

# Acetic acid in different type of vinegar brands



**ASSIGN  
BUSTER**

Despite the vast research regarding rusting, still many people do not recognize the harmful effect it can to environment and to take precaution measure to avoid or prevent rusting. Results of study show U. S. had to spend total \$276 billion, approximately 3. 1% of the nation's Gross Domestic Product (GDP) for corrosion direct cost. Therefore, these study is to find optional of artificial way to remove rusting from any other metal.

For my research, I choose vinegar as a substance that has the potential to remove the rust stain from metal due to presence of acid in its content.

Vinegar is easy to be obtained and usually use as households. I choose three different types of vinegar brands and analyzed its percentage by mass of acetic acid using acid-base titration technique. Then, I test the strength of each vinegar on rate of removing rust on rusted iron nail by removing the rust form. After that, I compare which vinegar has the highest rate of removing rust compared to its percentage by mass of acetic acid.

As the result, I found out that different type of vinegar has different percentage by mass of acetic acid. But my experiment shows that, the higher percentage of acetic mass in the vinegar content, does not always lead to high rate of rust stain removal. These maybe due to my limitation of the research because I assumed that only acetic acid in vinegar reacts with the iron(III) oxide.

Still, my research able to prove that vinegar can act as a potential rust stain remover but in low degree because acetic acid is weak acid. My research could help and provide people an easy way to remove rust from their accessories as vinegar could be easily obtained.

290 words

## 1. Introduction

Vinegar can be define as “ a sour liquid obtained by result through acetic fermentation of dilute alcoholic liquids and used as a condiment or preservative.” Aside from utilized widely, vinegar also can accommodate more than one purpose which usually used to enhance food taste. Vinegar is made through two stage of biological processes. These distinct process resulted from the action of innocuous microorganisms. In these process, yeast and “ Acetobacter” is used to convert sugars (carbohydrates) into acetic acid. The first stage of process is called alcoholic fermentation. It occurs when yeasts convert natural sugars to alcohol under controlled conditions. In the second stage of process, “ Acetobacter” which is a group of bacteria, changes the alcohol resulted from alcoholic fermentation to acid. This is the acid fermentation that forms vinegar. Since vinegar can be made from anything with sugar, there are probably too many variants to count made in countries throughout the world.[1](Kellen, 2005, Vinegar Institute Site)

Rust is define as the red or orange coating that forms on the surface of iron when exposed to air and moisture surroundings, consisting mass of ferric hydroxide. These ferric oxide is formed through oxidation. Rust forms due to the reaction of oxygen dissolved in dihydrogen monoxide(water) with iron. Rust also can be known or called as corrosion of metal.[2] (Holleman, Wiberg, 2001 “ Inorganic Chemistry” Academic Press: San Diego)

Rust is a general term to describe several different oxides that formed when an iron undergo corrosion. Some of the oxides are  $\text{Fe}(\text{OH})_2$ ,  $\text{Fe}(\text{OH})_3$ ,  $\text{FeO}(\text{OH})$ , and  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ . The prevalent rust that can be found is a reddish-brown,  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ . The oxygen in the air dissolve in water and promote the rust to start to compose. The rust also can be determine as an electrochemical process. The process of exchange of electrons (electricity) is conducted by chemical reactions in part of the electrical circuit. The surface of metal that exposed to electrolyte will undergo series of chemical reactions. Oxidation reactions (corrosion) occur at the surface of the anode while reduction reactions occur at the surface of the cathode.[3] (Jones, Denny (1996) Principles and Prevention of Corrosion.)

