SACRED HEART COLLEGE

PHYSICAL SCIENCE

Preliminary Examination (Grade 12)

PAPER 2

25th JULY 2016

TIME: 3 hours + 10 minutes reading time

MARKS: 200

EXAMINER:

Mr F Hollingworth

MODERATOR:

Mr D Armour

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1. This paper consists of:
   - a question paper numbered up to page 14,
   - an Answer Sheet for the Multiple Choice questions,
   - a Data and Formulae sheet

   Please make sure that your question paper is complete.

2. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided. 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.

3. **START EACH QUESTION ON A NEW PAGE.**

4. It is in your own interest to write legibly and to set your work out neatly.

5. Show your working in all calculations.

6. Where appropriate take your answers to 2 decimal places unless instructed otherwise.

QUESTION 1 Use the attached Multiple Choice Answer Sheet for Question 1.

1.1 Which one of the following molecules is the most polar?

A. C_2H_2
B. NH_3
C. CH_3I
D. N_2

1.2 The melting point of HBr is higher than the melting point of HCl because of the stronger … between HBr molecules.

A. Hydrogen bonding forces
B. Covalent bonds
C. London forces
D. Dipole-dipole forces

1.3 A hypothetical reaction reaches equilibrium at 10 °C in a closed container according to the following balanced equation:

$$A(g) + B(g) \rightleftharpoons AB(g) \qquad \Delta H < 0$$

The temperature is now increased to 25 °C. Which ONE of the following is correct with regard to the new equilibrium when compared with the original equilibrium?

	Rate of the forward reaction	Yield of products
A.	Increased	Decreased
B.	Decreased	Increased
C.	Increased	Increased
D.	Decreased	Decreased

1.4 Which one of the following is a weak polyprotic acid?

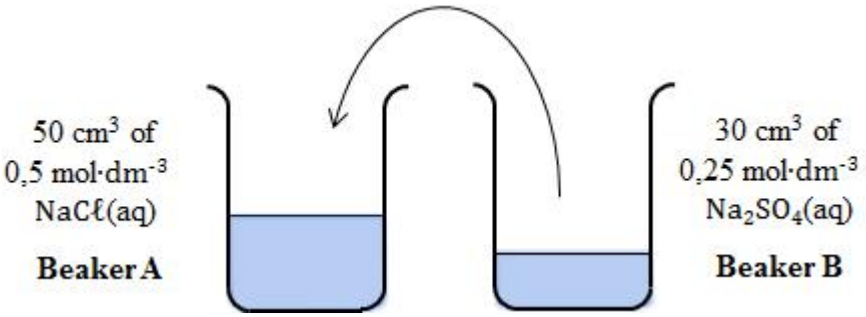
A H_2SO_4

B NH_4OH

C CH_3COOH

D H_3PO_4

1.5 Consider beakers A and B as illustrated below:



30 cm^3 $Na_2SO_4(aq)$ solution in beaker B is added to 50 cm^3 of the $NaC\ell(aq)$ solution in beaker A. Which one of the following represents the correct calculation for the **new concentration** of $Na^+(aq)$ ions in beaker A?

A. $\frac{0,025 + 0,0075}{0,050}$

B. $\frac{0,025 + 0,015}{0,050}$

C. $\frac{0,025 + 0,0075}{0,080}$

D. $\frac{0,025 + 0,015}{0,080}$

1.6 Which one of the following represents the products formed during the hydrolysis of sodium ethanoate (CH_3COONa)?

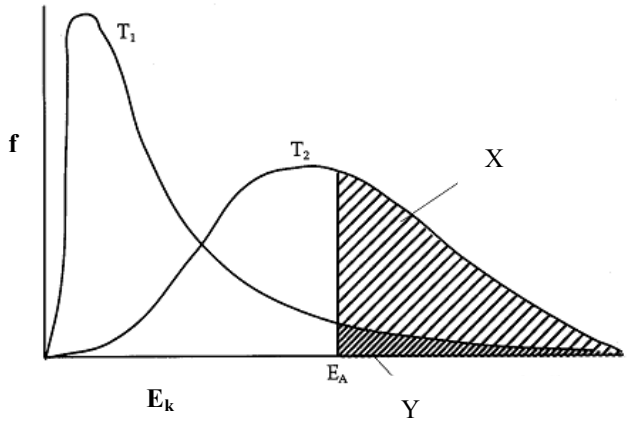
A. $CH_3COOH(aq)$ and $OH^-(aq)$

B. $CH_3COO^-(aq)$ and $Na^+(aq)$

C. $NaOH(aq)$ and $H_3O^+(aq)$

D. $Na^+(aq)$ and $OH^-(aq)$

1.7 The graph below represents the fraction of particles (f) against the kinetic energy (E_k) for an identical sample of reacting particles at two different temperatures, T_1 and T_2.



