Manual

Physical Chemistry
Lab work 2

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2010

PREFACE

This hand out covers the manual of physical chemistry lab work 2. It helps in preparing for working in physical chemistry laboratory. It condenses the detail experiments of the subject matter. This hand out is equipped by a theoretical review and student worksheet. The experiments chosen have been according to the equipments and materials in Physical Chemistry Laboratory. The hand out has been carefully prepared to assure accuracy and maximum usefulness.

Editor
Endang Widjajanti

EXPERIMENT 1

VISCOSITY MEASUREMENT BY OSWALD METHOD

A. Purpose

Measure relative viscosity number of various liquid by Oswald method

B. Introduction

Dynamic viscosity number, η, of a liquid (equation 2) is defined by the force, G, which is required to move parallel layers of liquid both having the area A and separated by dy with the velocity dν with respect to each other.

$$G = \eta A \frac{d\nu}{dy} \quad \text{......(1)}$$

or

$$\eta = \left(\frac{G}{A}\right)\frac{d\nu}{dy} \quad \text{......(2)}$$

which η : dynamic viscosity number, G : friction force, A : layer area, dν : velocity different between two layers separated by dy, and $d\nu/dy$: velocity gradient. According to equation (2), the unit of dynamic velocity number is gram cm^{-1} s^{-1}. One method to measure dynamic viscosity number is Oswald method.

According to Heagen Poseuille Law:

$$\eta = \frac{pr^4t}{8\nu l} \quad \text{......(3)}$$

$$p = \rho\ g\ h \quad \text{......(4)}$$

$$\eta = \frac{r^4 t\ \rho\ g\ h}{8\nu l} \quad \text{......(5)}$$

Which ρ = hydrostatic pressure, r = capillary radius, t = liquid moving time with volume V and height different h, l = capillary length.

This experiment use relative measurement to avoid the values of capillary diameter, gravitation, volume, that are difficult to be determined.

Arrangement of equation (5) yields to:

$$\eta = \frac{r^4 t_a\ \rho_a\ g\ h}{8\nu l} \quad \text{......(6)}$$

For substance X:

$$\eta = \frac{r^4 t_x\ \rho_x\ g\ h}{8vl} \quad \text{..}(7)$$

From equation (6) and (7), the new equation (8) was obtained.

$$\frac{\eta_x}{\eta_a} = \frac{t_x\ \rho_x}{t_a\ \rho_a} \quad \text{..}(8)$$

C. Experimental

1. Apparatus and Chemicals
   a. glass beaker
   b. Oswald equipment
   c. picnometer
   d. analytical balance
   e. vacuum pump
   f. stopwatch
   g. distilled water
   h. alcohol
   i. acetone
   j. substance X
2. Procedure
   1) Determine the density of the liquid by picnometer.
   2) Cleaned up the apparatus by cleaning acid and dried by vacuum pump.
   3) Fill the apparatus by adequate distilled water. Make the water level over the highest sign. Cover the tube hole by finger, and prepare the stopwatch. Move out the finger, switch the stopwatch on when the water appropriate at the up sign and switch of when the water appropriate at the bottom sign. Record the required time of liquid moving.
   4) Repeat step 3 for 3 times
   5) Repeat the experimental for alcohol, acetone and substance X
3. Calculation and Discussion

   The viscosity of liquid, $\rho = \frac{mass}{volume}$

   Dynamic viscosity number of substance is measured by comparing to the viscosity number of distilled water (equation 8). The viscosity numbers on various temperatures are listed in Table 1.

Table 1. Viscosity Numbers of Distilled Water on Various Temperatures

Temperature (^oC)	Viscosity number	Temperature (^oC)	Viscosity number	Temperature (^oC)	Viscosity number

25	0,8937	30	0,8007	35	0,7225
26	0,8737	31	0,7840	36	0,7085
27	0,8545	32	0,7679	37	0,6947
28	0,8360	33	0,7523	38	0,6814
29	0,8100	34	0,7371	39	0,6685

D. Questions

1. Pre Lab Questions
    a. What is the viscosity defined?
    b. Describe the various numbers of viscosities?
    c. How to determine the viscosity number? Explain!
2. Post Lab Questions
    a. How many methods to determine viscosity number? Explain!
    b. Explain the properties of liquid?
    c. Explain the method to determine velocity number!
    d. In this experiment, why we determine relative viscosity number, not absolute viscosity number?
    e. What factors affect the viscosity number?

WORKSHEET 1

VISCOSITY MEASUREMENT BY OSWALD METHOD

Name : ....**NIM** ....

Day & Date of Experiment : ....

Assistant : ....

1. Results

Mass of pycnometer : …………………. grams

Volume of pycnometer : …………………. mL

Viscosity of water : …………………. g/mL

Viscosity of alcohol : …………………. g/mL

Viscosity of acetone : …………………. g/mL

Viscosity of substance X : …………………. g/mL

No	Substance	Viscosity	Time (second)
1	Water	1 ……………………... 2 …………………….. 3 ……………………...	1 ……………………... 2 …………………….. 3 ……………………...
2	Alcohol	1 …………………….. 2 …………………….. 3 ……………………..	1 ……………………... 2 …………………….. 3 ……………………...
3	Acetone	1 …………………….. 2 …………………….. 3 ……………………..	1 ……………………... 2 …………………….. 3 ……………………...
4	X	1 …………………….. 2 ……………………..	1 ……………………... 2 ……………………..

