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ST ANNE'S DIOCESAN COLLEGE

TRIAL EXAMINATION – September 2023

PHYSICAL SCIENCES – PAPER 2

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 2-26: Questions 1 to 8
 - Pages 27-28: EXTRA PAPER
 - Pages 29-31: 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 27-28. 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	19	26	29	30	24	31	21	200

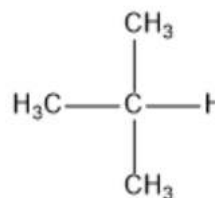
QUESTION 1 MULTIPLE CHOICE QUESTIONS

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 The correct systematic name for the compound below is...

- A butane
- B methylbutane
- C methylpropane
- D propane



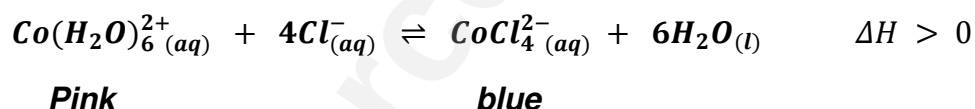
1.2 For a certain chemical reaction, the activation energy is 200 kJ and the thermal energy released when forming the products is 150 kJ. From this information, the value of ΔH ...

- | | |
|-------------|------------------------|
| A is 50 kJ | B is – 50 kJ |
| C is 350 kJ | D cannot be determined |

- 1.3 Which of the following statements regarding the equilibrium reaction given below is **true** ?



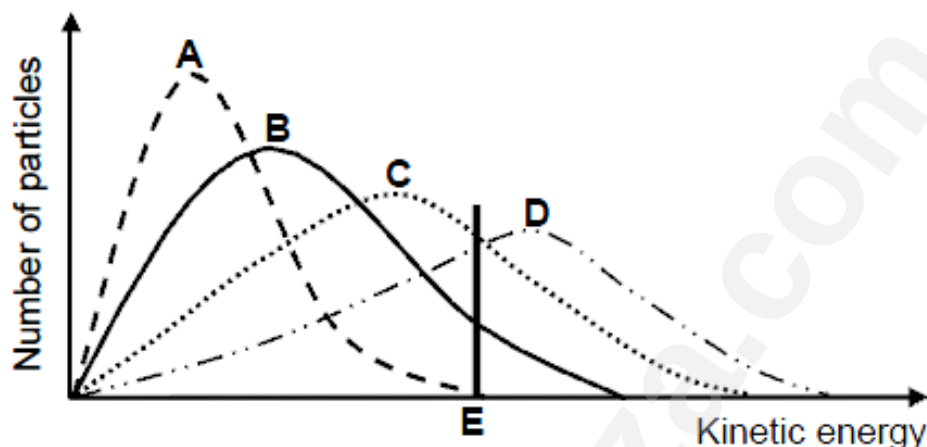
- A Chemical equilibrium is reached when the forward reaction stops
- B Chemical equilibrium is reached when the concentration of the product is equal to the concentrations of the reactants
- C When chemical equilibrium is reached the value of K_c is zero
- D Chemical equilibrium is reached when the concentrations of the product and reactants remain constant
- 1.4 The reaction represented by the equation below reaches equilibrium



Which ONE of the following changes will change the reaction mixture's colour from blue to pink?

- A Add a catalyst
- B Heat the reaction mixture in a water bath
- C Add a few drops of concentrated hydrochloric acid to the reaction mixture
- D Add water to the reaction mixture

- 1.5 The Maxwell-Boltzmann energy distribution curves below show the number of particles as a function of their kinetic energy for a reactant at four different temperatures. The activation energy of a certain chemical reaction is represented as E . Which ONE of these curves (**A**, **B**, **C** or **D**) represents the reactant which will have the fastest reaction rate?



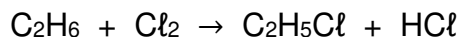
- 1.6 A pupil performing a titration consulted the following table of available indicators:

INDICATOR	pH RANGE OF INDICATOR
bromothymol blue	6,0 – 7,6
phenolphthalein	8,4 – 10,0
methyl orange	3,1 – 4,4

The pupil decided the indicator she should use would be *methyl orange*. The two species she was titrating against each other were:

- A ethanoic acid and sodium carbonate
- B ethanoic acid and sodium hydroxide
- C nitric acid and sodium hydroxide
- D nitric acid and sodium carbonate

- 1.7 The reaction of ethane with chlorine in the presence of ultraviolet light is given by the balanced chemical equation:

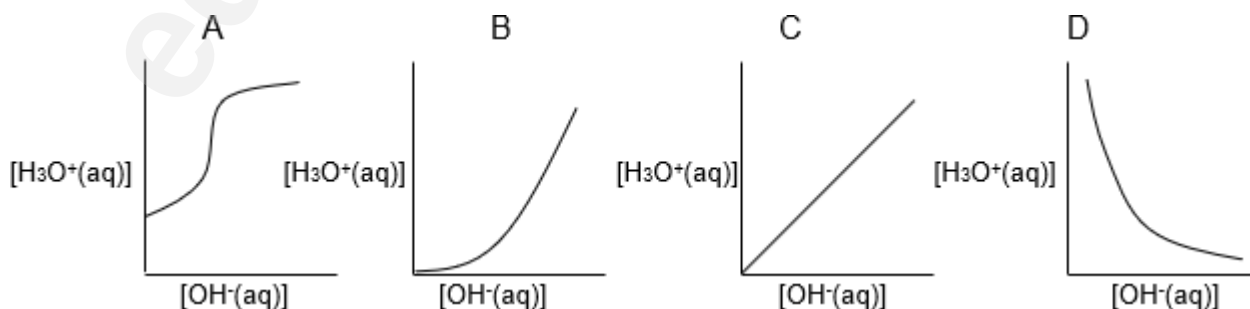


Which one of the following describes the type of chemical reaction taking place?

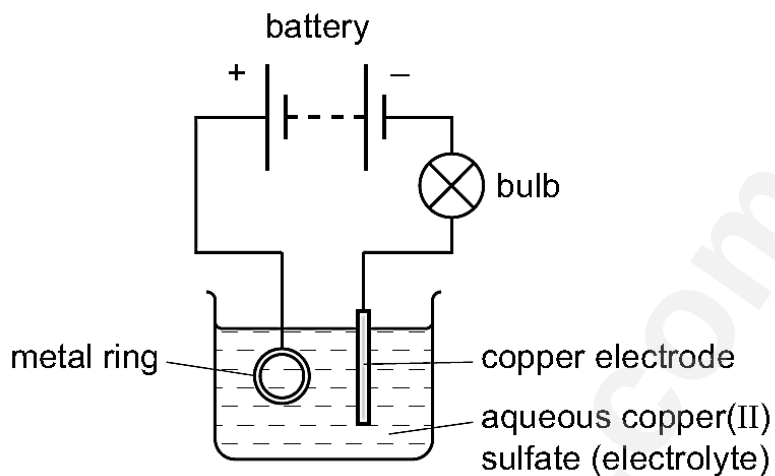
- A elimination
 - B substitution
 - C combustion
 - D addition
- 1.8 Consider hexanol ($\text{C}_6\text{H}_{13}\text{OH}$) and methanol (CH_3OH). Which of the statements below is the correct option when comparing their relative viscosity and solubility?