By observation, we could described that rust occurs very easily because the presence of air and water or wet condition virtually presence anywhere. We could see around ourselves rusting is occur greatly. Rust changes steel into a different material, one that is impuissant or weaker than the original steel. Rusting is a immensely colossal problem because so many things people use every day are made out of steel, like cars, bicycles, trucks, bridges, roofs, holding tanks, machinery, nuts, and bolts. When these objects are unprotected and exposed to water, they rust, and this damage can costs a lot of money. Rust also dangerous to human because a rusting iron nail can cause health issue such as tetanus if the iron nail pierce to human skin. Yet steel perpetuates to be widely used because it has an excellent strength-to-weight ratio. Also known as the best of all the common building materials. In addition, it is non-flammable, resistant to mold and termites, does not expand or contract under temperature changes, and can be made with a

consistent quality.[4] (Miller, L. (2003, July 31). Corrosion). Therefore, we must take alert and precaution about rusting of these iron metal.

The topic that be investigated in this extended essay is about rusting or corrosion and the way to prevent rust. Thus, my research question is to analyse the percentage by mass of acetic acid in different type of vinegar brands by using titration method and to investigate the potential of vinegar as rust stain remover. Therefore, my extended essay required two experimental procedures. My hypothesis for first experiment is that different types of vinegars have different percentage by mass of acetic acid. If the result of experiment one parallel with my hypothesis, second experiment could be carried out which is to investigate the potential of vinegar as rust stain remover. My hypothesis for second experiment is that the higher the percentage by mass of acetic acid in vinegar, the more efficient the vinegar to act as rust stain remover.

The significant of my research is to investigate a cheapest and easiest way to remove rust. In this research, I choose vinegar as the potential method to remove stain rust because vinegar contain acetic acid . Vinegar could be easily found and present almost in every living house. Because acid is corrosive, it occur to me that the acid could corrode the rust stain from metal. To test the validity of my statement, a research and experimental procedure is carried out to justify the validity of my research question. The chosen area of study is rusting since my experiment focus more on rusting.

These experiments included several methods such as acid - base titration. Vinegar is acidic. Therefore, it will be titrated with base solutions, sodium

hydroxide. The titration method is carried out to find the volume of base needed to neutralize the acid solution of vinegar. These method is essential for the experiment to find the percentage by mass of acetic acid in vinegar. Second method is rusting of iron nail. I could not choose any random iron nail to conduct my experiment because the result will not be accurate and precise as they could have different degree of rusting. Therefore, I buy iron nails that not rusted yet and undergo experimental procedure for the iron nails to rust under constant condition. These method needed to carry out so that the iron nails undergo rusting in constant activity. Then, the iron nails could be tested with the vinegar.

In my experiment, I used some instrument from the chemistry laboratory. The instruments I used is pH meter. The pH meter is used to find the pH of different type of vinegar. I also use burette which is necessary for the titration method. The burette is used to find the volume of base needed to neutralise the acidic solution. I also used electronic balance to weigh the iron nails initial mass before in undergo rusting and the final mass after the iron nails undergo rusting. Stopwatch is used to record the time taken for the acid to remove the rust stain.

\*Due to some error, all the pictures for the experiment have loss.

## **2. Methodology :**

### **2.1 Variables and method of controlling variables**

#### **Variable type**

#### **Variable**

#### **Method of controlling**

Independent

Different type of vinegar brands

By using vinegar of different brands for the experiment.

Dependent

Volume of sodium hydroxide needed to neutralize acid solution

By measured the volume of sodium hydroxide needed to neutralize acid solution using burette.

Controlled

Volume of vinegar used

Fixed the amount of vinegar is used for the experiment which is 2.0 ml.

temperature

The experiment is conducted in same room

Volume of distilled water added

Fixed the amount of volume distilled water added in the vinegar.

Add phenolphthalein

By adding 3 drops phenolphthalein to every vinegar solution in conical flask during experiment.

Concentration of sodium hydroxide

By fixed the concentration of sodium hydroxide used which is 1.0 M.

Table 1 : Variables for experiment to determine the percentage by mass of acetic acid in vinegars

## **Variable type**

### **Variable**

### **Method of controlling**

Independent

Type of vinegar used

By using vinegar of different brands for the experiment.

Dependent

Time taken to remove the rust stain

By recorded the time taken for different type of vinegars to remove the rust stain on the iron nail using stop watch.

