00389

The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Chemistry
Level	: 04
Name of the Examination	: Final Examination
Course Code and Title	**: CYU4302 – Practical Chemistry II**
Academic Year	: 2019/2020
Date	: 19/02/2021 (Friday)
Time	: 2.00 p.m. – 4.00 p.m.
Duration	: 02 hours

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **04** questions in **08** pages.
3. Answer **ALL 04** questions. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your index number in **ALL** pages of your answer script.

Some important universal constants are given below, in standard notation.

$R = 8.314\ JK^{-1}mol^{-1}$ $N_A = 6.023\times10^{23}\ mol^{-1}$ $F = 96,500\ C mol^{-1}$

$h = 6.63\times10^{-34}\ Js$ $c = 3.0\times10^{8}\ ms^{-1}$ $P_0 = 10^5\ Pa\left(Nm^{-2}\right) = 1\ bar$

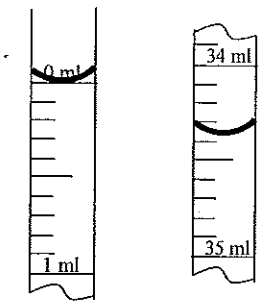
$e = 1.602177\times10^{-19}\ C$ $\pi = 3.14159$ $Log_e(X) = 2.303\ Log_{10}(X)$

Some equations used in chemistry are given below, in standard notation.

For $W = k[a \pm b]$; $(\delta W)^2 = k^2\left[(\delta a)^2 + (\delta b)^2\right]$

$$\log_{10}(\gamma_{\pm}) = -\frac{0.509\left|Z_+Z_-\right|\sqrt{I}}{1+1.25\sqrt{I}}$$

1. (a) A student carried out an acid base titration. The meniscus of the acid solution in the burette, at the beginning and at the endpoint, are shown in the figure.



At the beginning At the endpoint

(i) Properly, record the burette reading at the endpoint.

(ii) Briefly explain how you arrived at the reading recorded in part (i) above.

(iii) Calculate the error in the volume of acid used in the titration.

(iv) Properly record the volume of acid used in the titration in standard scientific notation.
Briefly explain your answer.

(50 marks)

(b) Answer either **Part A** or **Part B** (but **NOT** both).

Part A

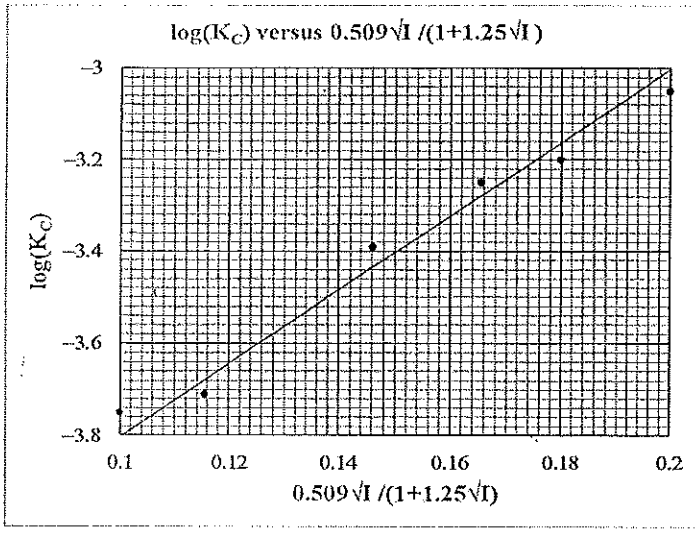
At 25^0C, a student determined the thermodynamic solubility product of a sparingly soluble salt, XY, by performing an experiment like the one you conducted with KHT. Here, XY, dissociated in aqueous medium as

$XY(s) \rightleftarrows X^{2+}(aq) + Y^{2-}(aq)$.

She prepared a series of saturated solutions of XY with different ionic strengths, I. The ionic strength was adjusted using a salt Q which does not react with $X^{2+}(aq)$ and $Y^{2-}(aq)$. Then, she measured the concentration of $X^{2+}(aq)$ and determined the concentration solubility product, K_C, in each of these solutions. She then determined K_T using a plot of $\log_{10}(K_C)$ versus $\left[\frac{0.509\sqrt{I}}{1+1.25\sqrt{I}}\right]$ which is shown below.

