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**BEAULIEU COLLEGE
DEPARTMENT OF PHYSICAL SCIENCES**

GRADE 12 PRELIMINARY EXAMINATIONS

PAPER II: CHEMISTRY

JULY 2017

Examiner: Mr M Naidoo

Time: 3 hours

Moderator: Ms van Schoor

Total: 200 marks

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of:
 - A question paper of 20 pages
 - An info sheet containing data and formulae
 - An answer sheetCheck that your question paper is complete.
2. Read the questions carefully.
3. Work out all your answers to **2 decimal** places unless otherwise stated.
4. **Start** each question on a new page.
5. Use the data and formulae whenever necessary.
6. Leave a line between your questions.
7. It is in your own interest to write legibly and to set your work out neatly.

*Acknowledgements: St Marys Waverley; <http://www.cie.org.uk/> ; St John's College,
<http://www.aqa.org.uk>*

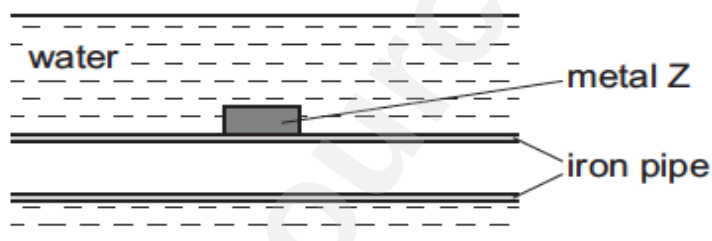
Question 1 Multiple Choice**[20 marks]**

In each of the following questions four possible answers are provided. Place a cross over the letter of the corresponding answer, on the Answer Sheet provided.

- 1.1 What are the correct anode (positive electrode) and cathode (negative electrode) products when aqueous copper(II) sulfate is electrolysed using copper electrodes?

	Anode product	Cathode product
A	Aqueous copper (II) ions	Copper metal
B	Aqueous copper (II) ions	Hydrogen gas
C	Oxygen gas	Copper metal
D	Oxygen gas	Hydrogen gas

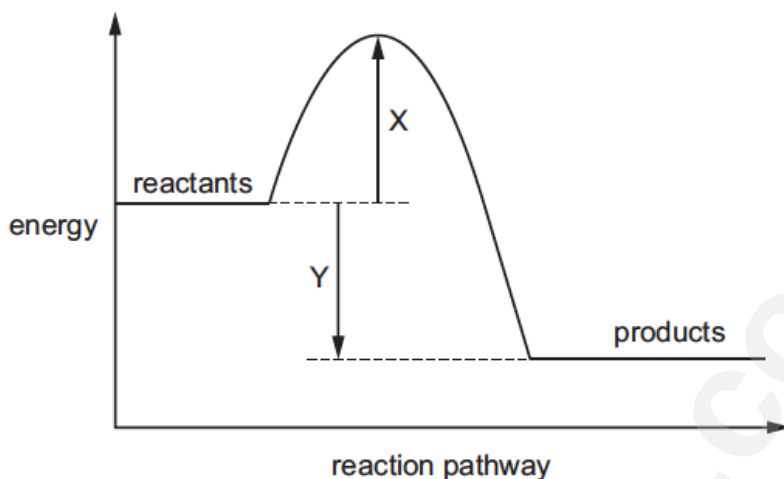
- 1.2 The diagram shows how an underwater iron pipe can be protected from rusting.



Metal Z can be 1..... because it is 2..... reactive than iron.
Which words correctly complete gaps 1 and 2?

	1	2
A	copper	less
B	copper	more
C	magnesium	less
D	magnesium	more

- 1.3 The diagram shows the energy profile of a chemical reaction. Two energy changes are labelled X and Y.



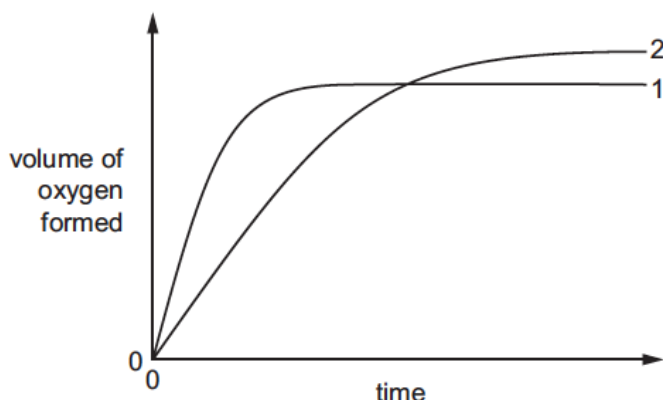
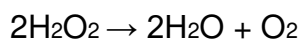
Which statement about the reaction is correct?

- A The activation energy of the reaction is $X + Y$.
 B The enthalpy change of the reaction is X .
 C The enthalpy change of the reaction is $X + Y$.
 D The reaction is exothermic
- 1.4 In which of these equilibria is the forward reaction favoured by an increase in pressure?
- A $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$
 B $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
 C $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
 D $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
- 1.5 Two esters have the same molecular formula, $\text{C}_3\text{H}_6\text{O}_2$. What are the names of these two esters?

- 1 methyl ethanoate
- 2 ethyl propanoate
- 3 ethyl methanoate
- 4 propyl methanoate

- A 1 and 2
 B 1 and 3
 C 2 and 4
 D 3 and 4

- 1.6 In the graph, curve 1 was obtained by observing the decomposition of 100 cm³ of 1,0 mol.dm⁻³ hydrogen peroxide solution, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve 2?