Controlled

Type of metal



By using the same metal throughout the experiment which is iron nail.

Temperature

The experiment is conducted in same room

Using same electronic balance

By using the same electronic balance to weigh the mass of iron nail.

Time for iron to rust

Fixed the time for the iron to rust which is 7 days or i week

Using same stopwatch

By fixed the type of stopwatch used to record the time taken.

Table 2 : Variables for experiment to determine the time taken for the vinegars to remove rust

## **2. 2 Methodology for neutralisation process**

To find the percentage by of acetic acid in different types of vinegar brands, a neutralisation process follow the standard procedure is carries out. First , the apparatus is set up . The burette is clamped on the retort stand. Then, 2. 0 ml of vinegar is measured using measuring cylinder. An empty conical flask is weighed. Then 2. 0 ml vinegar which is Earth Brand is poured in the conical flask. The conical flask is weighed again. This procedure has to be carried out to find the mass of 2. 0 ml of vinegar assumed that different vinegars has different density. After that, 48. 0 ml of distilled water is measured using measuring cylinder. Then, the distilled water is mixed with <https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

the vinegar in the conical flask. This procedure has to be carried out because vinegar is very concentrated so dilution process has to be done. The pH meter is used to find the pH value of vinegars.

After mixed, the initial weight of vinegar with conical flask is measured using weighing balance. Then, sodium hydroxide is filled in the burette. The conical flask is placed under the burette. 3 drops of phenolphthalein is added into the diluted vinegar.

The neutralisation process is started as soon the alkali is added into the conical flask.

The sodium hydroxide is assumed to only react with the acetic acid presence in the vinegar. The conical flask is swirled gently. The initial colour for the acidic solution is colourless. As the acid solution undergo titration, the colour change from colourless to pale pink colour. The end of titration is indicated when the mixture remains in pale pink colour. The titration process is stopped.

The volume of sodium hydroxide needed to neutralise 2.0 ml of vinegar is recorded and final weight of vinegar with conical flask is weighed. The experiment above is repeated twice to get the average reading of volume of sodium hydroxide needed to neutralise the acid solution. All the data is recorded in the table. The experiment procedure above is then repeated using different type of vinegar which is Yeo's and Jalen.

Burette,  $\pm 0.05 \text{ cm}^3$

Different vinegar brands (Jalen, Yeo's, Earth Brand)

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

Beaker,  $\pm 0.5$

Conical flask,  $\pm 0.5$

Retort stand and clamp

Pipette and pH meter

Phenolphthalein

Weighing balance,  $\pm 0.0001$

Sodium hydroxide (1.0 molar)

Rod and distilled water

### **2.3 Methodology for rusting process and rust stain removal**

This experimental procedure is carried out because it is hard to determine the degree of rusting of any random metal. Therefore, I fixed the type of metal used which is iron nails and the time left for iron to rust which is approximately 7 days (1 week).

The materials are ready and apparatus needed is set up. The initial mass of each iron nail is weighed and the data is recorded. The 5 iron nails are marked such as iron nail A, iron nail B and consecutively by using a small piece of paper attached to each nail. Then, a mineral bottle is cut to get the bottom part of mineral bottle and form a cup like. Then, the cup is filled with small amount of tap water. All iron nails are dipped in the water and left to be exposed to air in the laboratory for seven days.

After seven days , all iron nails are take out from the bottle. Then, each iron nail which already rusted now is weighed again to get mass of rust with the iron nail. The mass of rust formed on each iron nail is found by subtracted the final weight of iron nail with its initial weigh. Then, the average mass of rust formed is calculated. All the data of the experiment is recorded in a table. The experiment above is repeated twice.

The process to remove rust stain is carried out. Vinegar is inserted into a transparent cup. The rusted iron nail is immersed into the cup contained vinegar. The reaction is observed. The time taken for the iron rust to be remove completely by the vinegar from the iron nail is recorded by using stopwatch. The same procedure done to all 5 iron nails . The average time taken needed to remove the rust is calculated. The data and result is tabulated. The experiment above is repeated using different type of vinegars.

