

Gaokao Chemistry Lab Essentials: A 37-Minute Revision Animation Checked Line by Line Against the Textbooks

Five core lab skills and all 87 experiments in the five PEP senior-high chemistry textbooks. Every step comes with the correct action and its reason, and every claim is sourced to a textbook page and quote. The bilingual animation was made entirely in code on an Android phone.

October 4, 2026 • Gaokao • Lab Chemistry • PEP Textbooks • Video Production • AI



高考化学 • 实验操作要点 — Gaokao Chemistry Lab Technique Essentials

Gaokao Chemistry • Lab Technique Essentials (高考化学 • 实验操作要点) is a 37-minute 2D animated revision video for students preparing for China's national college entrance exam. It has two halves. The first teaches the five lab skills that are examined most often. The second goes through the experiments in all five current People's Education Press (PEP, 人教版) senior-high chemistry textbooks, one card per experiment, 87 cards in total. It is 16:9, 1080p at 30 fps, with an original score and bilingual subtitles (Simplified Chinese above, English below).

One rule came before everything else: **safety content must be correct**. Every procedure and every reason had to be found in a textbook first and written into a sourced fact sheet. Only then could it appear on screen. A wrong or unsafe practice is never animated as a step to follow. It appears only as a still inside a red "X 错误 WRONG" frame, always next to the correct version.

Every frame was drawn by Python code and rendered on the CPU of an Android phone. Claude Opus 5.5, working in Claude Code, read and cross-checked the textbooks, wrote the script, the drawing code and the music, and ran the quality checks. I set the brief, approved the storyboard, and decided what each round of additions should cover.

What the video covers

Time	Section
0:00	Title
0:07	Part 1 Order of adding chemicals (making ethyl acetate)
1:19	Part 2 Diluting concentrated sulfuric acid
2:19	Part 3 Heating a test tube safely
3:26	Part 4 Collecting and testing gases
5:31	Part 5 Using and reading a burette and a balance
7:09	Part 6 Textbook experiments • Compulsory Book 1 (24)
14:28	Part 7 Textbook experiments • Compulsory Book 2 (21)
22:12	Part 8 Textbook experiments • Elective 1 (17)
28:16	Part 9 Textbook experiments • Elective 2 (5)
30:07	Part 10 Textbook experiments • Elective 3 (20)
37:04	Recap

Parts 1–5 each end with a short **实拍** (real footage) segment: clips of real experiments taken from Bilibili, muted and credited on screen. Most are re-uploads of PEP's own textbook companion videos, and only segments showing the correct procedure were used.

After every demo whose experiment has a figure in the textbook, a short **教材原图** (textbook figure) scene shows that figure itself for about five seconds, labelled with the book, printed page and figure number, so students can find it in their own copy. There are 65 of these scenes, with 78 figures.

Part 1: The order of adding chemicals

The example is Experiment 7-6 in Compulsory Book 2, making ethyl acetate. The textbook order is: put 3 mL of ethanol in the tube, then **slowly add 2 mL of concentrated sulfuric acid while shaking the tube**, then 2 mL of acetic acid, and finally a few pieces of broken porcelain. Elective 3 (Lab Activity 1) uses different amounts but the same order.

1 加药顺序
Order of adding chemicals

教材依据 必修第二册 p.77 • 九年级下册 p.66 • 选择性必修3 p.61

密度 Density

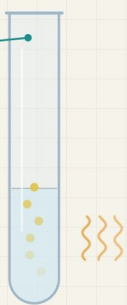
1.84 g/cm³

浓硫酸
conc. H₂SO₄

0.789 g/cm³

乙醇
ethanol

浓硫酸慢慢加入
conc. acid in slowly



混合时放出热量
mixing releases heat
九年级下册 p.68 • 复旦实验讲义

慢慢加入较轻的液体中并振荡，热量才能散开
Adding it slowly to the lighter liquid, shaking, spreads the heat

Conc. H₂SO₄ is 1.84 g/cm³, ethanol 0.789 g/cm³. Adding the dense acid slowly to the lighter liquid while shaking spreads the heat.

- **Why ethanol first?** The textbook does not print a reason. The video's explanation is derived from facts the textbook does state. Concentrated sulfuric acid is dense (1.84 g/cm³) and releases a lot of heat as it mixes, so it goes slowly into the lighter liquid while the tube is shaken to spread the heat. This is the same principle as diluting the acid. The fact sheet marks this claim as derived, not quoted.
- **Broken porcelain** prevents bumping (sudden violent boiling) when the mixture is heated.
- **The delivery tube ends above the saturated Na₂CO₃ solution**, not in it, to prevent suck-back.
- **Result:** a clear, oily, fragrant layer of ethyl acetate collects on top of the Na₂CO₃ solution.

