Stanford Lake College

PHYSICAL SCIENCES

PRELIMINARY EXAMINATION

PAPER II: CHEMISTRY

SEPTEMBER 2016

GRADE 12

EXAMINER: Mr K.A. Railton **MODERATOR: Mr D. Park**

TIME: 3 HOURS **200 MARKS**

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - A Question paper of **14 pages** with **7 questions**
   - A Datasheet
   - An Answer Booklet

   Please ensure your paper is complete.
2. **ALL** of the questions in this paper must be answered.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. **QUESTION 1** consists of **10** multiple-choice questions. There is only one correct answer to each question. The questions are answered on the inside front cover of your Answer Booklet. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A.	B.	C	D.

   Here the answer C has been marked.
6. **QUESTION 1, 4.5** and **6.7.2** must be answered in the **ANSWER BOOKLET.**
7. **START EACH QUESTION ON A NEW PAGE.**
8. An approved calculator (non-programmable, non-graphical) may be used.
9. Show your working in all calculations.
10. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
11. Express **ALL** answers correct to **TWO** decimal places, unless stated otherwise.
12. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1: MULTIPLE CHOICE

Choose the most correct answer to each of the following questions. The letter that corresponds with your choice of the correct answer must be marked with a cross in your Answer Booklet.

1.1. What amount of oxygen gas (in moles) contains 1.8×10^{22} molecules.

A. 0.03
B. 33.44
C. 1.2×10^{24}
D. 1.08×10^{46}

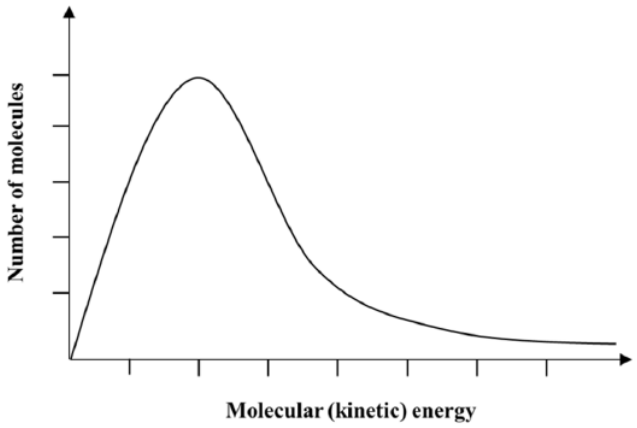
(2)

1.2. What bonds can be attributed to silicon dioxide's high boiling point?

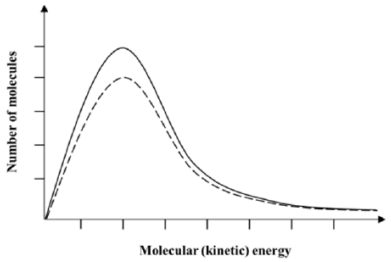
A. Metallic bonds
B. Covalent bonds
C. Hydrogen bonds
D. Ionic bonds

(2)

1.3. The Maxwell-Boltzmann energy distribution curve represents the variation of the kinetic energy of the molecules of a gas at room temperature.



Which curve applies for the same gas at a lower temperature?

A


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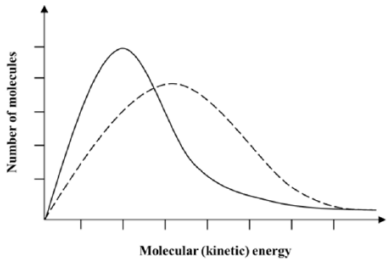
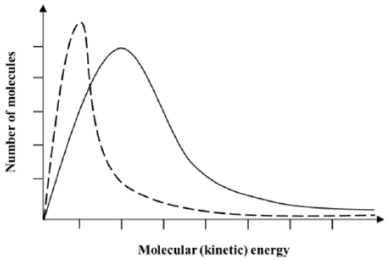
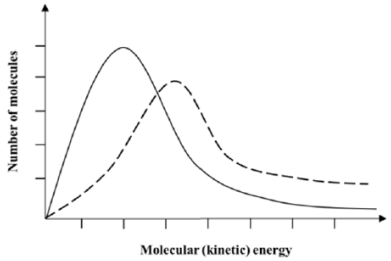


C


D


(2)

1.4. For which reaction at equilibrium does a decrease in volume of the container cause a decrease in product/s at constant temperature?