### **list of apparatus and materials**

Burette,  $\pm 0.05 \text{ cm}^3$

Beaker,  $\pm 0.5$

Bottle cup

Different vinegar brands (Jalen, Yeo's, Earth Brand)

Conical flask , $\pm 0.5$

Measuring cylinder,  $\pm 0.05$

Weighing balance ,  $\pm 0.0001$

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

5 Iron nails

Distilled water

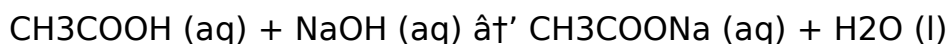
### 3. Data collection and processing

#### Qualitative data

The initial colour of vinegar and sodium hydroxide is colourless. The colour of vinegar solution remains colourless even after phenolphthalein is added.

When the mixture undergo titration process, the mixture remains colourless but when the end point of titration reach, the colour of mixture turns from colourless to pale pink.

Equation for the neutralization process =



### Calculation of percentage by mass of acetic acid in vinegars.

#### 1. Earth Brand

#### Calculate number of moles for NaOH

$$= \frac{MV}{1000}$$

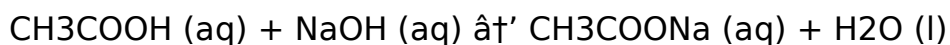
$$= \frac{32.54 \times 1.0}{1000}$$

$$(32.54 \text{ ml of NaOH solution added} \times 1.0 \text{ molar of NaOH})$$

$$= \frac{32.54}{1000}$$

$$= 0.03254 \text{ moles of NaOH}$$

$$\text{uncertainties} = \left( \frac{0.05}{32.54} \right) \times 100\% = 0.15\%$$



From the equation, the acetic acid in vinegar reacts with sodium hydroxide in a 1: 1 ratio.

1 mole of acetic acid reacts with 1 mole of sodium hydroxide to form 1 mole of sodium acetate and 1 mole of water. Thus, 0.03254 mole of acetic acid reacts with 0.03254 mole of sodium hydroxide to form 0.03254 mole of sodium acetate and 0.03254 mole of water.

### **Calculate the amount of acetic acid in Earth Brand.**

Element

Symbol

Atomic mass

Carbon

C

12.0107

Hydrogen

H

1.00794

Oxygen

O

15. 9994

To find the molar mass for acetic acid, CH<sub>3</sub>COOH

Table 5: Shows the element and its atomic mass[4]

Therefore, Molecular mass calculation:

$$12.0107 + 1.00794 \times 3 + 12.0107 + 15.9994 + 15.9994 + 1.00794$$

$$= \mathbf{60.05196 \text{ g/mol}}$$

To find the mass of acetic acid in vinegar is given by the formula

number of mole x molar mass of acetic acid

$$\text{Thus, } 0.03254 \text{ moles} \times 60.05196 \text{ g/mol} = 1.954 \text{ g of acetic acid} \pm 0.15 \%$$

### **To calculate the percentage by mass of acetic acid in vinegar (Earth Brand):**

Mass of vinegar use = 2.2837 g

$$\text{uncertainties} = (0.0001/2.2837) \times 100\% = 0.0044 \%$$

mass of acetic acid in vinegar = 1.9540 g

The percentage by mass of acetic acid

$$= (1.9540/2.2837) \times 100 = 85.56 \%$$

$$\text{uncertainties} = 0.0044 + 0.15 = 0.1544 \%$$

Therefore, the percentage by mass of acetic acid in Earth Brand is

= 85.56 % ± 0.15 %

The method of calculation of percentage by mass of acetic acid for other vinegars is same with the calculation above. Therefore, the result for the calculation is tabulated.