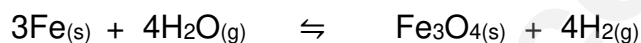
- A adding some 0,1 mol.dm⁻³ hydrogen peroxide solution
 B lowering the temperature
 C using less manganese(IV) oxide
 D using a different catalyst
- 1.7 Which of the following statements is **not true** for a 0,1 mol.dm⁻³ solution of the **strong acid**, HCl?
- A $[\text{H}_3\text{O}^+] > [\text{OH}^-]$
 B $[\text{OH}^-] = 0$
 C $\text{pH} < 7$
 D $[\text{Cl}^-] = 0,1 \text{ mol.dm}^{-3}$
- 1.8 Choose the combination that will contain the largest number of hydronium ions in solution.

	Formula of acid or base	Concentration (mol.dm ⁻³)	Volume (dm ³)
A	CH ₃ COOH	2	3
B	HCl	3	2
C	H ₂ SO ₄	2	3
D	Ca(OH) ₂	3	3

1.9 The correct IUPAC systematic name for $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)=\text{C}(\text{CH}_2\text{CH}_3)\text{CH}_3$ is

- A 2,3-diethylbut-2-ene
- B 2-ethyl-3-methylpent-2-ene
- C 4-ethyl-3-methylpent-3-ene
- D 3,4-dimethylhex-3-ene

1.10 The reaction of iron filings with steam can be represented by the following equation:



The appropriate equilibrium constant expression for this reaction would be:

- | | |
|---|---|
| <p>A $K_c = \frac{[\text{H}_2]^4}{[\text{H}_2\text{O}]^4}$</p> | <p>B $K_c = \frac{[\text{H}_2]^4}{[\text{H}_2\text{O}]^4}$</p> |
| <p>C $K_c = \frac{[\text{H}_2]^4[\text{Fe}_3\text{O}_4]}{[\text{Fe}]^3[\text{H}_2\text{O}]^4}$</p> | <p>D $K_c = \frac{[\text{H}_2]^4[\text{Fe}_3\text{O}_4]}{[\text{Fe}]^3}$</p> |

[10 x 2 = 20 marks]

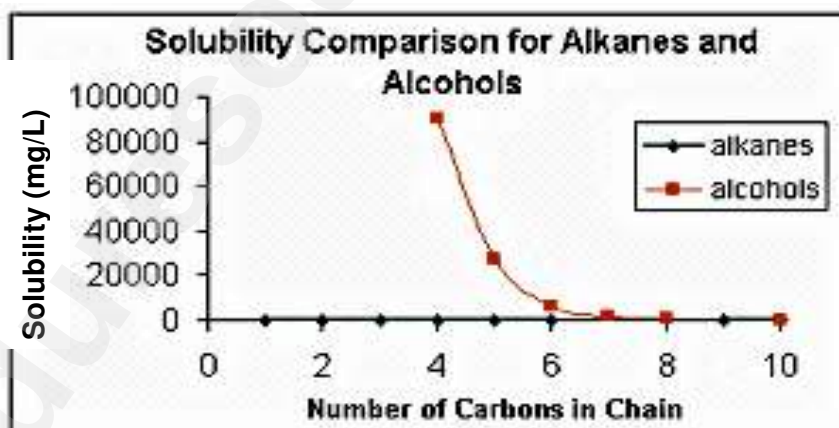
Question 2 Chemical Bonding [15 marks]

2.1 You are provided with a list of substances below. The states (physical indicators) of each substance is at room temperature. Answer the questions below.

Ne(g)	KBr(s)	Na(s)	HF(g)	C(s)	PH₃(g)
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Select only **one** substance from the list above that:
(only write down the question number and the substance)

- 2.1.1 is an inert, monatomic substance.
- 2.1.2 has a high melting point due to strong electrostatic forces between the cations and anions.
- 2.1.3 has bonds which have an electronegativity difference of zero.
- 2.1.4 has delocalised valence electrons.
- 2.1.5 has pure covalent bonds and has an extremely high melting point due to its giant lattice structure.
- 2.1.6 has Hydrogen bonding intermolecular forces. (6)
- 2.2. The graph below indicates the solubility trends for alkanes and alcohols at a specific temperature. The line graph for alkanes lies on the x-axis. Examine the graph and answer the questions below.

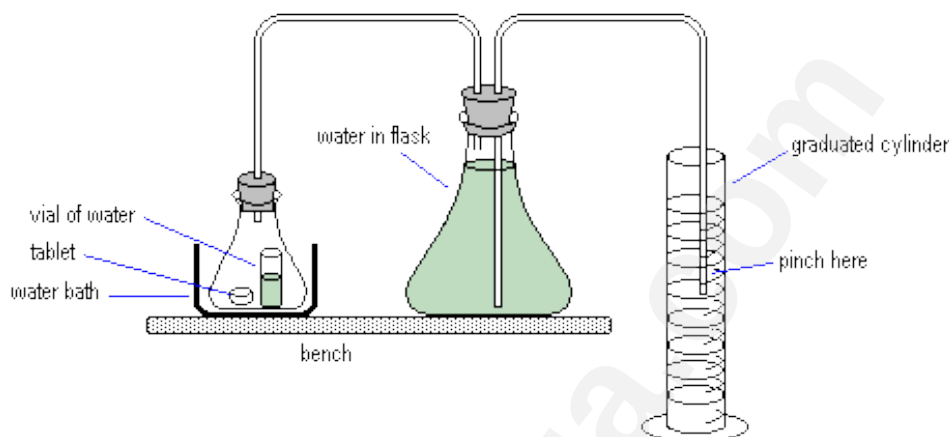


<https://www.google.co.za>

- 2.2.1 Name the specific type of intermolecular forces in alkanes. (1)
- 2.2.2 State the trend that is observed regarding alcohols. (1)
- 2.2.3 The graph indicates the solubility of alcohols with 4 carbon atoms and above. Predict the solubility of methanol. (2)
- 2.2.4 With reference to intermolecular forces, explain why alcohols display the trend shown in the graph above. (5)

Question 3 Energy and rates**[32 marks]**

- 3.1 The rate of carbon dioxide gas evolution from the reaction of an antacid tablet with excess water was investigated at different temperatures. The experimental set-up is shown below.