	HIGHEST VISCOSITY	HIGHEST SOLUBILITY
A	$\text{C}_6\text{H}_{13}\text{OH}$	CH_3OH
B	CH_3OH	$\text{C}_6\text{H}_{13}\text{OH}$
C	CH_3OH	CH_3OH
D	$\text{C}_6\text{H}_{13}\text{OH}$	$\text{C}_6\text{H}_{13}\text{OH}$

- 1.9 The relationship between $[\text{H}_3\text{O}^+(\text{aq})]$ and $[\text{OH}^-(\text{aq})]$ at a constant temperature is best represented by:



- 1.10 The diagram shows apparatus used in an attempt to electroplate a metal ring with copper.



The experiment did not work. Which change is needed in order to make the experiment work?

- A Add solid copper sulphate to the electrolyte.
- B Increase the temperature of the electrolyte.
- C Replace the copper electrode with a carbon electrode.
- D Reverse the connections to the battery.

[10 x 2 = 20]

QUESTION 2 BONDING

2.1 Define the term *intermolecular force* (2)

2.2 Consider the following list of compounds:

Calcium carbonate	CaCO₃
Methane	CH₄
Hydrogen sulphide	H₂S
Water	H₂O
Ethane	C₂H₆

2.2.1 Name the type of **intermolecular force** found in ethane. (2)

2.2.2 Name the type of **intramolecular bond** found in calcium carbonate. (2)

2.2.3 What specific type of **intramolecular bond** is found in H₂S? Justify your answer with a calculation. (3)

2.2.4 Which compound listed above will have the highest melting point? Give a reason for your answer. (2)

- 2.3 The table below shows the boiling points of methane and a selection of fluoromethanes.

Compound	Formula	Boiling point (°C)
Methane	CH ₄	–161
Fluoromethane	CH ₃ F	–78
Difluoromethane	CH ₂ F ₂	–52
Trifluoromethane	CHF ₃	–82
Tetrafluoromethane	CF ₄	–128

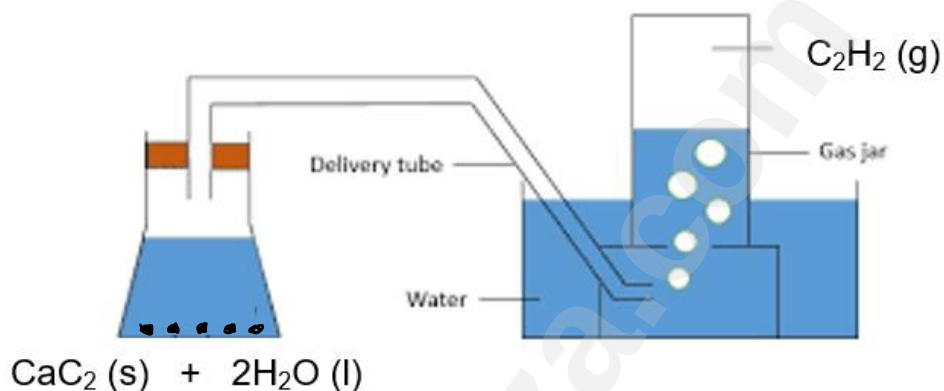
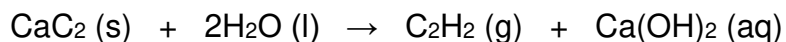
- 2.3.1 Draw the structural formula of CF₄ and show the polarity of the covalent bonds in the molecule on your diagram. (2)

- 2.3.2 Explain why CF₄ is a non-polar molecule. (2)

- 2.3.3 Explain why the boiling point of CH₃F is higher than that of CF₄. (4)

QUESTION 3 RATES OF REACTION

Ethyne (C_2H_2) can be produced by the reaction of calcium carbide with water according to the equation below:



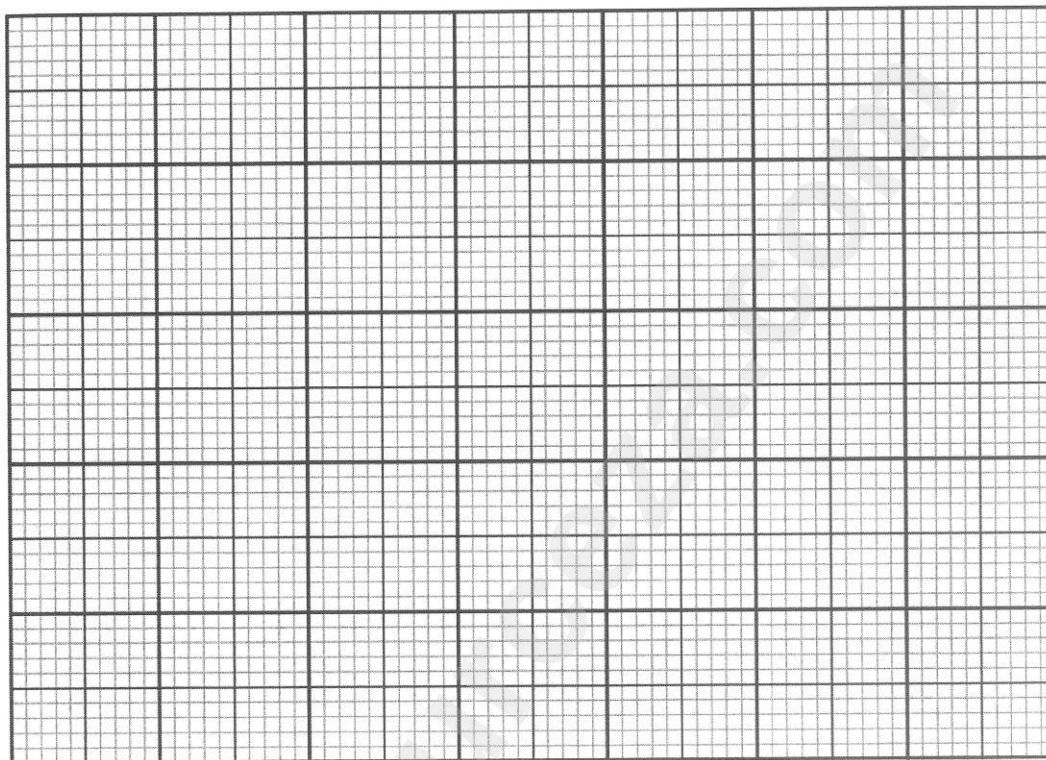
The table below shows the results obtained in an experiment carried out to measure the volume of ethyne produced. In this experiment, the CaC_2 was the limiting reactant and water was in excess.

