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ST ANNE'S DIOCESAN COLLEGE
TRIAL EXAMINATION 2024



PHYSICAL SCIENCES – PAPER 2 CHEMISTRY

Name and Surname _____

Teacher _____

Examination
number:

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Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

- This paper consists of:
 - Page 2 Multiple Choice Answer Grid
 - Pages 2-28: Questions 1 to 8
 - Pages 29-30: EXTRA PAPER
 - Pages 31-33: CHEMISTRY DATA SHEET, PERIODIC TABLE and REDOX TABLE

Please make sure that your question paper is complete.

- You may detach the data sheets if necessary.
- Read the questions carefully and answer all questions on the question paper in the space provided. If extra paper is needed make use of the space on pages 29-30. Label your questions clearly on the extra space section.
- Show your working in all calculations, including the equations used.
- Units need not be included in the working of calculations, but appropriate **units must be shown in the answer.**
- Where appropriate, round off your answers to two decimal places.

The use of other IEB teachers' questions, in whole or in part, is gratefully acknowledged.

For marking purposes

Question	1	2	3	4	5	6	7	8	TOTAL
Mark									
Out of	20	16	22	27	38	27	19	31	200

QUESTION 1 MULTIPLE CHOICE QUESTIONS

Answer these questions on the multiple choice answer sheet below. Make a cross X in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

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

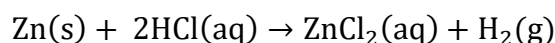
1.1 Which of the following statements **best** defines *electronegativity* ?

- A the energy released when an electron is added to an atom
- B the attraction of an atom to an electron
- C the tendency of an atom to form a cation
- D the pull of an atom on a bonding pair of electrons

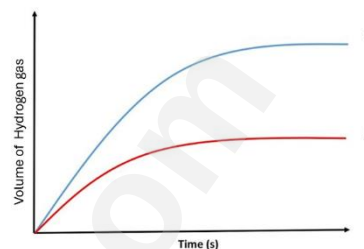
1.2 When considering experimental data which of the following terms best describes an experimental result that is close to a known value?

- A precise
- B accurate
- C reliable
- D trustworthy

- 1.3 15 g of zinc and 200 cm³ of hydrochloric acid of 0,2 mol·dm⁻³ were added to a flask. The following reaction took place.



The reaction continued for some time and produced a graph of volume of H₂ vs time shown here (A). The reaction was repeated and a second graph (B) was produced. What caused the change (from Graph A to B) in the graph?



- A An increase in the mass of zinc.
 - B An increase in the concentration of HCl (aq).
 - C An increase in the volume of HCl (aq).
 - D Using powdered zinc in place of the granules.
- 1.4 The reaction below represents an equilibrium of cobalt chloride in ethanol.



The solution undergoes a change which causes the solution to undergo a colour change from blue to pink. What is the change that may have caused the colour change?

- A An increase in temperature.
- B Addition of a catalyst.
- C The addition of concentrated hydrochloric acid.
- D An increase in pressure.

- 1.5 Hydrochloric acid ionises completely in water to form a solution of concentration $0,05 \text{ mol.dm}^{-3}$. The concentration, in mol.dm^{-3} , of **OH^- ions** in this solution of hydrochloric acid will be:
- A 5×10^{-16}
 - B 2×10^{-13}
 - C 1×10^{-13}
 - D 1×10^{-15}
- 1.6 Which of the following can reduce a solution of Ni^{2+} ions but not a solution of Zn^{2+} ions under standard conditions?
- A Cd
 - B Mg
 - C Cu
 - D H_2
- 1.7 The cell potential of a galvanic cell in which a standard **aluminium** half-cell is connected to a standard half-cell with metal X as the electrode, is 1,53 V. Which one of the following metals could represent metal X?
- A Pb
 - B Sn
 - C Au
 - D Ni

1.8 Which one of the following compounds is a SATURATED hydrocarbon?

- A $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$
- B $\text{CH}_3\text{CH}_2\text{CCH}$
- C $\text{CH}_3\text{CHCHCH}_3$
- D $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CHCH}_2$

1.9 A scientist investigates a factor which influences boiling points of alkanes. She determines the boiling points of the first six straight chain alkanes. Which one of the following is the independent variable in this investigation?

- A Boiling point
- B Functional group
- C Branching
- D Chain length

1.10 The correct IUPAC name for the molecule shown below:

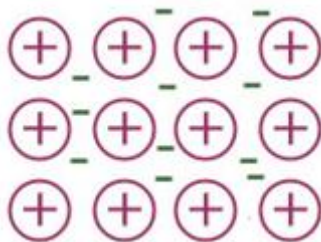


- A 3-ethyl-2-methylheptane
- B 5-methyl-4-ethylhexane
- C 4-ethyl-5-methylhex-1-ene
- D 2-methyl-3-ethylhex-5-ene

[20 marks]

QUESTION 2 BONDING

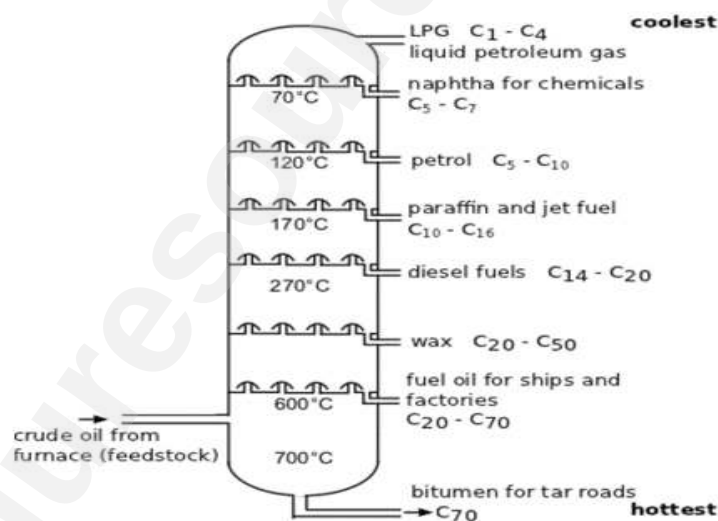
2.1 Consider the following diagram.



