

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.

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1. You are provided with the following:

Q₁: A solution made by dissolving 7 g of iron (II) sulphate crystals (FeSO₄·xH₂O) in 1000 ml of boiled and cooled dilute sulphuric acid

Q₂: 0.02 M KMnO₄ solution

Q₃: Dilute sulphuric acid

Procedure

(i) Pipette 25 cm³ of Q₁ into a conical flask

(ii) Add 20 cm³ of Q₃ to acidify the solution

(iii) Titrate the mixture with Q₂ from the burette until a faint permanent pink colour appears

(iv) Record the volume of Q₂ used

(v) Repeat titration to obtain consistent titre values

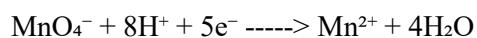
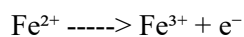
Average titre volume = 23.60 cm³

Summary

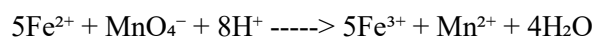
25 cm³ of Q₁ required 23.60 cm³ of Q₂ to complete the reaction

Questions

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



(b) Write the overall ionic reaction equation



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

Volume of KMnO_4 used = $23.60 \text{ cm}^3 = 0.02360 \text{ dm}^3$

Concentration of $\text{KMnO}_4 = 0.02 \text{ mol/dm}^3$

Moles of $\text{KMnO}_4 = 0.02 \times 0.02360 = 0.000472 \text{ mol}$

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

Moles of $\text{Fe}^{2+} = 0.000472 \times 5 = 0.00236 \text{ mol}$

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

Molarity of Fe^{2+} in $Q_1 = 0.00236 \div 0.025 = 0.0944 \text{ mol/dm}^3$

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

Mass of $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ in $1 \text{ dm}^3 = 7.00 \text{ g}$

Moles of $\text{FeSO}_4 \cdot x\text{H}_2\text{O} = 0.0944 \text{ mol}$

Molar mass = $7.00 \div 0.0944 = 74.15 \text{ g/mol}$

Let molar mass of $\text{FeSO}_4 \cdot x\text{H}_2\text{O} = 152 + 18x$

So, $152 + 18x = 74.15$

$x = (74.15 - 152) \div 18 = 8$

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:

Y₁: 0.02 M iodine dissolved in 0.2 M KI

Y₂: 0.25 M acetone solution

Y₃: 0.01 M sodium hydrogen carbonate solution

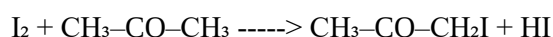
Y₄: 0.01 M sodium thiosulphate solution

Y₅: 1.00 M sulphuric acid

T: Starch solution

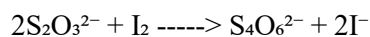
Theory

The iodination of acetone follows this mechanism:



Rate law: $\text{rate} = k[\text{acetone}][\text{H}^+][\text{I}_2]$

Reaction between iodine and thiosulphate:



Procedure

- (i) Add 80 cm³ of Y₂ to 100 cm³ conical flask, add 15 cm³ of Y₁
- (ii) After 3 mins, remove 10 cm³ and titrate with Y₄ 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

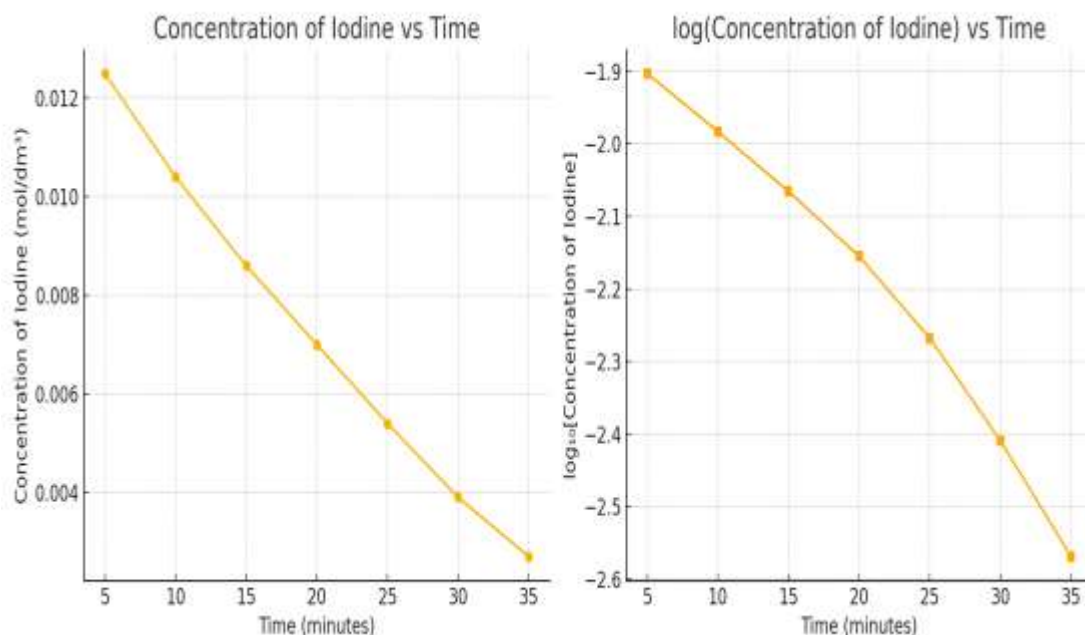
Time and volume of Y₄ used → calculate concentration of iodine using:

moles = $(0.01 \times V)/1000$, then divide by 0.01 dm³ (since sample = 10 cm³)

(b) Draw the following graphs:

(i) Concentration of iodine vs time

(ii) $\log(\text{concentration of } I_2) \text{ vs time}$



(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)	$10 \times \text{volume of S in TT} / \text{volume of S in P}$	$10 \times \text{volume of S in TT} / \sqrt{\text{volume of S in P}}$
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 = $0.004 / 0.0008 = 5$

$\rightarrow 10 \times 2 / 8 = 0.500$

$\rightarrow 10 \times 2 / \sqrt{8} = 20 / 2.828 = 0.177$

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 = $0.0058 / 0.00118 = 4.92$

$\rightarrow 10 \times 3 / 11.80 = 0.492$

$\rightarrow 10 \times 3 / \sqrt{11.80} = 30 / 3.435 = 0.180$

(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.