Time (s)	0	30	60	90	120	150	180	210
Volume of ethyne (cm^3)	0	60	96	120	140	148	152	152

3.1 Define *Reaction Rate*. (2)

3.2 Using data from the table, determine the average rate of reaction (in $\text{cm}^3 \cdot \text{s}^{-1}$) between 60 and 90 seconds. (2)

- 3.3 On the graph paper below, draw a graph to represent the data in the table. You may go up in 30s for the x-axis only. Insert the best fit line. (7)



- 3.4 Determine, from your graph, the volume of ethyne that had been produced at time 105 s. Label this point on your graph. (2)
- 3.5 What does the gradient of your graph indicate? Show how this can be deduced by referring to the gradient formula. (2)

- 3.6 For each of the following time intervals
- Describe the gradient of the graph
 - State how this relates to the rate of reaction

3.6.1 0 – 30 s (2)

3.6.2 60 – 150 s (2)

3.6.3 180 – 210 s (2)

- 3.7 On your graph paper in Question 3.3, sketch the graphs you would have obtained if the conditions of the experiment had been changed in each of the following ways (all other conditions remained the same)

Label the lines 3.7.1 & 3.7.2 on the graph.

3.7.1 the temperature was decreased (2)

3.7.2 only half the calcium carbide was used but it was crushed into a more finely divided state. (3)

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QUESTION 4 EQUILIBRIUM

Sulphur trioxide is formed industrially in a closed system during the Contact Process. This reaction is an example of dynamic equilibrium:



4.1.1 State Le Chatelier's principle. (2)

4.1.2 Explain what happens to the amount of SO_3 if the volume of the container is decreased. (3)

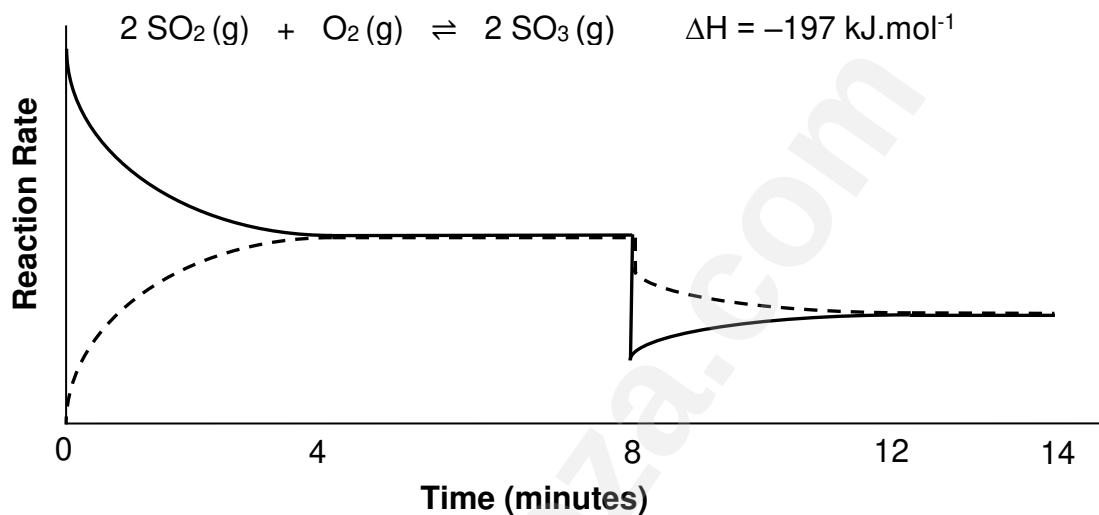
4.1.3 Explain what happens to the amount of SO_3 if the temperature of the equilibrium mixture is increased. (3)

4.2 Explain in terms of the collision theory what happens to the *rate of the forward reaction* when the temperature is increased. (3)

- 4.3 The conditions often used in the Contact process are $T = 400\text{ }^{\circ}\text{C}$ and atmospheric pressure $P = 101,3\text{ kPa}$. Explain the choice of temperature and pressure for this process. (3)

- 4.4 4 mol of sulphur dioxide (SO_2) and 2,5 mol of oxygen (O_2) are sealed in a 500 cm^3 container and allowed to reach equilibrium at an unknown temperature. At equilibrium 3 mol of sulphur trioxide (SO_3) are found in the container. Calculate the value of the equilibrium constant at this temperature. (6)

- 4.5 Consider the graph shown below which illustrates changes in reaction rates for a period of 14 minutes during the Contact Process.



- 4.5.1 Which reaction rate (forward or reverse) is represented by the solid line? (1)

- 4.5.2 Why do these lines have curved shapes as seen on the graph? (2)

- 4.5.3 When does the reaction reach equilibrium for the first time? (1)

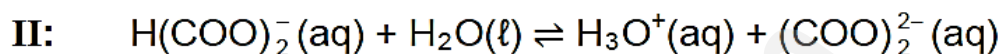
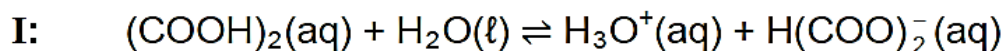
- 4.5.4 Deduce what happened to the reaction mixture at $t = 8$ minutes.
Explain your answer fully. (4)

- 4.5.5 How will the equilibrium constant, K_c be affected by the disturbance you named in Question 4.5.4 ?
Only state Increase, Decrease or Stays the same. (1)

[29]

QUESTION 5 ACIDS AND BASES

5.1 Oxalic acid is an example of an acid that can donate two protons and thus ionises in two steps as represented by the equations below:



5.1.1 Write down ONE word for the underlined phrase in the above sentence. (1)

5.1.2 Identify the TWO bases in **reaction II**. (Write only the formula.) (2)

5.1.3 Define *Amphoteric substance*. (2)

5.1.4 Write down the FORMULA of the substance that acts as the *ampholyte* in **reactions I and II**. (1)

5.1.5 A standard solution of $(\text{COOH})_2$ of concentration $0,20 \text{ mol} \cdot \text{dm}^{-3}$ is prepared by dissolving a certain amount of $(\text{COOH})_2$ in water in a 250 cm^3 volumetric flask. Calculate the mass of $(\text{COOH})_2$ needed to prepare the standard solution. (3)

- 5.2 Three hypothetical acids H_2X , HY and HZ are listed below. The acid ionisation constant K_a for the ionisation of each in water at 25°C is also shown.