2.1.1 What type of bonding is represented by the diagram? (1)

2.1.2 Give an example of a substance that would have this type of bonding. (1)

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



The larger chain hydrocarbons can be cracked to produce shorter chained hydrocarbons.

One of the products of cracking is the hydrocarbon, methane gas.

2.2.1 Draw the Lewis structure of one molecule of methane gas. (3)

- 2.2.2 Explain, with reference to intermolecular forces, why the boiling point of methane is much lower than that of diesel fuels. (4)

- 2.3 Methane gas can be collected by the downward displacement of water. This method is, however, not suitable for the collection of ammonia gas (NH_3).

- 2.3.1 Complete the information in the following table. Write the names of the required bonds or forces in the space in the table. (3)

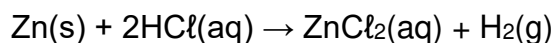
Substance	Intramolecular bonds	Intermolecular forces
Methane (CH_4)	Polar covalent bonds	
Ammonia (NH_3)		

- 2.3.2 Consider your answers to Question 2.3.1 above. Hence explain why the downward displacement of water is used as a method for collecting methane gas but not ammonia gas. (4)

[16 marks]

QUESTION 3 RATES OF REACTION

Aamilah and Sophie use the reaction of EXCESS hydrochloric acid (HCl) with zinc (Zn) to investigate factors which influence reaction rate. The balanced equation for the reaction is:



They use the same volume of hydrochloric acid and 1,2 g of zinc in each of five experiments.

The reaction conditions and temperature readings before and after completion of the reaction in each experiment are summarised in the table below.

Experiment	REACTION CONDITIONS				Time (s)
	Concentration of HCl (mol·dm ⁻³)	Temperature (°C)		State of division of the 1,2 g of Zn	
		Before	After		
1	0,5	20	34	granules	50
2	0,5	20	35	powder	10
3	0,8	20	36	powder	6
4	0,5	35	50	granules	8
5	0,5	20	34	granules	11

- 3.1 Is the reaction between hydrochloric acid and zinc EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer by referring to the data in the table. (2)

- 3.2 Give a reason for the difference in reaction rate observed for Experiments 1 and 2. (2)

- 3.3 The learners compare the results of Experiments 1 and 3 to draw a conclusion regarding the effect of concentration on reaction rate. Give a reason why this is not a fair comparison. (2)

- 3.4 As part of the experiment the effect of a catalyst was tested.

- 3.4.1 Explain, by referring to the collision theory how adding a catalyst affects the rate of reaction. (4)

- 3.4.2 Look carefully at the conditions listed in the table. Between which two experiments was a catalyst used? Write down the experiment numbers. (2)

- 3.5 Draw a **rough sketch** (not to scale) of rate of reaction (g.s^{-1}) against time(s) for experiments 1 and 2. Pay attention to the shape of the graphs and label each line you draw with the experiment number. (4)



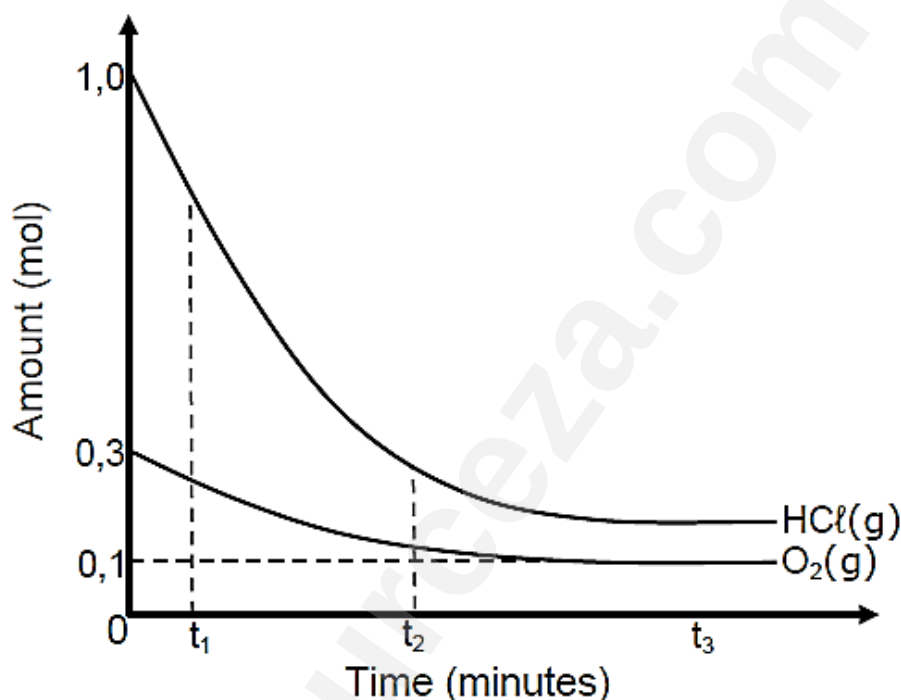
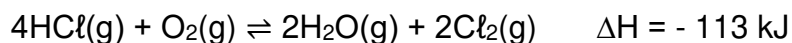
3.6.1 Calculate the number of moles of zinc that react with the hydrochloric acid in Experiment 4. (3)

3.6.2 Calculate the average rate at which the hydrochloric acid reacts in Experiment 4 in mol.s^{-1} (3)

[22 marks]

QUESTION 4 CHEMICAL EQUILIBRIUM

The reaction between hydrogen chloride and oxygen reaches equilibrium in a closed container according to the following balanced equation. Initially the reaction vessel contained no H_2O and Cl_2 .



4.1 The graph above, not drawn to scale, shows how the amounts of reactants present in the container change with time at a specific temperature. The volume of the container is 5 dm^3 .