Type of vinegar brands

Mass of vinegar of 2.0 ml (g)

Mass of acetic acid in vinegar (g)

Mole of acetic acid

Percentage by mass of acetic acid (%)

Uncertainties

**(%)**

Earth brand

2.2837

1.9540

0.03254

85.56

0.15

Yeo's



2. 0402

1. 7073

0. 02843

83. 68

0. 18

Jalen

2. 0626

1. 9018

0. 03167

92. 20

0. 16

Table 6 : Result of the calculation for experiment one

## **Discussion**

The 2. 0 volume for vinegar used needed to be weighed to find the mass of vinegar as I assumed the density for vinegar is different from density of water. From the result, it shows that different vinegars has different density, therefore different vinegars will have different mass of 2. 00 volume used.

I also assumed that during neutralisation process, the sodium hydroxide will only reacts with the acetic acid presence in the vinegar. Based on the result ,

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

it shows that different type of vinegar brands has different percentage by mass of acetic acid of vinegar of different brands. Jalen has the highest percentage by mass of acetic acid followed by Earth Brand and Yeo's. These explained that why different vinegars have different ph value. Acetic acid is weak acid. The higher the percentage by mass of acetic acid, the lower the pH value of the vinegar.

Hypothesis for experiment one is accepted. Different type of vinegar has different percentage of acetic acid of vinegar. Thus, experiment two can be conducted.

### **3. 2 Data collection and processing for experiment 2**

#### **Quantitative data**

##### **Earth Brand**

Type of metal

Nail

Initial weight of iron nail before rusting process(g)

$\pm 0.0001$

Final weight of iron nail after rusting process (g)

$\pm 0.0001$

Mass of rust produced on iron nail (g)

$\pm 0.0002$

Time taken for rust stain on iron nail to be remove by vinegar (s)

$\pm 0.01$

Iron nail

A

7.3261

8.7281

1.4020

273.51

B

7.3233

8.7453

1.4220

287.43

C

7.3236

8.7547

1.4311

306. 35

D

7. 3241

8. 7281

1. 4040

280. 38

E

7. 3233

8. 7505

1. 4272

295. 73

Average time taken for the rust stain to be removed by vinegar

288. 68

Table 7: Result for experiment two showing average time taken to remove rust stain

using Earth Brand

Type of metal

Trial

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

Initial weight of iron nail before rusting process(g)

$\pm 0.0001$

Weight of iron nail after rust stain is remove by vinegar (g)

$\pm 0.0001$

Amount of removed iron (g)

$\pm 0.0002$

Iron nail

A

7.3261

6.7987

0.5274

B

7.3233

6.7894

0.5339

C

7.3236

6. 7734

0. 5502

D

7. 3241

6. 7842

0. 5399

E

7. 3233

6. 7661

0. 5572

Table 8: Table show the amount of iron that formed the rust

### **Yeo's**

Type of metal

Nail

Initial weight of iron nail before rusting process(g)

±0. 0001

Final weight of iron nail after rusting process (g)

±0. 0001

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

Mass of rust produced on iron nail (g)

$\pm 0.0002$

Time taken for rust stain on iron nail to be removed by vinegar (s)

$\pm 0.01$

Iron nail

A

7.3267

8.7799

1.4532

363.61

B

7.3248

8.7237

1.3989

309.35

C

7.3253

8. 7673

1. 4420

343. 31

D

7. 3301

8. 7776

1. 4475

344. 63

E

7. 3277

8. 7500

1. 4223

323. 97

Average time taken for the rust stain to be removed by vinegar

336. 87

Table 9: Result for experiment two showing average time taken to remove rust stain using

Yeo's

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>



Type of metal

Trial

Initial weight of iron nail before rusting process(g)

$\pm 0.0001$

Weight of iron nail after rust stain is remove by vinegar (g)

$\pm 0.0001$

Amount of removed iron (g)

$\pm 0.0002$

Iron nail

A

7.3267

6.7932

0.5335

B

7.3248

6.8355

0.4893

C

7. 3253

6. 7821

0. 5432

D

7. 3301

6. 7728

0. 5573

E

7. 3277

6. 8172

0. 5105

Table 10: Table show the amount of iron that formed the rust

## **Jalen**

Type of metal

Nail

Initial weight of iron nail before rusting process(g)