Part 2: Diluting concentrated sulfuric acid

2 稀释浓硫酸
Diluting concentrated sulfuric acid

教材依据 人教版 九年级下册 p.67 实验10-6

✓ 正确 RIGHT

戴好护目镜
wear goggles

酸入水
acid into water

沿烧杯内壁
down the inner wall

慢慢注入
pour slowly

玻璃棒不断搅拌
keep stirring

水 water

用玻璃棒不断搅拌，并戴好护目镜
Stir all the time with a glass rod. Wear goggles.

Acid into water, down the inner wall, slowly, stirring all the time, goggles on

The rule is one sentence: **pour concentrated sulfuric acid slowly down the inner wall of the container into water, stirring all the time with a glass rod. Never pour water into concentrated sulfuric acid.** Wear goggles.

The textbook prints the reason too (Grade 9 Book 2, p. 68). Water is less dense, so it would float on top of the acid. The heat released as the acid dissolves would boil that water instantly and spray acid droplets in all directions.

2 稀释浓硫酸
Diluting concentrated sulfuric acid

教材依据 人教版 九年级下册 p.68

✗ 错误 WRONG

把水倒进浓硫酸 (切勿操作)
Water into conc. acid: never do this

放热 → 沸腾 → 飞溅
heat → boils → sprays acid

水密度较小，浮在上面
less dense water floats on top

浓硫酸 1.84 g/cm^3
conc. H_2SO_4

✓ 正确 RIGHT

正确：浓硫酸注入水中
Right: acid into water

酸入水
acid into water

沿内壁
down the wall

慢慢倒
slowly

记住：酸入水，沿内壁，慢慢倒，不断搅
Remember: acid into water, down the wall, slowly, stirring

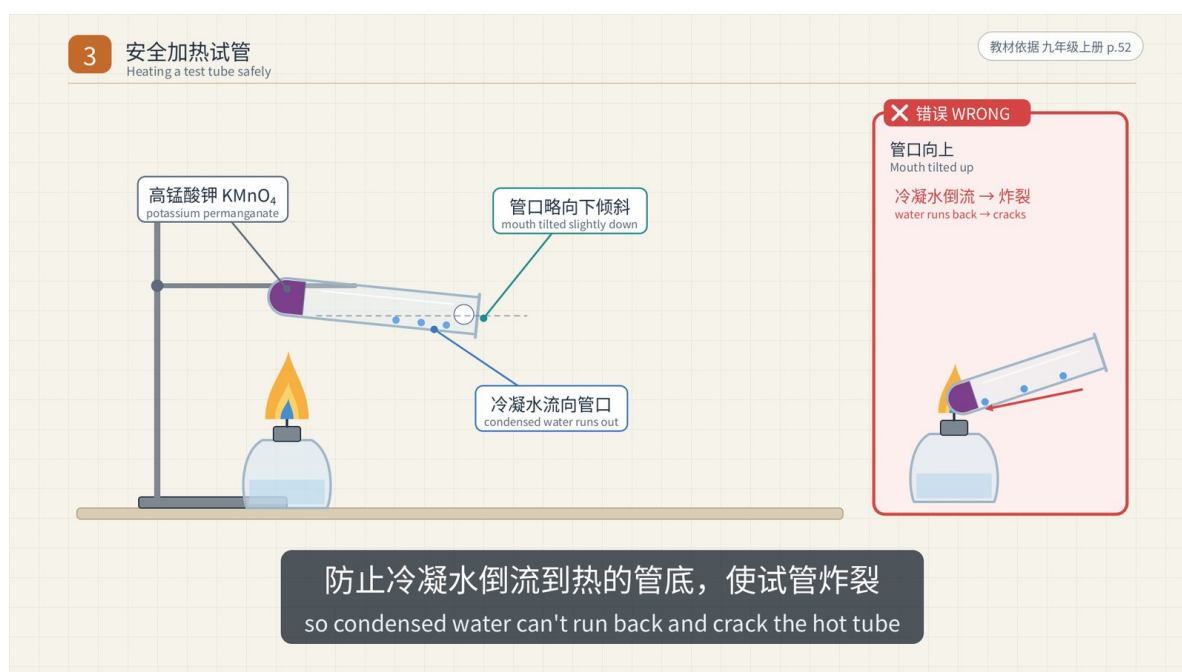
Left: the wrong practice appears only as a still in a red frame. Right: the correct practice.

If acid gets on your skin, rinse at once with plenty of water, then apply 3–5 % NaHCO_3 solution. The senior textbook applies the same rule in Experiment 5-3 of Compulsory Book 2: once the reaction mixture has cooled, it is poured slowly into a tube holding a little water.