Source:

<http://www.reachoutmichigan.org/funexperiments/quick/csustan/gasevol.htm>

The set-up allows carbon dioxide gas produced in the reaction on the left to push down on the water surface of the water in the central flask which then pushes water into the graduated measuring cylinder on the right. Initially, water is suctioned through the right hand tube so that as soon as gas is produced, water will be deposited into the measuring cylinder.

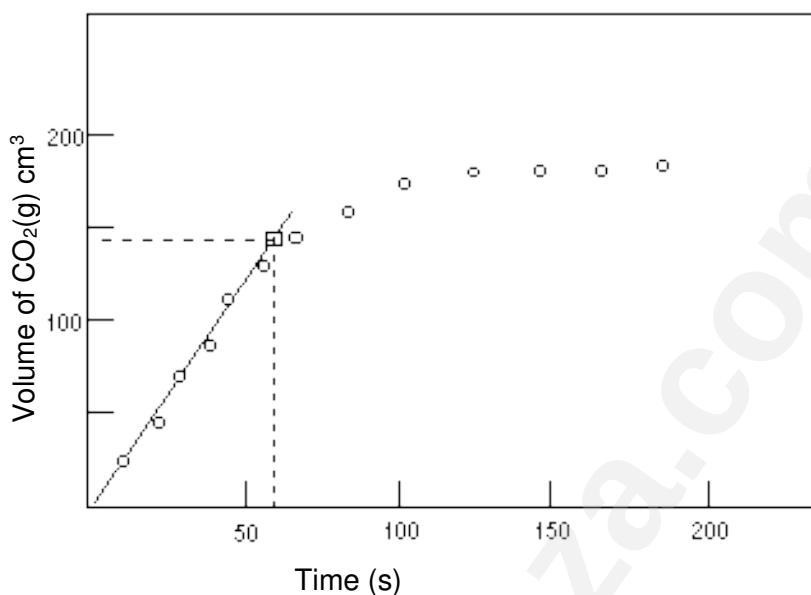
By measuring the volume of water displaced, the experimenter has an indirect measure of the volume of the carbon dioxide gas that was produced.

The temperature of the water in the vial and the water in the water bath is changed for different investigations.

To start the reaction, the smaller flask on the left is swirled, hence bringing the water and tablet into contact.

- 3.1.1 Name the dependant variable in this investigation. (1)
- 3.1.2 Give a suitable hypothesis for this investigation. (2)
- 3.1.3 Name one measure experimenters should implement to ensure that the results of this investigation are reliable? (1)

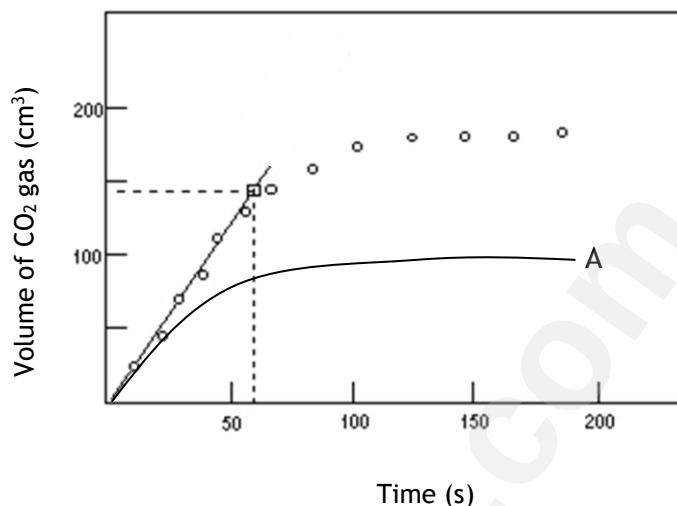
The following graph shows a set of results obtained by the experimenters for water at room temperature:



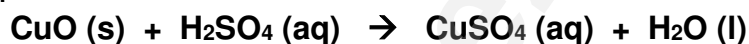
<http://www.reachoutmichigan.org/funexperiments/quick/csustan/gasevol.htm>

- 3.1.4 A line has already been drawn on the graph. What does gradient of this line represent? (2)
- 3.1.5 On the graph on the answer sheet provided, draw in a line of best fit for the data set represented by the small circles. (2)
- 3.1.6 Assume that the temperature for the reaction is increased. On the answer sheet, draw a second line onto the graph from 3.1.5 to indicate this new condition. Label it 3.1.6. (2)
- 3.1.7 Use principles of kinetic theory to discuss how temperature influences the rate of the reaction. (3)

- 3.1.8 Give one way (other than a change in temperature) in which the following curve (labelled A) could be produced. (2)



- 3.2 Consider the reaction represented by the balanced chemical equation given below:



The CuO is in excess. The reaction time was determined using a PASCO pH probe by recording how long it took for the pH of the solution to change from 0,7 (acidic) to 7 (neutral).

The following table shows five sets of results based on the reaction above. Only in experiment A has the time for the reaction been recorded.

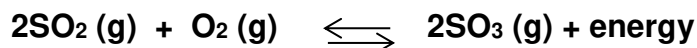
Experiment	Moles of H_2SO_4 [mol]	Volume of H_2SO_4 [cm^3]	Mass of CuO [g]	Form of the solid CuO	Time for pH to change from 0,7 $\rightarrow$ 7 [s]
A	0,035	50	5,5	Powder	12,5
B	0,035	70	5,5	Powder	
C	0,021	30	5,5	Powder	
D	0,035	50	5,5	Lump	
E	0,042	25	5,0	Powder	