Which of the following statements is true of the reacting particles and the Maxwell Boltzmann distribution curve above?

A $T_1 > T_2$ with area Y representing the fraction of particles having insufficient energy to react.

B $T_2 > T_1$ with area X representing the fraction of particles having sufficient energy to react.

C $T_2 > T_1$ with area X representing the amount of product at temperature T_2.

D $T_1 > T_2$ with area Y representing the amount of product at temperature T_1 .

1.8 The emf of a galvanic cell is found to be 1,2 V under standard conditions.
The following half-reactions and standard electrode potentials are provided:

$P^+ + e^- \rightleftharpoons P \quad E^\theta = -1{,}8\ V$
$Q^{2+} + 2\,e^- \rightleftharpoons Q \quad E^\theta = +0{,}3\ V$
$R^+ + e^- \rightleftharpoons R \quad E^\theta = -0{,}9\ V$
$S^{2+} + 2e^- \rightleftharpoons S \quad E^\theta = -0{,}3\ V$

Which of the substances P, Q, R and S will act as the anode and cathode respectively?

A. P and R
B. R and Q
C. R and S
D. P and S

1.9 Which one of the following compounds is a saturated hydrocarbon?

A. $CH_3CH(CH_3)CH_3$
B. $CH_3CH_2CHCH_2$
C. $CH_3CHCHCH_3$
D. $CH_3C(CH_3)_2CHCH_2$

1.10 During the electro-refining of copper, the impure copper, known as blister copper, is the anode of an electrolytic cell while a pure copper plate is used as the cathode. Blister copper contains several metal impurities, most commonly silver (Ag), gold (Au), iron (Fe) and zinc (Zn). Which statement describes best what happens to these impurities during the process?

A. Silver is oxidised to Ag^+ and stays in the solution.
B. Zinc metal is oxidised to Zn^{2+} and stays dissolved in the solution.
C. Iron metal does not react and sinks to the bottom of the cell in the sludge.
D. Gold ions, Au^{3+}, are reduced to the metal and sink to the bottom of cell in the sludge.

[2 marks each = 20]

QUESTION 2

2.1 Define the following terms:

2.1.1 Homologous series (3)

2.1.2 Functional group (2)

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

A. C_3H_7Cl	**B. $CH_3CHCHCH_3$**	**C. C_3H_8**
D $CH_3CH_2COOCH_3$	**E. $CH_3CH_2CH(OH)CH_3$**	**F. C_4H_{10}**
G $CH_3CH_2CH_2CH_2COOH$	**H. $CH_3C(CH_3)CH_2$**	

2.2.1 To which homologous series does each of the following belong?

2.2.1.1 **B** (1)

2.2.1.2 **G** (1)

2.2.1.3 **H** (1)

2.2.2 **Name** the functional group in each of the following:

2.2.2.1 **A** (1)

2.2.2.2 ` **E** (1)

2.2.2.3 **G** (1)

2.2.3 Give the IUPAC names for **G** and **H** respectively (4)

2.2.4 Consider the compound **D.**

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

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

2.2.4.3 Give two reasons why sulphuric acid is used in the reaction in question 2.2.4.2. (3)

2.2.5 Write a balanced equation for the complete combustion of compound **C**. (4)

108 g of C_3H_8 initially took part in the above combustion.

2.2.5.1 Determine the number of moles of C_3H_8 that was initially present. (2)

2.2.5.2 Calculate the volume of O_2 gas, at STP, that was used up in the reaction. (3)

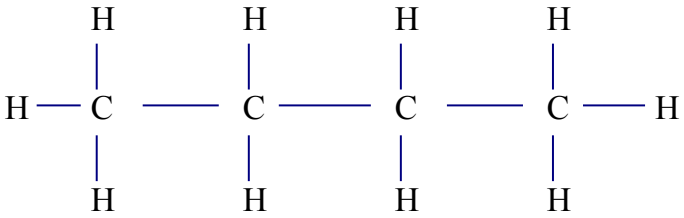
2.2.5.3 Calculate the mass of carbon dioxide that was formed when 108 g of C_3H_8 reacted completely. (3)

2.2.5.4 When an additional amount of C_3H_8 was added to the reaction mixture, an extra 67,2 dm^3 of oxygen, at STP, was required to react completely with it. Calculate the additional mass of C_3H_8 that was added. (5)