4.1.1 How does the rate of the forward reaction at time t_1 compare to that at time t_2 ? Write down GREATER THAN, SMALLER THAN or EQUAL TO. Use the graphs to give a reason for the answer. (2)

4.1.2 How does the rate of the forward and the reverse reactions compare at time t_3 ? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

4.1.3 Calculate the number of moles of HCl at equilibrium. Hint: use amounts from the graph on the previous page to complete an ICE TABLE. (4)

4.1.4 Calculate the number of moles of H_2O and Cl_2 at equilibrium. (3)

4.1.5 Write down an expression for the equilibrium constant (K_c) for this reaction. (2)

4.1.6 Calculate the equilibrium constant (K_c) for this reaction at this temperature. (5)

- 4.2 The temperature is NOW increased. How will this change affect the value of the equilibrium constant? Write down INCREASES, DECREASES or REMAINS THE SAME. Explain your answer. (4)

- 4.3 How will each of the following changes affect the equilibrium concentration of $\text{Cl}_2(\text{g})$? Write down INCREASES, DECREASES or REMAINS THE SAME

- 4.3.1 Water vapour is added into the container. (2)

- 4.3.2 A catalyst is added. (2)

- 4.3.3 The volume of the container is increased. (2)

[27 marks]

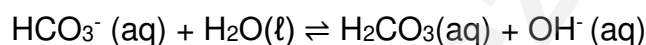
QUESTION 5 ACIDS AND BASES

Sulfuric acid is a diprotic acid.

5.1 Define an acid in terms of the Lowry-Brønsted theory. (1)

5.2 Give a reason why sulfuric acid is referred to as a diprotic acid. (2)

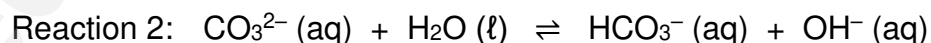
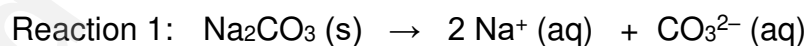
5.3 The hydrogen carbonate ion can act as both an acid and a base. It reacts with water according to the following balanced equation:



5.3.1 Write down ONE word for the underlined phrase. (1)

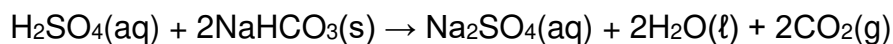
5.3.2 $\text{HCO}_3^- (\text{aq})$ acts as a base in the above reaction. Write down the formula of the conjugate acid of $\text{HCO}_3^- (\text{aq})$. (1)

5.4 When Na_2CO_3 is dissolved in water, the following hydrolysis reactions occur:



Referring to the reactions above, explain why sodium carbonate in solution is basic. (2)

- 5.5 Lucy accidentally spills some sulfuric acid of concentration $6 \text{ mol}\cdot\text{dm}^{-3}$ from a flask on the laboratory bench. Assume that the H_2SO_4 ionises completely. Taylor tells her to neutralise the spilled acid by sprinkling sodium hydrogen carbonate powder onto it. The reaction that takes place is:

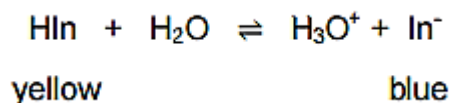


The fizzing, due to the formation of carbon dioxide, stops after Lucy has added 27 g sodium hydrogen carbonate to the spilled acid.

- 5.5.1 Calculate the volume of sulfuric acid that spilled. Assume that all the sodium hydrogen carbonate reacts with all the acid. (5)

- 5.5.2 Lucy now dilutes some of the $6 \text{ mol}\cdot\text{dm}^{-3}$ sulfuric acid solution in the flask to $0,1 \text{ mol}\cdot\text{dm}^{-3}$. Calculate the volume of the $6 \text{ mol}\cdot\text{dm}^{-3}$ sulfuric acid solution needed to prepare 1 dm^3 of the dilute acid. (3)

- 5.6 An indicator, HIn, is a weak acid. The reaction of HIn with water can be represented by the following chemical equation:



- 5.6.1 Explain what is meant by 'HIn is a weak acid'. (2)

- 5.6.2 What colour will this indicator be in an acid solution? Give a reason for your answer, based on equilibrium principles. (3)

- 5.7 Solution X is ethanoic acid of concentration $0,2 \text{ mol.dm}^{-3}$

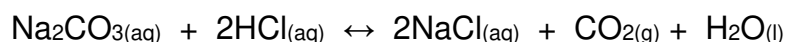
Solution Y is nitric acid of concentration 0.2 mol.dm^{-3}

Which solution (X or Y?) would you expect to have :

- 5.7.1 The lower K_a value? Explain your answer. (2)

- 5.7.2 The greater electrical conductivity? Explain your answer. (2)

- 5.8 A standard solution of sodium carbonate (Na_2CO_3) with a concentration of $0,2 \text{ mol.dm}^{-3}$ is used in a titration to neutralise hydrochloric acid (HCl). The balanced chemical equation for the reaction is as follows:



- 5.8.1 Write a balanced chemical equation showing the complete ionisation of hydrochloric acid in water. (3)

During the titration, 25 cm^3 of the standard solution of sodium carbonate, of concentration $0,2 \text{ mol.dm}^{-3}$ is measured into a conical flask using a pipette. Hydrochloric acid of unknown concentration is added to the flask swirling constantly, until the end point of the titration is reached. The titration is repeated three times and the volume of hydrochloric acid is recorded in the table below each time. (Refer to the balanced chemical equation given in 5.8 above)

	Volume of sodium carbonate solution (cm^3)	Volume of hydrochloric acid at end point (cm^3)
Trial 1	25	16,9
Trial 2	25	16,5
Trial 3	25	17,5
Trial 4	25	16,4

- 5.8.2 Explain the term “end point”. (2)

- 5.8.3 Which of the above results would you discard? Explain why you would discard this result. (2)

5.8.4 Using the results in the table (excluding the result you would discard):

5.8.4.1 calculate the average volume of hydrochloric acid used. (1)

