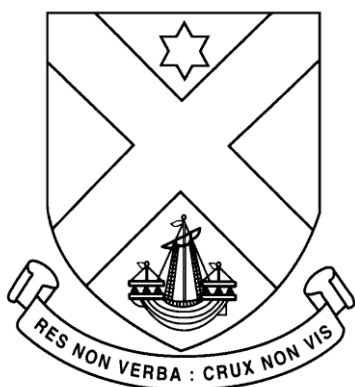




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Exam Number / name: _____



ST ANNE'S DIOCESAN COLLEGE

TRIAL EXAMINATION 2017

PHYSICAL SCIENCES

PAPER 2 CHEMISTRY

Time: 3 hours

200 Marks

Examiner: S Schwartz

Moderator: M Schwartz (MHS)

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

- Weighting of knowledge areas (**Target**): Quantitative Chemistry 9,5%(10%) / Bonding 12%(10%) / Energy change & Rates 12,5%(10%) / Equilibrium 18%(15%) / Acids & Bases 13%(15%) / Electrochemistry 18%(20%) / Organic 17%(20%)
- Cognitive Levels (**Target**): 1 – 17%(15%); 2 – 40%(40%); 3 – 32%(35%); 4 – 11%(10%)

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

- This paper consists of:
 - p2-13 Questions 1 to 8;
 - p15-18 Chemistry Data Sheets Tables 1 to 4
 - p19 APPENDIX A
 - p20 APPENDIX B

Please make sure that your question paper is complete.

- The data sheets may be detached if necessary.
- Read the questions carefully and answer in any order, with clear numbering.
- Show your working in all calculations, including equations used.
- Units need not be included in the working of calculations, but appropriate units must be shown in the answer.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	TOTAL	
/20	/27	/29	/32	/28	/30	/19	/15	/200	%

QUESTION 1

MULTIPLE CHOICE QUESTIONS

(use APPENDIX A)

Four options are provided as possible answers to the following questions.
Each question has only ONE correct answer.

1.1 Which statement is true?

- A A non-polar molecule always has non-polar bonds.
- B A non-polar molecule cannot have polar bonds.
- C A linear molecule with both sides of the molecule having the same electronegativity is non-polar.
- D CO_2 has polar bonds so it is a polar molecule.

1.2 Molar concentration is...

- A The number of moles of solute per unit volume of solution.
- B The number of moles of solute per unit volume of solvent.
- C The number of moles of solute in a solution.
- D The number of moles of solvent per unit volume of solution.

1.3 When SO_3 is heated in a sealed tube, it begins to decompose and eventually an equilibrium is reached with SO_3 , O_2 and SO_2 all present in the tube. When this equilibrium is reached...

- A SO_3 is no longer decomposing.
- B SO_2 and O_2 are no longer combining with each other.
- C the mass of SO_3 is equal to the combined mass of SO_2 and O_2 .
- D the mass of SO_3 present in the mixture remains constant.

1.4 Three substances, X, Y and Z_2 are mixed. The reaction which occurs takes place in two steps as follows:



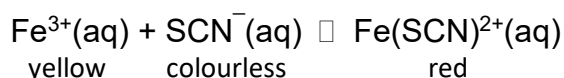
Which one of the substances acts as a catalyst?

- A X
- B Y
- C XZ_2
- D Z_2

1.5 A few pieces of granulated zinc are placed in a beaker containing 40 cm^3 of 0.1 mol.dm^{-3} hydrochloric acid at 25°C . Which one of the following factors will NOT increase the initial rate of this reaction?

- A Increasing the temperature of the acid solution to 50°C
- B Breaking up the granulated zinc into smaller pieces
- C Using 80 cm^3 of 0.1 mol.dm^{-3} hydrochloric acid at 25°
- D Using 40 cm^3 of 0.2 mol.dm^{-3} hydrochloric acid at 25°C

- 1.6 The equation below represents a system at equilibrium:



What colour change will be seen if the concentration of SCN^{-} ions is decreased?

The solution will...

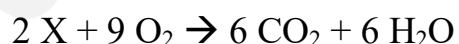
- A turn a red colour
 B turn a pale yellow colour
 C turn colourless
 D not change colour
- 1.7 Which of the following aqueous solutions, at a temperature of 25°C , will have the lowest pH?