		3 ……………………..	3 ……………………...

2. **Discussion:**
   a. The viscosity number is………………………………………………….
   ………………………………………………………………………………
   b. The relative viscosity number could be determined by ……… methods, i.e. …………………………………………………………………..……....
   ………………………………………………………………………………
   c. The factors on determination of relative viscosity number are …………….
   ………………………………………………………………………………
   ………………………………………………………………………………
   d. The conclusion based on the result of the determination of relative viscosity number by Oswald methods are ………………………………….
   ………………………………………………………………………………
   ………………………………………………………………………………
   ………………………………………………………………………………

Assistant comment

Assistant signature

EXPERIMENT 2

VISCOSITY MEASUREMENT BY HOPPLER METHOD

E. Purpose

Measure relative viscosity number of various liquid by Hoppler method

F. Introduction

Dynamic viscosity number, η, of a liquid (equation 2) is defined by the force, G, which is required to move parallel layers of liquid both having the area A and separated by dy with the velocity dν with respect to each other.

$$G = \eta A \frac{d\nu}{dy}$$

………………………………………………………………...…(1)

or

$$\eta = \left(\frac{G}{A}\right)\frac{d\nu}{dy}$$

………………………………………………………………...…(2)

which η : dynamic viscosity number, G : friction force, A : layer area, dν : velocity different between two layers separated by dy, and dν/dy : velocity gradient. According to equation (2), the unit of dynamic velocity number is gram cm^{-1} s^{-1}. One method to measure dynamic viscosity number is Hoppler method.

According to Stokes Law, at the maximum velocity of ball, the equilibrium occur, so that the friction force = weight force (Archimedes force).

$$6\eta r V_{maks} = \frac{4}{3}\pi r^3(\rho_a - \rho_1)g$$

……………………………………………………….…(3)

$$\eta = \frac{\frac{2}{9}\pi r^2(\rho_a - \rho_1)g}{V_{maks}}$$

……………………………………………………….....(4)

Which: V_{max} = h/t, ρ_a = liquid viscosity, ρ_1 = ball density, and t = time of ball fall from the height, h.

This experiment use relative measurement to avoid the values of capillary diameter, gravitation, volume, that are difficult to be determined.

For water and substance X:

$$\eta_a = \frac{\frac{2}{9}\pi r^2(\rho_a - \rho_1)gt_a}{V_{\max}}$$

....(5)

$$\eta_a = \frac{\frac{2}{9}\pi r^2(\rho_x - \rho_1)gt_x}{V_{\max}}$$

....(6)

Hence:

$$\frac{\eta_x}{\eta_a} = \frac{(\rho_x - \rho_1)t_x}{(\rho_a - \rho_1)t_a}$$

....(7)

Equation (1) and (2) known as Hittorf`s Rules. Different color, in this experiment, can be used to distinct limitation moving by using particular metal that promote particular color in the reaction with certain anion or indicator using.

G. Experimental

1. Apparatus and Chemicals
   a. glass beaker
   b. picnometer
   c. analytical balance
   d. ball
   e. stopwatch
   f. distilled water
   g. alcohol
   h. acetone
   i. substance X
2. Procedure
   6) Determine the ball density and liquid viscosity.
   7) Drop the ball into water filled tube. Switch the stopwatch on when the ball at the upper sign and switch off when the ball at the bottom sign. Record the required time.
   8) Repeat step 2 for 3 times
   9) Repeat the experimental for alcohol, acetone and substance X

3. Calculation and Discussion

The viscosity of liquid, $\rho = \frac{mass}{volume}$

Dynamic viscosity number of substance is measured by comparing to the viscosity number of distilled water (equation 7). The viscosity numbers on various temperatures are listed in Table 1.

Table 1. Viscosity Numbers of Distilled Water on Various Temperatures

Temperature (^oC)	Viscosity number	Temperature (^oC)	Viscosity number	Temperature (^oC)	Viscosity number
25	0,8937	30	0,8007	35	0,7225
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27	0,8545	32	0,7679	37	0,6947
28	0,8360	33	0,7523	38	0,6814
29	0,8100	34	0,7371	39	0,6685

H. Questions

1. Pre Lab Questions
    a. What is the viscosity defined?
    b. Describe the various numbers of viscosities?
    c. How to determine the viscosity number? Explain!
2. Post Lab Questions
    a. How many methods to determine viscosity number? Explain!
    b. Explain the properties of liquid?
    c. Explain the method to determine velocity number!
    d. In this experiment, why relative viscosity number is determined, not absolute viscosity number?
    e. What factors affect the viscosity number?