(i) Define K_C and K_T of XY in terms of the concentrations of $X^{2+}(aq)$ and $Y^{2-}(aq)$, and identify all the parameters in them.

(ii) Using the definitions, write down a relationship between K_C and K_T of XY.



(iii) Using the answer in part (ii) above, deduce the value of m and the relationship between c and K_T in the equation $\log_{10}(K_C) = m\left[\frac{0.509\sqrt{I}}{1+1.25\sqrt{I}}\right] + c$ for XY.

(iv) Explain why the student prepared solutions <u>saturated</u> with XY.

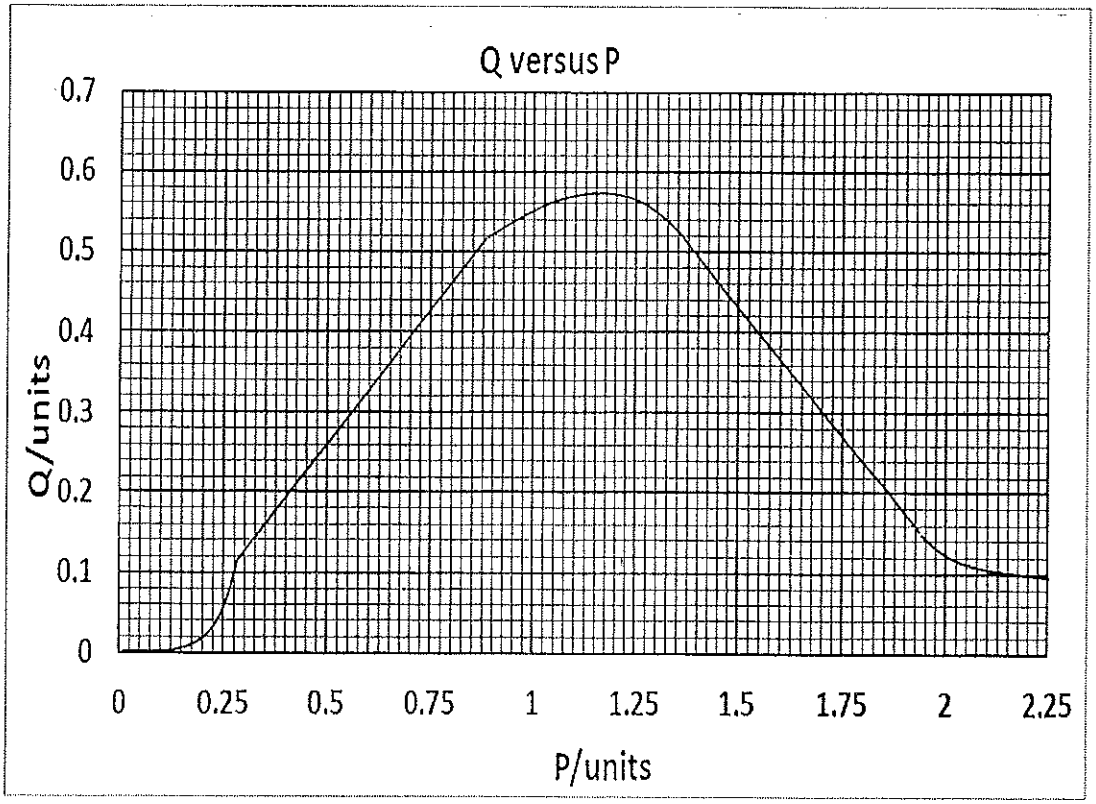
(v) Using the plot made by the student, determine the value of K_T at 25^0C.

(50 marks)

Part B

P and Q are two measurable physical quantities of a system. P can be changed by varying the temperature. Q changes when P is changed. According to a theory, the relationship between P and Q is linear (straight line), viz. $Q = mP + c$ where m and c are constants.

A student measured Q as a function of P. The plot he made is shown below.



(i) Estimate the range/s of validity of the theory (in units the student has used). Briefly explain your answer.

