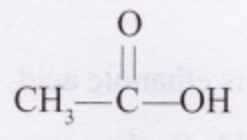
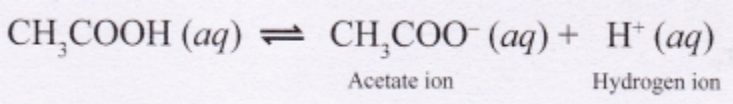
Properties of Acetic Acid

Introduction

> Acetic acid is a member of carboxylic acid group and it's IUPAC name is ethanoic acid.



> Acidic property of CH3COOH is due to its ability to produce hydrogen ions (H^+) in water.



> The members of the homologous series of the carboxylic acids are found in fruits and in vinegar.
> It belongs to a functional group -COOH.
> Acetic acid is a monocarboxylic acid as it contains only one —COOH group.
> The oxidation of ethanol to ethanoic acid turns alcoholic drinks sour when exposed to air.
> Ethanol + Oxygen —> Ethanoic acid + Water
> This reaction occurs if wine, beer or cider is left out open to the air, it eventually becomes vinegar, not fit for drinking but it is very nice in salad dressing.
> Acetic acid is a weak acid and it ionizes only partially.
> Acetic acid is completely miscible in water to form homogeneous solution.
> In the chemical industry, ethanoic acid can be manufactured on a large scale by oxidising the alcohol named ethanol.

Uses of (carboxylic acids). Acetic acid:

> 5-8% solution of acetic acid in water is called vinegar.
> It is used as a food preservative and in food flavourings.
> Acetic acid is used as coagulant in the manufacture of rubber.
> It is used in the manufacture of various dye stuffs and perfumes.
> It is used in the manufacture of rayon fibre.
> It is used as a solvent.

EXPERIMENT – 5

Aim

To study the following properties of acetic acid (ethanoic acid):
(i) odour (smell)

(ii) solubility in water
(iii) effect on litmus
(iv) reaction with sodium bicarbonate

Theory

Acetic Acid

> The chemical name and formula of acetic acid is ethanoic acid, CH_3COOH.
> The functional group — COOH group is responsible for the properties of acetic acid. —COOH is called carboxyl group.
> It is also called glacial acetic acid, because it freezes at 16.6°C.
> Acetic acid is soluble in water.
> It has vinegar like smell.
> It dissociates in water to form CH_3COO and H+ ions. The dissociation is partial and hence it is called weak acid.
> It turns blue litmus red.
> It reacts with sodium bicarbonate to liberate CO_2 gas.

$$\underset{\text{Sodium bicarbonate}}{NaHCO_3(s)} + \underset{\text{Acetic acid}}{CH_3COOH(l)} \longrightarrow \underset{\text{Sodium acetate}}{CH_3COONa(aq)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

> Acetic acid reacts with alcohol to form ester. This reaction is called esterification. Esters have fruity smell.

$$\underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Ethyl alcohol}}{C_2H_5OH} \longrightarrow \underset{\text{Ethyl acetate (Ester)}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

Materials Required

Test tubes, water, litmus paper, test tube stand, a dropper, a beaker, a cork fit in a test tube with bent tube fixed in it.
Chemicals Required: Acetic acid (ethanoic acid), Distilled water, Sodium bicarbonate and Freshly prepared lime water.

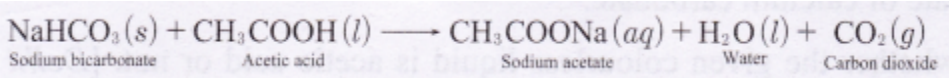
Procedure

1. Dilute the given acetic acid with distilled water in a beaker.
2. Pour 5 ml of acetic acid in a test tube and perform the following tests:

S.No.	Test	Experiment	Observation	Inference
1.	Odour	Take 5 mL of acetic acid in a test tube and smell it by wafting.	It has a peculiar pungent smell, (vinegar like smell)	Acetic acid has a vinegar like smell.