5.8.4.2 calculate the concentration of the hydrochloric acid solution
(Give your answer correct to 3 decimal places.) (4)

5.8.5 Using the following table, choose a suitable indicator for the titration of the sodium carbonate solution with hydrochloric acid and briefly justify your choice of indicator. (2)

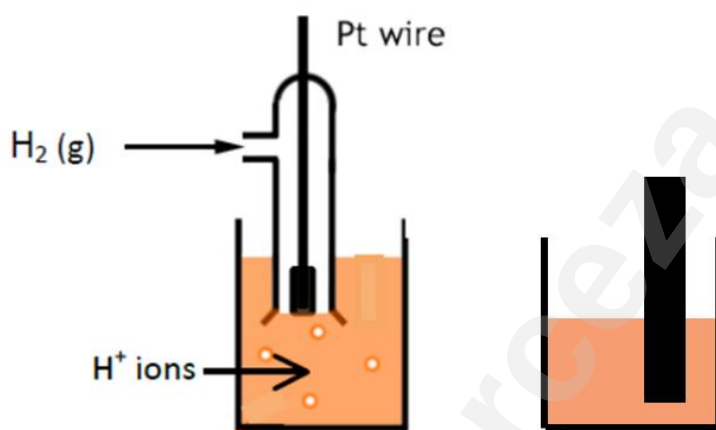
Indicator	pH Range
Phenolphthalein	8,2 – 10
Bromothymol Blue	7
Methyl Orange	3,2 – 4,4

[38 marks]

QUESTION 6 GALVANIC CELL

A hydrogen reference electrode is used to measure the standard electrode potential of an unknown half-cell.

- 6.1 Insert the missing apparatus into the diagram below to show the complete setup used to measure the standard electrode potential of a galvanic cell. Label the Anode and Cathode if hydrogen is the reference electrode. (4)



- 6.2 What is meant by the standard electrode potential of a half-cell, as seen on the redox table? (3)

- 6.3 Suggest a suitable electrolyte for use in the standard hydrogen electrode. (1)

The table below shows the reading on a voltmeter when three different metal half-cells (A , B and C) are connected to the standard hydrogen electrode.

Half-cell	Voltmeter reading (V)
A^{2+}/A	+0,24
B^{+}/B	+1,15
C^{3+}/C	-1,42

6.4 Define reducing agent. (2)

6.5 Referring to the table above, which metal (A, B or C) is the weakest reducing agent? (1)

6.6 Which of the metals is a stronger reducing agent than hydrogen? Clearly explain your choice. (2)

6.7 Write the cell notation for the Galvanic cell set up between the standard hydrogen electrode and the metal in half-cell B. Phase symbols and conditions do not need to be shown. (3)

- 6.8 Consider a galvanic cell set up between metals A and C.
Hint: note the charge numbers of the ions A^{2+}/A and C^{3+}/C

6.8.1 Write the anode half reaction. (2)

6.8.2 Write the cathode half reaction. (2)

6.8.3 Write the net cell reaction. (3)

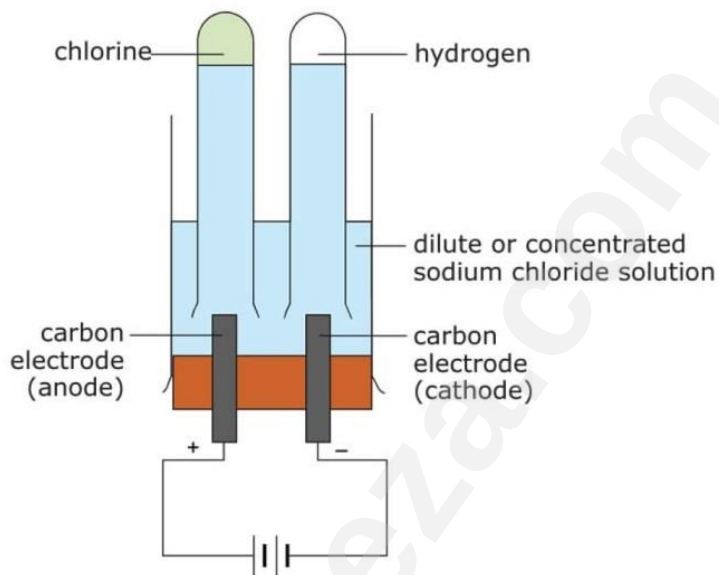
6.8.4 Calculate the emf of the cell under standard conditions. (3)

6.8.5 Give the symbol of the oxidising agent in this cell. (1)

[27 marks]

QUESTION 7 ELECTROLYSIS

7.1 Sodium chloride can be easily dissolved in water. The diagram below shows the apparatus used to electrolyze sodium chloride solution. Two gases, hydrogen and chlorine, are formed as products.



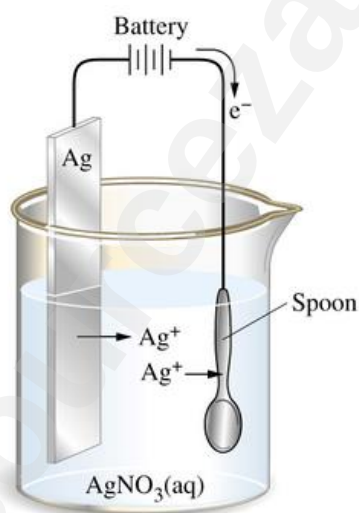
7.1.1 Define *cathode* (1)

7.1.2 Write down the half-reaction that takes place at the cathode. (2)

7.1.3 Why is carbon used for the electrodes? (2)

7.1.4 What effect will diluting the sodium chloride have on this process? Explain in detail the effect on the OUTCOME of this process. (3)

7.2 Electroplating is the process by which a metallic coating is deposited on another metal using an electrolytic reaction. The picture below shows how a nickel spoon can be plated with silver in a silver nitrate solution.