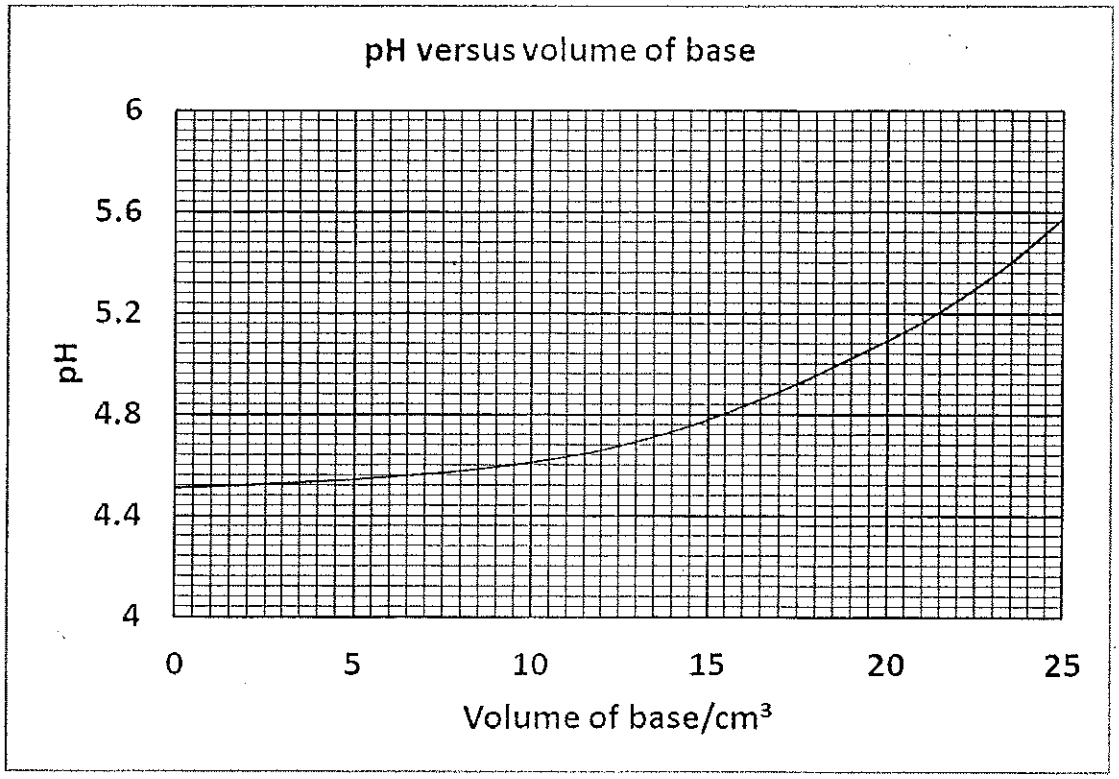
(ii) Determine the possible values of the constants m and c for the range/ranges.

(50 marks)

2. (a) Answer either **Part A** or **Part B** (but **NOT** both).

Part A

A student performed a weak acid (HA) - strong base (BOH) titration. To determine the end point, she measured the pH (of the reaction mixture) after addition of known volumes of base. Part of her plot of pH versus the volume of base added is shown in the figure. The dissociation constant of the acid at the temperature of the experiment was 6.3×10^{-6} mol dm^{-3}. The volume of acid and the concentration of the base used for the titration were 30.00 cm^3 and 0.100 mol dm^{-3}.



(i) Using the definition of pH, explain why the pH of the reaction mixture increased when the base is added.

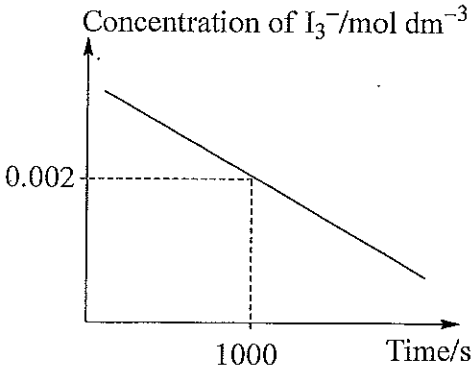
(ii) Determine the volume of base added at the end point.
Briefly explain your answer using the Henderson equation.