2.	Solubility in water	Take 2 mL of acetic acid in a test tube, add 10-15 mL of water and shake.	It dissolves in water to form homogeneous solution.	Acetic acid is soluble in water in all proportions.
3.	Effect on Litmus	Use clean dropper and pour 1-2 drops of acetic acid on blue-litmus paper.	Blue litmus paper turns red.	Acetic acid turns blue litmus red.
4.	Sodium bicarbonate	Take a pinch of sodium bicarbonate in a clean test tube and add 1 mL of dilute acetic acid in the test tube.	Reaction begins, brisk effervescence is seen, a colourless gas is evolved.	Acetic acid and sodium bicarbonate react to liberate CO2 gas.
		Fix a cork with bent delivery tube in the mouth of above test tube. Dip the other end of delivery tube to a test tube containing lime water.	The gas turns lime water milky.	CO2 gas evolved above reacts with calcium hydroxide to form calcium carbonate which is insoluble in water. Ca(OH)2 + CO2 —> CaCO3 + H20 (White precipitate)

Reactions



Precautions

1. Acetic acid should be handled with care.
2. The vapours of the chemicals should not be inhaled.
3. Add only small amount of $NaHCO_3$ to ethanoic acid to control the intensity of CO_2 evolved.
4. Use freshly prepared lime water for CO_2 test.

Viva Voce

Question 1:
Give the IUPAC name of acetic acid.
Answer:
Ethanoic acid.

Question 2:
Name the functional group present in acetic acid.
Answer:
The functional group in acetic acid is carboxylic group.

Question 3:
State the temperature at which acetic acid freezes.
Answer:
16.6°C.

Question 4:
What is the smell of acetic acid?
Answer:
It has pungent or vinegar like smell.

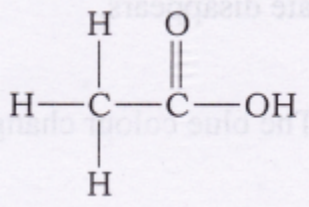
Question 5:
Give the formula of lime water.
Answer:
$Ca(OH)_2$.

Question 6:
Name the alkyl group present in acetic acid.
Answer:
Methyl (—CH_3).

Practical Based Questions

Question 1:
Give the molecular formula of acetic acid.
Answer:
CH_3COOH.

Question 2:
Give the structural formula of acetic acid.



Question 3:
State one test to show that acetic acid is an acid.
Answer:
It turns blue litmus paper red.

Question 4:
How can you prepare fresh lime water?
Answer:
Lime and water together gives fresh lime water, the reaction is highly exothermic in nature.
$CaO(s) + H_2O)(l) \longrightarrow Ca(OH)_2(aq)$

Question 5:
What happens when sodium bicarbonate reacts with acetic acid?
Answer:
Carbon dioxide gas is evolved and sodium acetate and water is obtained.

Question 6:
Give the test for carbon dioxide.
Answer:
When carbon dioxide is passed through freshly prepared lime water, the lime water turns milky.

Question 7:
In the CO_2 test why does lime water turn milky?
Answer:
Due to the formation of insoluble white precipitate of calcium carbonate.

Question 8:
Write two tests you would perform to detect, whether the given colourless liquid is acetic acid or not. **[Delhi 2013]**
Answer:
Two tests:
(i) If we put a drop of the given colourless liquid on blue litmus paper, if the blue litmus paper changes to red, then the given acid is acetic acid.

(ii) If we smell the given liquid and the liquid gives a smell like that of vinegar, then the given acid is acetic acid.

Question 9:
What happens when acetic acid is added in a solution of Na_2CO_3 in a test tube? Write the equation for detecting the gas evolved. **[All India Delhi 2014]**
Answer:
CO_2 gas is evolved with brisk bubbles in this reaction.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$$

White ppt. is formed, when C02 gas is passed through the lime water.

$$CO_2(g) + \underset{\text{Lime Water}}{Ca(OH)_2(aq)} \longrightarrow \underset{\text{White ppt.}}{CaCO_3(s)} + H_2O(l)$$