7.2.1 Write down the half-reaction that takes place at the positive electrode. (1)

7.2.2 Write down the half-reaction that takes place at the negative electrode. (1)

- 7.2.3 Apart from the fact that it is preferable to use an electrolyte that contains the ion involved in plating. Why would sodium chloride not be a suitable electrolyte in this cell? (2)

- 7.2.4 Tints is asked to calculate the time taken for the silver bar to lose 6,35 g of silver when the current is 4 A.

She starts as follows:

$$\begin{aligned}n &= \frac{m}{M} \\&= \frac{6,35}{108} \\&= 0,059 \text{ mol}\end{aligned}$$

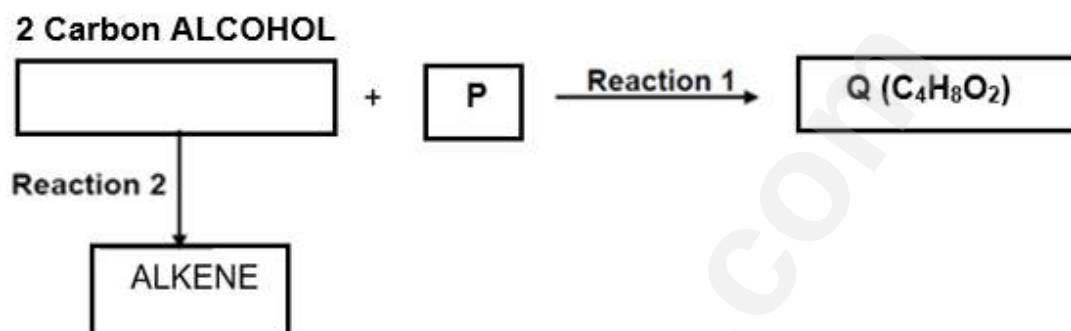
This is correct, ($n = 0,059 \text{ mol}$) but this is where Tints is stuck and she doesn't know how to continue the calculation.

Complete the calculation for her in the space below. Convert your final answer to minutes. (7)

[19 marks]

QUESTION 8 ORGANIC CHEMISTRY

- 8.1 The flow diagram below shows two organic reactions. The letter P represents an organic compound.



Use the information in the flow diagram above to answer the questions that follow.

- 8.1.1 Name the type of reaction represented by Reaction 1. (1)

-
- 8.1.2 Draw the structural formulae of the:

- a) 2 carbon alcohol (2)

- b) alkene (2)

- 8.1.3 Give the IUPAC name of compound P. (1)
-

Reaction 2 takes place in the presence of an acid catalyst and heat.

Write down the:

8.1.4 GENERAL REACTION type of Reaction 2. (1)

8.1.5 name and give the chemical formula of the acid catalyst. (2)

Different structural isomers of compound Q exist.

8.1.6 Define the term "structural isomers". (2)

8.1.7 Draw a functional isomer of compound Q. (2)

8.1.8 The alkene is burnt in excess oxygen. Write a balanced chemical equation for this reaction. (3)

8.2 Consider the following reactions involving organic compounds:

Reaction Number	CHEMICAL REACTION	CONDITIONS
1	$\text{CH}_2\text{ClCH}_2\text{Cl} \rightarrow \text{CH}_2\text{CHCl} + \text{HCl}$ Compound A Compound B	Hot concentrated solution of NaOH In an ethanol solvent i.e. absence of water.
2	$\text{CH}_2\text{CHCH}_3 + \text{Br}_2 \rightarrow \text{X}$ Compound C	Room temperature.
3	$\text{C}_8\text{H}_{18} \rightarrow \text{Z} + \text{C}_2\text{H}_4$ Compound D Compound E	Thermal cracking at high temperature and pressures without a catalyst.

8.2.1 Name the SPECIFIC TYPE of reaction indicated in the above table by:

Reaction Number 1 _____ (1)

Reaction Number 2 _____ (1)

8.2.2 Give the IUPAC name of compound A. (3)

8.2.3 Compound D and E belong to different homologous series.

a) Define homologous series. (2)

b) Give the NAME of the homologous series for compound D. (1)

- c) Give the GENERAL FORMULA of the homologous series for compound E. (1)

- 8.2.4 Which of the compounds A to E can be described as unsaturated? Explain your answer. (3)

- 8.2.5 Give the molecular formula of compound Z. (1)

- 8.2.6 Reaction 3 can be carried out at lower temperatures if a catalyst is used. Discuss the economic implications of lower temperatures in this reaction. (2)

[31 marks]

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EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES (CHEMISTRY)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Standard pressure	$p^\ominus$	$1,01 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature	$T^\ominus$	$273 \text{ K (0 } ^\circ\text{C)}$
Avogadro's constant	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$
Faraday's constant	F	$96\,500 \text{ C} \cdot \text{mol}^{-1}$

TABLE 2 CHEMISTRY FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$	$n = \frac{V}{V_m}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$K_w = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$ at 25 °C (298 K)	
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$		
$q = It$ $q = nF$	$E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$ $E_{\text{cell}}^{\theta} = E_{\text{oxidising agent}}^{\theta} - E_{\text{reducing agent}}^{\theta}$	

TABLE 3 PERIODIC TABLE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 1 H	2 3 Li	3 4 Be	4 5 B	5 6 C	6 7 N	7 8 O	8 9 F	9 10 Ne	Electronegativity								
Relative atomic mass																	
11 23 Na	12 24.3 Mg	13 27 Al	14 28 Si	15 31 P	16 32 S	17 35.5 Cl	18 40 Ar										
19 39 K	20 40 Ca	21 45 Sc	22 48 Ti	23 51 V	24 52 Cr	25 55 Mn	26 56 Fe	27 59 Co	28 59 Ni	29 63.5 Cu	30 65.4 Zn	31 70 Ga	32 72.6 Ge	33 75 As	34 79 Se	35 80 Br	36 84 Kr
37 85.5 Rb	38 88 Sr	39 89 Y	40 91 Zr	41 93 Nb	42 96 Mo	43 99 Tc	44 101 Ru	45 103 Rh	46 106 Pd	47 108 Ag	48 112 Cd	49 115 In	50 119 Sn	51 121 Sb	52 128 Te	53 127 I	54 131 Xe
55 133 Cs	56 137.3 Ba	57 87 La	58 72 Hf	59 73 Ta	60 74 W	61 75 Re	62 76 Os	63 77 Ir	64 78 Pt	65 79 Au	66 80 Hg	67 81 Tl	68 82 Pb	69 83 Bi	70 84 Po	71 85 At	72 86 Rn
87 Fr	88 Ra																

