Ethanoic acid (acetic acid), CH3COOH: structure, properties and the four reactions

The second carboxylic acid: a methyl group on a carboxyl group (-COOH: a C=O and an O-H on the same carbon). C2H4O2, 60.05 g/mol (PubChem CID 176). The O-H hydrogen is the one released as H+. Hydrogen bonding (dimers) gives it a high boiling point for its size.

Property	Value	Source
Formula; molar mass	CH3COOH (C2H4O2); 60.05 g/mol	PubChem
Boiling point	391.2 K = 118.1 °C	NIST WebBook
Melting point	289.6 K = 16.5 °C (pure acid freezes in a cold room: glacial)	NIST WebBook
Density	about 1.05 g/cm³	handbook
Solubility	miscible with water	
pKa (Ka)	4.76 (1.7 x 10^-5 mol/dm³) at 25 °C	handbook
pH of 0.1 mol/dm³	about 2.9	from Ka
In vinegar	4-8% by volume	food standards
Hazard	pure acid corrosive and flammable (flash point about 39 °C); vinegar harmless	safety data sheets

The four reactions (salts are ethanoates)

With	Equation	Observation
Metal (Mg)	Mg + 2CH3COOH -> (CH3COO)2Mg + H2	slow fizzing; squeaky pop
Carbonate (Na2CO3)	Na2CO3 + 2CH3COOH -> 2CH3COONa + H2O + CO2	fizzing; limewater milky
Base (NaOH)	NaOH + CH3COOH -> CH3COONa + H2O	neutralisation, warms
Alcohol (ethanol), conc. H2SO4 catalyst, warm	CH3COOH + C2H5OH <-> CH3COOC2H5 + H2O	ethyl ethanoate: pear-drop smell (an ester)

Weak against strong, 0.1 mol/dm³ each

	Ethanoic acid	Hydrochloric acid
Ionisation	partial, about 1% (CH3COOH <-> CH3COO- + H+)	complete (HCl -> H+ + Cl-)
pH	about 3	about 1
With magnesium	slow	fast
Alkali to neutralise 25 cm³	same volume	same volume
Conductivity	low	high

Strong/weak = degree of ionisation; concentrated/dilute = amount dissolved. Glacial ethanoic acid is concentrated and weak.

From sciencewithshobha.com/blog/ethanoic-acid-acetic-acid-formula-ch3cooh-structure-properties-reactions-and-uses-for-gcse-and-a-level/ · 1-on-1 online physics, chemistry and biology, KS3 to A level, Grades 6 to 12, free 30-minute first class.

Making it, the family, the curriculum, and a practice set

[ ] Vinegar: Acetobacter oxidise ethanol with air: C2H5OH + O2 -> CH3COOH + H2O (why open wine sours)
[ ] Industry: methanol carbonylation, CH3OH + CO -> CH3COOH, rhodium (Monsanto) or iridium (Cativa) catalyst
[ ] Lab (A-level): ethanol -> ethanal -> ethanoic acid with acidified potassium dichromate, orange to green
[ ] Uses: vinegar and pickling, descaling (reacts with CaCO3), vinyl acetate (PVA glue, paints), cellulose acetate (film, fibres), esters as solvents, ethanoic anhydride for aspirin, acetate buffers

Acid	Formula	Common name	Boiling point
Methanoic	HCOOH	formic (ant stings, nettles)	101 °C
Ethanoic	CH3COOH	acetic (vinegar)	118 °C
Propanoic	C2H5COOH	propionic (bread preservative)	141 °C
Butanoic	C3H7COOH	butyric (rancid butter)	164 °C

General formula CnH2n+1COOH; each CH2 adds about 20 °C to the boiling point; all weak acids (pKa 4-5); salts end -oate; esters with alcohols.

Curriculum	Where
England	GCSE Chemistry organic (carboxylic acids, weak acids, esters; triple on most boards); A-level carboxylic acids, esters, Ka
CBSE	Class 10 Carbon and its Compounds (these four reactions); Class 12
Australia	Year 11-12 Chemistry organic and acids
US	AP Chemistry weak acids, Ka, acetate buffers
Ontario	Grade 12 SCH4U organic and equilibrium

Practice

1. Draw the displayed formula of ethanoic acid and circle the functional group.
2. Balanced equation for ethanoic acid with sodium carbonate; name the gas and its test.
3. Why does 0.1 mol/dm³ ethanoic acid have a higher pH than 0.1 mol/dm³ HCl?
4. Name the ester from ethanoic acid and methanol, and the catalyst.
5. Why is pure ethanoic acid called glacial?
6. 25 cm³ of ethanoic acid needs 20 cm³ of 0.1 mol/dm³ NaOH. Concentration of the acid?

Answers

1. CH3-C(=O)-OH with all atoms; circle the -COOH. 2. Na2CO3 + 2CH3COOH -> 2CH3COONa + H2O + CO2; carbon dioxide turns limewater milky. 3. It is a weak acid: only about 1% of molecules ionise, so the H+ concentration is about 100 times lower. 4. Methyl ethanoate; concentrated sulfuric acid. 5. It freezes at about 17 °C, forming ice-like crystals in a cold laboratory. 6. Moles NaOH = 0.1 x 0.020 = 0.002 = moles acid (1:1); concentration = 0.002 / 0.025 = 0.08 mol/dm³.