Question 10:
A compound 'X' in its aqueous solution form, is added to acetic acid taken in a test tube. Then a gas is evolved. This gas turns lime water milky. Name the compound 'X', and the gas evolved. Also write the equation for the reaction. **[All India Delhi 2011]**
Answer:
Compound 'X' can be Na_2CO_3 (Sodium carbonate)
The gas evolved is CO_2 gas.

$$Na_2CO_3(s) + \underset{\text{Acetic acid}}{2CH_3COOH(l)} \longrightarrow 2CH_3COONa(aq) + CO_2(g) + H_2O(l)$$

NCERT Lab Manual Questions

Question 1:
Which gas is evolved when ethanoic acid reacts with sodium hydrogen carbonate?
Answer: Carbon dioxide gas is evolved when ethanoic acid reacts with sodium hydrogen carbonate.

$$CH_3COOH(l) + NaHCO_3(s) \longrightarrow CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

Question 2:
How will you test that the liberated gas is carbon dioxide?
Answer:
By conducting lime water test: Allow the released gas to pass through freshly prepared lime water, if it turns lime water milky then the liberated gas is CO_2.
Note: On passing excess of carbon dioxide through the lime water, the milky precipitate disappears.

Question 3:
How will you show that ethanoic acid is acidic in nature?
Answer:
By litmus paper test: Use blue litmus paper and put two drops of ethanoic acid on it. The blue colour changes to red indicating the acidic nature of ethanoic acid.

Question 4:
Where do you find the use of ethanoic acid in day-to-day food products?
Answer:
Ethanoic acid is used as a preservative in keeping the food products preserved for longer use.

Question 5:
What is the common name of ethanoic acid as sold in the market in the form of its dilute solution?
Answer:
Ethanoic acid in its dilute solution form is known as vinegar in the market.

Question 6:
What type of reaction takes place between ethanoic acid and sodium hydroxide solution?
Answer:
Ethanoic acid neutralizes sodium hydroxide (base) to form salt and water.

$$CH_3COOH\ (l) + NaOH\ (aq) \longrightarrow CH_3COONa\ \ (aq) + H_2O\ (l)$$

Multiple Choice Questions (MCQs)

Questions based on Procedural and Manipulative Skills

1. The number of carbon atoms present in ethanoic acid is:
(a) 1 (b) 3 (c) 2 (d) 4

2. The functional group in ethanoic acid is:
(a) -OH
(b) -CO
(c) -COOH
(d) -CHO

3. The odour of ethanoic acid resembles with
(a) Tomato juice
(b) Kerosene
(c) Orange juice
(d) Vinegar

4. Ethanoic acid reacts with sodium bicarbonate to form:
(a) carbon dioxide gas
(b) sodium ethanoate and carbon dioxide gas
(c) carbon dioxide gas and water
(d) sodium ethanoate, carbon dioxide gas and water

5. The freezing temperature of ethanoic acid is:
(a) 10°C (b) 20°C (c) 18°C (d) 16°C

6. -COOH, present in ethanoic acid is called:
(a) alcohol group
(b) carboxylic group
(c) alkyl group
(d) ketone group

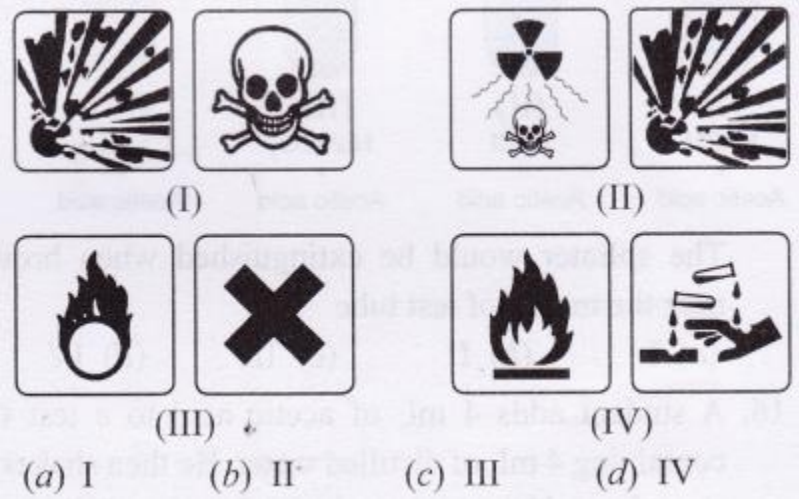
7. Acetic acid reacts with sodium bicarbonate and liberates carbon dioxide gas. The carbon dioxide gas is tested with lime water. Lime water is a solution of:
(a) lemon juice in water
(b) calcium chloride in water
(c) calcium bicarbonate in water
(d) calcium hydroxide in water