A. $CaCO_{3\,(s)} \rightleftharpoons CaO_{(s)} + CO_{2\,(g)}$

B. $2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$

C. $HC\ell_{(g)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C\ell^-_{(aq)}$

D. $SO_{2\,(g)} + NO_{2\,(g)} \rightleftharpoons SO_{3\,(g)} + NO_{(g)}$ (2)

1.5. The pH of an aqueous solution of HCl is 3. How will adding distilled water to the HCl solution affect the ionization constant of water (K_w) and the OH^- concentration?

	K_w	**$[OH^-]$**
A.	Increase	Increase
B.	Decrease	Decrease
C.	Remain the same	Increase
D.	Remain the same	Decrease

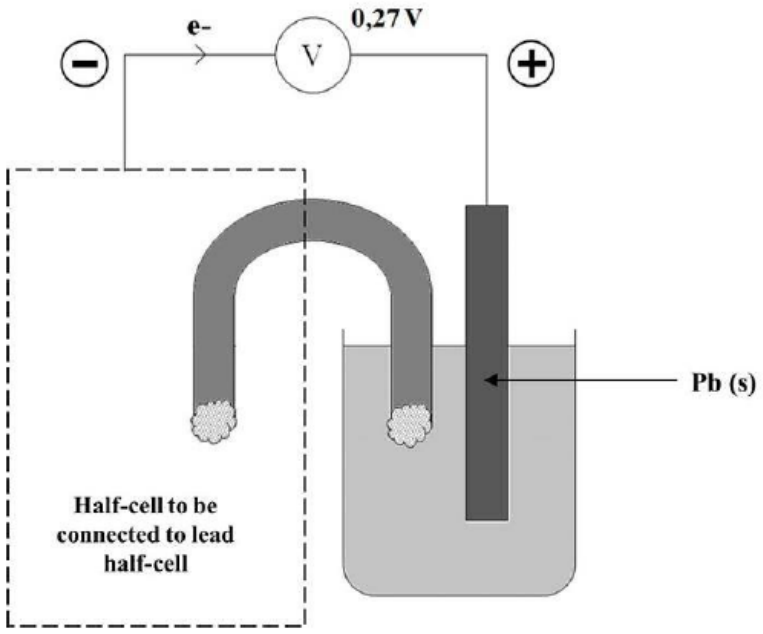
(2)

1.6. Which one of the acids listed below is an example of a polyprotic acid?

A. Nitric acid
B. Hydrochloric
C. Ethanoic acid
D. Sulphuric acid

(2)

1.7. Which one of the following half-cells would have to be connected to a $Pb|Pb^{2+}$ half-cell to obtain a voltmeter reading of 0.27 V in the following standard electrochemical cell?



A. Pt, H_2S | S
B. Cr | Cr^{3+}
C. Cd | Cd^{2+}
D. Sn | Sn^{2+}

(2)

1.8. Given the redox reaction below, identify the reducing agent.

$Fe^{2+}_{(aq)} + Zn_{(s)} \rightarrow Fe_{(s)} + Zn^{2+}_{(aq)}$

A. Fe^{2+} C. Zn^{2+}

B. Fe D. Zn (2)

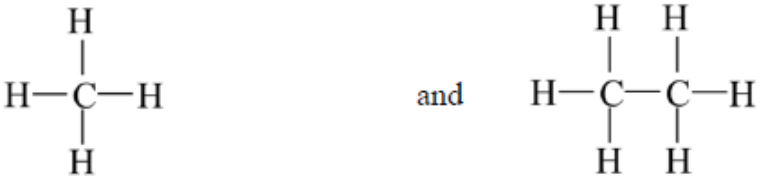
1.9. What type of reaction is represented by the following:

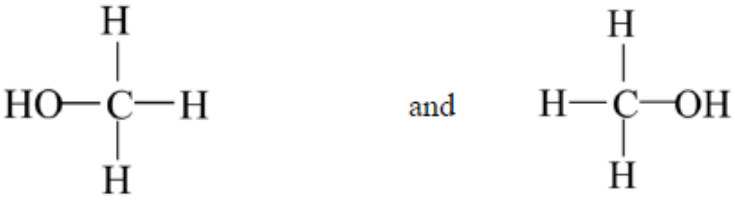
$$\mathbf{CH_2 = CH_2 + H_2 \rightarrow CH_3CH_3}$$

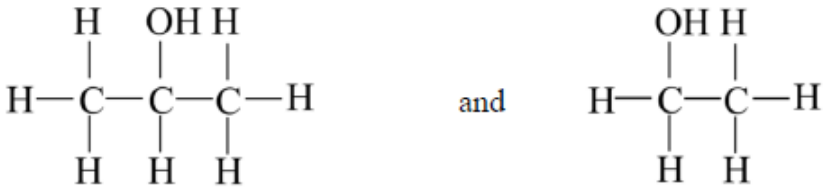
A. Hydrogenation C. Substitution

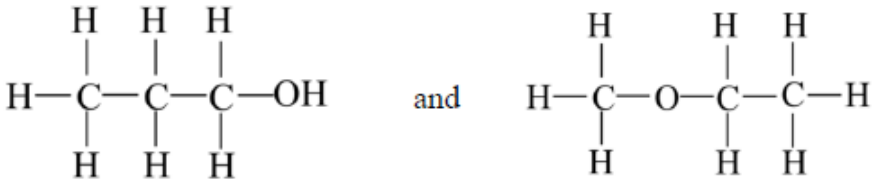
B. Halogenation D. Hydrohalogenation (2)

1.10. Which structural formulae below represent compounds that are isomers of each other?

A 

B 

C 

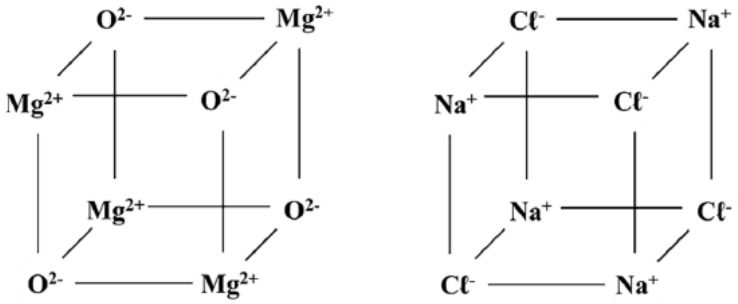
D 

(2)

[20]

QUESTION 2: CHEMICAL BONDING
(Adapted from St Mark's, Prelims 2015)

The structures below show the crystal lattices of magnesium oxide and sodium chloride.



Magnesium oxide **Sodium Chloride**

2.1. Name the type of crystal lattice of which the above two compounds are an example. (1)

2.2. When are these compounds able to conduct electricity? Explain briefly. (3)

2.3. Explain why ionic lattices have high melting points. (2)

2.4. Suggest which of these substances will have the higher melting point. Explain fully. (3)

The table below shows information concerning the first three alkanes and the first three alcohols.

No. Carbon	Alkane	Boiling Point (^oC)	Alcohol	Boiling Point (^oC)
1	Methane	-164	Methanol	65
2	Ethane	-89	Ethanol	79
3	propane	-42	1-Propanol	97

2.5. Propanol and propane are both fuels used in combustion. One is a gas at room temperate and the other is a liquid. State which is a gas at room temperature and explain fully by referring to intermolecular forces. (4)

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QUESTION 3: ENERGY CHANGE AND RATES OF REACTION

To investigate the rate of reaction, a 5 g tablet of magnesium carbonate reacts with an excess of 200 cm^3 of a 1 $mol.dm^{-3}$ hydrochloric acid solution. The reaction vessel temperature was controlled and set at 40°C. The students collected the gas and recorded the results at set time intervals. The balanced chemical equation for this reaction is:

$$MgCO_{3\,(s)} + 2HCl_{\,(aq)} \rightarrow MgCl_{2\,(aq)} + CO_{2\,(g)} + H_2O_{\,(l)}$$