- 3.2.1 Prove that the CuO is in excess in reaction A. (5)
- 3.2.2 Consider reactions A and D. Which one will have the slower rate? (1)
- 3.2.3 Which of the reactions A to E will have the same rate. Give a reason for your answer. Support your answer by showing appropriate calculations. (5)
- 3.2.4 Which of the reactions (A to E) will have the smallest time reading in the last column? (1)
- 3.2.5 Which of the reactions (A to E) will produce less products at the end of the reaction? (1)
- 3.2.6 Which of the following changes will have **no** influence on the rate of this reaction?
- A Decreasing the temperature
 - B Reducing the pressure on the system
 - C Using a catalyst
- (1)
- 3.2.7 Give a reason for your choice of answer in 3.2.6 above. (2)
- 3.2.8 What feature (other than the changing pH) could the experimenters use as an indicator of the extent of progress of this reaction? (1)

[32]

Question 4 Chemical equilibrium [29 marks]

Sulfur dioxide reacts with oxygen to form sulfur trioxide according to the equation



4.1.1 Write an expression for the equilibrium constant, K_c , for this reaction. (2)

4.1.2 Samples of sulfur dioxide, oxygen and sulfur trioxide were added to a flask of volume $1,40 \text{ dm}^3$ and allowed to reach equilibrium at a given temperature. The flask contained $0,0550 \text{ mol}$ of sulfur dioxide and $0,0720 \text{ mol}$ of sulfur trioxide at equilibrium. The K_c has the numerical value of $27,9$ under these conditions. Calculate the amount, in moles, of oxygen gas in this equilibrium mixture (work out your answer work to 3 decimal places). (5)

4.1.3 The experiment above was repeated with the same amounts of sulfur dioxide, oxygen and sulfur trioxide at the same temperature but in a smaller flask. The mixture was allowed to reach equilibrium.

- State the effect, if any, of using a smaller flask on the value of K_c . (1)
- State the effect, if any, of using a smaller flask on the amount of sulfur trioxide at equilibrium. Using Le Chatelier's principle, explain your answer. (4)

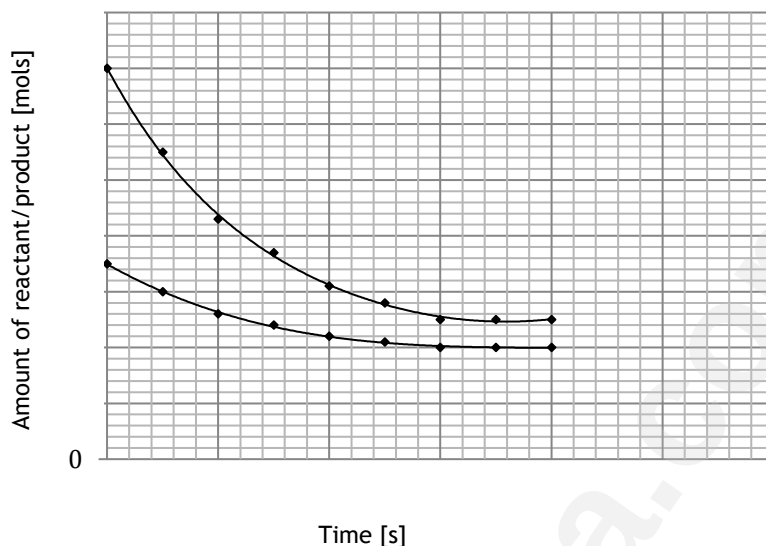
In a similar experiment, another sample of sulfur dioxide, oxygen and sulfur trioxide were added to a flask.

4.2.1 Explain what is meant by the term dynamic chemical equilibrium. (2)

Sensors inside the vessel allowed the recording of the amounts of reactants and products present as the reaction progressed. The table below gives the results that were recorded.

	Amount of reactant and product [mols]		
Time [s]	SO_2	O_2	SO_3
0	0,35	0,7	0,00
10	0,30	0,55	0,10
20	0,26	0,43	0,18
30	0,24	0,37	0,22
40	0,22	0,31	0,26
50	0,21	0,28	0,28
60	0,20	0,25	0,30
70	0,20	0,25	0,30
80	0,20	0,25	0,30

You are provided with a partially completed graph representing some of the data given in the table. This graph is also reproduced on your answer sheet.



4.2.2 On the graph provided on the answer sheet, complete the graph given by doing the following:

- Insert the scale on each axis that was used to plot the given graphs. (2)
- Label the lines on the graph representing SO_2 and O_2 . (1)
- Using the data from the table, plot the amount of product (sulfur trioxide) versus time on the same set of axes. Include a line of best fit. (4)
(Show all plotted points clearly)

Now use your completed graph to answer the following questions.

- How long does it take for the reaction to reach equilibrium? (1)
- How can you tell this from the graph in 4.2.2? (2)
- Compare the rate of the forward reaction to the rate of the reverse reaction at 50 seconds. (1)

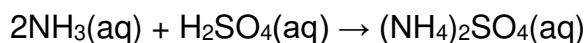
When $t = 80 \text{ s}$, the sealed container is heated causing a rapid rise in temperature. Equilibrium is re-established after an additional 20 s and is maintained for a further 20 s.

- Show the effect of an increase in temperature on the amounts of SO_2 , O_2 and SO_3 for the time 80 s to 120 s by completing the lines on the graph for this period on your answer sheet. (4)

Question 5 Acids and Bases

[23 marks]

- 5.1 Titrations involve volumetric analysis where the experimenter is tasked with determining the concentration of an unknown solution. In the following titration, ammonia and sulfuric acid is used.