Part 3: Heating a test tube safely

- The outside of the tube must be dry, and the liquid must fill no more than $\frac{1}{3}$ of the tube.
- Slide the tube holder on and off from the bottom, and grip the tube $\frac{1}{4}$ – $\frac{1}{3}$ of the way down from the mouth.
- First warm the bottom of the tube evenly (preheat), then heat it steadily in the **outer flame** of the spirit lamp.
- Never point the mouth at yourself or anyone else.
- Never let a hot tube touch cold water, or it may crack.

When **heating a solid** such as potassium permanganate, tilt the mouth of the tube **slightly downward**, so that condensed water cannot run back onto the hot bottom and crack the tube. Figure 5-13 in Compulsory Book 2 holds the tube the same way when making ammonia from NH_4Cl and Ca(OH)_2 .



So condensed water can't run back onto the hot bottom and crack the tube

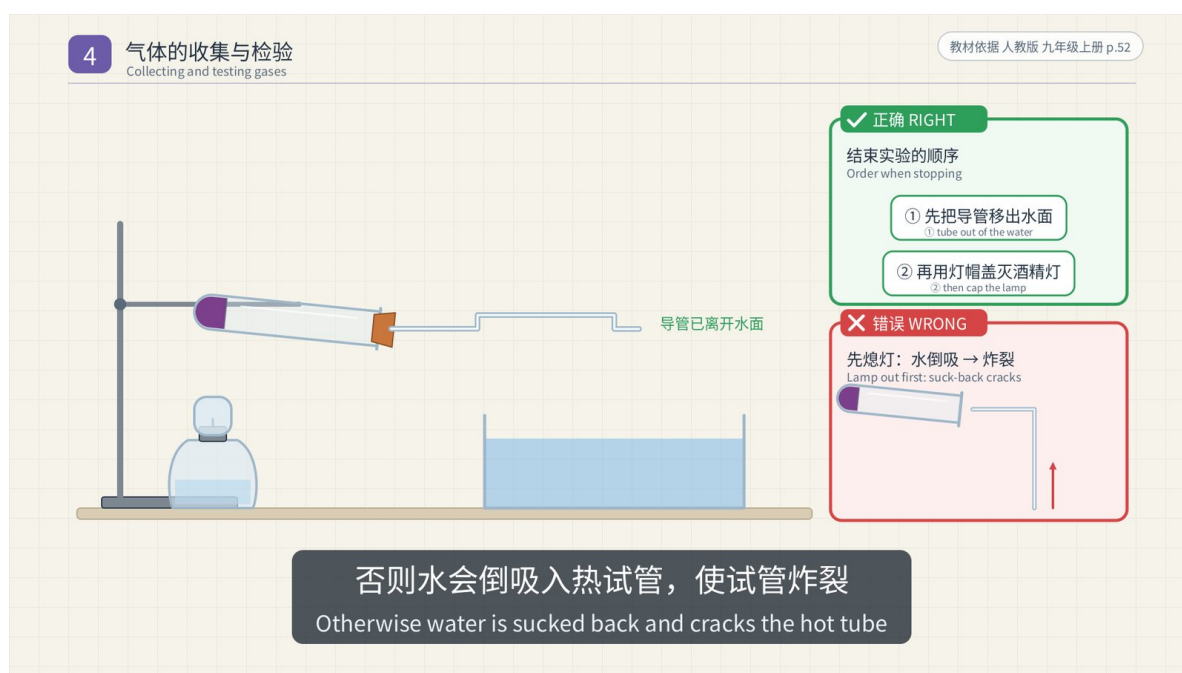
The video never gives a specific angle such as "45°", because the current textbook doesn't.

Part 4: Collecting and testing gases

Choose a collection method from the gas's **density relative to air**, its **solubility in water**, and **whether it reacts with water**:

Gas	Method	Why
O ₂	Over water	Only slightly soluble in water
CO ₂	Upward displacement of air	Denser than air
H ₂	Over water, or downward displacement of air	Insoluble in water and lighter than air
NH ₃	Downward displacement of air only	Lighter than air and extremely soluble (about 1 : 700)

When collecting over water, wait until bubbles come **steadily and evenly** before you start, because the first bubbles are mostly air pushed out of the apparatus. When you stop, **take the delivery tube out of the water first, then put out the lamp with its cap**. In the wrong order, water is sucked back into the hot tube, which cools suddenly and cracks.



Tube out of the water first, then cap the lamp. In the wrong order, water is sucked back.