WORKSHEET 2

VISCOSITY MEASUREMENT BY HOPPLER METHOD

Name : **……………………………..** **NIM** **…………………...**

Day & Date of Experiment : **…………………………………………………………….**

Assistant : **…………………………………………………………….**

3. Results

Mass of pycnometer : …………………. grams

Volume of pycnometer : …………………. mL

Viscosity of water : …………………. g/mL

Viscosity of alcohol : …………………. g/mL

Viscosity of acetone : …………………. g/mL

Viscosity of substance X : …………………. g/mL

No	Substance	Viscosity	Time (second)
1	Water	1 ……………………... 2 …………………….. 3 ……………………...	1 ……………………... 2 …………………….. 3 ……………………...
2	Alcohol	1 …………………….. 2 …………………….. 3 ……………………..	1 ……………………... 2 …………………….. 3 ……………………...
3	Acetone	1 …………………….. 2 …………………….. 3 ……………………..	1 ……………………... 2 …………………….. 3 ……………………...
4	X	1 …………………….. 2 …………………….. 3 ……………………..	1 ……………………... 2 …………………….. 3 ……………………...

4. **Discussion:**
   a. The viscosity number is……………………………………………………………….
      ………………………………………………………………………………………
      …
   b. The relative viscosity number could be determined by …………….…… methods,
      i.e.………………………………………………………………….………..…
      …....
      ………………………………………………………..……………………
   c. The factors on determination of relative viscosity number are …………………….
      ………………………………………………………………………………………
      …
      ………………………………………………………………………………………
      …
   d. The conclusion based on the result of the determination of relative viscosity number by Hoppler methods are ………………..…………………………………….
      ………………………………………………………………………………………
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      ………………………………………………………………………………………
      …
      ………………………………………………………………………………………
…

EXPERIMENT 3

DETERMINATION SURFACE TENSION BY DU NUOY METHOD

A. Purpose

Determine the surface tension of water/etanol mixture as function of the mixture ratio.

B. Theory

To create a surface requires work that changes the Gibbs energy of a thermodynamics system,

$$dG = -SdT + VdP + g\,dA \qquad (1)$$

where g is the surface tension, the free energy per unit surface area. Since a surface always involves two phases, the surface tension depends on the nature of the substances between which the surface is formed. If surface segregation of material occurs in a solution, then the surface tension of the solution may depend on concentration in complex way. Surface tension for liquids against liquid called interfacial tensions. Such interfacial tensions can be different from the surface tensions of liquids against air.

Surface tension produces several observable phenomena. The spreading of a film of oil on water is an example of the effect of surface tension (Fig.1). A molecule in a liquid is subject to force exerted by all molecules surrounding it

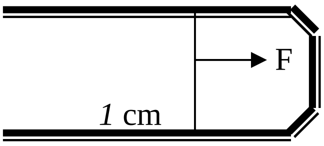


Fig.1

$$\gamma = \frac{F}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

F : Force (acts along the edge of length *l*)
l : tangential to the surface in order to maintain the liquid film

When an inner ring of radius r is used, the length of the edge is

$$l = 2.\, 2\pi r \quad \ldots\ldots(3)$$

so the force F is $4\pi r\gamma$ ……(4)

Using the du Nouy balance likes in Figure.2 inner ring is r and outer ring is R, arranged Eq.(4) in form Eq.(5)and Eq. (6)

Force of inner surface $= 2\pi r\gamma$ ……(5)

Force of outer surface $= 2\pi R\gamma$ ……(6)

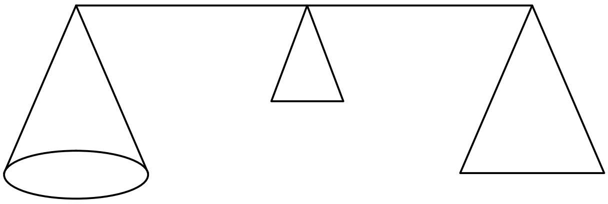


Figure 2. du Nouy balance

force of exerted (F) = m g ....(7)

Force of gravity $= 2 \pi r \gamma + 2 \pi R \gamma$ ....(8)

When the thickness ring is very thin, and $R = r$, so Eq (8) can be rewriten in Eq.(9)

Force of gravity $= 4 \pi R \gamma$..(9)

At the time the ring detached, an equilibrium occurs, the force of gravity balance with force of exerted such as Eq. (10)

$4 \pi R \gamma = m g$ ....(10)

The surface tension can be expressed by Eq.(11)

$$\gamma = \frac{mg}{4\pi R} \quad \text{..(11)}$$

C. Procedure

3. Apparatus and chemicals

a. Du Nouy balance	1 set
b. Volumetric flask	50 mL
c. Volumetric pipette	10 mL
d. Ethanol	
e. Distilled water	

4. Procedure

10) Make up the following mixtures as table 1

Table 1. The composition of ethanol/ water mixtures

Number of sample	Water (mL)	Etahanol (mL)
1	10	90
2	30	70
3	50	50
4	70	30
5	90	10

11) Fill the dish with the water

12) Measure the temperature of water
13) Place the platina ring on the surface of the water
14) Determine the magnitude of force required to release the ring from the surface of the liquid
15) Using the same method as above determine the surface tension of various ethanol water mixtures (Table. 1)

D. Question

a. Plot the surface tension of water/ethanol mixtures as function of ethanol concentration (unit of surface tension is Nm^{-1})
b. How are the relation between the pure liquid and its mixtures, make a conclusion
c. Compare the experimental results with the literature values

WORKSHEET 3

DETERMINATION SURFACE TENSION BY Du NUOY METHOD

Name : ....NIM ....