	COMPOUND	CONCENTRATION ($\text{mol}\cdot\text{dm}^{-3}$)	VOLUME (cm^3)
A	H_2SO_4	0,2	100
B	NaOH	0,2	200
C	HCl	0,3	100
D	CH_3COOH	0,3	100

- 1.8 Which one of the following is NOT a redox reaction?

- A $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$
 B $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^{-}$
 C $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$
 D $\text{Mg} + 2 \text{Ag}^{+} \rightarrow \text{Mg}^{2+} + 2 \text{Ag}$

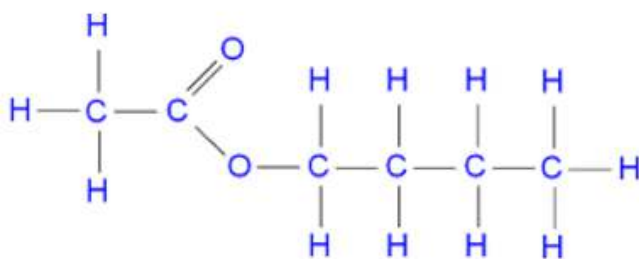
- 1.9 Compound X undergoes a combustion reaction as follows:



The IUPAC name of compound X is...

- A propane B propene C propanol D hexene

1.10 The structural formula of an ester is shown below.



Which one of the following is correct?

	IUPAC name	Formed by the reaction between...
A	Ethyl butanoate	Ethanol and butanoic acid
B	Butyl ethanoate	Ethanol and butanoic acid
C	Ethyl butanoate	Butanol and ethanoic acid
D	Butyl ethanoate	Butanol and ethanoic acid

[10 X 2 = 20]

QUESTION 2 BONDING

2.1 The following substances are all in the **solid phase**. Write the numbers 2.1.1 – 2.1.10 on your answer paper. Complete the table below, stating clearly the **SPECIFIC** type of force or bond that must be broken when the substance **melts** (e.g. polar covalent bond, London force) and the **SPECIFIC** type(s) of particle(s) held together by that force or bond (e.g. non-polar molecules, atoms).

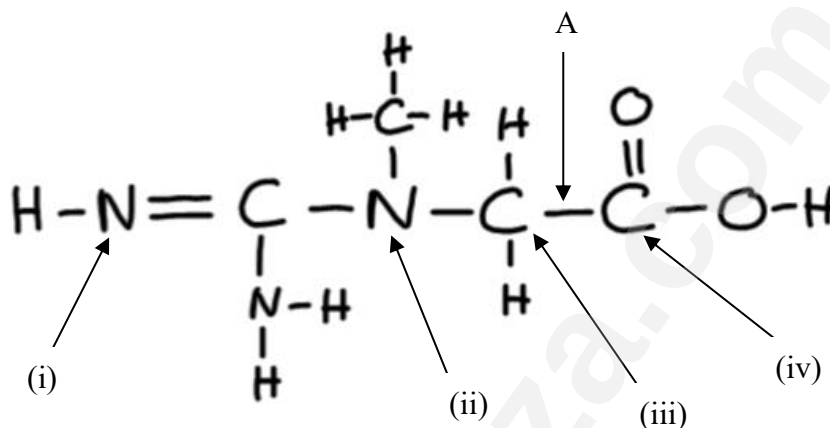
SUBSTANCE	TYPE OF FORCE (OR BOND) WHICH MUST BE BROKEN WHEN SUBSTANCE MELTS	TYPE OF PARTICLE(S) HELD TOGETHER BY FORCE (OR BOND)
Silicon dioxide	2.1.1	2.1.6
Iron	2.1.2	2.1.7
Ammonia	2.1.3	2.1.8
Chlorine	2.1.4	2.1.9
Lithium sulphate	2.1.5	2.1.10

(10)

Q2 continues overleaf...

- 2.2 Creatine, $C_4H_9N_3O_2$, is naturally synthesised in the liver and kidneys at a rate of about 8,3 mmol per day. It is also taken as a supplement by athletes wishing to gain muscle mass. It is classified as a *nitrogenous organic acid*.

