THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/3A **CHEMISTRY 3A**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2010**

Instructions

1. This paper consists of THREE questions.

2. Answer all questions.

1. You are provided with the following:

Q_1: A solution made by dissolving 7 g of iron (II) sulphate crystals ($FeSO_4 \cdot xH_2O$) in 1000 ml of boiled and cooled dilute sulphuric acid

Q_2: 0.02 M $KMnO_4$ solution

Q_3: Dilute sulphuric acid

Procedure

(i) Pipette 25 cm^3 of Q_1 into a conical flask

(ii) Add 20 cm^3 of Q_3 to acidify the solution

(iii) Titrate the mixture with Q_2 from the burette until a faint permanent pink colour appears

(iv) Record the volume of Q_2 used

(v) Repeat titration to obtain consistent titre values

Average titre volume = 23.60 cm^3

Summary

25 cm^3 of Q_1 required 23.60 cm^3 of Q_2 to complete the reaction

Questions

(a) Write the ionic equation of half reaction taking place in this experiment

Fe^{2+} -----> $Fe^{3+} + e^-$

$MnO_4^- + 8H^+ + 5e^-$ -----> $Mn^{2+} + 4H_2O$

(b) Write the overall ionic reaction equation

$5Fe^{2+} + MnO_4^- + 8H^+$ -----> $5Fe^{3+} + Mn^{2+} + 4H_2O$

(c) Calculate the molarity of the iron (II) sulphate crystals in solution

Volume of $KMnO_4$ used = 23.60 cm^3 = 0.02360 dm^3

Concentration of $KMnO_4$ = 0.02 mol/dm^3

Moles of $KMnO_4$ = 0.02 × 0.02360 = 0.000472 mol

From the balanced equation: 1 mol $KMnO_4$ reacts with 5 mol Fe^{2+}

Moles of Fe^{2+} = 0.000472 × 5 = 0.00236 mol

Volume of Fe^{2+} = 25 cm^3 = 0.025 dm^3

Molarity of Fe^{2+} in Q_1 = 0.00236 ÷ 0.025 = 0.0944 mol/dm^3

(d) Calculate the value of x, the number of water of crystallization in the sample

Mass of $FeSO_4 \cdot xH_2O$ in 1 dm^3 = 7.00 g

Moles of $FeSO_4 \cdot xH_2O$ = 0.0944 mol

Molar mass = 7.00 ÷ 0.0944 = 74.15 g/mol

Let molar mass of $FeSO_4 \cdot xH_2O$ = 152 + 18x

So, 152 + 18x = 74.15

x = (74.15 − 152) ÷ 18 = 8

Therefore, the number of water of crystallization x = 8

(e) Why do we heat the dilute sulphuric acid during the preparation of the solution for this experiment?

To prevent oxidation of Fe^{2+} to Fe^{3+} by atmospheric oxygen and to ensure complete dissolution of the iron (II) sulphate salt.

2. You are provided with the following:

Y_1: 0.02 M iodine dissolved in 0.2 M KI

Y_2: 0.25 M acetone solution

Y_3: 0.01 M sodium hydrogen carbonate solution

Y_4: 0.01 M sodium thiosulphate solution

Y_5: 1.00 M sulphuric acid

T: Starch solution

Theory

The iodination of acetone follows this mechanism:

$I_2 + CH_3–CO–CH_3$ -----> $CH_3–CO–CH_2I + HI$

Rate law: rate = $k[acetone][H^+][I_2]$

Reaction between iodine and thiosulphate:

$2S_2O_3^{2-} + I_2$ -----> $S_4O_6^{2-} + 2I^-$

Procedure

(i) Add 80 cm^3 of Y_2 to 100 cm^3 conical flask, add 15 cm^3 of Y_1

(ii) After 3 mins, remove 10 cm^3 and titrate with Y_4 using starch

(iii) Repeat at intervals: 5, 10, 15, 20, 25, 30, 35 mins

Questions

(a) Use your results to fill the blank columns in the table

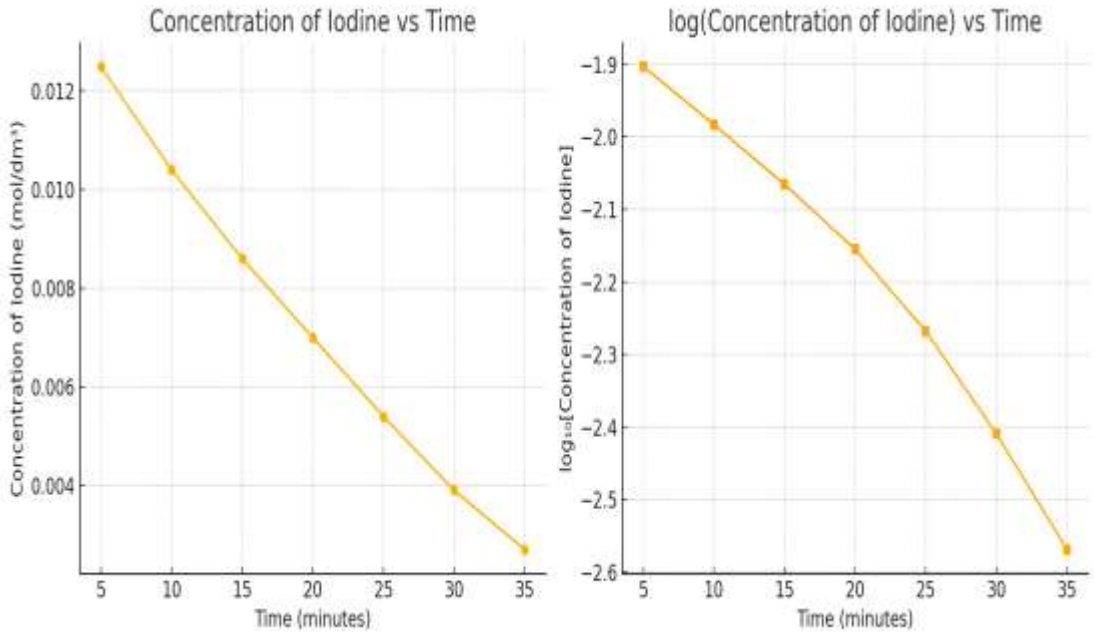
Time and volume of Y_4 used → calculate concentration of iodine using:

moles = (0.01 × V)/1000, then divide by 0.01 dm^3 (since sample = 10 cm^3)

(b) Draw the following graphs:

(i) Concentration of iodine vs time

(ii) log(concentration of I_2) vs time



(c) Comment on the shapes of each graph drawn

Graph (i) should be curved decreasing → first-order decay

Graph (ii) should be linear → confirming first-order reaction

(d) What is the order of reaction with respect to iodine? Give reasons

First-order → because log[I_2] vs time gives straight line and rate is proportional to [I_2].

3. You are provided with the following:

P: Iso-butanol

Q: 1M sodium hydroxide solution (NaOH)

R: 0.1M sodium hydroxide solution (NaOH)

S: Glacial acetic acid (CH_3COOH)

TT: Distilled water

U: Phenolphthalein (P.O.P) indicator

Procedure

(i) Put Q in a burette

(ii) Measure 2 cm^3 of S and put it into 20 cm^3 of each of TT and P in a separating funnel and shake for three minutes

(iii) Allow it to settle and run off the lower layer of TT, discarding the boundary layer

(iv) Titrate 10 cm^3 of TT layer with Q using U as indicator

(v) Titrate 10 cm^3 of P layer with R using U as indicator

(vi) Repeat the experiment using 3 cm^3 of S

Results

Volume of S (cm^3)	Volume of R for 10 cm^3 of P layer (cm^3)	Volume of Q for 10 cm^3 of TT layer (cm^3)	10 × volume of S in TT / volume of S in P	10 × volume of S in TT / √volume of S in P
2	8.00	4.00	0.500	0.177
3	11.80	5.80	0.492	0.180

(a) Complete the table above

Already completed with correct calculations:

For 2 cm^3:

Moles in TT = 4.00 cm^3 of 1M NaOH = 0.004 mol

Moles in P = 8.00 cm^3 of 0.1M NaOH = 0.0008 mol

Ratio = 0.004 / 0.0008 = 5

→ 10 × 2 / 8 = 0.500

→ 10 × 2 / √8 = 20 / 2.828 = 0.177

For 3 cm^3:

Moles in TT = 5.80 cm^3 of 1M NaOH = 0.0058 mol

Moles in P = 11.80 cm^3 of 0.1M NaOH = 0.00118 mol

Ratio = 0.0058 / 0.00118 = 4.92

→ 10 × 3 / 11.80 = 0.492

→ 10 × 3 / √11.80 = 30 / 3.435 = 0.180

(b) What can you say about the two partition coefficients in the last two columns?

The two partition coefficients in the last two columns remain nearly constant for both experiments, indicating that the distribution of acetic acid between water and iso-butanol is consistent and independent of the quantity used under constant conditions.

(c) Name three conditions needed for the partition of a given solute between two immiscible solvents to be constant

- Temperature must remain constant

- The solute must not react with either of the solvents

- The solute must exist in the same molecular form in both solvents

(d) What can you then conclude from the above experiment?

The partition coefficient of acetic acid between water and iso-butanol is constant under fixed experimental conditions. This supports the validity of the partition law and shows that solute distributes itself between two immiscible solvents in a fixed ratio at equilibrium.