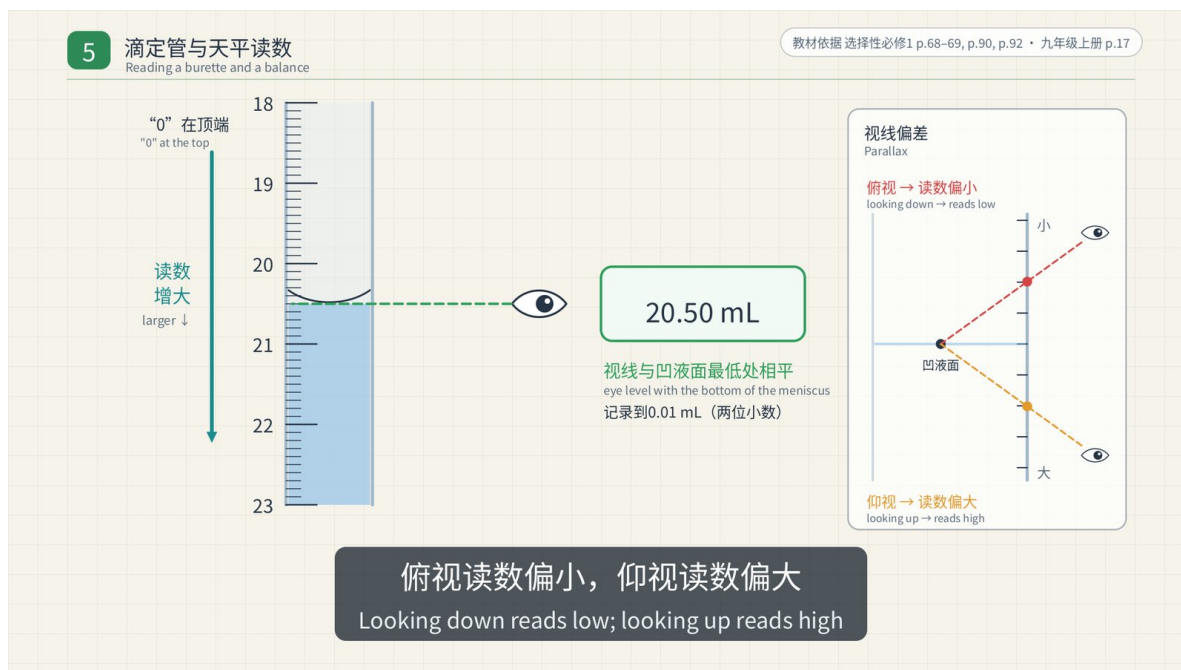
Tests: a glowing splint relights in O₂. CO₂ turns limewater milky, and a burning splint held at the mouth of the jar goes out when the jar is full. NH₃ turns moist red litmus paper blue. Always **test hydrogen for purity before lighting it**: a sharp squeaky pop means it is impure, and a soft pop means it is fairly pure. Elective 3 repeats this rule for ethyne.

Part 5: The burette and the balance

The burette (Elective 1, Lab Activity 2) is set up in this order: check that the tap doesn't leak → rinse 2–3 times with the solution it will hold → fill to 2–3 mL above the "0" mark and clamp it vertically → expel air bubbles from the tip → set the level and record the reading.

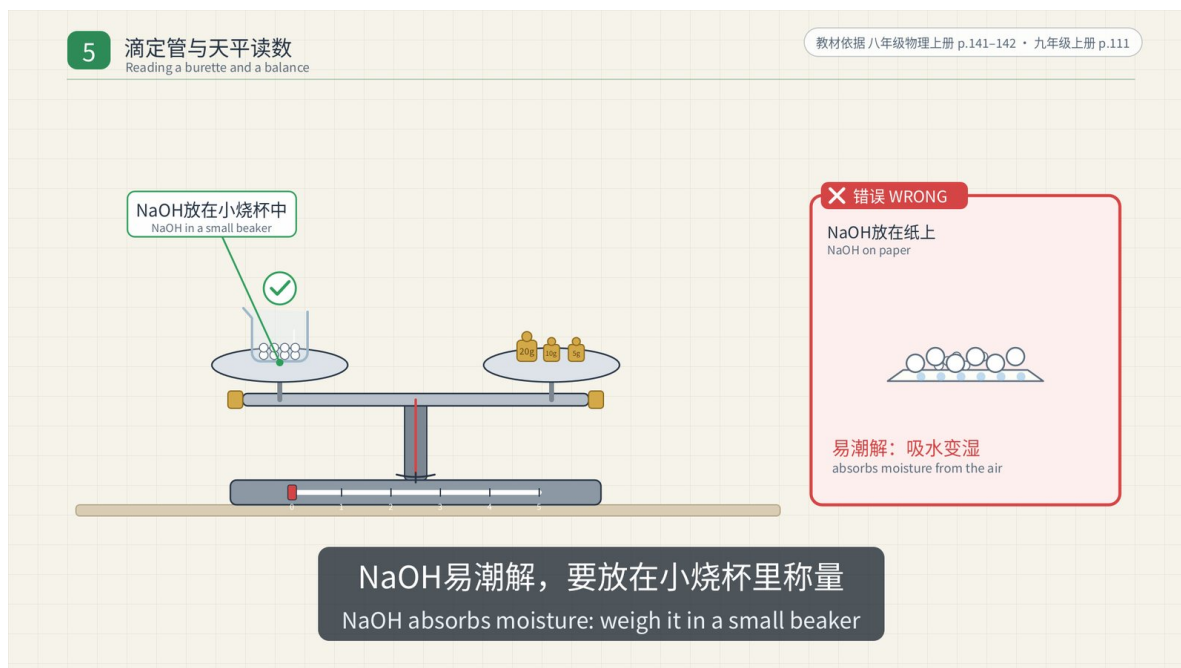
- The "0" mark is at the **top**, and readings increase downward. Record to 0.01 mL, for example 20.00 mL.