The structural formula of creatine is as follows:

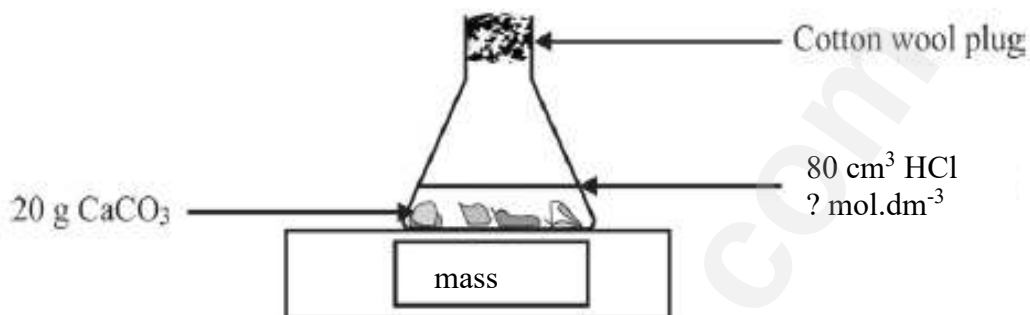


- 2.2.1 Redraw this molecule including all the lone pairs. (2)
- 2.2.2 **Draw** and **name** the functional group which makes this molecule an organic acid. (2)
- 2.2.3 Decide and explain whether or not you would expect this molecule to be soluble in water. (3)
- 2.2.4 State the molecular geometry around each of the atoms labelled (i) to (iv). (4)
- 2.2.5 Classify and define the bond labelled A. (3)
- 2.2.6 Calculate the mass of creatine produced by the body each day. (3)

[27]

QUESTION 3 REACTION RATES

A flask containing 80 cm^3 of hydrochloric acid is placed on an electronic scale. 20 g of calcium carbonate chips is carefully dropped into the flask. A loose cotton wool plug is placed in the neck of the flask to prevent splashing. The mass of the flask, together with its contents, is recorded every 30 s in order to determine the rate of the reaction that occurs. The data is recorded in the table.



Time(min)	0	0,5	1	1,5	2	2,5	3	3,5	4	4,5
Mass(g)	169,1	168,1	167,5	167,2	166,9	166,8	166,7	166,6	166,6	166,6

- 3.1 Write down the chemical equation representing the reaction that occurs in the flask. (3)
- 3.2 Explain why the mass decreases with time. (2)
- 3.3 Explain why the mass eventually becomes constant. (2)
- 3.4 Suggest an alternative method that could be used to determine the rate of this reaction. (2)
- 3.5 On Appendix B, complete the table to show that the total mass lost is $2,5 \text{ g}$; then plot a graph of mass loss vs time on the graph paper provided. (2 + 6)
- 3.6 Refer to your graph to explain whether the reaction rate increases or decreases as the reaction proceeds. (2)
- 3.7 Starting with the total mass lost ($2,5 \text{ g}$), use the information given above to...
- 3.7.1 Deduce which reactant was the limiting reactant. (5)
- 3.7.2 Calculate the original concentration of the hydrochloric acid. (3)
- 3.8 On the graph paper, sketch in the line that you would expect to obtain if the HCl was heated before adding the CaCO_3 . (2)

[29]

QUESTION 4

CHEMICAL EQUILIBRIUM

- 4.1 Calcium carbonate and magnesium carbonate both decompose on heating as shown by the following equations:



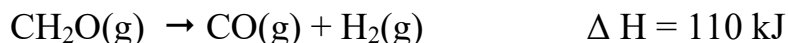
The table below gives some equilibrium constants at different temperatures for these two reactions.

Temperature(°C)	CaCO ₃ K _c	MgCO ₃ K _c
25	$4,6 \times 10^{-25}$	$1,5 \times 10^{-13}$
400	$5,2 \times 10^{-8}$	$1,9 \times 10^{-2}$
800	$4,8 \times 10^{-3}$	29,9