Day & Date of Experiment

Observation

No	Substance	F	R	γ
1	Water			
2	Ethanol			
3	Palm oil			
4	Hand wash			
5	detergent			

Discussion

EXPERIMENT 4

DETERMINATION SURFACE TENSION BY CAPYLLARY METHOD

D. Purpose

Determine the surface tension relative of pure liquids

E. Theory

To create a surface requires work that changes the Gibbs energy of a thermodynamics system,

$$dG = -SdT + VdP + g\, dA$$

(1)

where g is the surface tension, the free energy per unit surface area. Since a surface always involves two phases, the surface tension depends on the nature of the substances between which the surface is formed. If surface segregation of material occurs in a solution, then the surface tension of the solution may depend on concentration in complex way. Surface tension for liquids against liquid are called interfacial tensions. Such interfacial tensions can be different from the surface tensions of liquids against air.

Surface tension produces several observable phenomena. The rise of a liquid in a capillary is the result of surface tension. Consider the situation depicted in Fig.1, in which the end of a capillary tube of radius r, is immersed in a liquid. For sufficiently small capillaries, one observes a substantial rise of liquid to height h, in the capillary because of the force exerted on the liquid due the surface tension (γ) and the contact angle between the surface of the liquid and the surface of capillary tube is θ

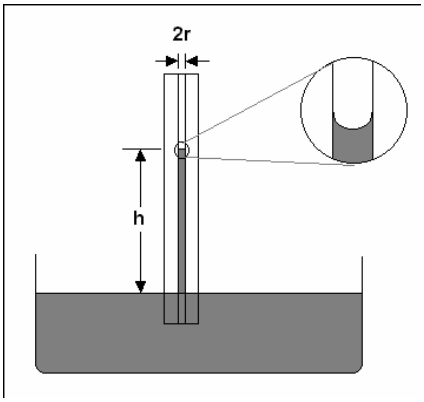


Figure.1 Capillary rise due to surface tension

The forcé of exerted = $2 \pi r \gamma \cos \theta$ ....(1)

The force of gravity = $\pi r^2 h \rho g$..(2)

ρ is the density of the liquid, g is the acceleration due to gravity

Equilibrium occurs when the force of gravity balance point can be used as a means to measure the surface tension

$2 \pi r \gamma \cos \theta = \pi r^2 h \rho g$ ....(3)

$\gamma = ½ r h \rho g / \cos \theta$ ....(4)

where the contact angle has been assumed to be 0^o , gives a simple expression for the surface tension

$$\gamma = ½ \, r \, h \, \rho \, g \text{ ....} (5)$$

If we know the surface tension of the water against air, we can determine the surface tension relative of others liquids such as methanol, ethanol, palm oil, etc. The surface tension of water is :

$$\gamma_a = ½ \, r \, h_a \, \rho_a \, g \text{ ....} (6)$$

and the surface tension of other liquid (example X) is

$$\gamma_X = ½ \, r \, h_X \, \rho_X \, g \text{..} (7)$$

arrangement eq (6) and (7) gives an expression of the surface tension of x :

$$\gamma_x = \frac{h_x \, \rho_x}{h_a \, \rho_a} \gamma_a \text{ ....} (8)$$

F. Procedure

5. Apparatus and Chemicals
   - a. Capillaries tube
   - b. Glass beaker 100 mL
   - c. Picnometer
   - d. Thermometer
   - e. distilled water
   - f. Methanol
   - g. Palm oil,
   - e. hand wash, dishwashing detergent
6. prosedure
   - 16) Determine the density of the liquid by picnometer.
   - 17) Add enough water to the beaker so that the bottom of the capillary can easily be immersed in it. Measure the water temperature
   - 18) Immerse the capillary to the beaker, record the height of the liquid in the capillary and in the beaker. The measurement technique is straightforward.
   - 19) The difference of these is the capillary rise. Each measurement should be made after the system is disturbed and allowed to return to equilibrium.
   - 20) Repeat the step 3 and 4 for 3 x
   - 21) Repeat this experiment with other liquids

D. Questions

1. Pre Lab Questions
   a. What is the surface tension defined?
   b. How to determine the surface tension relative ? Explain!
2. Post Lab Questions
   a. Explain the properties of liquid?
   b. Explain the method to determine !
   c. In this experiment, why we determine relative surface tension, not absolute surface tension ?
   d. What factors affect the surface tension?

WORKSHEET 4

DETERMINATION SURFACE TENSION BY CAPYLLARY METHOD

Name : ....NIM ....

Day & Date of Experiment

Observation

No	Substance	h	ρ	γ
1	Water			
2	Methanol			
3	Palm oil			
4	Hand wash			
5	detergent			

Discussion

EXPERIMENT 5

ADSORPTION

I. Purpose

Determine the type of isotherm adsorption and calculate the heat of adsorption

J. Theory

Adsorption, the binding of molecules or particles to a surface, must be distinguished from absorption, the filling of pores in a solid. The binding to the surface is usually weak and reversible. Just about anything including the fluid that dissolves or suspends the material of interest is bound. When a substance is attached to a surface is is called adsorption, is this case the substance is attached to the internal surface of adsorbent . When a substance is absorbed in a different medium it is called absorption. When a gas is taken in a solution it is called absorption.

Adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent, or metallic) of the constituent atoms of the material are filled by other atoms in the material. However, atoms on the surface of the adsorbent are not wholly surrounded by other adsorbent atoms and therefore can attract adsorbates. The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorption (characteristic of covalent bonding).

Physisorption, also called physical adsorption, is a process in which the electronic structure of the atom or molecule is barely perturbed upon adsorption. The weak bonding of physisorption is due to the induced dipole moment of a nonpolar adsorbate interacting with its own image charge in the polarizable solid.

Chemisorption is a classification of adsorption characterized by a strong interaction between an adsorbate and a substrate surface, as opposed to physisorption which is characterized by a weak Van der Waals force. The types of strong interactions include chemical bonds of the ionic or covalent variety, depending on the species involved. The activity level of adsorption is based on the concentration of substance in the water, the temperature and the nature of the substance.

Temperature effects on adsorption are profound, and measurements are usually at a constant temperature. Graphs of the data are called isotherms. The most common shape of the graph of amount adsorbed per unit weight of adsorbent versus the concentration in the fluid in equilibrium is typical Adsorption Isotherm. There are basically two well established types of adsorption isotherm: the Freundlich adsorption isotherm and the Langmuir adsorption isotherm. An adsorption isotherm is presented by a curve relating the concentration of a solute on the surface of an adsorbent, to the concentration of the solute in the liquid with which it is in contact.

The empirical equation proposed by Freundlich:

$N = K\,C^{a}$ ....(1)

$\text{Log } N = \log K + a \log C$...(2)

Where : N : weight adsorbed per unit weight of adsorbent
C : concentration in fluid
K and a : coefficients which are the value depends on adsorbent dan adsorbate

Langmuir derived a relationship for x and C based on some quite reasonable assumptions. These are: a uniform surface, a single layer of adsorbed material, and constant temperature. The rate of attachment to the surface should be proportional to a driving force times an area. The driving force is the concentration in the fluid, and the area is the amount of bare surface. If the fraction of covered surface is x/m , the rate per unit of surface is:

$$N = \frac{k_1 k_2 C}{1 + k_1 C} \qquad (3)$$

$$\frac{C}{N} = \frac{1}{kNm} + \frac{C}{Nm} \qquad (4)$$

N : weight adsorbed per unit weight of adsorbent
Nm : N for a complete monolayer
C : concentration in fluid
k : a coefficients

K. Procedure

1. Equipment

a.	Erlenmeyer Flask 100 mL	6
b.	Burette and utility clamp	
c.	Graduated cylinder 50 mL	1
d.	Volumetric flask 50 mL	2
e.	filter	

2. Chemicals
   - a. Acetic acid solution 0,3 M
   - b. NaOH solution 0,5 M
   - c. indicator phenolphtalien
   - d. charcoal
   - e. distilled water

3. Procedure
   - b. Prepare these solutions in the volumetric flasks:

No sample	Volume of acetic acid (mL)	Volume of distilled water (mL)
1	50	0
2	40	10

3	30	20
4	20	30
5	10	40

c. Determine the initial concentration of acetic acid in each sample by titrimetri method. Titrate two 5 mL of acetic acid solution with 0,5 M NaOH solution using phenolpthalien as an indicator.
d. Place 0,5 gram of charcoal into each of five erlenmeyer flasks. Add 30 mL of a different acetic acid solution to each flask. The flask should be tightly stoppered, then shaken periodically for 15 minutes, and allowed to equilibrate for overnight at room temperature.
e. After overnight, the equilibium of the sample is reached, the sample are filtered. Determine the final concentration of acetic acid in each sample by titrimetri method. Titrate two 5 mL aliquots of each sample with 0,5 M NaOH solution using phenolpthalien as an indicator.

D. Calculations

The number of moles of acid adsorbed onto the charcoal by substracting the final concentration from initial concentration, then multiplying by the solution volume and dividing by the charcoal weight (gram). Plot isotherms for room temperature, then determine whether a Freundlich (log N vx log C) or Langmuir (c/N vs C)

E. Quetions

1. Pre lab questions
   a. What is adsorbate and adsorbent use in this experiment ?
   b. What is the function of NaOH solution
   c. Describe the differences between adsorption and absorption?
   d. What factors affected the adsorption capacity ?

2. Post lab questions
   a. What is the adsorption definition ?
   b. Using the result, explain the differences between Freundlich and Langmuir isotherm adsorption
   c. Describe the adsorption capacity of charcoal

WORKSHEET 5

ADSORPTION

Nama : .... NIM ....

Date of experiment : ....

Assistant : ....

1. Result

No	V $_{\text{asetic acid}}$ (mL)	V$_{\text{water}}$ (mL)	V$_{\text{NaOH}}$ ((mL) Initial titration	[asam asetat]$_{\text{awal}}$ (M)	V$_{\text{NaOH}}$ (mL) Final titration	[asam asetat]$_{\text{final}}$ (M)
1	50	0				
2	40	10				
3	30	20				
4	20	30				
5	10	40				

2. Discussion

e. Definition of adsorption is...

....

....

f. The differences between Feundlich and Langmuir isotherm adsorption are……..

....

....

c. Description of Adsorption capacity is ……………………………………………

....