- Read with your eye level with the lowest point of the meniscus.
- Because the scale increases downward, **looking down at the meniscus gives a reading that is too low, and looking up gives one that is too high.** This is the opposite of a measuring cylinder.



Looking down reads low; looking up reads high

The tray balance: put it on a level surface → move the rider to zero → turn the balancing nuts until the pointer is centred → **object in the left pan, weights in the right**, adding the weights with tweezers. Chemicals never go directly on the pan. NaOH absorbs moisture from the air, so it is weighed in a container such as a small beaker.



NaOH absorbs moisture: weigh it in a small beaker

The video does not say that "a tray balance reads to 0.1 g". It is commonly taught, but it is not stated in the textbooks cited.

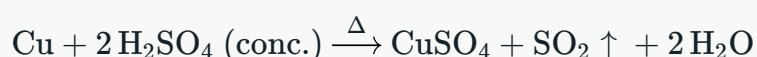
Parts 6–10: 87 experiments from five textbooks

The second half is a sequence of experiment cards. On the left, the apparatus is animated. On the right, the card lists the **procedure**, the **observation** and a **note or reason**, with the equation printed in the textbook along the bottom. The current PEP senior-high chemistry series has five books, and every experiment in each one is covered:

- **Compulsory Book 1 (24):** $\text{Fe}(\text{OH})_3$ colloid and the Tyndall effect, sodium and its compounds, flame tests, chlorine and how to prepare it, testing for Cl^- , making a solution of known molar concentration, interconverting Fe^{2+} and Fe^{3+} , aluminium with acid and alkali, halogen displacement, trends across period 3, and more.
- **Compulsory Book 2 (21):** SO_2 , copper with concentrated sulfuric acid, testing for SO_4^{2-} , NO and NO_2 , the ammonia fountain and preparing ammonia, copper with nitric acid, purifying crude salt, galvanic cells, reaction rates, methane and chlorine, ethene, ethanol, tests for glucose, starch, proteins, and more.
- **Elective 1 (17):** heat of neutralisation, reaction rates, how concentration, pressure and temperature shift an equilibrium, strong and weak electrolytes, salt hydrolysis, precipitate conversion, acid–base titration, cells and electrolysis, corrosion and its prevention, electroplating, a fuel cell, and more.
- **Elective 2 (5):** ways to obtain crystals, extracting iodine, copper and iron complexes, and the silver–ammonia ion.
- **Elective 3 (20):** distillation, extraction and recrystallisation, making ethyne, benzene and toluene, hydrolysis and elimination of halogenoalkanes, ethene from ethanol, phenol, the silver mirror test and freshly made $\text{Cu}(\text{OH})_2$ with ethanal, acid strength of carboxylic acids, ester hydrolysis, functional-group tests, sugars, cellulose, proteins, phenol–formaldehyde resin, and more.

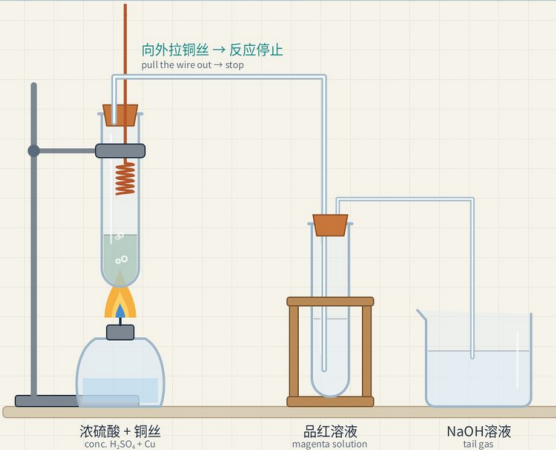
Here are a few representative cards.