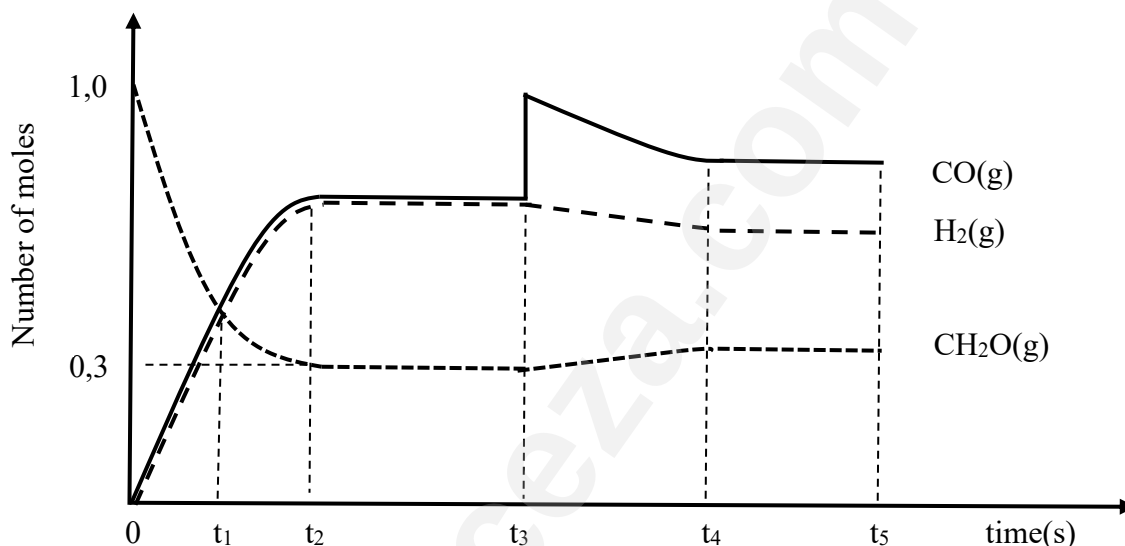
- 4.1.1 Explain why these are both classified as heterogeneous reactions. (1)
- 4.1.2 Which of these carbonates is more stable on heating? Give a reason for your answer. (3)
- 4.1.3 Are the forward reactions exothermic or endothermic? Explain your answer clearly, making reference to Le Chatelier's Principle. (4)
- 4.1.4 Write the equilibrium constant expression for the decomposition reaction of MgCO₃. (2)
- 4.1.5 In one experiment, 21 g of MgCO₃ is placed in a closed 2000 cm³ flask and then heated until equilibrium is established at 400°C. Using your answer to Q 4.1.4 and data from the above table as a starting point, calculate the mass of unreacted MgCO₃ remaining in the flask. (7)

Q4 continues overleaf...

- 4.2 1 mol of $\text{CH}_2\text{O(g)}$ is placed in a 2 dm^3 container. The $\text{CH}_2\text{O(g)}$ decomposes according to the chemical equation below:



Refer to the equation and the graph below (not drawn to scale) to answer the questions.



- 4.2.1 At what time did the system first reach equilibrium? (1)
- 4.2.2 Explain your reasoning for Q 4.2.1. (1)
- 4.2.3 Compare the rate of the forward and reverse reactions at time t_1 . (1)
- 4.2.4 Using the given information, calculate the equilibrium constant K_c for this reaction when it first reached equilibrium. (6)
- 4.2.5 Explain the changes occurring from time t_3 to time t_4 . (5)
- 4.2.6 How will K_c be influenced by the change in Q 4.2.5. State one of no change / increase / decrease. (1)

[32]

QUESTION 5 ORGANIC CHEMISTRY

Consider the condensed structural (semi-structural) formulae of the organic compounds given below.

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$	B	$\text{CH}_2\text{ClCH}_2\text{CH}_3$	C	$\text{CH}_3\text{CH}_2\text{CH}_3$
D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	E	$\text{CH}_3\text{CH}=\text{CH}_2$	F	HCOOH

- 5.1 Name compound A. (2)
- 5.2 Give the name of the homologous series to which compound D belongs. (1)
- 5.3 Brainy Bertha says: "Compounds A and B are chain isomers." Explain why she is incorrect. (1)
- 5.4 Predict and explain which of compounds C or E would have the higher boiling point. (4)
- 5.5 Compounds C and E are both colourless gases at room temperature. Describe the chemical test that could be carried out to distinguish between them. Also explain the reasoning behind the observations in the test. (5)
- 5.6 Explain with reference to the relevant intermolecular forces why compound D is a liquid at room temperature (boiling point 98°C) whereas compound C is a gas (boiling point -42°C). (4)
- 5.7 Compound E can be produced from compound D. What specific type of reaction does compound D need to undergo in order to form compound E? (2)
- 5.8 Which of compounds A to F, when added to water, would cause the pH to decrease? (1)
- 5.9 Compound A is boiled with an aqueous solution of potassium hydroxide (KOH). Write a balanced equation for the reaction which takes place using semi-structural formulae for the organic compounds. (2)
- 5.10 Give the **structural formula AND the name** of the organic product formed in the reaction between compounds D and F when gently heated together in the presence of concentrated sulphuric acid. (4)
- 5.11 Write a balanced chemical equation for the reaction which occurs when compound C reacts with chlorine gas in the presence of UV light. (2)

[28]

