider sulphuric acid, H_2SO_4 :

5.2.1 Write the acid dissociation reactions for H_2SO_4 as it loses one proton at a time. (3)

5.2.2 Identify a conjugate base in the process. (1)

5.3 Ethanoic acid is considered to be a weak acid.

5.3.1 Write a balanced chemical equation for ethanoic acid in water. (2)

5.3.2 Write the K_a expression for this reaction. (2)

5.3.3 Will the value of K_a for ethanoic acid be higher or lower than K_a of sulphuric acid? (2)

5.3.4 Why is ethanoic acid considered weak whilst sulphuric acid is strong? (2)

5.3.5 Compare the strengths of acids and their conjugate bases and refer to how the values of the K_a and K_b reflect these strengths. (4)

[18]

Question 6

Given the neutralisation reaction between hydrochloric acid and magnesium hydroxide:



(2)

6.1 Define a standard solution.

6.2 A standard solution of magnesium hydroxide with concentration $0,4 \text{ mol.dm}^{-3}$ is required. Calculate the mass of magnesium hydroxide that should be measured out for 250 ml of solution. (5)

6.3 Find the concentration of the hydrochloric acid solution if 36 ml of hydrochloric acid reacts completely with 25 ml of magnesium hydroxide. (3)

6.4 After the reaction was complete, the solution was heated and the salt collected. It was found to have a mass of 8,58 g.

6.4.1 Calculate the theoretical mass of salt that should form. (3)

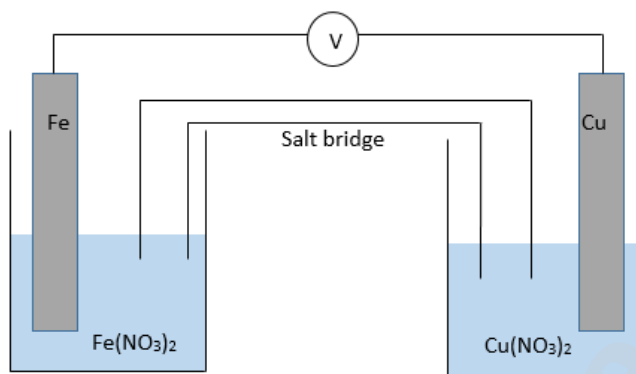
6.4.2 Calculate the percentage purity of the magnesium hydroxide originally measured out. (4)

6.5 Would the salt that formed be an acidic or a basic salt? (2)

[19]

Question 7

A Galvanic cell is constructed as shown in the diagram below. Use it and the Standard Reduction Potential table to answer the questions that follow.



- 7.1 Write the cell notation for the cell shown in the diagram. (2)
- 7.2 Write the reaction that occurs at the anode. (2)
- 7.3 Write the formula of the oxidising agent in the cell. (2)
- 7.4 What are the requirements for this standard cell? (2)
- 7.5 Calculate the cell potential assuming the standard requirements are met. (4)
- 7.6
- 7.6.1 What is the purpose of the salt bridge? (2)
- 7.6.2 Suggest a suitable electrolyte for the salt bridge. (1)
- 7.7 Describe TWO examples of physical evidence that indicate the cell is running. Ignore the voltmeter reading. (2)

- 7.8 Many houses use hot water radiators for heating. Household water pipes made of copper carry hot water into the steel radiators. The radiators contain a high percentage of iron.

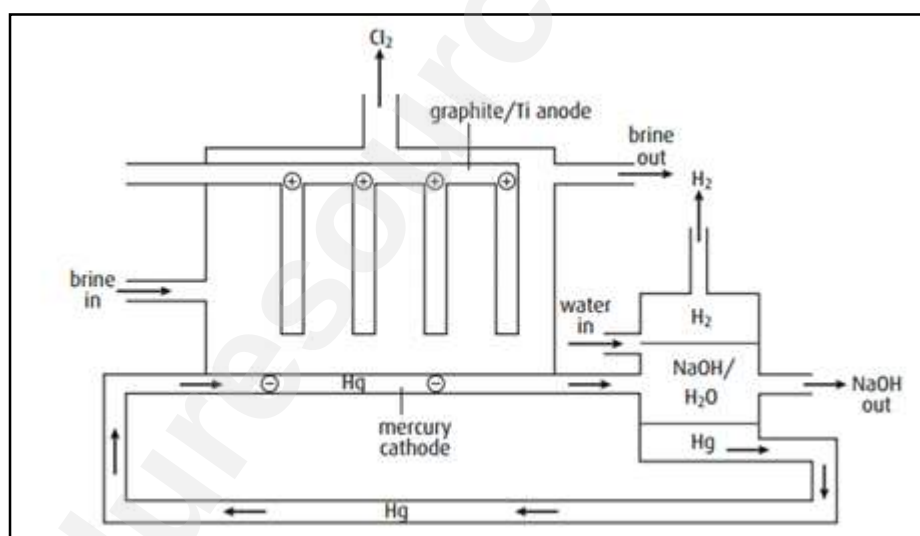
<https://www.sciencedirect.com/topics/engineering/copper-pipe>

- 7.8.1 Explain why corrosion will occur in the radiator. (4)
- 7.8.2 Will the problem be increased or lessened by the fact that hot water is used rather than cold? Explain your answer. (3)

[24]

Question 8

The electrolytic cell is of huge value in industry. In different processes, brine is processed in different ways to produce similar products. The mercury cell is shown below:



<https://level8chem.wordpress.com/the-chlor-alkali-industry/>

8.1 Name one major disadvantage of using the mercury cell. (1)

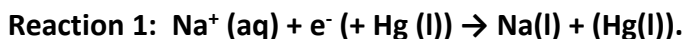
8.2 The first step in the process is to extract chlorine gas.