Copper and concentrated sulfuric acid (Compulsory Book 2, Exp. 5-3). When the tube is heated, the gas given off bleaches magenta solution, which shows that SO_2 has formed. Pulling the copper wire up stops the reaction. Once cool, the mixture is poured slowly into a little water, and the solution turns blue. NaOH solution absorbs the tail gas.



7 教材实验 • 必修第二册
 Textbook experiments: Compulsory Book 2

教材依据 必修第二册 p.5 实验5-3



实验5-3

浓硫酸与铜的反应
Copper and concentrated sulfuric acid

操作 Procedure

- 浓硫酸中插入螺旋状铜丝，加热，气体通入品红溶液
Heat a copper spiral in conc. H₂SO₄, pass the gas into magenta

现象 Observation

- 品红溶液褪色：生成了SO₂
The magenta fades: SO₂ is produced

操作 Procedure

- 向外拉铜丝终止反应；冷却后把试管里的物质慢慢倒入少量水中
Pull the wire out to stop; once cool, pour the mixture slowly into a little water

现象 Observation

- 溶液呈蓝色：生成了CuSO₄
The solution is blue: CuSO₄ has formed

注意 / 原理 Note / reason

- 浓硫酸是氧化剂，自身被还原成SO₂；尾气用NaOH溶液吸收
Conc. H₂SO₄ is the oxidant, reduced to SO₂; NaOH absorbs the tail gas
- 浓硫酸有很强的腐蚀性，注意安全防护
Conc. H₂SO₄ is highly corrosive; protect yourself

$$\text{Cu} + 2\text{H}_2\text{SO}_4(\text{浓}) \xrightarrow{\Delta} \text{CuSO}_4 + \text{SO}_2 \uparrow + 2\text{H}_2\text{O}$$

浓硫酸有很强的腐蚀性，注意安全防护
Conc. H₂SO₄ is highly corrosive: protect yourself

Compulsory Book 2, Experiment 5-3

Copper and nitric acid (Exp. 5-8). With concentrated acid the reaction is vigorous, the solution turns green, and red-brown gas appears above it. With dilute acid there are bubbles and the solution turns blue. Dilute acid produces colourless NO, which only turns into red-brown NO₂ when it meets oxygen in the air.



NO₂ and water (Exp. 5-5). In a syringe, NO meets air and turns into red-brown NO₂. Shaking it with water fades the colour and shrinks the volume. Industry makes nitric acid this way:



Methane and chlorine: substitution (Exp. 7-1). The tube wrapped in aluminium foil shows no change. In the tube left in the light (but not in direct sunlight), the gas colour fades, oily drops form on the wall, and the water level rises.

7 教材实验 • 必修第二册
Textbook experiments: Compulsory Book 2

教材依据 必修第二册 p.64 实验7-1

颜色变浅 • 油状液滴 • 液面上升

饱和NaCl溶液

铝箔套住 (暗处) wrapped in foil (dark)

放在光亮处 in diffuse light

实验7-1
甲烷与氯气的取代反应
Methane and chlorine: substitution

操作 Procedure

- 排饱和NaCl溶液法收集CH₄和Cl₂，一支套铝箔，一支放光亮处
Collect CH₄ + Cl₂ over brine; wrap one tube in foil, put one in light

现象 Observation

- 无光照不反应；光照时气体颜色变浅，管壁出现油状液滴，水面上升
No light, no reaction. In light: colour fades, oily drops form, water rises

注意 / 原理 Note / reason

- 氢原子被氯原子逐一取代，生成4种氯代物和HCl
H atoms are replaced one by one: four chloromethanes plus HCl

$$\text{CH}_4 + \text{Cl}_2 \xrightarrow{\text{光}} \text{CH}_3\text{Cl} + \text{HCl}$$

氢原子被氯原子逐一取代，生成4种氯代物和HCl
H atoms are replaced one by one: four chloromethanes plus HCl

Compulsory Book 2, Experiment 7-1: no light, no reaction

Ethyne from calcium carbide (Elective 3). Calcium carbide reacts very violently with water, so **saturated brine** is used instead to slow the reaction down. The gas is passed through CuSO₄ solution to remove H₂S and other impurities, then **separately** into acidified KMnO₄ and into bromine in CCl₄: first one tube, then the delivery tube is moved to the other. Both decolourise. The gas is tested for purity before it is lit. Making ethene from ethanol (Experiment 3-2) works the same way: NaOH solution removes the impurities, then the gas goes separately into each solution.