2.2.6

2.2.6.1 What are *isomers*? (2)

2.2.6.2 Compound **F** can exist in two isometric forms, one of which is illustrated below:



Draw the structural formula and give the IUPAC name of the second isomer (4)

2.2.6.3 Which of the two isomers in question 2.2.6.2 will have the lower boiling point? Use the concept of intermolecular forces to explain your answer. (4)

2.2.7 Consider compound **G**. Compound **G** is an example of an organic molecule which exhibits functional isomerism.

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

2.2.7.2 Draw the structural formula and give the IUPAC name of a functional isomer of compound **G.** (4)

2.2.8 Consider the chemical reactions of compounds **E, H** and **A** below:

E: $CH_3CH_2CH(OH)CH_3 \rightarrow CH_3CH_2CHCH_2 + H_2O$

H: $CH_3C(CH_3)CH_2 + H_2O \rightarrow CH_3CH(CH_3)CH_2OH$

A: $C_3H_7C\ell + NaOH \rightarrow C_3H_7OH + NaC\ell$

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

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

[61]

QUESTION 3

A chemical equilibrium is established in a closed system with a fixed volume of 1 dm^3. Initially **11 moles of hydrogen gas** and **11 moles of iodine gas** are mixed. The colour of the mixture is deep purple due to the high concentration of iodine vapour. The purple colour fades when <u>equilibrium</u> is established to a pale pink, when there are **17 moles of HI present**.

$$\underset{\text{colourless}}{H_{2(g)}} + \underset{\text{purple}}{I_{2(g)}} \rightleftharpoons \underset{\text{colourless}}{2HI_{(g)}} \quad (\Delta H < 0)$$

3.1 What is meant by the term '***dynamic chemical equilibrium"***? (3)

3.2 When the colour becomes pale pink has the reaction ceased? Explain. (2)

3.3 Write an equilibrium constant (K_c) expression for this reaction. (2)

3.4 Using the information given above, calculate the value of the equilibrium constant (K_c) at this temperature. (5)

3.5 State Le Chatelier's Principle. (3)

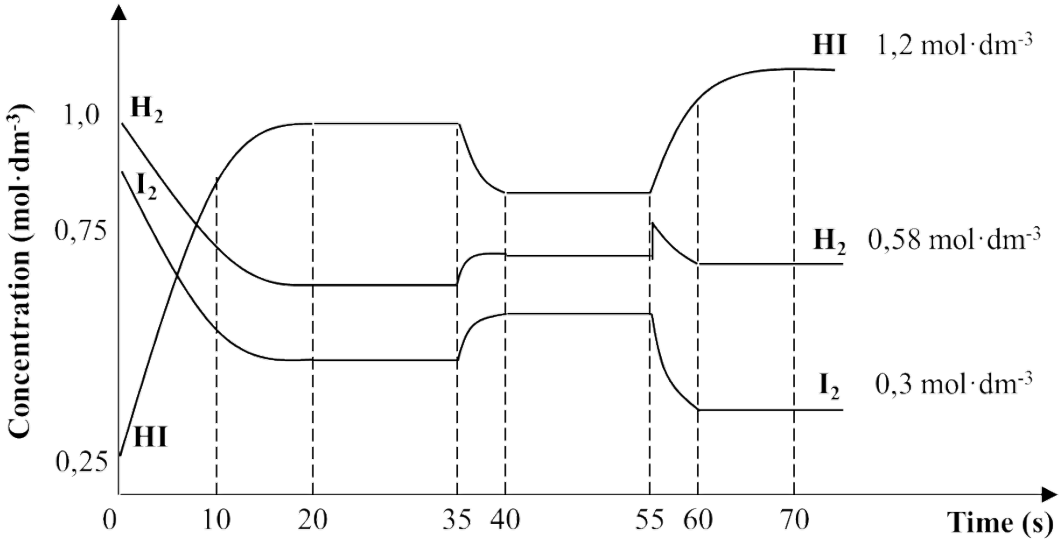
3.6 Use Le Chatelier's Principle to predict and explain the effect of a decrease in temperature on:

3.6.1 The yield of hydrogen iodide (2)

3.6.2 The intensity of the colour of the equilibrium mixture (2)

3.7 What change if any, will an increase in pressure on the equilibrium mixture have on the yield of hydrogen iodide? Explain. (2)