Acid	K_a
H_2X	$2,8 \times 10^{-3}$
HY	$1,2 \times 10^6$
HZ	6×10^{-4}

- 5.2.1 Define a *strong acid*. (2)

- 5.2.2 Give one example of a strong acid and a weak acid. Choose from the acids in the table H_2X , HY or HZ . (2)

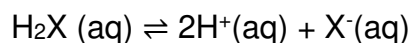
STRONG ACID: _____

WEAK ACID: _____

- 5.2.3 Which acid, H_2X , HY or HZ , will have the lowest pH in water? Justify your choice by referring to the K_a values above. Assume that the concentration of each acid is the same. (3)

- 5.2.4 Which acid, H_2X , HY or HZ , will be the weakest electrical conductor in water? Justify your choice. Assume that the concentration of each acid is the same. (3)

5.2.5 The equation for the ionisation of H_2X in an aqueous solution is:



The concentration of unionised H_2X in a solution at 25°C is $0,2 \text{ mol}\cdot\text{dm}^{-3}$.

a) Write an expression for K_a for H_2X . (2)

b) Calculate the concentration of X^- ions in the solution. (3)

5.2.6 $25,0 \text{ cm}^3$ of acid HZ is neutralised in a titration by $32,4 \text{ cm}^3$ of $0,1 \text{ mol}\cdot\text{dm}^{-3}$ NaOH solution. An aqueous solution of the salt NaZ is produced in the reaction.

a) Write down a balanced chemical equation for the reaction of HZ with NaOH . (The phase label of each substance is not required.) (2)

b) Calculate the concentration of acid HZ used in this titration. (4)

[30]

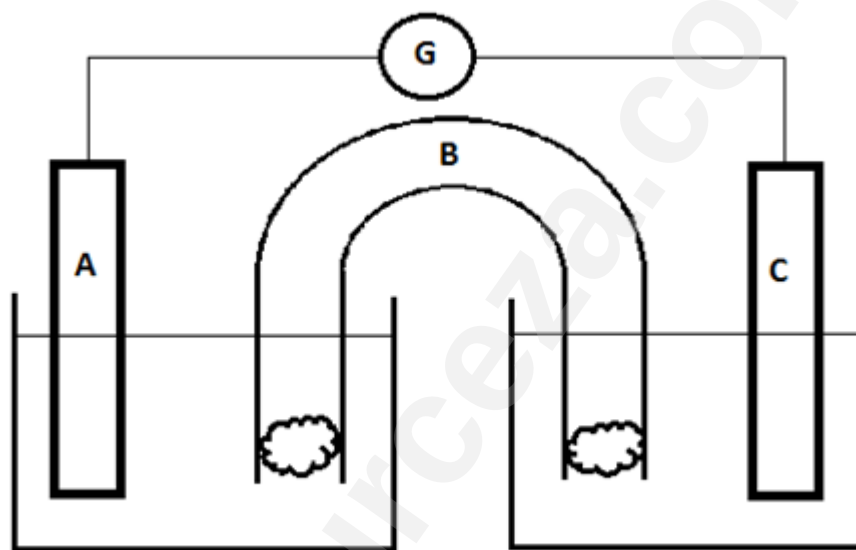
QUESTION 6 GALVANIC CELL

Rachel sets up a simple Galvanic cell with a current flowing through the galvanometer G. She hopes that all her classmates score full marks for this question.

Electrode A is made of magnesium and is placed in a magnesium nitrate solution.

Electrode C is made of aluminium and is placed in an aluminium nitrate solution.

Tube B is filled with a potassium chloride solution. Cotton wool seals both ends but aqueous ions are able to move in and out of Tube B.



6.1 Name the component labelled B. (1)

6.2 Describe two properties of an electrode. (2)

6.3 Write down the half-reaction occurring at Electrode A. (2)

6.4 Which electrode is the cathode? (A or C?) (1)

6.5 Write down the correct cell notation. (no standard conditions or phase labels required). (3)

6.6 State the specific **standard conditions** for this cell? (3)

6.7 Describe the energy conversion that will occur in this cell. (2)

6.8 Will electrons flow from left-to-right or right-to-left through G? (1)

6.9 Fully describe the flow of ions out of B. (2)

6.10 Determine the emf of this cell under standard conditions. (3)

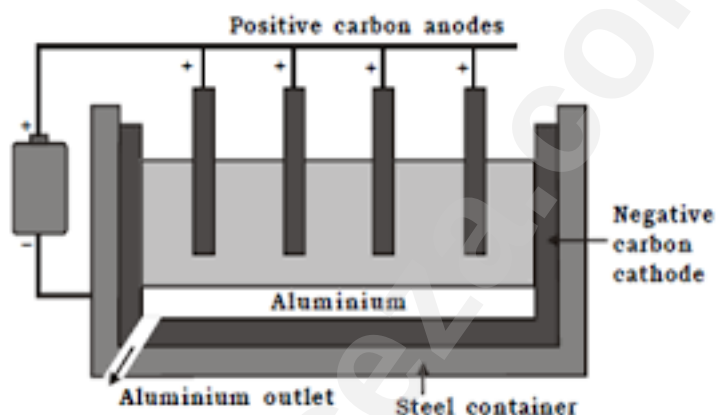
6.11 Suggest two methods of increasing the current produced by this cell. (2)

6.12 Define *reducing agent* (2)

[24]

QUESTION 7 ELECTROLYSIS

7.1 Aluminium is extracted from its mineral ore, bauxite, using electrolysis. The main production of aluminium in South Africa occurs at BHP Billiton, in Richard's Bay, KZN. The aluminium oxide (alumina) is dissolved in molten cryolite (Na_3AlF_6), and then electrolysed in huge carbon-lined tanks. The molten aluminium is then removed, as shown in the diagram below:



7.1.1 Define *Cathode* (2)

7.1.2 Write down the half-reaction which occurs at the cathode. (2)

7.1.3 What is the benefit of the alumina being dissolved in molten cryolite? (2)

7.1.4 How is CO_2 produced in the process? (2)

- 7.1.5 The melting point of aluminium is 660°C . Why is the aluminium removed from the chamber in liquid form? (2)

- 7.1.6 The amount of aluminium (Al) required to make one soft drink can is 14,9g. Assume a current of 10 A is passed through the molten alumina.