8. Acetic acid is:
(a) soluble in water
(b) strong acid
(c) insoluble in water
(d) odourless

9. Following signs are usually shown on the bottles
of commercial acetic acid. The symbols indicate respectively that acetic acid is: **[Delhi 2011]**

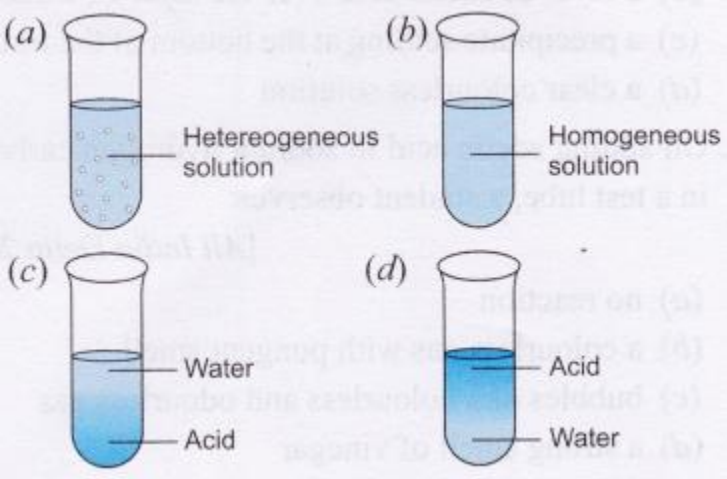
(a) Flammable and corrosive
(b) Radioactive and flammable
(c) Oxidizing and corrosive
(d) Flammable and explosive

10. The pair of safety symbols you notice on the bottles of commercial acetic acid available in the laboratory, is shown in-



Questions based on Observational Skills

11. On adding water to acetic acid the solution obtained would appear as in:

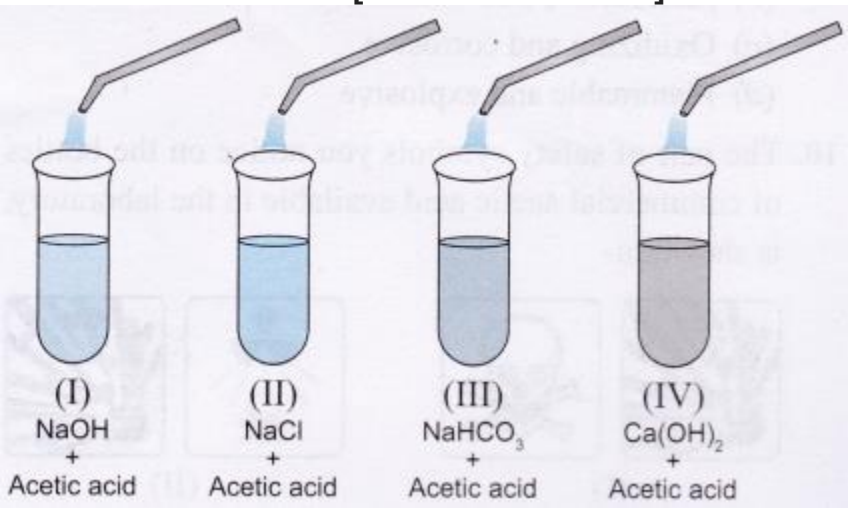


12. 10 mL of acetic acid was added to 10 mL of water and the mixture was shaken, it was observed that:
(a) a heterogeneous solution was obtained
(b) acid formed a layer at the top
(c) acid formed a layer at the bottom
(d) a homogeneous solution was obtained.