3.1. State without explaining, how the rate of gas production will be affected if:

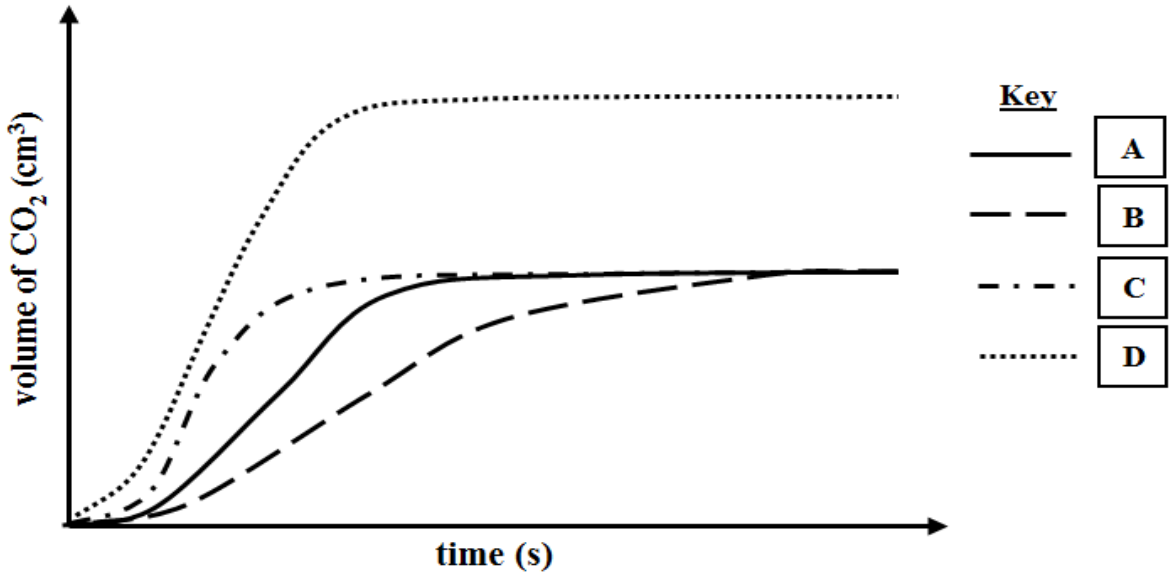
3.1.1. A 5g crushed $MgCO_3$ table is used. (1)

3.1.2. 300 cm^3 of the 1 $mol.dm^{-3}$ HCl is used. (1)

3.2. Explain your answer to 3.1.2 in terms of molecular collision theory. (3)

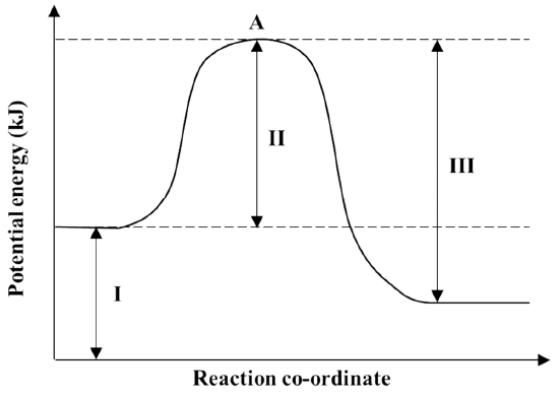
The students carried out further experiments between the reaction n of the tablets with excess hydrochloric acid to investigate various factors which may affect the rate of reaction. The details of their experiments are tabulated below and results were plotted for each. Experiment 1 was the initial test which is labelled as A in the graph.

Experiment	**1**	**2**	**3**	**4**
Volume of acid (cm^3)	200	200	200	200
Concentration of acid ($mol.dm^{-3}$)	1	1	1.2	1
Number of 5 g tablets	1	2	1	1
Temperature (°C)	40	40	40	30



3.3. Match the graphs B, C and D to the experiments 2, 3 and 4 and give a reason for each choice. (6)

3.4. Consider the potential energy profile graph for the reaction below.



3.4.1. The graph has been labelled I-III to represent some of the energies that are illustrated by this energy profile. Identify each of these energies on the profile. (3)