10 教材实验 • 选择性必修3
Textbook experiments: Elective 3

教材依据 选择性必修3 p.37 探究

饱和食盐水

电石 CaC₂

除H₂S

褪色

褪色

分别通入 separately

CuSO₄溶液

酸性KMnO₄

溴的CCl₄溶液

探究
乙炔的制取与性质
Making and testing ethyne (acetylene)

操作 Procedure

- 电石中逐滴加入饱和氯化钠溶液
Drip saturated brine onto calcium carbide

注意 / 原理 Note / reason

- 反应非常剧烈，用饱和食盐水代替水以减小反应速率
It is very violent: brine instead of water slows it down
- 先通过CuSO₄溶液除去H₂S等杂质
Pass the gas through CuSO₄(aq) first to remove H₂S

现象 Observation

- 乙炔分别通入酸性KMnO₄溶液和溴的CCl₄溶液，均褪色
Ethyne goes separately into acidified KMnO₄ and into Br₂ in CCl₄; both fade

注意 / 原理 Note / reason

- 点燃前先检验纯度，防止爆炸
Test its purity before lighting it, to prevent an explosion

$$\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{CH}\equiv\text{CH} \uparrow$$

点燃前先检验纯度，防止爆炸
Test its purity before lighting it, to prevent an explosion

Elective 3: after the wash, separately into acidified KMnO₄ and Br₂ in CCl₄

10 教材实验 • 选择性必修3

Textbook experiments: Elective 3

教材依据 选择性必修3 p.38 图2-6

教材原图

From the textbook

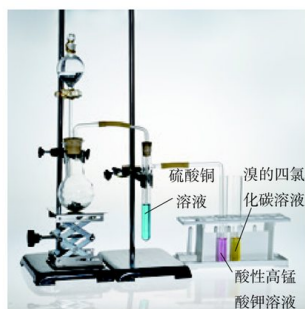


图2-6 乙炔的实验室制取及性质检验

教材原图：图2-6

From the textbook: Fig. 2-6

The textbook figure that follows: Elective 3, p. 38, Fig. 2-6

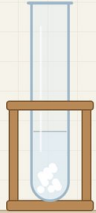


The silver mirror and freshly made $\text{Cu}(\text{OH})_2$. Both tests appear twice: for glucose (Compulsory Book 2, Exp. 7-7) and for ethanal (Elective 3, Exp. 3-7 and 3-8). To make the silver-ammonia solution (Tollens' reagent), add ammonia solution dropwise to AgNO_3 until the precipitate that first forms **just dissolves**. Then warm the tube in a water bath, and a silver mirror forms on the glass. For the second test, 5 drops of CuSO_4 solution go into 2 mL of 10 % NaOH , so the NaOH is in excess, giving freshly made $\text{Cu}(\text{OH})_2$. Heating it with the aldehyde gives a brick-red Cu_2O precipitate. The video keeps the textbook term "freshly made $\text{Cu}(\text{OH})_2$ " (新制的 $\text{Cu}(\text{OH})_2$): none of the five books uses the name Fehling's reagent (斐林试剂).

10 教材实验 • 选择性必修3
Textbook experiments: Elective 3

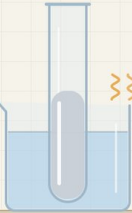
教材依据 选择性必修3 p.69 实验3-7

沉淀恰好溶解
just dissolves



1 mL 2% AgNO₃

银镜
silver mirror



银氨溶液 + 乙醛

实验3-7

乙醛的银镜反应
Ethanal: the silver mirror reaction

操作 Procedure

- 洗净试管中AgNO₃溶液边振荡边逐滴加氨水，至最初的沉淀恰好溶解
In a clean tube add NH₃(aq) dropwise to AgNO₃ until the first precipitate just dissolves
- 滴入3滴乙醛，振荡后放在热水浴中温热
Add 3 drops of ethanal, shake, warm in a hot-water bath

现象 Observation

- 生成的银附着在试管壁上形成银镜
Silver deposits on the glass as a mirror

注意 / 原理 Note / reason

- 银氨溶液是弱氧化剂；银镜反应常用来检验醛基
Tollens' reagent is a mild oxidant; the mirror is a test for -CHO

$$\text{CH}_3\text{CHO} + 2[\text{Ag}(\text{NH}_3)_2]\text{OH} \xrightarrow{\Delta} \text{CH}_3\text{COONH}_4 + 2\text{Ag} \downarrow + 3\text{NH}_3 + \text{H}_2\text{O}$$

银氨溶液是弱氧化剂；银镜反应常用来检验醛基
Tollens' reagent is a mild oxidant; the mirror is a test for -CHO

Elective 3, Experiment 3-7

Ester hydrolysis (Elective 3). Ethyl acetate is warmed at 70–80 °C with water, with dilute sulfuric acid, and with NaOH solution. The ester layer disappears fastest in alkali. In acid, hydrolysis is reversible. In alkali, the acetate salt forms, so the reaction goes to completion.