$\pm 0.0001$

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

Final weight of iron nail after rusting process (g)

$\pm 0.0001$

Mass of rust produced on iron nail (g)

$\pm 0.0002$

Time taken for rust stain on iron nail to be removed by vinegar (s)

$\pm 0.01$

Iron nail

A

7.3241

8.7523

1.4282

323.09

B

7.3213

8.7400

1.4187

316.75

C

7. 3280

8. 7484

1. 4204

321. 19

D

7. 3223

8. 7691

1. 4468

342. 11

E

7. 3310

8. 7748

1. 4438

341. 28

Average time taken for the rust stain to be remove by vinegar

328. 96

Table 11: Result for experiment two showing average time taken to remove rust stain using

Jalen

Type of metal

Trial

Initial weight of iron nail before rusting process(g)

$\pm 0.0001$

Weight of iron nail after rust stain is remove by vinegar (g)

$\pm 0.0001$

Amount of removed iron (g)

$\pm 0.0002$

Iron nail

A

7.3241

6.7767

0.5474

B

7.3213

6. 7852

0. 5361

C

7. 3280

6. 7883

0. 5397

D

7. 3223

6. 7450

0. 5773

E

7. 3310

6. 7957

0. 5353

Table 12: Table show the amount of iron that formed the rust

### **Quantitative data**

The iron nail pale brown in colour while the tap water and the vinegar is colourless.

When the iron nail is left in the bottle cup, there is no immediate reaction occurred.

After several hours, a reddish brown substance start to appear around the iron nail.

After several days more reddish brown substance deposited around the iron nail like coated it.

When the iron is immersed in vinegar inside a cup bottle, bubble formed and the reddish brown substance fall off from the iron nail.

The colour of vinegar turned slightly from colourless to pale reddish and the reddish substances settle at the bottom of the cup bottle. Later, it dissolve in the vinegar.

#### 4. Processed result

Type of metal

Vinegar Brand

Trial

Percentage by mass of acetic acid in vinegar (2. 00 ml of vinegar) (%)

Uncertainties

**(%)**

Mass of rust produce on iron nail (g)

$\pm 0.0001$

<https://assignbuster.com/acetic-acid-in-different-type-of-vinegar-brands/>

Time taken to remove rust stain (s)  $\pm 0.01$

Rate of rust stain remover

(g/s)

Iron nail

Earth

Brand

A

85.56

0.0108

1.4020

273.51

0.0051

B

0.0105

1.4220

287.43

0.0049



C

0. 0103

1. 4311

306. 35

0. 0047

D

0. 0107

1. 4040

280. 38

0. 0050

E

0. 0104

1. 4272

295. 73

0. 0048

### **Average rate of rust stain remove**

**0. 0049**

Type of metal

Vinegar Brand

Trial

Percentage by mass of acetic acid in vinegar (2.00 ml of vinegar) (%)

Uncertainties

(%)

Mass of rust produce on iron nail (g) $\pm$ 0.0001

Time taken to remove rust stain (s) $\pm$ 0.01

Rate of rust stain remover

(g/s)

Iron nail

Yeo's

A

83.68

0.0096

1.4532

363.61

0.0040

B

0. 0104

1. 3989

309. 35

0. 0045

C

0. 0098

1. 4420

343. 31

0. 0042

D

0. 0098

1. 4475

344. 63

0. 0042

E

0. 0101

1. 4223

323. 97

0. 0044

## **Average rate of rust stain remove**

**0. 0043**

Type of metal

Vinegar Brand

Trial

Percentage by mass of acetic acid in vinegar (2. 00 ml of vinegar) (%)

Uncertainties

**(%)**

Mass of rust produce on iron nail (g) $\pm$ 0. 0001

Time taken to remove rust stain (s) $\pm$ 0. 01

Rate of rust stain remover

(g/s)