3.4.2. Define the term *heat of reaction* (2)

3.4.3. Does the graph represent the potential energy changes for an exothermic or endothermic reaction? Explain how you came to this conclusion. (2)

3.4.4. The same reaction takes place in the presence of a catalyst.

a) Define a *catalyst* (2)

b) How does a catalyst affect the rate of reaction and heat of reaction? Sketch an potential energy profile graph and use it to explain your answer. (4)

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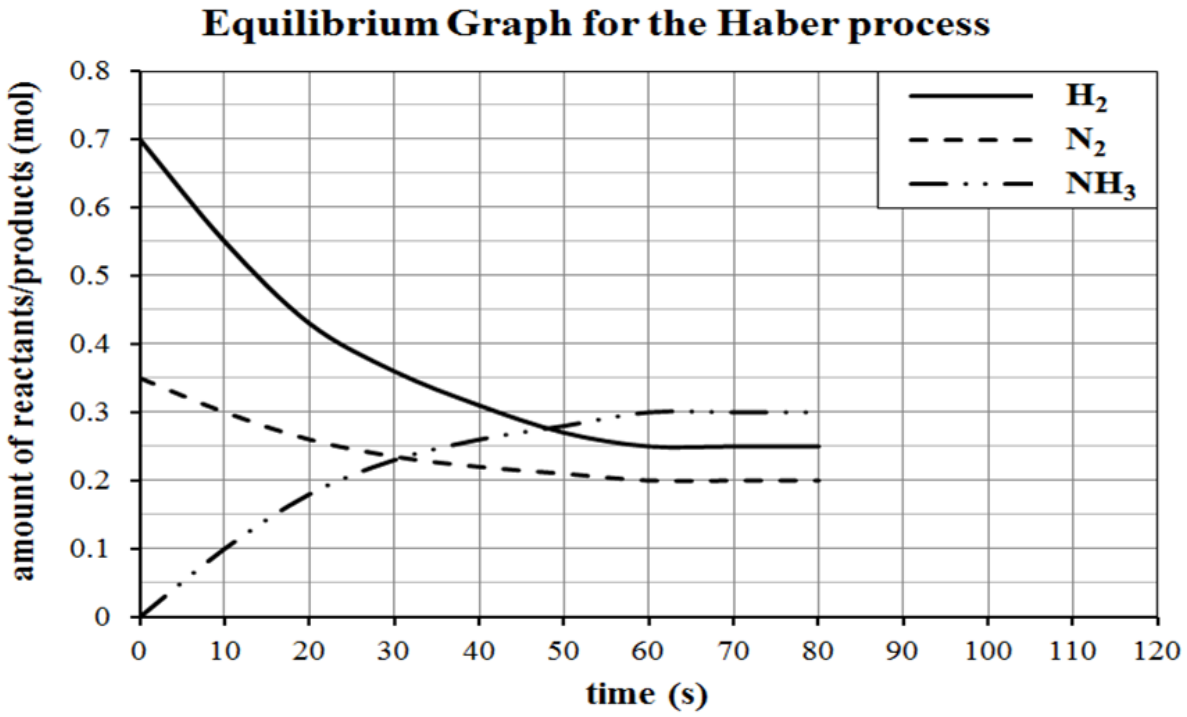
QUESTION 4: CHEMICAL EQUILIBRIUM

The reaction representing the formation of ammonia in the Haber process is shown below.

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \quad \Delta H = -46\ kJ.mol^{-1}$$

0.35 mols of N_2 and 0.70 mols of H_2 were added to a sealed reaction vessel which has a volume of 1 dm^3 and allowed to reach dynamic chemical equilibrium. The amount of reactants and product present in the vessel as time progressed was plotted and the graph is shown below. Use the graph to answer the following questions.



4.1. When the system had reached equilibrium, it was found that 0.3 mol of NH_3 was present. Show, by means of calculations, that the graph accurately represents the amount of reactants at equilibrium. (4)

4.2. Write an expression for K_c. (2)

4.3. Calculate K_c when the system had reached equilibrium for the first time. (2)

At 80 s, the sealed contain is heated causing the temperature to rise rapidly. Equilibrium is re-established after 20 s and maintained for a further 10 s.