TABLE 4 STANDARD ELECTRODE POTENTIALS

	Half-reaction	$E^{\ominus}$ / volt	
	$\text{Li}^+ + \text{e}^- \rightleftharpoons \text{Li}$	-3,05	
	$\text{K}^+ + \text{e}^- \rightleftharpoons \text{K}$	-2,93	
	$\text{Cs}^+ + \text{e}^- \rightleftharpoons \text{Cs}$	-2,92	
	$\text{Ba}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ba}$	-2,90	
	$\text{Sr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sr}$	-2,89	
	$\text{Ca}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ca}$	-2,87	
	$\text{Na}^+ + \text{e}^- \rightleftharpoons \text{Na}$	-2,71	
	$\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$	-2,37	
	$\text{Al}^{3+} + 3\text{e}^- \rightleftharpoons \text{Al}$	-1,66	
	$\text{Mn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mn}$	-1,18	
	$2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-$	-0,83	
	$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$	-0,76	
	$\text{Cr}^{3+} + 3\text{e}^- \rightleftharpoons \text{Cr}$	-0,74	
	$\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$	-0,44	
	$\text{Cd}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cd}$	-0,40	
	$\text{Co}^{2+} + 2\text{e}^- \rightleftharpoons \text{Co}$	-0,28	
	$\text{Ni}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni}$	-0,25	
	$\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$	-0,14	
	$\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$	-0,13	
	$\text{Fe}^{3+} + 3\text{e}^- \rightleftharpoons \text{Fe}$	-0,04	
	$2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0,00	
	$\text{S} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+0,14	
	$\text{Sn}^{4+} + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}$	+0,15	
	$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{SO}_2(\text{g}) + 2\text{H}_2\text{O}$	+0,17	
	$\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$	+0,34	
	$2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$	+0,40	
	$\text{SO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{S} + 2\text{H}_2\text{O}$	+0,45	
	$\text{I}_2 + 2\text{e}^- \rightleftharpoons 2\text{I}^-$	+0,54	
	$\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$	+0,68	
	$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$	+0,77	
	$\text{Hg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Hg}$	+0,79	
	$\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightleftharpoons \text{NO}_2(\text{g}) + \text{H}_2\text{O}$	+0,80	
	$\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$	+0,80	
	$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0,96	
	$\text{Br}_2 + 2\text{e}^- \rightleftharpoons 2\text{Br}^-$	+1,09	
	$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1,21	
	$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1,23	
	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1,33	
	$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-$	+1,36	
	$\text{Au}^{3+} + 3\text{e}^- \rightleftharpoons \text{Au}$	+1,42	
	$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1,51	
	$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1,77	
	$\text{F}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{F}^-$	+2,87	

Increasing strength of oxidising agent

Increasing strength of reducing agent

TRIAL P2 MEMO

QUESTION 1

1.1 D ✓✓

1.2 B ✓✓

1.3 B ✓✓

1.4 A ✓✓

1.5 B ✓✓

1.6 A ✓✓

1.7 A ✓✓

1.8 A ✓✓

1.9 D ✓✓

1.10 C ✓✓

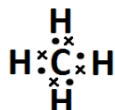
[20]

QUESTION 2

2.1.1 metallic bonding ✓ (1)

2.1.2 copper ✓ any metal example (1)

2.2.1



- ✓ valence electrons each element
 - ✓ share position correct
 - ✓ 1 carbon and 4 hydrogens (electrons closer to Carbon)
- (3)

2.2.2

- Both molecules have London forces ✓
 - Methane is a smaller molecule than diesel.
 - Methane has a smaller electron density (or smaller surface area) ✓
 - The temporary dipoles in methane are weaker (or fewer)
 - Therefore the London forces in Methane are weaker ✓
 - Less energy is required to overcome the forces in methane ✓
 - Methane has a lower boiling point
- (4)

2.3.1 Methane: London Forces (induced dipole) ✓

Ammonia: Polar covalent bonds ✓

And IMF's Hydrogen bonds ✓

(3)

2.3.2

Does not relate to solubility = 0

states **CH₄ is insoluble** ✓and **NH₃ is soluble** ✓ only 1 mark if they refer to solubility in general, or if learners use terms such as "bond", "react" or "mix"Mentions **polarity of water** (or hydrogen bonds) ✓Mentions polarity of CH₄ OR NH₃ ✓

- Methane is insoluble in water
 - As methane is a non-polar molecule with London forces and water is a polar molecule with hydrogen bonds (comparison to water)
 - Because methane does not dissolve in water it bubbles to the top and can be collected
 - Ammonia is very soluble in water
 - Both ammonia and water are polar molecules with Hydrogen bonds (similar strength of IMF) they will therefore attract each other
 - Therefore the ammonia dissolves in water and does not bubble to the top and displace the water.
- (4)

[16]

QUESTION 3

3.1 Exothermic ✓ temperature increases ✓. in all reactions (2)

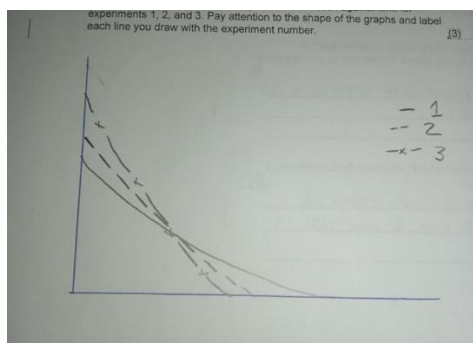
3.2 Exp 2 uses a powder ✓ therefore surface area ✓ has increased. (2)