8.2.1 Write the reaction that produces the gas. (2)

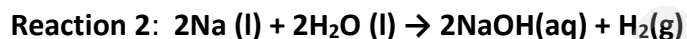
8.2.2 Is this an oxidation or a reduction reaction? (1)

8.2.3 Does this reaction occur at the anode or the cathode? (1)

8.3 In the mercury cell, sodium metal forms an amalgam with mercury in



The depleted brine is channelled to a second container where it reacts with water in



The mercury is recycled back into the process.

8.3.1 Is Reaction 1 an oxidation or reduction reaction? (1)

8.3.2 Which substance acts as the cathode? (1)

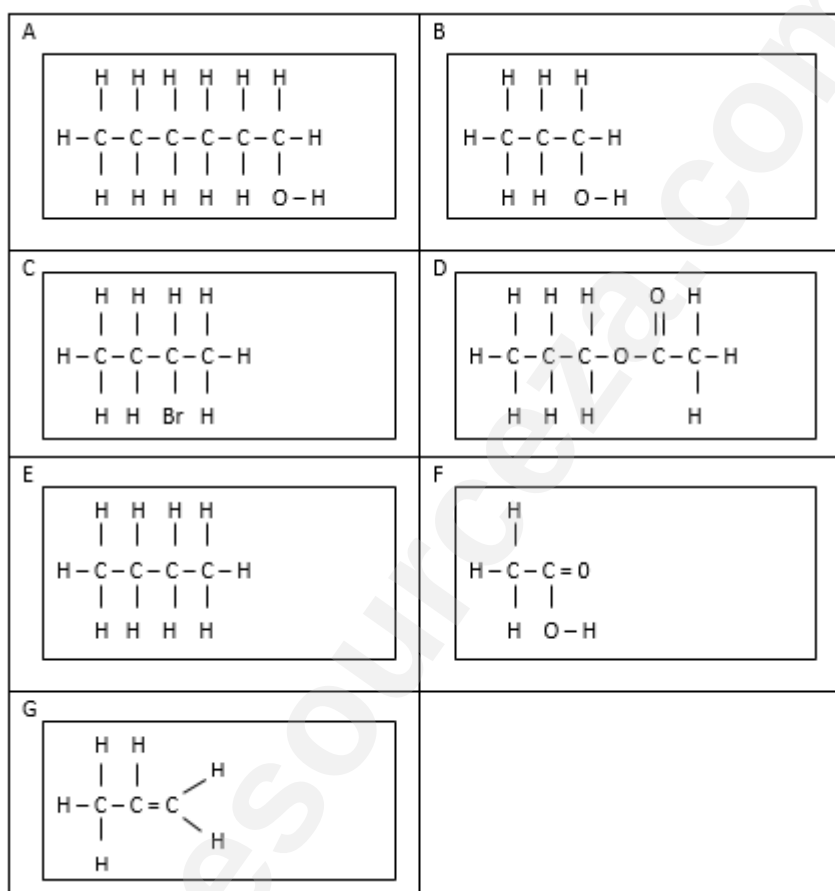
8.3.3 In Reaction 2, use oxidation numbers to show which substance is oxidised and which is reduced. (3)

8.3.4 Explain how relative strengths of oxidising and reducing agents supports your previous answer. (3)

[13]

Question 9 Organic chemistry

Use the following organic compounds to answer the questions. Where you are asked which compound answers the question, you may write simply the letter of that compound (A – G).



9.1

- | | |
|---|-----|
| 9.1.1 Which compound (A - G) is an alkane? | (1) |
| 9.1.2 Give the homologous series formula for these compounds. | (1) |
| 9.1.3 Give the IUPAC name for this compound. | (1) |
| 9.1.4 Draw a structural isomer for this compound. | (2) |
| 9.1.5 Name the isomer you have drawn. | (2) |

9.2 For compound B

9.2.1 To which homologous series does this belong? (1)

9.2.2 What is the name of the functional group that identifies such compounds. (1)

9.3

9.3.1 Define an *unsaturated hydrocarbon*. (2)

9.3.2 Identify 1 compounds (A - G) that is an unsaturated hydrocarbon. (1)

9.3.3 Give its IUPAC name. (2)

9.4 Compound E can be converted into a haloalkane by reacting it with Cl_2 .

9.4.1 Name the general and specific type of reaction that is required to convert compound E into a haloalkane. (2)

9.4.2 Give the reaction conditions that are required for the reaction. (1)

9.4.3 Which compound (A - G) is a haloalkane? (1)

9.5

9.5.1 Which compound (A - G) is a carboxylic acid? (1)

9.5.2 Name the compound. (1)

9.5.3 Which compound (A - G) is the product of esterification? (1)

9.5.4 Name the product. (2)

9.5.5 To which homologous series does this compound belong? (1)

9.5.6 Which other compound (A - G) must be reacted with the carboxylic acid to form the product identified in 9.5.3? (1)

9.5.7 H_2SO_4 is added to this reaction. What is its role in the reaction? (1)

9.6

9.6.1 Which compound (A - G) will undergo a dehydration reaction to form an alkene? (1)

9.6.2 Write the balanced chemical equation for this reaction indicating reaction conditions. Use condensed structural formula in your equation. (4)

9.7

9.7.1 Of compounds A and B, which one will have the highest boiling point? (1)

9.7.2 Why? (1)

9.7.3 Of compounds B and E, which one will have the higher boiling point? (1)

9.7.4 Why? (1)

9.8 Write the condensed formula of the compound that produced compounds E and G when it underwent a *cracking* reaction? (2)

[37]

TOTAL: 200