4.4. State *Le Chatelier's Principle.* (3)

4.5. Using the graph provided in the **Answer Booklet**, sketch how the graph would change when the temperature is increased. (3)

4.6. Explain the change in the amount of reactants and product by making reference to Le Chatelier's Principle. (4)

[18]

QUESTION 5: ACIDS AND BASES
(Adapted from Woodridge College, Prelims 2014)

Sulphur dioxide gas, amongst other gases, is released as a pollutant when coal, a fossil fuel, is burned in a power station. This gas is highly soluble and will dissolve easily in atmospheric water to form sulphurous acid, a form of acid rain. The acid ionises in water according to the following equation:

$$H_2SO_{3\,(g)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_3^-{}_{(aq)}$$

5.1. Define an *acid* according to the Lowry-Bronsted model. (1)

5.2. Name the H_3O^+ cation produced by this ionisation reaction. (1)

5.3. Identify the solute and solvent in the above reaction. (2)

A student collects some rain water after a heavy storm. He wants to determine the concentration of the sulphurous acid in the rain water. To do this he decides to titrate the rain water against a standard solution of potassium hydroxide.

5.4. Write a balanced chemical equation for the reaction between sulphurous acid and potassium hydroxide. (4)

5.5. The following table lists the indicators that are most commonly used in a titration.

Indicator	**pH Range**
Phenolpthalein	8.2 - 10
Bromothymol Blue	6.0 – 7.6
Methyl Orange	3.2 – 4.4

5.5.1. Which indicators would be most suitable to find the equivalence point when sulphurous acid reacts with potassium hydroxide in a titration? (1)

5.5.2. Hydrolysis of a salt is where a salt reacts with water and water decomposes. The following balanced chemical equation shows the hydrolysis of water.

$$H_2O_{(l)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}$$

a) Write the dissociation of the salt produced in the titration of sulphurous acid and potassium hydroxide. (2)

b) Use your knowledge of hydrolysis; explain your answer to 5.5.1. (5)

5.6. Bromocresol green is another suitable indicator for this reaction. Bromocresol green is a weak acid which ionizes according to the following balanced chemical equation (the bromocresol green ion is simply written as **BG^-** for the purposes of this equation):

$$\underset{\text{(yellow)}}{HBG_{(aq)}} + H_2O_{(l)} \rightleftharpoons \underset{\text{(blue)}}{BG^-_{(aq)}} + H_3O^+_{(aq)}$$

Using Le Chatelier's Principle, explain why bromocresol green displays a blue colour in a basic solution. (4)

5.7. What is a *standard solution*? (1)

5.8. Calculate the mass of potassium hydroxide which must be used to make 300 cm^3 of a 0.1 $mol.dm^{-3}$ solution. (4)

5.9. Calculate the hydronium ion concentration in the 0.1 $mol.dm^{-3}$ KOH solution and state how this relates to the pH of the solution. (4)

5.10. It was found that 15 cm^3 of potassium hydroxide neutralises 0.375 litres of sulphurous acid. Calculate the concentration of the sulphurous acid. (4)

5.11. Scientists will often wash down the sides of the conical flask with distilled water when performing a titration. This additional water does not affect the equivalence point.