EXPERIMENT 6

DETERMINATION OF ACID DISSOCIATION CONSTANT

L. Purpose

Determine dissociation degree (α) and dissociation constant (K_d) of acetic acid

M. Introduction

Specific conductivity of solution (L_s) is the conductivity between two electrodes 1 cm^2 in area and 1 cm apart. The dimension of conductivity is $ohm^{-1}cm^{-1}$ (siemens). Conductivity could be measured by using conductometer.

Equivalent conductivity play an important rule on electrolyte solution. Equivalent conductivity is defined by the conductivity of 1 mol electrolyte solution between two electrodes 1 cm apart. The relation between equivalent conductivity and specific conductivity represent by the equation (1)

$$\Lambda_c = \frac{1000}{C} L_s \text{, ohm}^{-1}\text{ cm}^2\text{ mol ekivalen}^{-1} \quad \text{..(1)}$$

C = concentration of electrolyte (mol quivalent.liter^{-1})

L_s = specific conductivity ($ohm^{-1}cm^{-1}$ or siemens)

For a known L_s and concentration, Λ_c could be measured. Kohlousch`s Law obtain for dilute strong electrolyte solution.

$$\Lambda_c = \Lambda_0 - b\sqrt{C} \quad \text{...(2)}$$

Which:

Λ_c = equivalent conductivity at concentration C

Λ_0 = equivalent conductivity at infinite dilution

C = concentration

B = constant

By plotting graph Λ_c vs. $\sqrt{C}$, according to equation (2), Λ_0 determined by extrapolation and b as the slope.

Equation (2) could not obtain for weak electrolyte. On infinite dilution, weak electrolyte also completely ionizes and each ion move freely without being affected by opposite ion. In the other word, equivalent conductivity on infinite dilution equal to equivalent conductivity of its ions.

Hence:

$\Lambda_0 = l^o_+ + l^o_-$

……………………………………………..………….(3)

Which:

l^o_+ and l^o_- are equivalent conductivities of positive and negative ions

For acetic acid, arrangement of equation (3) yields

Λ_0 HAc $= l^o_+ + l^o_-$

………………………………..……………….(4)

Also represented by

Λ_0 HAc $= (l^o_{H^+} + l^o_{Cl^-})$ - $(l^o_{Na^+} + l^o_{Ac^-})$ - $(l^o_{Na^+} + l^o_{Cl^-})$

………………….……(5)

or

Λ_0 HAc $= \Lambda_0$ HCl $+ \Lambda_0$ NaAc $+ \Lambda_0$ NaCl

………………...………(6)

For weak electrolyte at every concentration:

$$\alpha = \frac{\Lambda_c}{\Lambda_o}$$

……………………………………………………………….(7)

which: α = dissociation degree.

The equilibrium in the solution is

$$\mathrm{HAc} \rightleftharpoons \mathrm{H^+} + \mathrm{Ac^-}$$

$$C(1-\alpha) \qquad\qquad C\alpha \qquad C\alpha$$

$$K_d = \frac{(C\alpha)(C\alpha)}{C(1-\alpha)} = \frac{C\alpha^2}{(1-\alpha)}$$

……………………………………...…(8)

Which: K_d = acetic acid dissociation constant

N. Experimental

1. Apparatus and Chemicals
    a. conductometer equipment
    b. glass beaker
    c. NaCl solution: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M
    d. HCl solution: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M

e. sodium acetate solution: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M

f. acetic acid solution: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M

g. distilled water

2. Procedure

   1) Rinse the electrode with distilled water.

   2) Determine specific conductivity of water by immerse the censor probe into the water. Use volumetric flash to contain the solution.

   3) Determine the specific conductivity NaCl solution on various concentrations: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M by using conductometer.

   4) Determine the specific conductivity HCl solution on various concentrations: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M by using conductometer.

   5) Determine the specific conductivity sodium acetate solution on various concentrations: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M by using conductometer.

   6) Determine the specific conductivity acetic acid solution on various concentrations: 0.1 M; 0.005 M; 0.0125 M and 0.00625 M by using conductometer.

O. Questions

a. Determine the equivalent conductivity for each compound (use equation 1)

b. For all compound, derive Λ_c to $\sqrt{C}$, so that Λ_o and b could be determined.

c. Determine the value of dissociation degree and dissociation constant for acetic acid.

WORKSHEET 6

DETERMINATION OF ACID DISSOCIATION CONSTANT

Name : .... NIM ....

Day & Date of Experiment : ....

Assistant : ....

5. Results

Compound	Specific conductivity				
NaCl	0.1 M	0.05 M	0.025 M	0.0125 M	0.00625 M
HCl					
Sodium acetate					
Acetic acid					

Λ_c NaCl = ……………………………………..

Λ_c HCl = ……………………………………..

Λ_c sodium acetate = ……………………………………..

Λ_c acetic acid = ……………………………………..

α CH_3COOH =……………………………………..

K_d = ……………………………………..

EXPERIMENT 8 AND 9

DECOMPOSITION REACTION OF HYDROGEN PEROXIDE

P. Purpose

Determine the order of decomposition reaction of hydrogen peroxide .

This experiment is involved two part. Part one, the student determine the purity of hydrogen peroxide used. And the second part, the student determine the order of decomposition reaction of hydrogen peroxide use the part one result.