- 7.1.6.1 How many moles of aluminium are needed to make one can? (2)

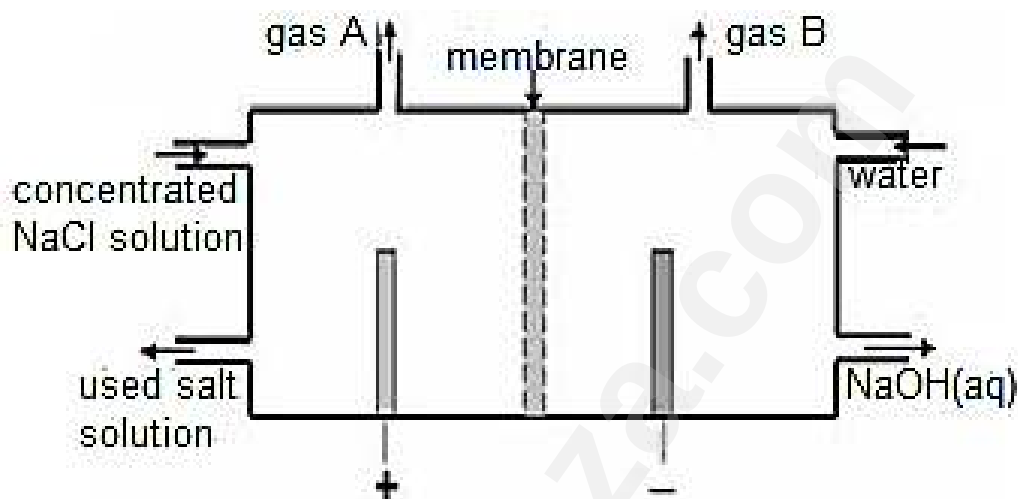
- 7.1.6.2 How many moles of electrons are transferred in this reaction when producing enough aluminium for one can ? (2)

- 7.1.6.3 How many electrons is your answer to 7.1.6.2? (2)

- 7.1.6.4 Calculate the total charge transferred. (2)

- 7.1.6.5 Calculate how long it takes to make enough aluminium for one can. (3)

- 7.2 Approximately 97 million tons of chlorine gas are used throughout the world annually. Chlorine gas is produced industrially by the electrolysis of a concentrated solution of NaCl . The diagram below represents a membrane cell used in the production of chlorine gas in the chlor-alkali industry.



- 7.2.1 State the energy conversion in this cell. (2)

- 7.2.2 What is the common name for the saturated NaCl solution used in the chlor-alkali process? (1)

- 7.2.3 What is the function of the membrane in the membrane cell? (2)

7.2.4 Write down the formula of the gas released at the anode in this cell. (1)

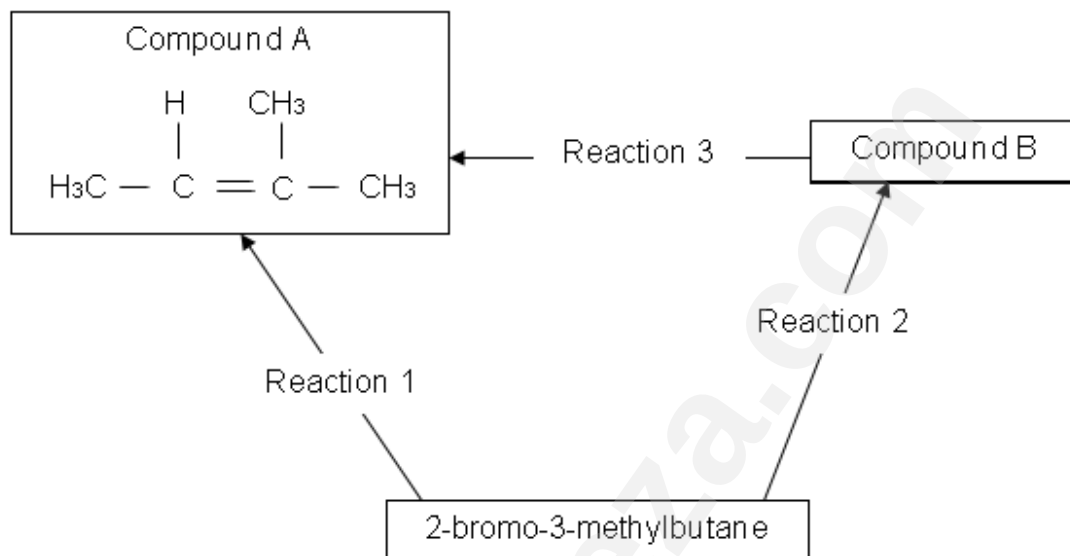
7.2.5 Write down the half reaction occurring at the **cathode** in this cell. (2)

7.2.6 Refer to the Table of Standard Electrode Potentials to explain why sodium metal is NOT produced at the cathode in the membrane cell. (2)

[31]

QUESTION 8 ORGANIC

The flow diagram below shows how two organic compounds, A and B, can be made from 2-bromo-3-methylbutane.



8.1 Define *homologous series* (2)

8.2 Name the homologous series to which 2-bromo-3-methylbutane belongs. (2)

8.3 Draw the structural formula of 2-bromo-3-methylbutane. (3)

8.4 Reaction 1 takes place in a concentrated solution of NaOH in an ethanol solvent to form compound A. No water is present.

8.4.1 Name the general type of reaction which takes place. (1)

8.4.2 State the other reaction condition required for this reaction. (1)

8.4.3 Give the IUPAC name of compound A. (2)

8.5 Reaction 2 takes place in a warm aqueous alkali solution while heating under reflux.

8.5.1 Name the specific type of reaction which takes place. (1)

8.5.2 Explain why is it necessary for reaction 2 to be heated **under reflux**? (2)

8.5.3 Draw the structural formula of compound B. (3)

8.6 Using molecular formulae, write a balanced equation for the combustion of compound A in excess oxygen. (4)

[21]

THE END YOU MADE IT

"Never be afraid to try something new. Remember, amateurs built the ark, professionals built the Titanic." By Vance Neudorf