Every claim has a source

The fact sheet was written before anything was built. Every action, observation and reason in the video corresponds to a row that names the book, the page and the quote:

- The claims in Parts 1–5 are numbered F1.x to F5.x.
- The 87 experiment cards rest on 254 claims quoted from the textbooks (T) and 50 derived claims (D). Each derived claim states its basis, for example "the textbook asks this question but does not print the answer".
- A script compared every quotation with the text layer of the textbook PDFs. Of 357 fragments, 354 matched automatically. The other three were checked by hand: a table, and two equations whose subscripts and superscripts the PDF scrambles.

The checking also turned up several widely taught statements that the current textbooks do not support, so they were kept out of the subtitles: a "45°" tilt for a heated test tube, "a tray balance reads to 0.1 g", and any written rule about the distillation thermometer position or the direction of the cooling water. Review also caught a card whose first draft drew a heated solid in a tube with its mouth pointing up. It was fixed before release. A later review led to a pass over all the apparatus drawings. Test tubes now stand in a rack instead of floating. Thermometers sit inside the tube, not beside it. Tubes heating a solid are clamped to an iron stand. Every tube that gas passes through on its way to the next one has a two-hole stopper, with the long tube in and the short tube out. Delivery tubes leave through the stopper, not through the glass wall.

All the sources are published by People's Education Press: the senior-high chemistry textbooks Compulsory Books 1 and 2 and Electives 1, 2 and 3. For the basic operations, the video also cites the Grade 9 chemistry books (Books 1 and 2) and the Grade 8 physics book, which explains how to use a balance. The senior textbooks build on these junior-school operations and often refer students back to them, so those rules are cited from the junior books.

How it was made

- **A fixed tempo.** The score runs at 100 beats per minute, so one beat is exactly 0.6 s, or 18 frames. Every scene starts on a bar, and every key action lands on a beat with a chime accent.
- **Bilingual subtitles.** There are 459 cues. The Chinese line has at most 8 characters per second, the English line at most 16 characters per second, and every cue stays on screen for at least 1.2 s. A separate .srt file and a clean version without subtitles are also provided.
- **Resumable chunked rendering.** Each scene is rendered as its own chunk, along with a hash of the code and data it depends on. After an interruption, only missing or changed chunks are rendered again. When three more textbooks and dozens of experiments were added to a finished version, the existing chunks did not need to be rendered again.
- **Automated quality checks.** All 22 checks pass:
 - subtitles stay inside the title-safe area, never overlap, and meet the reading-speed limits;
 - the video is BT.709-encoded and tagged as such;
 - loudness is -16.1 LUFS integrated, with a true peak of -1.8 dBTP;
 - audio-video sync is within 0 ms;
 - the running time is exactly 2236.8 s (67,104 frames).

要点回顾
Recap

1 加药顺序 乙醇 → 浓硫酸 → 乙酸 ethanol → acid → acetic acid 边振荡边慢慢加 slowly, shaking	2 稀释浓硫酸 酸入水 acid into water 沿内壁 · 不断搅 down the wall · stir	3 安全加热试管 先预热 preheat first 管口不对着人 mouth away from people	4 气体的收集与检验 先撤导管再熄灯 tube out, then lamp out 点燃H₂前验纯 test H₂ purity	5 滴定管与天平读数 视线平凹液面 eye level with meniscus 左物右码 object left, weights right
---	--	--	---	---

依据：人教版 化学必修第一、二册 · 选择性必修1、2、3 · 九年级化学上、下册 · 八年级物理上册
Sources: PEP textbooks — see the fact sheet for page references

内容依据人教版教材核对

Checked against the PEP (人教版) textbooks

The closing recap: five skills, one line each

In numbers

Running time	37:17 (30 fps, 67,104 frames)
Scenes	185 (including 65 textbook-figure scenes)
Textbook experiment cards	87, covering all five PEP senior-high chemistry books
Real-footage clips	22, muted and credited
Subtitles	459 bilingual cues
Fact sheet	Claims F1–F5 for the basic skills, plus 254 textbook quotes (T) and 50 derived claims (D)

Credits and rights

The score, animation and graphics are original. The 教材原图 scenes reproduce figures from People's Education Press textbooks, which hold the rights to them. The real-footage clips are excerpts of other people's Bilibili uploads, most of them re-uploads of PEP textbook companion videos, and the rights belong to their owners. They play muted and credited, which suits private study and classroom use. Before publishing the full video, get permission from the rights holders or replace those segments.