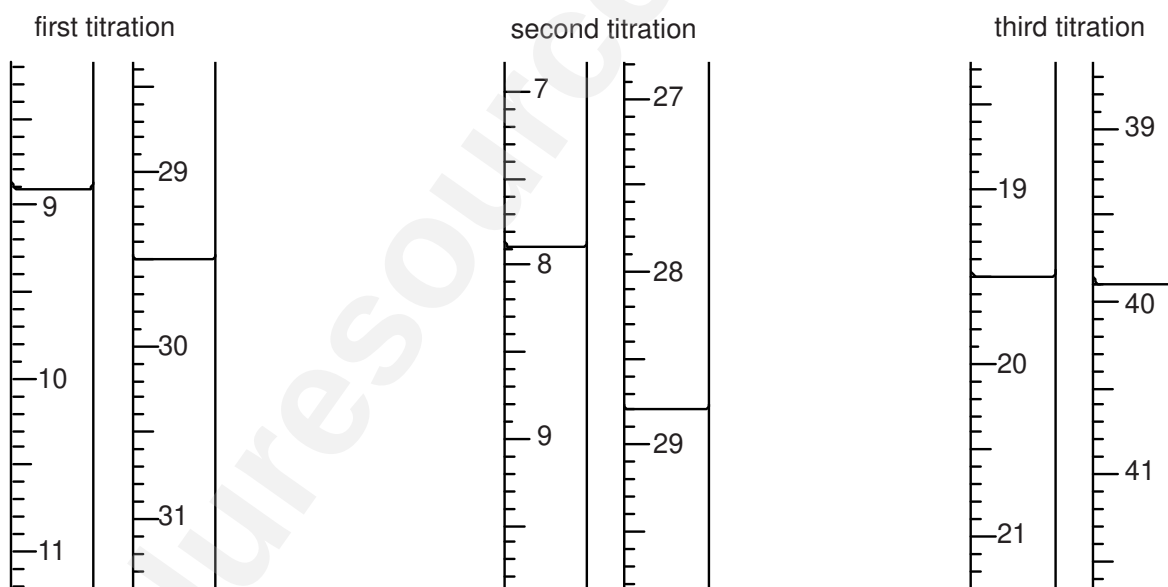


25,0 cm³ of **ammonia** is transferred to a conical flask and a few drops of phenolphthalein indicator are added. A burette is filled with 0,100 mol.dm⁻³ sulfuric acid. The sulfuric acid is added to the conical flask until the end-point is reached. Phenolphthalein is colourless in acid solution and pink in alkaline solution.

5.1.1 What is the colour of the solution in the conical flask:

- before sulfuric acid is added,
- at the end-point? (1)

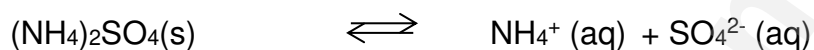
5.1.2 The experimenter does three titrations. The diagrams show parts of the burette with the liquid levels at the beginning and end of each titration.



Use the diagrams to complete the following table on the answer sheet. (3)

titration number	1	2	3
final burette reading (cm ³)			
initial burette reading (cm ³)			
volume of sulfuric acid (cm ³)			

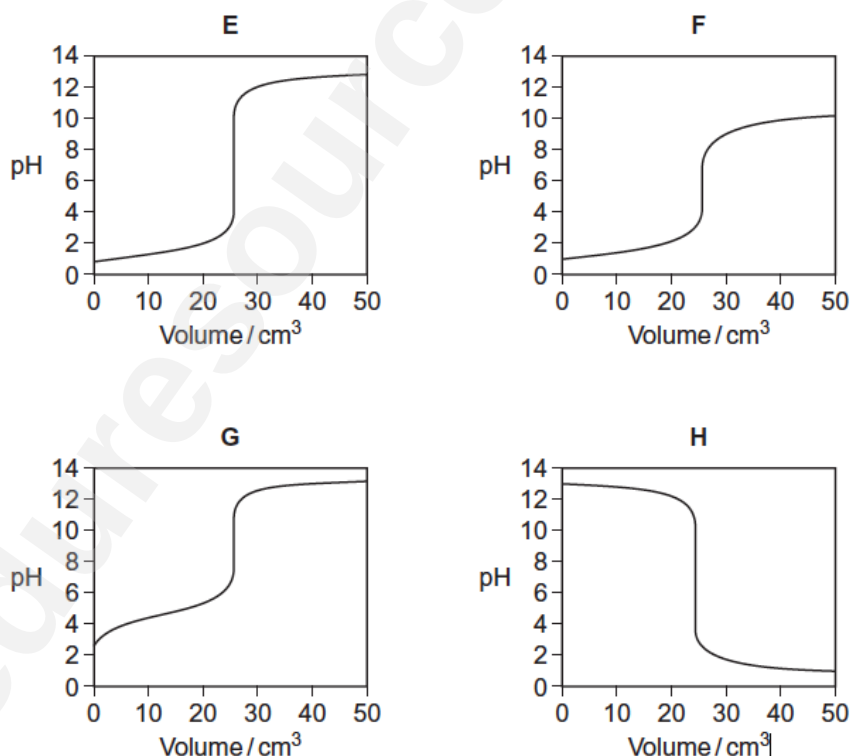
- 5.1.3 Using these results, calculate the average volume of sulfuric acid. (1)
- 5.1.4 Calculate the number of moles of sulfuric acid in the average volume of 0.100 mol.dm⁻³ sulfuric acid. (3)
- 5.1.5 Hence, calculate the concentration of the **ammonia** solution. (3)
- 5.1.6 Define a weak base. (2)
- 5.1.7 Consider the hydrolysis of ammonium sulphate according to the equation below:



With reference to the above equation, explain why a aqueous solution of the salt ammonium sulphate would be acidic. You may refer to the auto-ionisation of water in your explanation. (4)

- 5.2 Titration curves, labelled E, F, G and H, for combinations of different aqueous solutions of acids and bases are shown in Figure 1. All solutions have concentrations of 0,1 mol.dm⁻³.

Figure 1



From the curves E, F, G and H, choose the curve produced by the addition of:

- 5.2.1 sodium hydroxide to 25 cm³ of ethanoic acid
- 5.2.2 ammonia to 25 cm³ hydrobromic acid (high K_a value)

5.2.3 hydrochloric acid to 25 cm³ of potassium hydroxide

(3)

Table 2 shows information about some acid-base indicators.

Table 2

Indicator	pH range	Lower pH colour	Higher pH colour
pentamethoxy red	1.2–3.2	violet	colourless
naphthyl red	3.7–5.0	red	yellow
4-nitrophenol	5.6–7.0	colourless	yellow
cresol purple	7.6–9.2	yellow	purple

5.2.4 Which indicator in Table 2 could be used for the titration that produces curve E but not for the titration that produces curve F?