5.11.1. What is the reason for 'washing down' the sides of the conical flask? (1)

5.11.2. Why would the equivalence point not affected by the addition of water? (1)

5.12. You are given a sulphuric acid solution and a sulphurous acid solution, both with a concentration of 2 M.

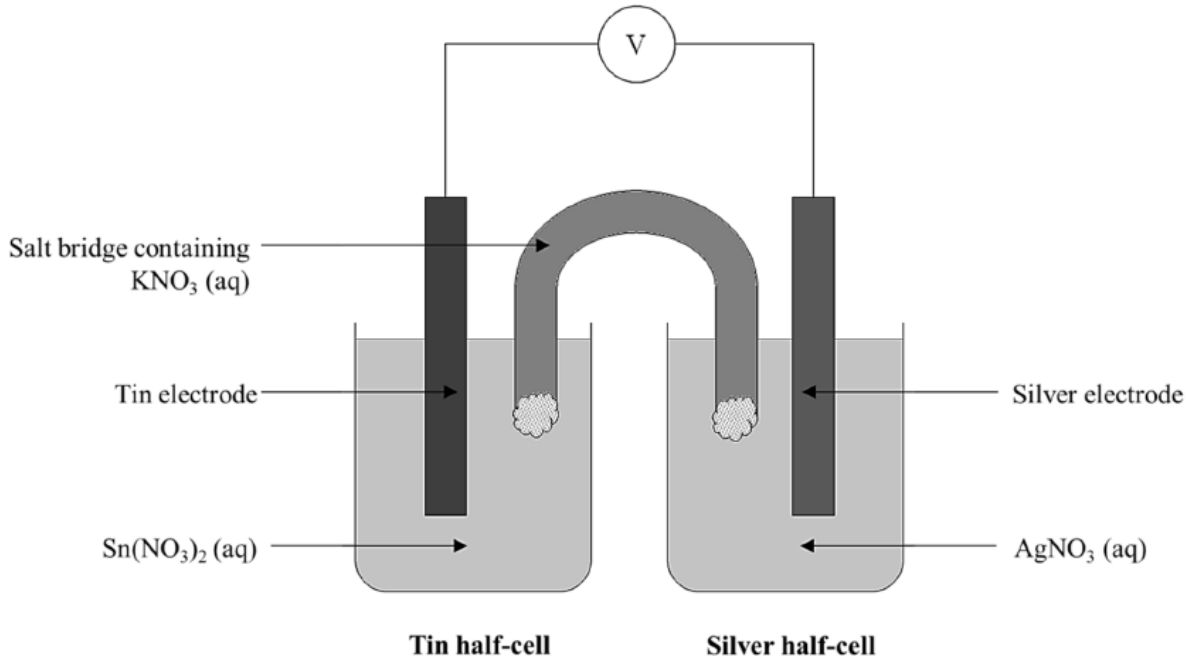
5.12.1. Why would sulphurous acid have a lower K_a value? Explain fully. (2)

5.12.2. Why would sulphuric acid have a better electrical conductivity? Explain fully. (2)

[39]

QUESTION 6: ELECTROCHEMISTRY
(Adapted from Clifton College, Prelims 2014)

Consider the tin-silver galvanic cell shown in the diagram below. It has been set up under standard conditions. The two half cells are connected by a salt bridge which contains a saturated aqueous solution of potassium nitrate.



6.1. Explain how a salt bridge maintains electrical neutrality of the solutions in the two half-cells and completes the circuit. (2)

6.2. If the potassium nitrate in the salt bridge was replaced with de-ionised distilled water what would be the reading on the voltmeter? Give a reason for your answer. (2)

6.3. Which substance will be the oxidising agent? Explain by making reference to the Table of Standard Electrode Potentials. (2)

6.4. Write the cell notation for this cell. (Standard condition need not be shown) (2)

6.5. Write the complete reaction for this cell. (3)

6.6. Use the table of Standard Electrode Potentials and calculate the emf of the tin-silver cell. (3)

6.7. Two learners conduct an experiment to determine how the change of mass of the tin (Sn) electrode depends on the time for which the current flows. The initial mass of the tin (Sn) electrode was 20 g. The results are tabulated on the next page.

Time (s)	Change in mass (g)
1800	0.225
3600	0.45
5400	0.69
7200	0.92

6.7.1. List one control variable that the learners must control to ensure that their experiment results in a fair test. (1)

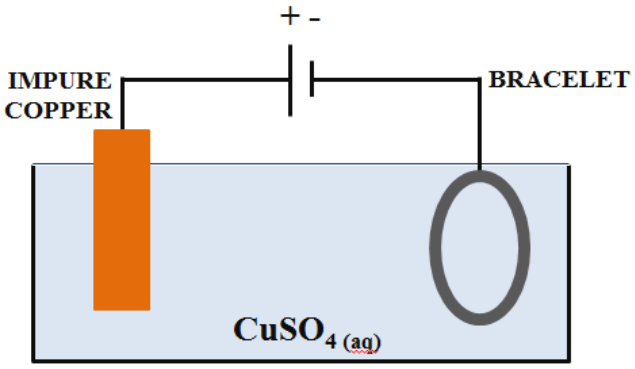
6.7.2. Plot the data on the graph paper provided in the **Answer Booklet**. (4)

6.7.3. Write a conclusion for the learner's experiment. (2)

6.7.4. Calculate the current of this galvanic cell using the graph and the following equation.

$$Q = n_e F$$ (6)

The students want to investigate the electroplating process. They decide to copper plate a metal bracelet. They could only find an old piece of impure copper which contained copper and zinc. They connect the bracelet and piece of copper to a battery and place it in an aqueous solution of copper sulphate ($CuSO_4$) as shown below.