Iron nail

Jalen

A

92. 20

0. 0101

1. 4282

323. 09

0. 0044

B

0. 0074

1. 4187

316. 75

0. 0045

C

0. 0102

1. 4204

321. 19

0. 0044

D

0. 0098

1. 4468

342. 11

0. 0042

E

0. 0099

1. 4438

341. 28

0. 0043

### **Average rate of rust stain remove**

**0. 0044**

Table 13: The overall result for the experiment and the rate of rust stain removal

### **Discussion**

To put in a simple words, rusting is the corrosion of iron and readily occurs in the metal in the presence of water , oxygen and iron. The formation of a reddish brown substance like which appeared and adheres to the iron nail is called rust. Based on the research, it shows that vinegar could serve as one of the substance that can remove rust stain on metal due to the presence of acid. From the experiment , It clearly shows that different vinegar has different degree of removing the rust stain because due to different percentage by mass of acetic acid in the different type of vinegars.

After rusting process occurs on the iron nail, the iron nail weighed more. This is because rust forms when iron metal is oxidized by oxygen in the presence of water. Iron oxide is another term for rust. Iron oxide as a molecule and consist of three elements which is of iron with oxygen and water. From the result obtained based on the experiment, it shows that the rust form is originally mass from the iron but the mass of oxygen and water comes from the atmosphere. When the rust form on the iron nail, the mass of iron rust increased by the mass of oxygen and water that combined with the iron. Therefore, iron nail weight more after rusting process occurs due to addition of these elements from atmosphere.

In the presence of oxygen and water,

Reduction half equation:  $4e^- + 2H_2O(l) + O_2(g) \rightarrow 4OH^-(aq)$

The tip or the head component of iron nail is easily oxidised. The crystal lattice of iron is distorted and the iron atoms will be facilely oxidised.

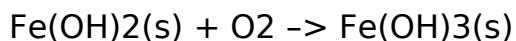
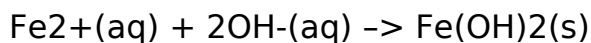
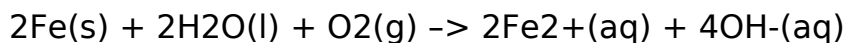
Oxidation half equation:  $2Fe(s) \rightarrow 2Fe^{2+}(aq) + 4e^-$

Therefore the overall net equation for the chemical reaction is

$2Fe(s) + 2H_2O(l) + O_2(g) \rightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$

The process continue. After that, the  $Fe^{2+}$  and  $OH^-$  ions will move and diffuse through the water. When both ions meet they will react to produce precipitate which iron (II) hydroxide,  $Fe(OH)_2$ . These iron (II) hydroxide then will be further oxidise to iron (III) hydroxide,  $Fe(OH)_3$  and will be dehydrated to produce rust.

Chemical equation for rusting process :



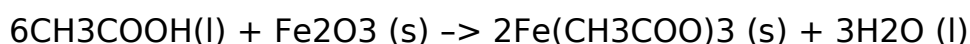
$\text{Fe(OH)}_3\text{(s)}$  - dehydrates  $\rightarrow \text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O(s)}$  or rust

Therefore, the chemical formula for rust is  $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O(s)}$  [5]

(Loh Wai Leng, Tan Yin Toon, Tan On Tin, 2011, oxidation and reduction)

Acetic acid is a weak acid that presence in vinegar. Vinegar works well than other strong acid because the presence of weak acid. Therefore, it will less attack the iron nail itself. Strong acid will corrode both the rust stain and the iron nail. To prevent that, substance with weak acid is preferable. When the iron nail with rust is soaked into the vinegar containing acid, the rust on iron nail will dissolve and loosen. The crumbly hydrated iron oxide will form a soluble salt, in these reaction between acetic acid and iron(III) oxide, it will formed iron acetate.

Equation of reaction between acetic acid and rust:



and ferric acetate,  $\text{Fe(CH}_3\text{COO)}_3$  is water soluble.

However, the hypothesis for my second experiment is rejected. Clearly from the experiment above, it shows there is no directly proportional rela