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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 1																	2 He 4
2	3 Li 7	4 Be 9																10 Ne 20
3	11 Na 23	12 Mg 24,3																18 Ar 40
4	19 K 39	20 Ca 40	21 Sc 45	22 Ti 48	23 V 51	24 Cr 52	25 Mn 55	26 Fe 56	27 Co 59	28 Ni 59	29 Cu 63,5	30 Zn 65,4	31 Ga 70	32 Ge 72,6	33 As 75	34 Se 79	35 Br 80	36 Kr 84
5	37 Rb 85,5	38 Sr 88	39 Y 89	40 Zr 91	41 Nb 93	42 Mo 96	43 Tc 99	44 Ru 101	45 Rh 103	46 Pd 106	47 Ag 108	48 Cd 112	49 In 115	50 Sn 119	51 Sb 121	52 Te 128	53 I 127	54 Xe 131
6	55 Cs 133	56 Ba 137,3		72 Hf 178,5	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 200,6	81 Tl 204,4	82 Pb 207	83 Bi 209	84 Po -	85 At -	86 Rn -
7	87 Fr 88																	

	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lw

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
↓

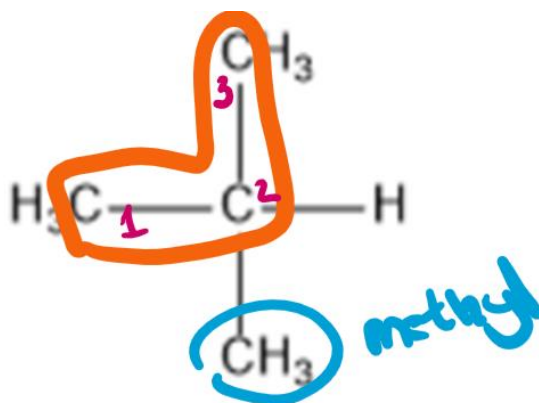
↑
Increasing strength of reducing agent

MEMO CHEMISTRY TRIALS PAPER 2023

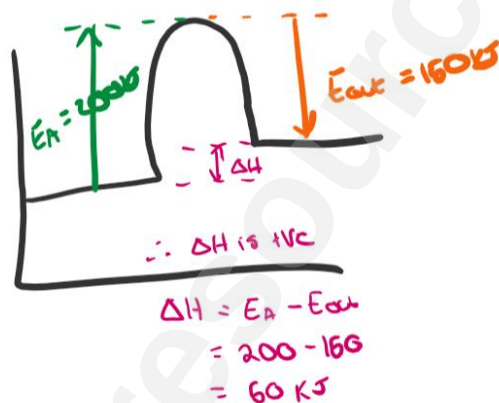
QUESTION 1 MULTIPLE CHOICE

1 MCQ Explanations

1.1. Answer C



1.2 Answer A

1.3 Answer D
Theory

1.4 Answer D

- A: Adding a catalyst does not affect equilibrium,
therefore there is NO COLOUR CHANGE
- B: Stress is an increase in temperature
The system counteracts by decreasing the temperature
The system favours the endothermic reaction
The system favours forward reaction
The mixture turns MORE BLUE
- C: The stress is an increase in Cl^- ions
The system counteracts by decreasing the $[\text{Cl}^-]$
The system favours the reaction which uses Cl^-

The system favours the forward reaction
The mixture turns MORE BLUE

- D The stress is an increase in the concentration of water (the solvent is ethanol and not water which is why we can talk about the concentration of water)

The system counteracts by decreasing the concentration of H_2O

The system favours the reaction which uses up H_2O

The system favours the reverse reaction

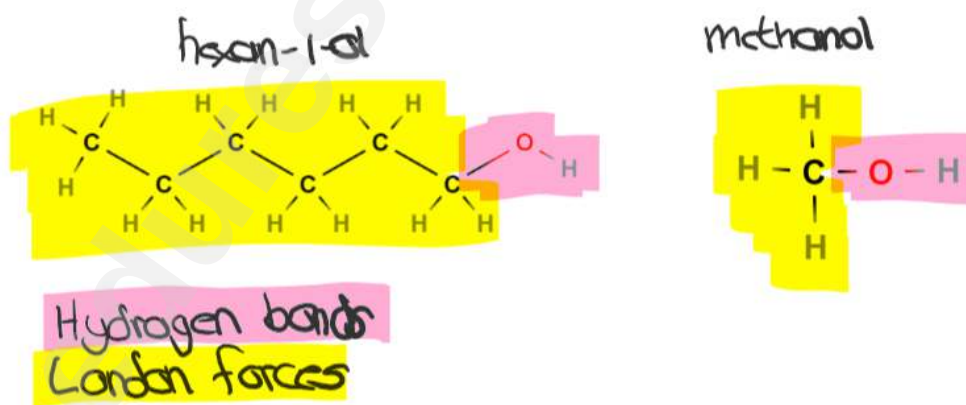
The mixture turns MORE PINK

- 1.5 Answer D
Theory

- 1.6 Answer D
Methyl orange changes colour around 3,1-4,4
so the salt produced must be acid
this means that we must be titrating a strong acid and weak base

- 1.7 Answer is B
Theory
(two reactants and two products means substitution)

- 1.8. Answer is A



Viscosity

Hexanol and methanol both have hydrogen bonds and London forces, however hexanol has stronger London forces

So the IMFs in hexanol are stronger

Therefore viscosity of hexanol is higher

Solubility

In methanol the hydrogen bonds form a larger portion of the molecule

In hexanol the London forces prevent the molecule from dissolving in water
Hence the solubility of methanol is higher

1.9 Answer D

From the equation $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$ we see that $[\text{H}_3\text{O}^+]$ is inversely proportional to $[\text{OH}^-]$ and the graph would be a hyperbola

1.10 Answer D

The object to be plated must be connected at the cathode (negative terminal) of the battery.

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QUESTION 2 BONDING

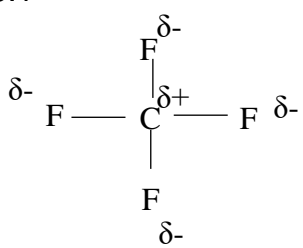
2.1 A force of attraction between molecules✓ , ions or atoms of a noble gas✓ (2)

2.2.1 London forces✓✓ (or Momentary – induced dipole forces) (2)

2.2.2 Ionic bond✓✓ (2)

2.2.3 $\Delta EN = 2,5 - 2,1 = 0,4$ ✓
Polar✓ covalent bond✓ (3)

2.2.4 CaCO_3 ✓
Ionic bond requires more energy to break than weak IMF's between molecules✓ (2)

2.3.1 ✓ single bonds
✓ polarity

(2)

2.3.2 Symmetrical charge distribution around the carbon atom✓✓
(Doesn't have a slightly positive end to the molecule) (2)

2.3.3 CH_3F has dipole-dipole✓ forces between its molecules

CF_4 has London forces✓ between its molecules

Dipole-dipole forces are stronger✓ than London forces

More energy is required to overcome the dipole-dipole forces and therefore CH_3F has a higher boil point.✓ (4)