Q. Theory

Much of the experimental aspect of chemical kinetics is concerned with the measurement of reaction rate. There are a couple of points worth making about this. First, the rate of a reaction is the change in the concentration or population of some reaction component with time.

$$rate = \frac{d[A]}{dt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

This is not always as straightforward as it sounds. First, how you define the rate may well depend on which reactant or product you are interested in. For example in the reaction A→ B the rate of the reaction could either be expressed in terms of the change in [A] with time or the change in [B] with respect to time. The two rates are just negative of one another:

$$\frac{d[A]}{at} = -\frac{d[B]}{dt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

The rate of a reaction can be expressed in a rate law, which shows how the rate at which products are formed depends upon the concentration of the reactants and the rate constant, k, such as : .

$$A \rightarrow produk$$

$$v = - \frac{d[A]}{dt} = k \; . \; [A]$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

For example the rate law for the reaction $2NO + 2H_2 \rightarrow N_2 + 2H_2O$ has been found experimentally to be:

$$\frac{d[H_2O]}{dt} = k[NO]^2[H_2] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

In this equation the power to which the concentration of a reactant is raised is the order of reaction with respect to that reactant; thus we say that the reaction is “1st order in hydrogen” and “2nd order in nitric oxide”. The overall order of the reaction is the sum of these coefficients, so this is a 3rd order reaction. The orders need not, and often do not, equal the stoichiometric coefficients in the overall equation, so the rate equation cannot be determined directly from the stoichiometric equation.

Equation (3) $-\frac{d[A]}{dt} = k \,.\, [A]$ may be rewritten in form Eq. (5) :

$$\frac{d[A]}{[A]} = -k.dt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

By Integration of the Eq.(3) : t as t_o (initial time) until t (time of reaction) and concentration [A] on t_o as [Ao] arranged the Eq (5) as

$$\ln\frac{[Ao]}{[A]} = k.(t-to) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

or $$\log\frac{[Ao]}{[A]} = \frac{k}{2{,}303}.(t-to) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

A Plot of the $\log\frac{[Ao]}{[A]}$ versus t is a straight line with a slope that gives the $\frac{k}{2{,}303}$ so the rate constant (k) can be calculated

R. Substances and apparatus

Apparatus

1. Erlenmeyer 250 mL 1
2. Erlenmeyer 100 mL 3
3. Graduate flask 10, 25 and 50 mL
4. burette
5. stopwatch
6. Measure flask 50 mL

Substances

1. Potassium Iodide solution 1M
2. Sulfuric acid solution 2 M
3. H_2O_2 3 % solution
4. $Na_2S_2O_3$ 0,5 N dan 0,1 N solution
5. Amilum indicator
6. Aquadest

Sebelum dan setelah digunakan semua alat harus dicuci dengan deterjen

D. Procedure

1. Determination of H_2O_2 concentration by Iodometry method

1. Add 1mL of KI solution 1 M and 15 mL H_2SO_4 1 M solution and 3 mL H_2O_2 solution 3 % on to an erlenmeyer 100 mL. Wait for 10 menits until a dark brown solution formed.
2. Then titrate the solution (1) with sodium tiosulphate 0,5 N solution until the color of solution change a brown pale and add an 1 mL amilum on to erlenmeyer (1), continue the titration until colorless solution formed. The total volume of $Na_2S_2O_3$ solution is V_o

3. Repeat this work

2. Determination the time of decomposition

1. Add a 15 mL H_2SO_4 1 M solution, 15 mL aquadest , 1 mL of KI 1 M solution and 5 mL amilum indicator
2. Add in to this erlenmeyer a 3 mL of H_2O_2 3 % solution. Measure this temperature of mixture and write the beginning time as a (t_0)
3. The add a 2 mL $Na_2S_2O_3$ 0,1 N solution. Observe till a blue solution appeared, and write this time of reaction as (t_1). Continue the addition of 2 mL $Na_2S_2O_3$ 0,1 N solution, write the time of reaction as t_2 at the color of solution become colorless. Wait several times until a blue color appear again, continue the addition of 2 mL of $Na_2S_2O_3$ 0,1 N solution. Write the each of $Na_2S_2O_3$ addition as t_3 , t_4 ……t_7

E. Calculation

1. Determination of H_2O_2 concentration

$$2\ H_3O^+ + 2\ I^- + H_2O_2 \rightleftharpoons 4\ H_2O + I_2$$

$$I_2 + 2\ S_2O_3^{-2} \rightarrow 2\ I^- + S_4O_6^{-2}$$

Normality is $H_2O_2 = (V\ S_2O_3^{-2} \ x\ N\ S_2O_3^{-2})/ 3\ N$ ………………………….…(11)

Molarity $H_2O_2 = ½ \ x\ N\ H_2O_2$ ………………………………………..……(12)

2. Kinetics of Reaction

V_o is total volume of tiosulfphate which is react with 3 mL H_2O_2 in step A. And V is volume of tiosulphate which is react with product Iodine , so $V_o - V$ is identic with volume of Iodine which is H_2O_2 react at t_n.