3.3 Two ✓ variables have been changed, therefore impossible to tell which of them has made the difference ✓ to the dependent variable. (2)

3.4.1 A catalyst will lower the activation E ✓
needed for the reaction, therefore more particles
will have sufficient ✓ E_k
more effective collisions per unit time ✓,
therefore reaction time is shorter (i.e. Quicker rate). ✓ (4)

3.4.2 Experiment 1 and 5 (2)

3.5



Exp 1 ✓ Exp 2 ✓

Axes labelled with unit ✓✓ (4)

3.6.1 $n = \frac{m}{M} = \frac{1,2}{65} = 0,018 \text{ mol}$ ✓ (3)

3.6.2 Mol ratio : $\text{HCl} : \text{Zn}$ (2:1) $\therefore 0,036 \text{ mol}$ ✓

$\text{Rate} = \frac{0,036}{8} = 4,5 \times 10^{-3} \text{ mol} \cdot \text{s}^{-1}$ (3)

[22]

QUESTION 4

4.1.1 Greater than ✓ - steeper gradient ✓ at time t_1 /gradient decreases from t_1 to t_2 (2)

4.1.2 Equal to ✓ (1)

4.1.3

	HCl	O ₂	H ₂ O	Cl ₂
R	4	1	2	2
I	1	0,3	0	0
C	4x0,2=0,8✓	0,2✓	0,4	0,4
E	0,2	0,1 ✓	0,4	0,4

(4)

$$n_{HCl} = 1 - 0,8 = 0,2 \text{ mol } \checkmark$$

4.1.4 $n_{H_2O} = 0,4 \checkmark + \checkmark$ for method.

$$n_{Cl_2} = 0,4 \checkmark \quad (3)$$

$$4.1.5 \quad K_c = \frac{[H_2O]^2 [Cl_2]^2}{[HCl]^4 [O_2]} \checkmark \quad (2)$$

$$4.1.6 \quad C = \frac{n}{v} \checkmark = (HCl) \frac{0,2}{5} = 0,04 \checkmark$$

$$= (O_2) \frac{0,1}{5} = 0,02 \checkmark$$

$$= (H_2O) \frac{0,4}{5} = 0,08 \checkmark$$

$$= (Cl_2) \frac{0,4}{5} = 0,08 \checkmark$$

$$\therefore K_c = \frac{(0,08)^2 \cdot (0,08)^2}{(0,04)^4 \cdot 0,02}$$

$$= 800 \checkmark$$

(5)

4.2 Stress: An increase in temperature

Response: will favour the reverse ✓ reaction,

Reason: as it is endothermic ✓, to try to reduce the heat. ✓

Question: This will decrease the yield $\therefore$ low K_c . ✓ (4)

4.3.1 Decrease ✓✓

4.3.2 Remain the same ✓✓

4.3.3 Decreases ✓✓

(6)

[27]

QUESTION 5

General feedback

- When comparing acids (e.g acid X and acid Y)
 - If you are asked about pH you need to refer to the concentration of H_3O^+
 - If you are asked about conductivity you need to refer to the concentration of free ions (which includes both the H_3O^+ and the anions)
 - If you are asked about K_a you need to refer to partial or complete ionisation
- Know the difference between equivalence point and end point.
- Hydrolysis: after writing the reaction mention specifically if H_3O^+ or OH^- is produced and then conclude if the solution is acidic or basic
- Ensure enough significant figures after doing a calculation.

5.1 Acid is a proton donor ✓ (1)

5.2 It has 2 protons or 2 H^+ to donate ✓ per molecule. ✓ (2)

5.3.1 amphoteric / amphiprotic ✓ (1)

5.3.2 H_2CO_3 ✓ (1)

5.4 The hydrolysis of sodium carbonate produces OH^- ions ✓ which makes the solution basic. ✓ (2)

5.5.1

$$\begin{array}{lll}
 n_{NaHCO_3} = \frac{m}{M} & NaHCO_3 : H_2SO_4 & V = \frac{n}{c} \checkmark \\
 n = \frac{27}{84} \checkmark & 2 : 1 & V = \frac{0,16}{6} \\
 n = 0,32 mol \checkmark & 0,16 mol H_2SO_4 \checkmark & V = 0,026 dm^3 \checkmark
 \end{array}
 \quad (5)$$

5.5.2 No. of moles remains the same

$$\therefore n = cV$$

$$\therefore (cV) = (cV)_{dil} \checkmark$$

$$6x = 0,1 \times 1 \checkmark$$

$$x = 0,017 dm^{-3} \checkmark \quad (3)$$

5.6.1 Acid that only partially ionises ✓ in aqueous ✓ solution. (2)

5.6.2 STRESS: when acid is added, there will be an increase in concentration of H_3O^+ ✓ ions.

RESPONSE: the reverse reaction favoured ✓

Therefore the solution turns Yellow. (3)

5.7.1 X ✓ : weak acid ∴ partially ionises ✓ ∴ low product yield and low K_a (2)

5.7.2 Y ✓ : complete ionisation ∴ more ions in solution ✓ ∴ greater conductivity. (2)

5.8.1 $HCl(aq) + H_2O(l) \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$ ✓ (3)

5.8.2 Point where an acid and a base have reacted and there is a change in colour of the indicator. ✓✓ (2)

5.8.3 $17,5 \text{ cm}^3$ ✓. Or Trial 3
Not close to other values / not precise ✓. (2)

5.8.4.1 $\frac{16,9+16,5+16,4}{3} = 16,6 \text{ cm}^3$ ✓ (1)