13. The odour of ethanoic acid is:
(a) suffocating (b) sweet fruit like
(c) vinegar like (d) burning carbon.

14. Vapours of acetic acid smell:
(a) pungent like vinegar (b) sweet like rose
(c) suffocating like sulphur dioxide
(d) odourless like water

15. A student added acetic acid to test tubes, I, II, III
and IV containing the labelled substances and then brought a burning splinter near the mouth of each test tube. **[All India Delhi 2011]**



Acetic acid Acetic acid The splinter would be extinguished when brought near the mouth of test tube (a) 1 (b) II (c) III (d) IV

16. A student adds 4 mL of acetic acid to a test tube
containing 4 mL of distilled water. He then shakes the test tube and leaves it to settle. After about 10 minutes he observes: **[Delhi 2012]**
(a) a layer of water over the layer of acetic acid
(b) a layer of acetic acid over the layer of water
(c) a precipitate settling at the bottom of the test tube
(d) a clear colourless solution

17. On adding acetic acid to sodium hydrogen carbonate in a test tube, a student observes: **[All India Delhi 2012]**
(a) no reaction
(b) a colourless gas with pungent smell
(c) bubbles of a colourless and odourless gas
(d) a strong smell of vinegar

18. Which one of the following are the correct observations about acetic acid? **[All India Delhi 2012]**
(a) It turns blue litmus red and smells like vinegar.
(b) It turns blue litmus red and smells like burning sulphur.

(c) It turns red litmus blue and smells like vinegar.
(d) It turns red litmus blue and has a fruity smell.

19. A student takes 2 mL acetic acid in a dry test tube and adds a pinch of sodium hydrogen carbonate to it. He makes the following observations: **[Delhi 2013, All India Delhi, 2014]**
I. A colourless and odourless gas evolves with a brisk effervescence.
II. The gas turns lime water milky when it is passed through it.
III. The gas bums with an explosion when a burning splinter is brought near it.
IV. The gas extinguishes the burning splinter that is brought near it.
The correct observations are:
(a) I, II and III (b) II, III and IV
(c) III, IV and I (d) IV, I and II

20. A student prepared 20% sodium hydroxide solution
in a beaker containing water. The observations noted by him are given below. [Delhi 2013]
I. Sodium hydroxide is in the form of pellets.
II. It dissolves in water readily.
III. The beaker appears cold when touched from outside.
IV. The red litmus paper turns blue when dipped into the solution.
The correct observations are:
(a) I, II and III (b) II, III and IV
(c) III, IV and I (d) I, II and IV

21. Select the correct observation about dilute solution of acetic acid. **[Outside Delhi 2013]**
(a) It smells like rotten egg and turn blue litmus red.
(b) It smells like vinegar and turns red litmus blue.
(c) It smells like rotten egg and turns red litmus blue.
(d) It smells like vinegar and turns blue litmus red.

22. In an experiment to study the properties of ethanoic acid, a student takes about 3 mL of ethanoic acid in a dry test tube. He adds an equal amount of distilled water to it and shakes the test tube well. After some time he is likely to observe that: **[Outside Delhi 2014]**
(a) a colloid is formed in the test tube.
(b) the ethanoic acid dissolves readily in water.
(c) the solution becomes light orange.
(d) water floats over the surface of ethanoic acid.

23. The most appropriate method of testing the colour of a given liquid is
(a) I (b) II (c) III (d) IV

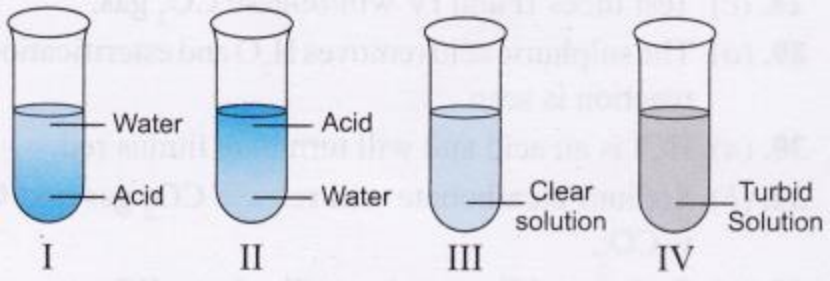
Questions based on Reporting and Interpretation Skills