3.8 The graph below shows how the concentration of products and reactant changes over a period of time.



3.8.1 Between which time intervals was the system NOT in equilibrium? (3)

3.8.2 Using Le Chatelier's Principle, identify and explain the changes made to the equilibrium mixture at 55 seconds (4)

3.8.3 How would each of the following be affected if the volume of the container was halved at 72 seconds. (Simply answer INCREASE, DECREASE, or STAY THE SAME)

3.8.3.1 The rate of the forward reaction (1)

3.8.3.2 The equilibrium position (1)

3.8.3.3 The value of K_c (1)

[31]

QUESTION 4

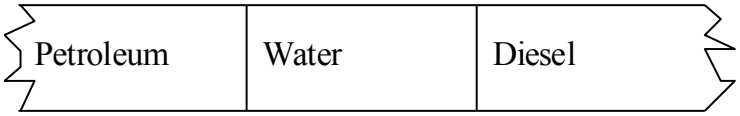
IODINE; DIAMOND; MAGNESIUM OXIDE;

HYDROGEN FLUORIDE; IRON

4.1 Of what units (particles) are each of the above substances composed? (5)

4.2 What force of attraction or bonding keeps the particles in each of the substances together? (5)

4.3 When pumping the fuels petroleum and diesel through a single pipeline, the operator introduces a column of water between the petroleum and the diesel as shown below:



4.3.1 What property of water in comparison to petroleum and diesel makes it possible to keep the petroleum and diesel separate? (3)

4.3.2 The water could be "coloured" by adding a small quantity of potassium permanganate ($KMnO_4$) to the water. Explain why only the water becomes coloured, but not the petroleum or diesel. (3)

4.3.3 Name an element which will colour the petroleum but not the water. (2)

[18]

QUESTION 5

5.1 Give the Bronsted-Lowry definition of an acid. (2)

5.2 Use the Brønsted-Lowry definition of an acid to write an equation for the ionisation of hydrofluoric acid in water. (2)

5.3 The acid ionisation constant for hydrofluoric acid, Ka (HF) = 7,2 x 10^{-4}
What does this value of Ka (HF) indicate about the strength of hydrofluoric acid? Explain. (3)

5.4 The carbonate ion (CO_3^{2-}) is a Bronsted-Lowry base.

5.4.1 Applying the Brønsted-Lowry definition of a base, write a chemical equation to represent the equilibrium reached when the carbonate ion acts as a base in its reaction with water. (2)

5.4.2 Identify the acid base (conjugate) pairs in the chemical equilibrium in question 5.4.1 (2)

[11]

QUESTION 6

6.1 Acid-base indicators are typically weak acids. We give the equation for the ionisation of the indicator, bromocresol green, in water to form ions. The colour of the ion that forms and the colour of the acid molecule, is given below the equation.

$$\underset{\text{Yellow}}{HIn\ (aq)} + H_2O\ (\ell) \rightleftharpoons H_3O^+\ (aq) + \underset{\text{Blue}}{In^-}$$

6.1.1 What will be the colour of bromocresol green in basic solution?
Explain using Le Chatelier's Principle. (3)

6.1.2 20 cm^3 of an ammonium hydroxide solution is titrated against a solution of hydrochloric acid of concentration 0,062 $mol.dm^{-3}$. The volume of HCl required when the end point is reached is 22,0 cm^3.

$$NH_4OH + HCl \rightleftharpoons NH_4Cl + H_2O$$

Calculate the concentration of the ammonium hydroxide solution. (3)

6.1.3 At the end point the conical flask contains a solution of ammonium chloride. Use equations to show the hydrolysis of the ammonium chloride, and deduce whether the solution is acidic or basic at the end point. (4)

6.1.4 Which of the following indicators, A, B or C would be most suitable for this titration?

Indicator	**pH range**
A	3,8 - 5,4
B	6,0 - 7,6
C	8,3 - 10,0

(2)

[12]

QUESTION 7

The following reaction takes place in an electrochemical cell:

$$Mg\,(s) + 2AgNO_3\,(aq) \rightarrow Mg(NO_3)_2\,(aq) + 2Ag\,(s)$$

7.1 Write down the cell notation of this cell. (2)

7.2 At what temperature is the emf of a standard cell measured? (1)

7.3 Give an equation for the oxidation half reaction (3)

7.4 Which metal is used as the anode? (2)

7.5 Determine the emf of the cell under standard conditions. (4)

This cell is connected to a bulb marked 3 V; 6 W. In theory the bulb should light up but it does not.