QUESTION 6 ACIDS AND BASES

6.1 Consider the four aqueous solutions in the table below.

A	0,1 mol.dm ⁻³ HNO ₃
B	0,1 mol.dm ⁻³ H ₂ SO ₄
C	0,1 mol.dm ⁻³ H ₃ PO ₄
D	0,1 mol.dm ⁻³ KOH

- 6.1.1 Describe how you would accurately prepare 100 cm³ of solution B from a 0,15 mol.dm⁻³ solution of H₂SO₄. (4)
- 6.1.2 K_a is known as the acid ionisation constant. For H₃PO₄, K_{a1} = 7,1 x 10⁻³. Write the equation for the ionisation reaction of H₃PO₄ corresponding to K_{a1}. (3)
- 6.1.3 Which of solutions A to D would have the highest pH? (1)
- 6.1.4 Place solutions **A to C** (NOT D) in order of electrical conductivity from lowest electrical conductivity to highest electrical conductivity. (2)
- 6.1.5 Explain your answer to Question 6.1.4. (4)
- 6.1.6 Solution D is at 25°C.
- (a) Calculate the hydronium ion concentration in solution D. Assume that the KOH is fully dissociated. (2)
- (b) Why is it necessary to specify that the temperature is 25°C? (1)

Q6 continues overleaf...

- 6.2 16,65 g of impure bicarbonate of soda, which contains some NaHCO_3 together with inert impurities, is made up to 250 cm^3 in a volumetric flask.

$20,00 \text{ cm}^3$ of this solution is transferred to a conical flask and a few drops of methyl orange solution is added.

The solution is titrated with a solution of HCl of concentration $0,290 \text{ mol.dm}^{-3}$ to an end point of $25,16 \text{ cm}^3$.

6.2.1 Name the item of glassware...

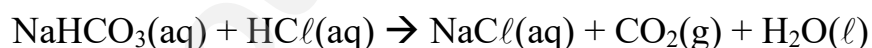
(a) used to transfer the $20,00 \text{ cm}^3$ of impure NaHCO_3 solution into the conical flask. (1)

(b) used to titrate the HCl solution into the conical flask. (1)

6.2.2 What is the function of the methyl orange solution? (2)

6.2.3 Differentiate between the *equivalence point* and the *end point* of a titration. (4)

6.2.4 The equation which represents the chemical reaction occurring during the titration is as follows:

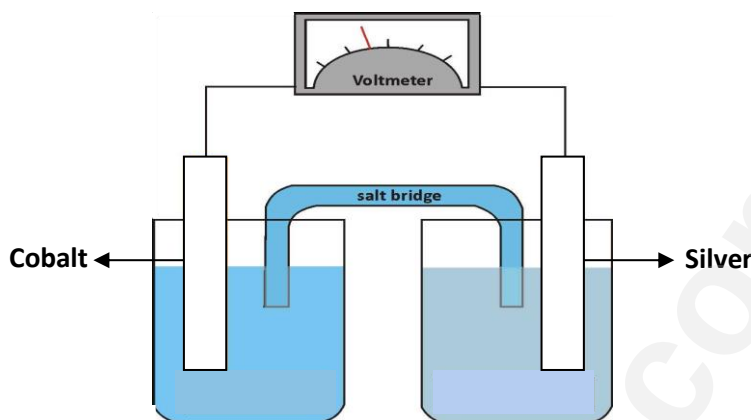


Calculate the percentage NaHCO_3 in the original sample of bicarbonate of soda. (5)

[30]

QUESTION 7 ELECTROCHEMISTRY

A galvanic cell is set up under standard conditions between silver (Ag) and cobalt (Co).