[19]

QUESTION 3 RATES OF REACTION

- 3.1 Reaction rate: change in concentration per unit time of either reactants or products ✓✓ (2)
- 3.2 Av. Rate = Total volume product produced/Total time
 = (120- 96)/30 ✓
 = 0,8 cm³.s⁻¹ ✓ (2)
- 3.3 Title/legend ✓
 Axes labelled correctly ✓✓
 Scales ✓
 Plotting ✓✓
 Best-fit curve ✓ (7)
- 3.4 Correct value ✓ (130 cm³ – check individual graphs) between 128 and 132
 Shown on graph ✓ (2)
- 3.5 Gradient indicates rate of reaction. ✓
 Gradient = $\Delta y/\Delta x$ ✓
 = Change in volume of gas produced/change in time ✓ (2)
- 3.6.1 Gradient is steep ✓ because rate of reaction is high. ✓
 Rate is high because concentration of reactants high. (2)
- 3.6.2 Gradient is decreasing ✓ because rate of reaction is decreasing. ✓
 Rate is decreasing because concentration of reactants is decreasing as reactants are used up (2)
- 3.6.3 Gradient is zero because reaction rate is zero. ✓
 Reaction rate zero because limiting reagent has been used up. ✓ (2)
- 3.7.1 initial gradient less steep ✓
 same volume of product reached but reached later ✓ (2)
- 3.7.2 initial gradient steeper ✓ end point reached earlier ✓
 only half the volume of gas ✓ (3)

[26]

QUESTION 4 EQUILIBRIUM

4.1.1 State Le Chatelier's principle: When an external stress is applied to a system in dynamic equilibrium, the equilibrium point will change in such a way to counteract the stress. (2)

4.1.2. Response: The forward reaction is favored✓

Reason: because it produces fewer moles of gas, thereby decreasing the pressure in the container. ✓

Result: ∴ the amount of SO₃ increases. ✓

OR

The stress is an increase in pressure

The system counteracts this by decreasing the pressure

By favoring the reaction which produces the **fewest moles of gas**✓

The **forward** reaction is favored✓

The amount of SO₃ **increases**✓ (3)

4.1.3. Response: The endothermic (reverse) ✓✓ reaction is favoured

Reason: because it absorbs heat✓

Result: ∴ The amount of SO₃ decreases.✓

OR

The stress is an increase in Temperature

The system counteracts this by decreasing the temperature/absorb heats

By favouring the **endothermic** reaction✓

The **reverse** reaction is favoured✓

The amount of SO₃ **decreases**✓ (3)

4.2.1 Kinetic energy of molecules increases so they **move faster**, ✓

Therefore more collisions per unit volume per unit time

More particles have **energy above the activation energy**✓ so a higher proportion of collisions are effective

Therefore more effective collisions per unit volume per unit time

Therefore the rate of reaction **increases**✓ (3)

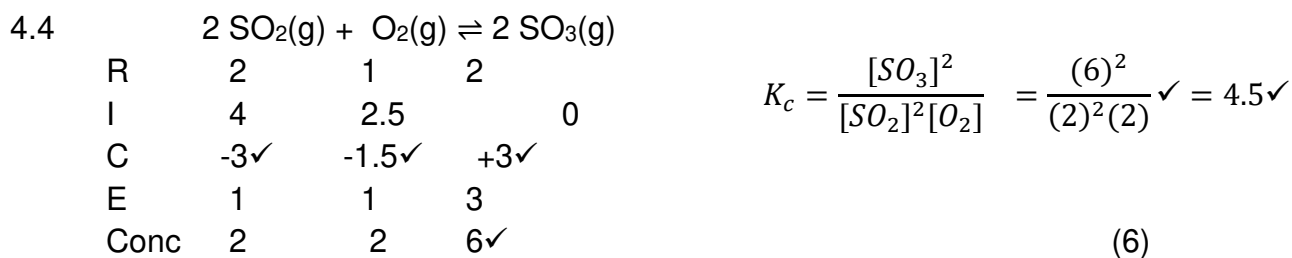
4.2.2 Since gas molecules are so far apart, the inert gas molecules will not interfere with or affect collisions between reacting particles, ✓

so the rate is unaffected. ✓ (2)

4.3 Although a low temperature will increase the yield (forward exothermic reaction favored), ✓

it will decrease the rate ✓ making the process uneconomical.

A high pressure would increase the yield, but not to such an extent that the extremely high cost of operating at high pressures is justified. ✓ (3)



4.5.1 rate of forward reaction ✓ (1)

4.5.2 The rate changes rapidly at first while reactant concentration is high✓, then less rapidly as reactant concentration decreases and number of collisions decreases. ✓ (2)

4.5.3 after 4 minutes (1)

4.5.4 Pressure is decreased ✓ causing both reaction rates to decrease
 Response: reverse reaction is favoured✓ thus rate of reverse reaction decreases less.
 Reason: It is favoured because it produces more moles of gas, thus increasing the pressure✓ in the container. (4)

OR

Decrease in pressure **decreases the rate of both** reactions✓

Stress is a **decrease in pressure** ✓

The system will try counteract this by increasing the pressure

By favoring the reaction which produces **more moles of gas**✓

Therefore **favoring the reverse** reaction ✓

(so rate of reverse reaction decreases less)

Note: A temperature decrease would also cause both reaction rates to decrease but the forward (exothermic) reaction would be favoured and its rate would decrease less. ✓ (4)

4.5.5 K_c will remain the same✓ (1)
[29]

QUESTION 5 ACIDS AND BASES

5.1.1 Diprotic ✓ (1)

5.1.2 H_2O ✓ $(\text{COO})_2^{2-}$ ✓ (2)

5.1.3 A substance that can act as either an acid or a base (2)

5.1.4 $\text{H}(\text{COO})_2^-$ ✓ (1)

In reaction 1 it is acting as a base, and in reaction 2 it is acting as an acid.

$$\begin{aligned}
 5.1.5 \quad c &= \frac{m}{MV} \\
 \therefore m &= cMV \checkmark \\
 &= 0,2 \times 90 \times 0,25 \checkmark \\
 &= 4,5 \text{ g} \checkmark
 \end{aligned}$$
(3)

5.2.1 A strong acid ionises completely ✓ in an aqueous solution ✓ (2)

5.2.2 strong – HY ✓
 weak = $\text{HZ} / \text{H}_2\text{X}$ ✓

(2)