(2)

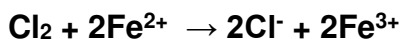
5.2.5 Give the colour change at the end point of the titration that produces curve H when naphthyl red is used as the indicator.

(1)

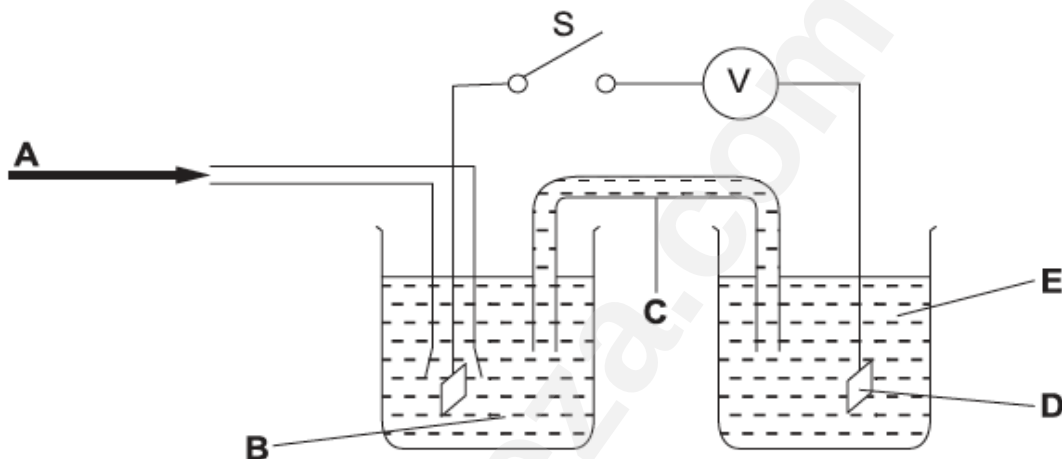
Question 6 Electrochemistry

[26 marks]

Chlorine gas and iron(II) ions react together in aqueous solution as follows.



The diagram below shows the apparatus needed to measure the E°_{cell} for the above reaction. Label **D** is an inert platinum metal electrode.



6.1.1 Explain the term *anode*. (2)

6.1.2 Provide the **names** of chemical substances for labels A, B, C and E. (4)

6.1.3 State the standard conditions under which the above galvanic cell will operate. (3)

The switch S is now closed.

6.1.4 State, which direction (left to right, or right to left) electrons would flow through a bulb when switch S is closed. (1)

6.1.5 Use the Table of Standard Electrode Potentials to calculate the E°_{cell} for this reaction when the switch is closed. (3)

6.1.6 A design modification was made to the above galvanic cell. The salt bridge was widened and made shorter. Explain how this change will affect the internal resistance and the capacity of the cell to deliver current. (3)

6.1.7 The concentration of chloride ions is decreased in the galvanic cell. Using a suitable principle, explain how this change will affect the emf of the cell. (3)

- 6.2 A solution of iron(III) chloride is used to dissolve unwanted copper from printed circuit boards. When a copper-coated printed circuit board is immersed in $\text{FeCl}_3(\text{aq})$, the solution turns pale blue and no solid is formed.



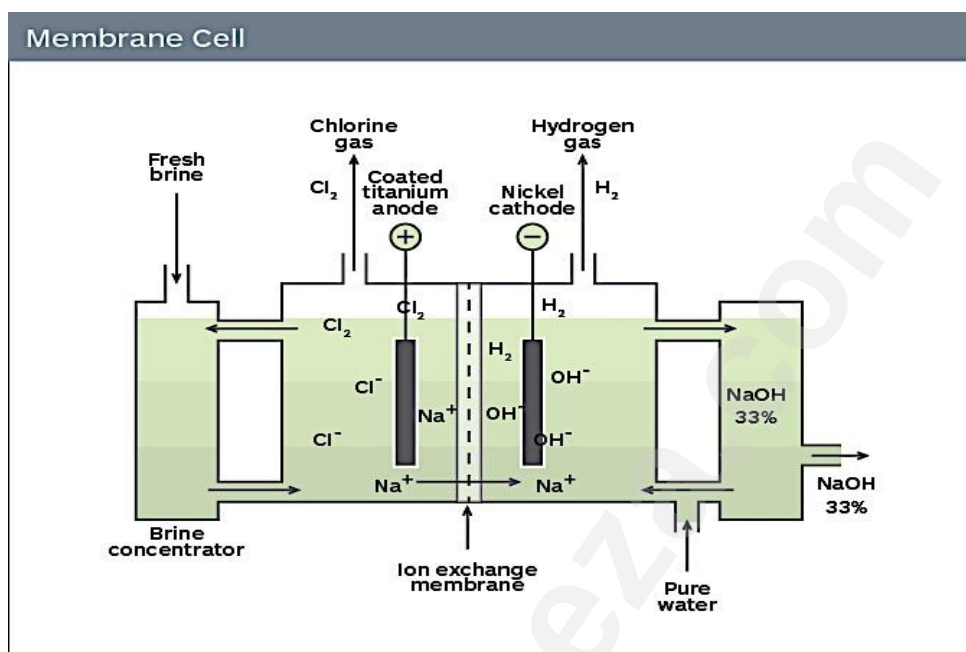
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- 6.2.1 Suggest a balanced ionic equation for the reaction between copper and iron(III) chloride. (3)
- 6.2.2 Calculate the E°_{cell} for the reaction in 6.2.1. (3)
- 6.2.3 Is the reaction spontaneous? (1)

Question 7 Electrolysis

[21 marks]

Consider the following diagram of the membrane cell extracted and answer the questions that follow.