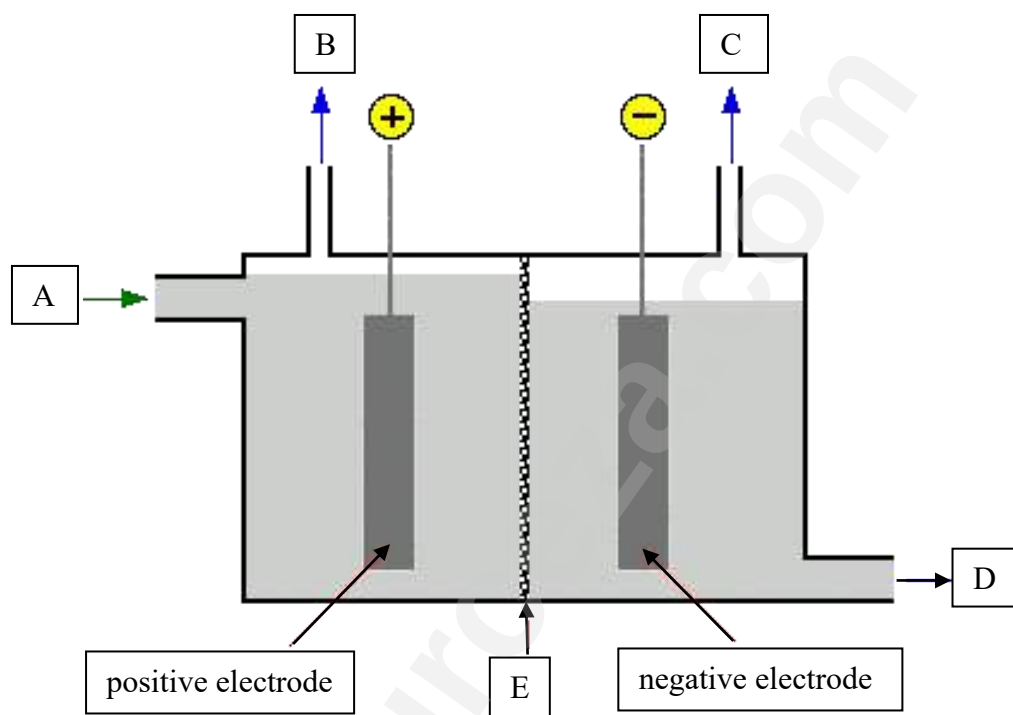


- 7.1 Describe a galvanic cell in terms of the energy transfer that takes place within it. (2)
- 7.2 Define *oxidation*. (1)
- 7.3 State the **specific** standard conditions that would be used for this cell between silver and cobalt. (2)
- 7.4 Suggest a suitable electrolyte to be used in the silver half-cell. (1)
- 7.5 Use your table of standard electrode potentials to give the equation for
 - 7.5.1 the reaction occurring at the anode (1)
 - 7.5.2 the reaction occurring at the cathode (1)
 - 7.5.3 the nett cell reaction (2)
- 7.6 Give the symbol of the oxidising agent in this cell. (1)
- 7.7 Calculate the emf of this cell under standard conditions. (2)
- 7.8 How will the emf of the cell be affected by the addition of extra Co^{2+} ions to the cobalt half-cell? Explain in terms of equilibrium principles. (3)
- 7.9 What will happen to the emf of this cell as the cell reaction approaches equilibrium? (1)
- 7.10 State two ways to increase the current that this cell can deliver without changing the emf. (2)

[19]

QUESTION 8 CHLOR-ALKALI PROCESS

The diagram below shows a cell used in the Chlor-Alkali industry. Note that the level of fluid on the left side is higher than on the right side.



- 8.1 Is this cell's positive electrode an anode, or a cathode? (1)
- 8.2 Name the particular cell that is illustrated above. (1)
- 8.3 Explain in detail why the fluid level is kept higher on the side containing the positive electrode. (4)
- 8.4 Name the substance used to make the divider E and mention two drawbacks of using this type of divider in comparison to more modern options. (3)
- 8.5 Write the chemical formula of substance B and state one use of this product. (2)
- 8.6 Write out the half reaction that occurs at the negative electrode. (2)
- 8.7 Give the name of the product that exits the cell at D, and state one use of this product. (2)

[15]

IT'S THE END!

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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^θ	$1,01 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature	T^θ	273 K
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 $c = \frac{m}{MV}$	$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14} \text{ at } 298 \text{ K}$	
$Q = It$	$E_{\text{cell}}^\theta = E_{\text{cathode}}^\theta - E_{\text{anode}}^\theta$ $E_{\text{cell}}^\theta = E_{\text{oxidising agent}}^\theta - E_{\text{reducing agent}}^\theta$	

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APPENDIX A

Exam number / name:

QUESTION 1**MULTIPLE CHOICE ANSWER GRID****MARK ONLY THE CORRECT ANSWER WITH A CROSS.**

eg.	A	~~B~~	C	D
-----	---	--------------	---	---

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

APPENDIX B (FOR QUESTION 3)

Time(min)	0	0,5	1	1,5	2	2,5	3	3,5	4	4,5
Mass(g)	169,1	168,1	167,5	167,2	166,9	166,8	166,7	166,6	166,6	166,6
Mass loss(g)										