5.2.3 the lowest pH is the highest $[\text{H}_3\text{O}]^+$ ✓
 HY has a very high K_a $\therefore$ high $[\text{H}_3\text{O}]^+$ as it ionises completely ✓
 HY has the lowest pH ✓

(3)

5.2.4 HZ ✓
 very low K_a value, which means it has not ionised much, ✓
 $\therefore$ not many free ions to carry a current ✓

(3)

$$5.2.5 \text{ a) } K_a = \frac{[\text{H}^+]^2[\text{X}^-]}{[\text{H}_2\text{X}]} \checkmark \checkmark$$
(2)

$$\begin{aligned}
 5.2.5 \text{ b) } 2,8 \times 10^{-3} \checkmark &= \frac{(2x)^2 x \checkmark}{0,2} \\
 4x^3 &= 1,4 \times 10^{-4} \\
 \therefore [x] &= 0,0519 \text{ mol} \cdot \text{dm}^{-3} \checkmark
 \end{aligned}$$
(3)



$$\begin{aligned}
 5.2.6 \text{ b) } \frac{n_a}{n_b} &= \frac{c_a V_a}{c_b V_b} \checkmark \\
 \frac{1}{1} &= \frac{c_a \cdot 25}{0,1 \times 32,4} \checkmark \\
 c_a &= \frac{0,1 \times 32,4}{25} \\
 &= 0,13 \text{ mol} \cdot \text{dm}^{-3} \checkmark
 \end{aligned}$$
(4)

[30]

QUESTION 6 GALVANIC CELL

- 6.1 salt bridge✓ (1)
- 6.2 conduct electricity and inert and provides solid surface area (any ✓✓) (2)
- 6.3 $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ ✓✓ (2)
- 6.4 C✓ (1)
- 6.5 $\text{Mg}/\text{Mg}^{2+} // \text{Al}^{3+}/\text{Al}$ ✓✓✓ negative marking (3)
- 6.6 T of 25°C ✓ and
conc of $1\text{mol}\cdot\text{dm}^{-3}$ for Mg^{2+} and
conc of $1\text{mol}\cdot\text{dm}^{-3}$ for Al^{3+} (3)
- 6.7 chemical to electrical✓✓ (2)
- 6.8 left to right✓ (1)
- 6.9 Cl^- to the left(A)(anode)(Mg) ✓
and K^+ to the right✓ (2)
- 6.10 $\text{emf} = E(\text{cathode}) - E(\text{anode})$ ✓
 $= -1,66 - (-2,37)$ ✓
 $= +0,71\text{V}$ ✓ (3)
- 6.11 shorter or wider salt bridge✓
Larger surface area of electrodes✓
Increased conc or T (any two) (2)
- 6.12 substance that donates electrons✓✓ (2)

[24]

QUESTION 7 – ELECTROLYSIS

7.1.1 Cathode is the electrode where reduction takes place ✓✓ (2)

7.1.2 $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ ✓✓ (2)

7.1.3 It reduces its melting point ✓ and $\therefore$ saves on energy costs. ✓ (2)

7.1.4 The oxygen gas ✓ produced at the anode reacts with the carbon ✓ which the anode is made of. (2)

7.1.5 The dissolving process takes place at 1000°C /at a higher temperature ✓ than the melting point of aluminium. ✓ (2)

7.1.6.1 $n = \frac{m}{M} = \frac{14,9}{27} \checkmark = 0,55 \text{ mol } \checkmark$ (2)

7.1.6.2 Mol ratio $\text{Al} : \text{e}^-$
 $1 : 3 \checkmark$
 $\therefore 3 \times 0,55 = 1,65 \text{ mol } \checkmark$ (2)

7.1.6.3 $N_{\text{e}^-} = n \times N_{\text{A}}$
 $= 1,65 \times 6,02 \times 10^{23} \checkmark$
 $= 9,93 \times 10^{23} \text{ e}^- \checkmark$ (2)

7.1.6.4 $9,93 \times 10^{23} \text{ e}^- \times 1,6 \times 10^{-19} \checkmark$
 $= 158\,880 \text{ C} \checkmark$ (2) accept $Q = 159761 \text{ C}$ if skip 7.1.6.3

7.1.6.5 $Q = It \checkmark$
 $\therefore t = \frac{Q}{I} = \frac{158\,880}{10} \checkmark$
 $= 15\,888 \text{ s (or 4,41 hours) } \checkmark$ (3)

7.2.1 Electrical ✓ $\rightarrow$ Chemical ✓ (2)

7.2.2 brine ✓ (1)

7.2.3 Allows for movement of positive ions ✓ (Na^+) from anode compartment to cathode compartment ✓. (2)

7.2.4 $\text{Cl}_2 \checkmark$ (1)

7.2.5 $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^- + \text{H}_2 \checkmark \checkmark$ (2)

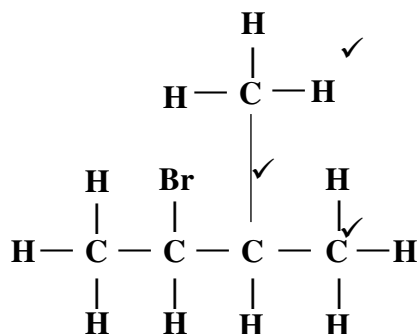
7.2.6 Water is a stronger oxidizing agent ✓ than Na^+ , (or Na^+ is a weaker oxidizing agent) $\therefore$ will have a greater tendency to be reduced ✓ / water will be preferentially reduced. (NB NOT accepting anything about reducing agents, as there is no oxidation at the cathode) (2)

QUESTION 8 ORGANIC

8.1 Define homologous series: compounds with the same general formula and functional group but which differ from each other by a single $-\text{CH}_2$ unit. (2)

8.2 Halo✓alkanes✓ (alkyl halides) (2)

8.3



8.4.1 Elimination✓ (1)

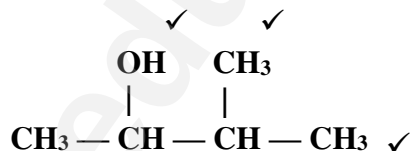
8.4.2 Heat✓ (1)

8.4.3 2-methyl✓but-2-ene✓ (2-methylbut-2-ene) (2)

8.5.1 Hydrolysis✓ (1)

8.5.2 Heat under reflux as reactants have low boiling points✓ and therefore would evaporate before the reaction is complete✓. To heat under reflux condenses evaporated gases back into the reaction solution. (2)

8.5.3



(3)

8.6 $2\text{C}_5\text{H}_{10} + 15\text{O}_2 \checkmark \rightarrow 10\text{CO}_2 \checkmark + 10\text{H}_2\text{O} \checkmark$ ✓balanced (4)

[21]