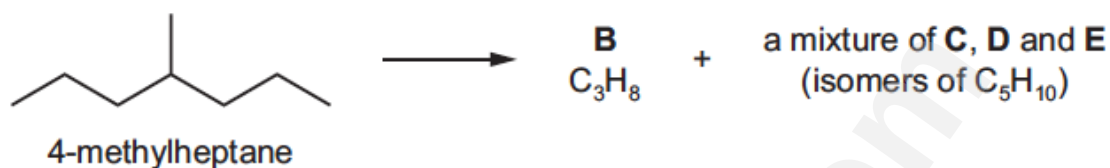


<https://www.google.co.za/search>

- 7.1.1 State the energy conversion taking place in the above cell. (2)
- 7.1.2 Use the Table of Standard Electrode Potentials to write down the equation for the half-reaction occurring at the **negative** terminal. (2)
- 7.1.3 Use the Table of Standard Electrode Potentials to explain why, under **standard conditions**, the more favoured reaction is the oxidation of water. (2)
- 7.1.4 Name the **reactant** in the reaction that occurs at the anode in this cell. (1)
- 7.1.5 The ion-exchange membrane is designed to allow sodium ions through and prevents two other ions from moving through.
- How is the ion-exchange membrane designed to allow sodium ions through? (2)
 - Name the ions that are not able to pass through the membrane. (2)
- 7.1.6 Write down the chemical name for caustic soda and name an important use of this substance. (2)
- 7.2 A constant current of 4 000 A is passed through the membrane cell in 2,5 minutes. Calculate the volume of chlorine gas produced, at STP, during this time. (8)

Question 8 Organic chemistry [34 marks]

Long chain alkanes such as 4-methylheptane (skeletal diagram shown) can be 'cracked' to produce shorter chain hydrocarbons, according to the equation provided below.



- 8.1.1 What type of reaction would you classify 'cracking' as? (1)
- 8.1.2 Provide the name of the homologous series to which substance B belongs. (1)
- 8.1.3 Substance **B** reacts with Cl_2 in the presence of light. Write a molecular chemical equation to show the products formed. (2)
- 8.1.4 Compound C burns completely in oxygen gas. Write a balanced molecular equation for this reaction. (4)
- 8.1.5 Define the term *isomers*. (2)
- 8.1.6 Compounds **C**, **D** and **E** are isomers with the molecular formula C_5H_{10} . On heating with concentrated acidified KMnO_4 , carboxylic acids (F,G,H) are formed
- compound C gives CO_2 and compound F ($\text{C}_4\text{H}_8\text{O}_2$),
 - D and E each give a 1 : 1 mixture of compounds G ($\text{C}_2\text{H}_4\text{O}_2$) and H ($\text{C}_3\text{H}_6\text{O}_2$).
- a) Draw structures for the following compounds in the boxes below. (6)

C	D	E
F	G	H

- b) Name the type of isomerism shown between **D** and **E**. (1)
- c) Compound **H** ($\text{C}_3\text{H}_6\text{O}_2$) reacts with ethanol to form an ester. Name the ester that will be formed and provide the reaction conditions required. (3)

8.2 Propene, $\text{CH}_3\text{CH}=\text{CH}_2$, reacts with bromine to give 1,2-dibromopropane.

8.2.1 This reaction is known as the test for saturation. Explain why. (2)

8.2.2 State the type of reaction that is occurring here. (1)

8.3 The table below indicates the boiling points of carboxylic acids.

Formula	Boiling Point
HCO_2H	101 °C
$\text{CH}_3\text{CO}_2\text{H}$	118 °C
$\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$	141 °C
$\text{CH}_3(\text{CH}_2)_2\text{CO}_2\text{H}$	164 °C

<https://sites.google.com/site/chemistryolp/properties-of-carboxylic-acids>

8.3.1 Deduce the general formula of carboxylic acids. (2)

8.3.2 State the type of intramolecular force, which exists in these compounds. (1)

8.3.3 Draw the structural formula and name one functional isomer for $\text{CH}_3\text{CO}_2\text{H}$. (3)

8.3.4 Explain fully the trend in boiling points indicated in the table. Make reference to the relevant intermolecular forces present. (4)

THE END!

Name: _____

GRADE 12 PRELIMINARY EXAMINATIONS

PAPER II: CHEMISTRY

JULY 2017

Question	Pupil's mark	Max. mark
1		20
2		15
3		32
4		29
5		23
6		26
7		21
8		34
TOTAL		200

Name: _____

Teacher: _____

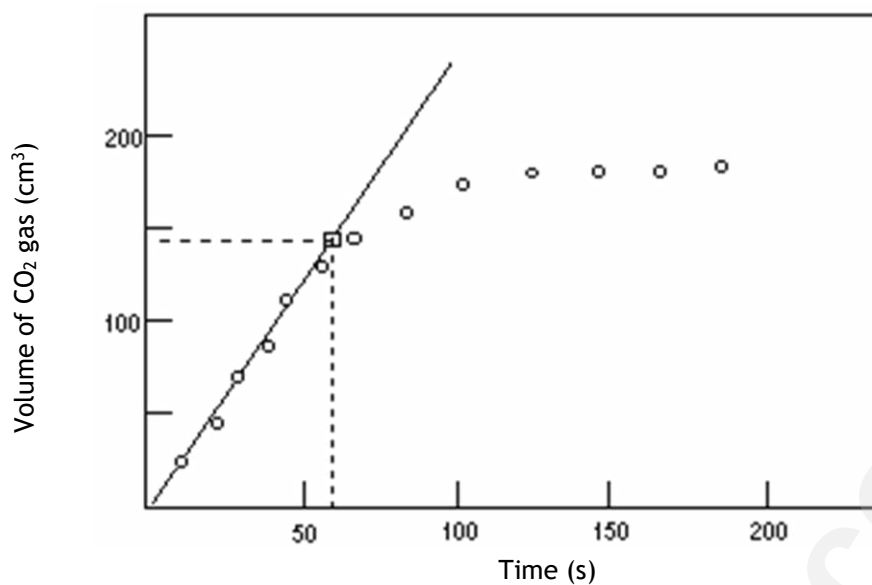
ANSWER SHEET FOR CHEMISTRY PRELIM EXAM 2017

Question 1 Multiple choice [20 marks]

Place a cross (X) over the correct answer.