5.8.4.2 for base
 $n = cV$
 $= (0,2)(0,025)$
 $= 0,05 \text{ mol}$

ratio 1:2
 $n_{\text{acid}} = 0,1$

$c = n/V$
 $= (0,1)/(16,6 \times 10^{-3})$
 $= 0,602 \text{ mol.dm}^{-3}$

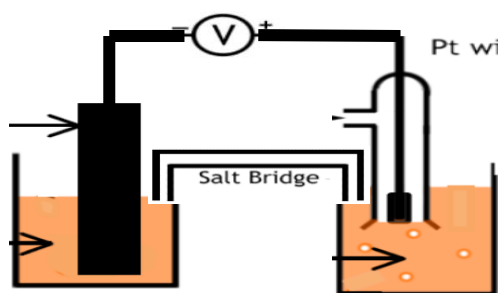
No answer mark if the answer is not given to three decimal places (4)

5.8.5 Methyl orange ✓ strong acid / weak base ✓ therefore low pH range (2)

[38]

QUESTION 6

6.1



- * Wire connecting half cells✓
- * Salt bridge connected correctly✓
- * Anode is the hydrogen half cell
- * Cathode is the metal half cell✓

(4)

6.2 The voltmeter reading ✓ when the half-cell in particular is connected to the std hydrogen half-cell✓ under standard conditions✓. (3)

OR

Indication of reducing ability of a substance compared to hydrogen gas✓ and oxidizing ability of a substance compared to Hydrogen ions✓, where a positive value indicates a stronger oxidizing agent (compared to hydrogen ions) ,and negative value indicates a stronger reducing agent (compared hydrogen gas). ✓

6.3 Hydrochloric acid ✓.(any strong acid) (1)

6.4 A substance that donates electrons ✓✓ (2)

6.5 B✓ (1)

6.6 C✓, it has a negative electrode potential✓, so according to the redox table this metal is above hydrogen gas making it a stronger reducing agent. (2)

6.7 Pt/H₂/H⁺//B⁺/B *1 mark for each half cell correct, 1 mark for salt bridge. (3)

6.8.1 $C \rightarrow C^{3+} + 3e^-$ ✓✓ (2)

6.8.2 $A^{2+} + 2e^- \rightarrow A$ ✓✓ (2)

6.8.3 $2C + 3A^{2+} \rightarrow 2C^{3+} + 3A$ ✓✓ + ✓for balancing coe from above (3)

6.8.4 $E^0_{\text{cell}} = E^0_{\text{oa}} - E^0_{\text{ra}}$

$$E^0_{\text{cell}} = 0.24 - (-1.42) \quad \checkmark \checkmark$$

$$E^0_{\text{cell}} = 1.66V \quad \checkmark \quad (3)$$

6.8.5 A^{2+} ✓ (1)

[27]

QUESTION 7

7.1.1 The electrode where reduction takes place. ✓ (1)

7.1.2 $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$ ✓✓ (2)

7.1.3 It can conduct electricity✓ and it does not react✓ (2)

7.1.4 If chloride ions are dilute
then water will be predominantly✓ oxidized at the anode✓
to form oxygen gas and not the chloride ions. ✓ (3)

7.2.1 $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$ (1)

7.2.2 $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ (1)

7.2.3 Chloride ions would react with the silver ions ✓ and take them out of solution
due to a precipitate being formed. ✓ (2)

7.2.4 Show mole ratio✓ 1:1 from $\text{Ag} : \text{e}^-$

$$Q = n \times F \quad \checkmark$$

$$= 0,059 \times 96500$$

$$= 5673,84 \text{ C} \quad \checkmark$$

$$\text{then } Q = It \quad \checkmark$$

$$5673,84 = 4 \times t \quad \checkmark$$

$$t = 1418 \text{ s} \quad \checkmark$$

$$t = 23,6 \text{ minutes} \quad \checkmark \quad (7)$$

OR Without using Faraday's constant:

$$n = N/NA$$

$$0,059 = N/6,02 \times 10^{23}$$

$$N = 3,55 \times 10^{22} \text{ electrons} \times 1,6 \times 10^{-19}$$

$$Q = 5682,88 \text{ C}$$

$$Q = It$$

$$5682,88 = 4 \times t$$

$$t = 1418 \text{ s}$$

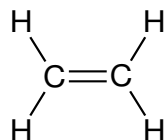
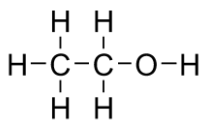
$$t = 23,6 \text{ minutes}$$

[19]

QUESTION 8 ORGANIC CHEMISTRY

8.1.1 Esterification ✓ (1)

8.1.2 ✓✓ (4)

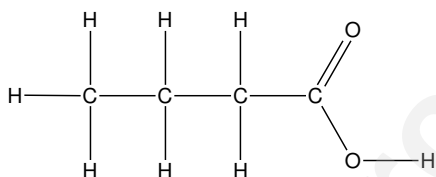


8.1.3 ethanoic acid ✓ (1)

8.1.4 I
elimination ✓ (1)8.1.5 H_2SO_4 : sulphuric acid OR H_3PO_4 ✓: phosphoric acid ✓ (2)

8.1.6 Molecules with the same molecular formula but different structural formulae. ✓✓ (2)

8.1.7 (2)

8.1.8 $\text{C}_2\text{H}_4 + 3\text{O}_2$ ✓(reactants) $\rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$ ✓(products) ✓(balancing) (3)

8.2.1 Reaction1: dehydrohalogenation ✓ (1)

Reaction2: halogenation ✓ (1)

8.2.2 1,2-dichloroethane ✓✓✓ (3)

8.2.3 a) A series of similar compounds which have the same functional group and general formula, in which each member differs by a single CH_2 unit. ✓✓ (2)

b) alkanes (1)

c) C_nH_{2n} (1)

8.2.4 B,C and E ✓✓(negative mark) chain contains double carbon-carbon bonds ✓ (3)

8.2.5 C_6H_{14} ✓ (1)

8.2.6 Low temperature less expensive ✓ than maintaining high temp BUT low temperatures also mean lower rate of reaction. ✓ (2)

[31]