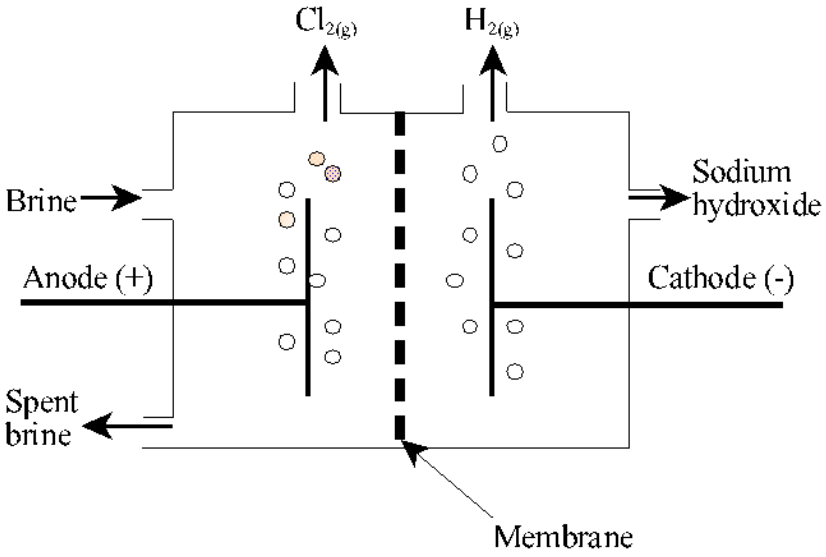
7.6 Calculate the current required by this bulb, then . . . (2)

7.7 . . . give two reasons why the bulb did not light up. (4)

[18]

QUESTION 8

Approximately 30 million tons of chlorine are used throughout the world annually. Chlorine is produced industrially by the electrolysis of brine. The diagram represents a membrane cell used in the production of chlorine gas.



8.1 What is brine? (2)

8.2 Write the electrochemical reaction taking place at the anode. (2)

8.3 There are three possible reduction reactions which could take place at the cathode:

$Na^+ + e^- \rightarrow Na$

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

$2H^+ + 2e^- \rightarrow H_2$

8.3.1 Which one of these reactions takes place? (3)

8.3.2 Give reasons as to why the other two reactions do not take place. (4)

8.4 Deduce the overall net cell reaction. (3)

8.5 The three products of this cell are chlorine, hydrogen and sodium hydroxide. These are very important in industry. Name **one** use for each of these products. (3)

[17]

QUESTION 9

9.1 In the commercial production of sulphuric acid (Contact Process), one of the stages is th

$$2SO_{2\,(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -196 \text{ kJ}$$

Write down the numbers 9.1.1 to 9.1.6 which correspond to the numbers in the table below, and state how the factors given would affect both the **yield** of SO_3 and the **r**

Factor	Yield	Rate
Increase in temperature	9.1.1	9.1.4
1. Addition of a catalyst	9.1.2	9.1.5
Replacing oxygen with air at the same pressure	9.1.3	9.1.6

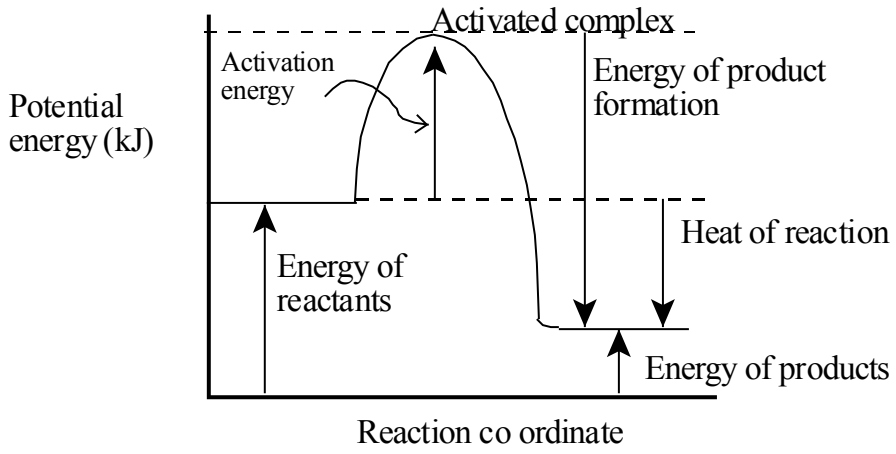
9.2 Draw a **neat** energy profile for the forward reaction. Include the following labels on your profile :

activation energy	energy of products
energy of reactants	activated complex
heat of reaction	energy of product formation

(6)

[12]

Total = 200


Activated complex
Activation energy
Energy of product formation
Potential energy (kJ)
Heat of reaction
Energy of reactants
Energy of products
Reaction co ordinate