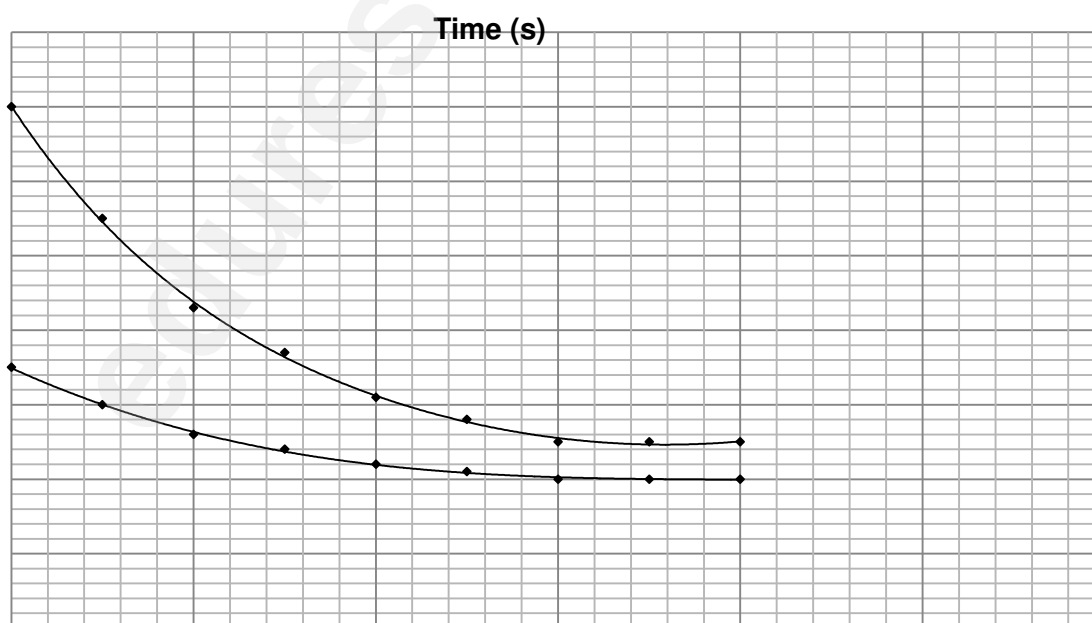
Question				
1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D
1.8	A	B	C	D
1.9	A	B	C	D
1.10	A	B	C	D

Question 3



Question 4

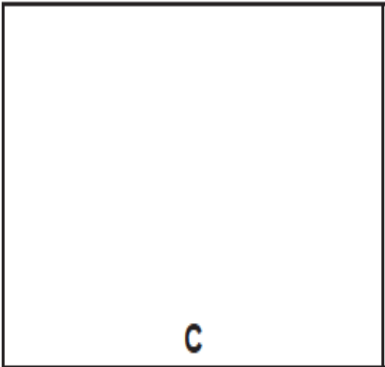
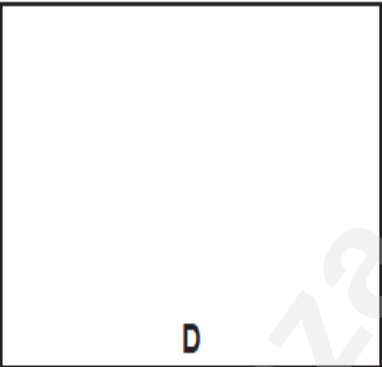
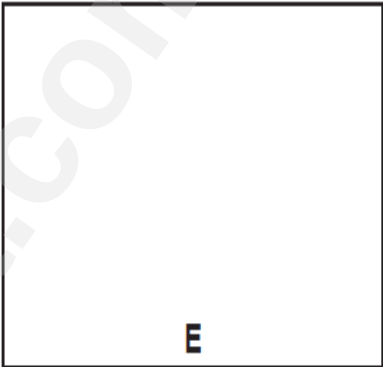
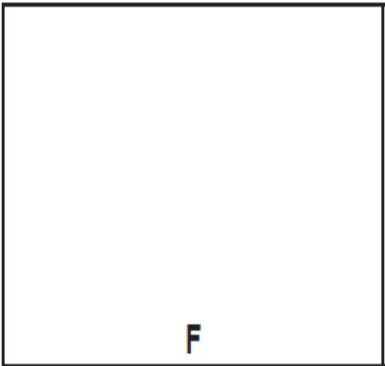
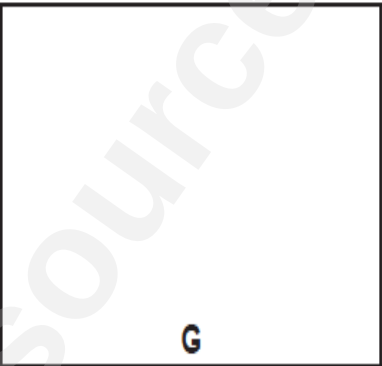
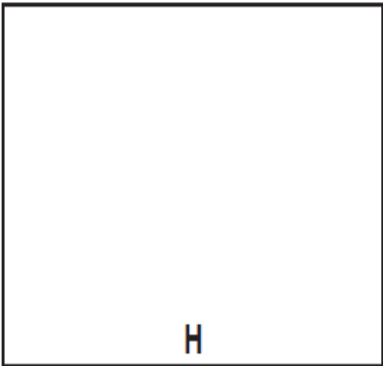
Amount of reactant/product([mols])



Question 5

titration number	1	2	3
final burette reading (cm ³)			
initial burette reading (cm ³)			
volume of sulfuric acid (cm ³)			

Question 8

 C	 D	 E
 F	 G	 H