Then tabulate yaour data in this table

no	V mL	t_n det	$(V_o - V)$ mL	$V_o / (V_o - V)$	log $V_o / (V_o - V)$	$(t_n - t_o)$ detik

Make a curve between log $V_o / (V_o - V)$ versus $t = (t_n - t_o)$. If the curve is linear, so the orde of reaction is 1 to the H_2O_2

F. Questions

1. Write the reaction
2. Using the curve, determine the order of H_2O_2 decomposition
3. Using the curve, verified that $t_{1/2} = 0,693/ k$
4. Calculate the value of k

WORKSHEET 8 and 9

DECOMPOSITION REACTION OF HYDROGEN PEROXIDE

Name : ....NIM ....

Day & Date of Experiment : ....

Assistant : ....

1. Reaction of this experiment :

....

....

....

OBSERVATION DATA

A. Determination of H_2O_2 concentration

No Sampel	V thiosulphate (mL)	Average of V thiosulphate	Calculation
1			
2			
3			

V_o = mL

no	V mL	T_n det	$(V_o – V)$ mL	$V_o / (V_o – V)$	$\log V_o / (V_o – V)$	$(t_n - t_o)$ second
1						
2						
3						
4						
5						
6						
7						

.

Answer of question

………

2. Using the curve, the ore of reaction is……………………………………………………………
   The value of k : ……………………………………………………………

3. Verification that $t_{1/2} = 0,693/ k$

………

………

………

………

………

………

Plotting a curve between $\log V_o / (V_o – V)$ versus $t =(t_n- t_o)$.

EXPERIMENT 10

POLARIMETRY

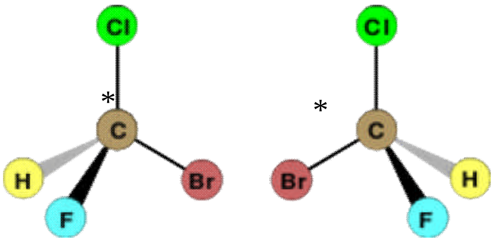
S. Purpose

Determine the concentration of optical activity solution with polarimeter

T. Theory

A monochromatic light is a transverse electrical and magnetic wave: the electric and magnetic fields are perpendicular to the direction of travel. If the electric field is confined to a single plane, the light is said to be linearly polarized. Polarized light is important in chemistry because some “optically active” compounds can rotate the plane of polarization of a linearly polarized beam. All chemicals also show these properties when placed in a strong magnetic field. These interactions of matter with polarized light can be used for analysis and especially for structure determination.

One of the physical properties of molecules that have asymmetric carbon atoms (like these four in the middle of glucose marked with *) is that the molecules will rotate the direction in which the light is vibrating as it passes through them. This property is called optical activity.



A simple polarimeter to measure this rotation consists of a long tube with flat glass ends, into which the sample is placed. At each end of the tube is a Nicol prism or other polarizer. Light is shone through the tube, and the prism at the other end, attached to an eye-piece, is rotated until all light is shut off. The angle of rotation is then read off of a scale. The specific rotation of the sample may then be calculated. Temperature can affect the rotation of light which should be accounted for in the calculations.

The rotation angle of polarization of the light (α) is :

$$\alpha = [\alpha]^{t}_{D}\, \ell\, d \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where α = rotation angle , $[\alpha]^{t}_{D}$ = specific rotation angle at t temperature and D sodium light source, ℓ = length of polarimeter tube, d = density of pure liquid, whereas the concentration of the solution is gram/ mL.

At the certain temperature, length of polarimeter tube and wave length, the Eq.(1) can be expressed in Equation. (2)

$$\alpha = k\, C,$$

where :

k is a constant depends on various factors besides the concentration. Plot the α to C, will obtain a straight line which is the standard curve. Using the standard curve and α of the sample can be determined the concentration of the sample.

1. Substances and equipment
   a. Beaker 100 cm^3
   b. Volumetric flask 50 cm^3
   c. Volumetric pipette 5 cm^3
   d. Polarimeter apparatus
   e. distilled water
   g. Various concentration of glucose solutions
2. Procedure
   a. Measure the the rotation angle polarization for pure water
   b. Measure the rotation angle of the polarization of each glucose standard solution
   c. Determine the rotation angle of the polarization of the sample solution
   d. Read of the rotation angle for three times

3. Calculation
   a. The angle of polarization readings should be corrected with the angle of water as a solvent so that $\alpha_s = \alpha_t - \alpha_{air}$, the αs are the real α, and α_t is readable, and α_{air} is α water as a solvent
   b. Make a graph of the C vs α_s
   c. Determine the concentration C of the α_s using the graph

WORKSHEET 10

POLARIMETRY

Nama : ....**NIM** ....

Date of experiment : ....

Assistant : ....

Observation

No	solution	Rotation Angle
1	Aquadest	
2	Sucrose 20%	
3	Sucrose 10%	
4	Sucrose 5%	
5	Sucrose 2,5%	
6	Sucrose 1,25%	
7	Sucrose x%	

Calculation

No	Solution	Angle corrected (α_s)
1	Aquadest	
2	Sucrose 20%	
3	Sucrose 10%	
4	Sucrose 5%	
5	Sucrose 2,5%	
6	Sucrose 1,25%	
7	Sucrose x%	

a. Plot curve α_s versus C

Equation :

The concentration of Sucrose x% solution = ……………….

b. We can Conclude that

....

....

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