(iii) Calculate the concentration of the acid.

(50 marks)

Part B

In studying the kinetics of the *acid catalysed iodination of acetone*, a student placed **X** ml of acetone, 10.00 ml of HCl and 75.00 ml of distilled water in a stoppered bottle. Then she added 10.00 ml of iodine solution, of concentration $\left[I_3^-\right] = 0.069 \text{ mol dm}^{-3}$, into the above-mentioned mixture and mixed well. She experimentally studied the variation of concentration of I_3^- in the above reaction mixture as a function of time, t (as you did in Experiment 1). A sketch of the plot she prepared is shown in the figure.



The iodination reaction is

$CH_3COCH_3 + I_3^- \xrightarrow{H^+ \text{(catalyst)}} CH_3COCH_2I + H^+ + 2I^-$. It is zero order in $\left[I_3^-\right]$. The rate depends on acid and acetone concentrations. However, they are in excess and the pseudo rate constant is $k' = 4.00 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}$ under the above-mentioned conditions. [The rate does not depend on any other chemical species.]

(i) Giving reasons, write down the relationship between $\frac{d\left[I_3^-\right]}{dt}$ and k'.

(ii) Derive an expression for $\left[I_3^-\right]$ at any time t.

(iii) Calculate the concentration of $\left[I_3^-\right]$ at $t = 0\text{s}$.

(iv) Calculate X assuming that the mixture was prepared at $t = 0\text{s}$. State any other assumption/s you make.

(50 marks)

(b) In studying the acid catalysed hydrolysis of methyl acetate (Experiment 4), a student added 5.00 cm^3 of methyl acetate into 50.00 cm^3 of a solution of HCl of concentration 1.0 mol dm^{-3}. The hydrolysis reaction was carried out in a water bath maintained at constant temperature. He followed the production of acetic acid by titrating 5.00 cm^3 samples of reaction mixture with NaOH. The samples were taken from the reaction mixture at different times, t. The concentration of NaOH was 0.300 mol dm^{-3}. The volume of NaOH used in titration with the sample taken at time t is denoted by V_t. The relationship between t and V_t is given by the following equation.

$$t = \frac{2.303}{k}\log_{10}\left(V_\infty - V_0\right) - \frac{2.303}{k}\log_{10}\left(V_\infty - V_t\right).$$

The plot, t versus $\log_{10}\left(V_\infty - V_t\right)$ he made is shown below.

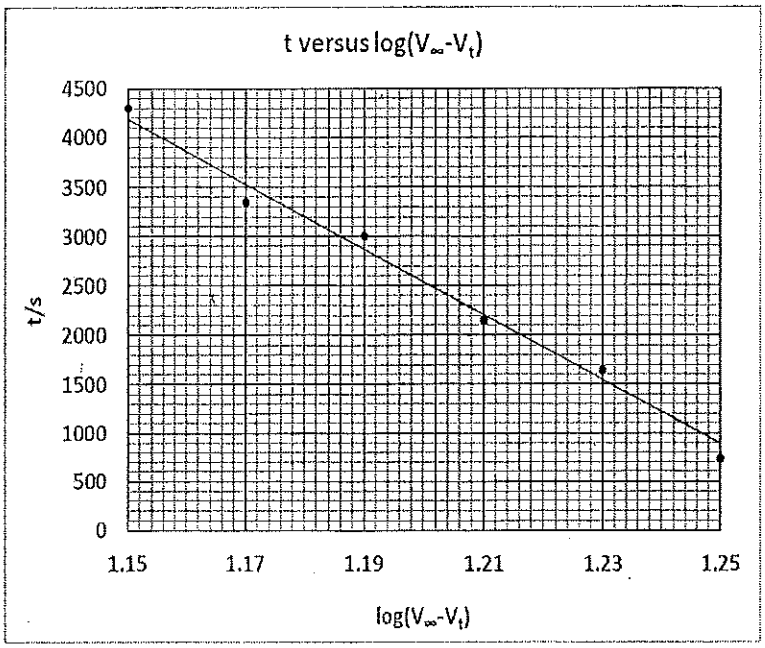
(i) Identify k, V_0 and V_∞ in the above equation.