6.8. State the energy conversion in an electrolytic cell. (2)

6.9. What substance will initially undergo oxidation? Explain by making reference to the Table of Standard Electrode Potentials. (2)

6.10. Write down the reduction half-reaction. (2)

[33]

QUESTION 7: ORGANIC CHEMISTRY

(Adapted from IEB Supplementary 2015)

Consider the organic compounds, represented by the letters A to H, below:

A: C_7H_7Cl	**B:** $CH_3CHCHCH_3$	**C:** C_7H_{14}
D: $CH_3CH_2COOCH_3$	**E:** $CH_3CH_2CH(OH)CH_3$	**F:** C_4H_{10}
G: $CH_3(CH_2)_3COOH$	**H:** $CH_3C(CH_3)CCH_2$	

7.1. Define the following terms:

7.1.1. Homologous series (3)

7.1.2. Unsaturated hydrocarbon (2)

7.2. To which homologous series do **B**, **F** and **G** belong? (3)

7.3. Name the functional group in **A** and in **E** respectively. (2)

7.4. Give the IUPAC names for **G** and **H** respectively (5)

7.5. Consider compound **D**.

7.5.1. Draw the structural formula and give the IUPAC name of each of the two organic compounds from which this substance in made. (4)

7.5.2. Name the type of organic chemical reaction by which this compound is made. (1)

7.6. The balanced chemical equation for the complete combustion of **C** is:

$$2C_7H_{14\,(l)} + 21O_{2\,(g)} \rightarrow 14CO_{2\,(g)} + 14H_2O_{\,(g)}$$

294 g of C_7H_{14} reacts with 784 dm^3 of oxygen gas at STP.

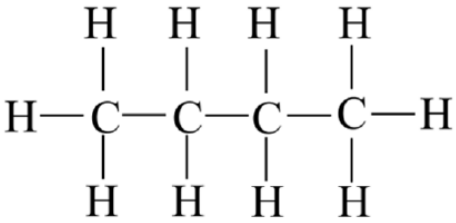
7.6.1. Determine the number of moles of C_3H_8 that was initially present. (3)

7.6.2. Which of the two reactants is the limiting reagent? (5)

7.6.3. Show that the total volume of gas that can be produced is 940.8 dm^3. (2)

7.6.4. It was found that the change in the volume of the combustion vessel was only100 dm^3. Calculate the percentage yield for this reaction. (4)

7.7. Compound **F** can exist in two isomeric forms, one of which is illustrated below.



7.7.1. Define the term *isomers*. (2)

7.7.2. Draw the structural formula and give the IUPAC name of the second isomer. (3)

7.7.3. Which one of the two isomers will have the lower boiling point? Explain fully by referring to intermolecular forces. (4)

7.8. Compound G is an example of an organic molecule which exhibits functional isomerism.

7.8.1. Explain what is meant by the term *functional isomerism.* (2)

7.8.2. Draw the structural formula and give the IUPAC name of a functional isomer of **G**. (3)

7.9. Consider the chemical reactions of compounds **A**, **E** and **H** below.

A:	**$C_3H_7Cl + NaOH \rightarrow C_3H_7OH + NaCl$**
E:	**$CH_3CH_2CH(OH)CH_3 \rightarrow CH_3CH_2CHCH_2 + H_2O$**
H:	**$CH_3C(CH_3)CCH_2 + Br_2 \rightarrow CH_3C(CH_3)C(Br)CH_2Br$**

7.9.1. Identify the type of reaction depicted in reactions **A**, **E** and **H** respectively. (3)

7.9.2. What other name is given to reaction **E**? (2)

[53]

TOTAL 200