24. Four test tubes A, B, C and D contain sodium hydroxide, sodium sulphate, ethanoic acid and sodium chloride respectively. In each of the test tubes is added a drop of blue litmus. The colour of litmus will change to red colour in case of:
(a) Test tube A (b) Test tube B
(c) Test tube C (d) Test tube D

25. Reaction of vinegar and baking soda produces:
(a) H_2 gas (b) CO_2 gas
(c) O_2 gas (d) NO_2 gas

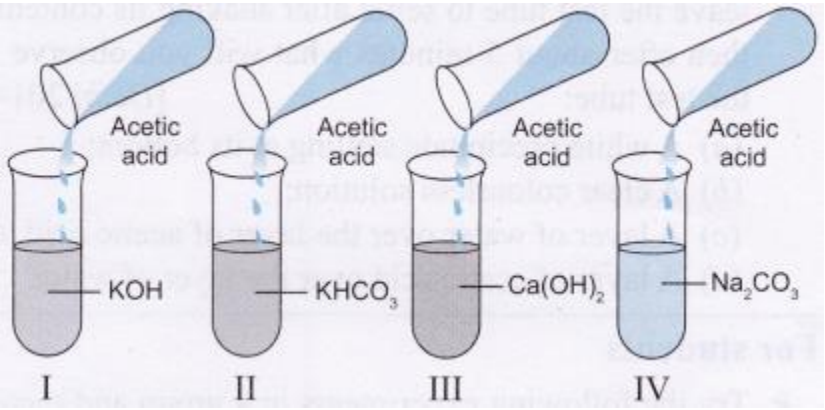
26. A sodium salt reacts with ethanoic acid. The reaction liberates a colourless gas that turns lime water milky. The sodium salt is of:
(a) sodium nitrate (b) sodium chloride
(c) sodium hydroxide (d) sodium bicarbonate

27. 10 mL each of acetic acid and water are mixed together and shaken in different test tubes as shown



The resulting mixture after standing would appear as shown in the test tube:
(a) I (b) II (c) III (d) IV.

28. A student added acetic acid to the test tubes I, II, III and IV



The lighted candle would be extinguished when placed near the mouth of the test tube:
(a) I and II (b) II and III
(c) II and IV (d) I and IV

29. Ethyl alcohol reacts with acetic acid in the presence of concentrated H_2SO_4 to form.
(a) ethyl acetate (b) diethyl ether
(c) propanoic acid (d) methyl acetate.

30. Acetic acid turns blue litmus red. What will happen if a few drops of dil. HCl are added to it?
(a) the mixture remains red
(b) the mixture turns blue
(c) the mixture turns colourless
(d) none of the above.

31. Acetic acid is added to a test tube containing a solution of a substance (P), which reacts with acid to form colourless and odourless gas. The gas (Q) turns lime water milky. The substance (P) and (Q) are:
(a) sodium hydroxide (P) and carbon dioxide (Q).
(b) sodium bicarbonate (P) and carbon dioxide (Q).
(c) calcium hydroxide (P) and hydrogen (Q).
(d) ethyl acetate (P) and hydrogen (Q).

32. Four test tubes of acetic acid labelled as A, B, C and D were kept.
In A sodium carbonate was added In B sodium bicarbonate was added In C sodium chloride was added In D sodium hydroxide was added.
Burning candle was brought near the mouth of each test tube. The candle would extinguish near the mouth of test tube.
(a) A and D (b) B and C
(c) A and B (J) B and D

33. Acetic acid solution turns: **[Delhi 2011]**
(a) blue litmus red
(b) red litmus blue
(c) blue litmus colourless
(d) red litmus colourless

34. Why you add about 2 mL of acetic acid to a test tube containing an equal amount of distilled water and leave the test tube to settle after shaking its contents, then after about 5 minutes what will you observe in the test tube: **[Delhi 2014]**
(a) A white precipitate settling at its bottom;
(b) A clear colourless solution;
(c) A layer of water over the layer of acetic acid, or
(d) A layer of acetic acid over the layer of water.