(ii) Calculate V_0. State any assumption/s you make.

(iii) Determine the following using the plot.

(α) Value of k.

(β) Value of V_∞.



(50 marks)

3. (a) The reaction, $X + Y \rightarrow Z$, was carried out to obtain product **Z**, which contained some unreacted **X**. Purity of a 12.70 g sample of crude **Z** was determined to be 95.3% (by weight).

(i) Calculate the amount of **Z** in the sample.

(ii) Solubilities of **X** and **Z** in ethanol are given below. Calculate the minimum volume of ethanol needed to recrystallize crude **Z**.

Temperature/ °C		27	78
Solubility (g/100 mL)	**X**	0.09	0.52
	Y	0.32	4.69

(iii) Suppose crude **Z** is recrystallized using the minimum volume of ethanol. Calculate the amount of **Z** lost during this process.

(iv) Calculate the purity of **Z** after first recrystallization.

(35 marks)

(b) Give reasons for the following observations made during recrystallization.

(i) An oily layer was formed when the compound was heated with the solvent.

(ii) Compound gave a coloured solution even after heating with some activated charcoal.

(iii) Filtered solution did not give any crystals on cooling it to room temperature.

(iv) Two layers were separated out when a solvent pair was used for recrystallization.

(v) Crystals formed were in the form of a fine powder.

(50 marks)

(c) Answer either **Part A** or **Part B** (but **NOT** both).

Part A

Explain in brief, the importance of following actions in setting up apparatus for distillation.

(i) Few boiling chips should be added to the distilling flask.

(ii) The mercury bulb of the thermometer should be positioned parallel to the opening that leads to the condenser.

(iii) Water inlet should be the lower arm of the condenser.

(15 marks)

Part B

A student has carried out a reaction under reflux.

(i) Explain the purpose of carrying out a reaction under reflux.

(ii) What are the differences between the assembly of reflux set up and distillation set up?

(iii) Give two advantages of using a heating mantle as the heat source for carrying out the reaction.

(15 marks)

4. (a) An esterification reaction was done using salicylic acid (2.0 g, MW. 138 g mol^{-1}) and acetic anhydride (5.0 mL, MW. 102 g mol^{-1}, d. 1.08 g mL^{-1}) to obtain acetyl salicylic acid (1.98 g, MW. 180 g mol^{-1}).

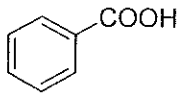
(i) Write the balanced equation for the reaction.

(ii) What is the limiting reagent of this reaction?

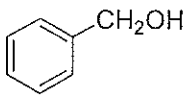
(iii) Calculate the percentage yield of the reaction.

(45 marks)

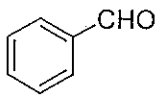
(b) Progress of a reaction was monitored by Thin Layer Chromatography (TLC) performed on silica gel plates. TLC plates were 'developed' by using dichloromethane as the mobile phase. Reaction mixture showed the presence of the following compounds several minutes after starting the reaction.



benzoic acid



benzyl alcohol



benzaldehyde

(i) What is meant by 'developing' the plate? Briefly explain how you accomplish this task.

(ii) Draw a fully labelled diagram of the TLC plate to show the pattern of spots.

(iii) Give reasons for the predicted pattern of spots.

(40 marks)

(c) Answer either **Part A** or **Part B** (but **NOT** both).

Part A

Vacuum filtration (suction filtration) is a technique to separate solid-liquid mixtures.

(i) Draw the set up you assemble for vacuum filtration.
Giving correct names, label all the parts in it.

(ii) Briefly explain why this method is **not** suitable if your goal is to retain the liquid.

(15 marks)

Part B

A widely used method for determination of the melting point of a compound is the capillary tube method.

(i) Draw a completely labelled diagram of a melting point apparatus you can assemble in the laboratory using easily available items.

(ii) Explain what is meant by 'mixed melting point' and the use of it.

(15 marks)

The END of paper