ANSWERS

1. (c)	2. (c)	3. (d)	4. (d)	5. (d)
6. (b)	7. (d)	8. (a)	9. (a)	10. (d)
11. (b)	12. (d)	13. (c)	14. (a)	15. (c)
16. (d)	17. (c)	18. (a)	19. (d)	20. (d)
21. (d)	22. (b)	23. (b)	24. (c)	25. (b)
26. (d)	27. (c)	28. (c)	29. (a)	30. (a)
31. (b)	32. (c)	33. (a)	34. (b)	

For students

> Try the following experiments in a group and record your observation.

1. Dilute the acetic acid as follows: put 2 drops of acetic acid in a test tube and add 15 mL of water in it, taste a drop of this dilute acid.
Observation'.
It tastes like _____
[**Precautions:** Taste under the supervision of a teacher]

2. Take 2 mL of ethyl alcohol in a test tube and add 2 mL of acetic acid to it, also add 2-4 drops of cone. H2S04. Heat the test tube in water bath.
Record your observation:
1. Smell the product formed in the test tube.
2. Test the sample with blue litmus paper.
3. Name the reaction.

3. Take 5 mL of acetic acid, record its temperature. Now, keep the test tube with acetic acid and thermometer inserted in it, in a beaker containing ice. Record your observations:
Temperature Nature of Acetic Acid
e.g. 20° liquid
18°C liquid
16°C solid

4. Use pH paper to find the acidic nature of acetic acid. Colour of pH paper indicates the strength of acid.

Scoring Key With Explanation

1. (c) "Eth" means two carbon atoms.
2. (c) Functional group of carboxylic acid is—COOH.
3. (d) Vinegar odour resembles ethanoic acid.
4. (d) Like all acids ethanoic acid reacts with $NaHCO_3$ to release CO_2 gas, water and sodium salt.
5. (d) It is also called glacial acetic acid because it freezes at 16.6°C.
6. (b) Functional group of carboxylic acid is—COOH.
7. (d) Lime water is calcium hydroxide in water i.e., $CaO + H_2O \longrightarrow Ca(OH)_2$.
8. (a) It dissolves in water in any ratio.
9. (a) The flame sign indicates flammable and the second symbol is of corrosion.
10. (d) Acetic acid is flammable and corrosive.
11. (b) It is completely soluble in water.
12. (d) It dissolves in water to form homogeneous solution.
13. (c) Acetic acid in water is vinegar.
14. (a) Acetic acid solution is vinegar.
15. (c) CO_2 gas will be released due to presence of carbonate ions in the test tube.
16.(d) Due to complete solubility in water it forms a homogeneous solution.
17. (c) CO_2 gas is released and bubbles are formed.
18. (a) Acetic acid shows acidic properties.
19. (d) All are the properties and tests for CO_2 gas
20. (d) All are the properties of NaOH.
21. (d) These are the properties of acetic acid.
22. (b) Ethanoic acid is soluble in water.
23. (b) The gases should not be smelled directly or kept too close to nose.
24. (c) Acids turn blue litmus red.

25. (b) Baking soda ‘has carbonate ions in it which are released when reacted with acid.
26. (d) Bicarbonates have carbonate ion which is released on reaction with acid.
27. (c) Acetic acid is soluble in water and hence gets clear solution.
28. (c) Test tubes II and IV will release CO_2 gas.
29. (a) The sulphuric acid removes H_2O and esterification reaction is seen.
30. (a) HCl is an acid and will turn blue litmus red.
31. (b) Sodium bicarbonate will release CO_2 gas and Q is CO_2.
32. (c) Both A and B test tubes will release CO_2 gas.
33. (a) Acids turn blue litmus red.
34. (b) It is miscible and dissolves completely in water.