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Name: _____ Class: _____ Date: _____

SECONDARY 3 · CHEMISTRY · EXPERIMENTAL CHEMISTRY

Experimental Chemistry

Theory and worked examples

Measuring time, temperature, mass and volume

Every experiment depends on measurements, and the apparatus you choose decides how precise they are. The precision of an instrument is the smallest change it can show: a burette can be read to 0.05 cm³ but a beaker only gives a rough volume. Choose the apparatus that is precise enough for the job, and record each reading to the precision of the instrument (for example, a burette reading as 23.40 cm³, not 23.4 cm³). Volumes of liquids are read at eye level at the bottom of the meniscus (the curved surface of the liquid).

KEY IDEA

Pick the apparatus by the size and the precision of the measurement: an exact fixed volume needs a pipette, a variable volume read to 0.05 cm³ needs a burette.

- A burette reads 0.00 at the top and 50.00 at the bottom, so the reading INCREASES as liquid runs out.
- Burette readings are written to 2 decimal places, ending in 0 or 5: 0.00, 12.35, 26.80.
- A pipette delivers one volume only; it cannot measure 18.65 cm³ or 22.15 cm³.

WORDS TO KNOW

precision	the smallest division an instrument can be read to, e.g. 0.05 cm³ for a burette
meniscus	the curved surface of a liquid in a narrow tube; read water and solutions at the bottom of the curve
titre	the volume of solution added from a burette in a titration (final reading – initial reading)

Quantity	Apparatus	Unit	Usually read to
time	stopwatch (or a data logger)	s, min	0.01 s on the display; human reaction time makes about 0.2 s the real limit
temperature	thermometer (−10 °C to 110 °C), or a temperature probe	°C	0.5 °C (probe: 0.1 °C)
mass	electronic balance	g	0.01 g
rough volume of a liquid	beaker or conical flask	cm^3	only approximate
volume of a liquid	measuring cylinder	cm^3	0.5 cm^3 (100 cm^3 cylinder); 0.1 cm^3 (10 cm^3 cylinder)
one exact, fixed volume	pipette (with a pipette filler)	cm^3	its fixed volume, e.g. 25.0 cm^3 or 10.0 cm^3
any volume up to 50 cm^3	burette	cm^3	0.05 cm^3
volume of a gas	gas syringe (up to 100 cm^3)	cm^3	1 cm^3

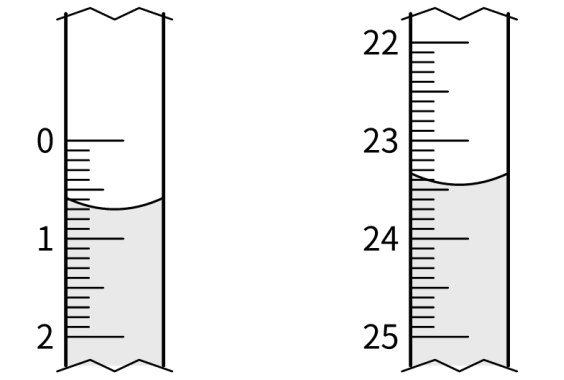
WORKED EXAMPLE

The diagram shows the burette at the start and at the end of a titration.

(a) State the initial and final readings.

(b) Calculate the volume of acid added.

(c) Explain why a measuring cylinder would not be suitable for adding this volume.



1. Each small mark is 0.1 cm^3; the bottom of the meniscus can sit on a mark or halfway between two marks (0.05 cm^3).
2. The scale increases downwards, so the initial reading is the smaller number.
3. Volume added = final reading − initial reading = 23.45 − 0.70 = 22.75 cm^3.

(a) Initial reading 0.70 cm³; final reading 23.45 cm³. (b) 23.45 – 0.70 = 22.75 cm³. (c) A measuring cylinder can only be read to about 0.5 cm³; a burette measures a variable volume to 0.05 cm³, which this answer needs.

TRY THIS

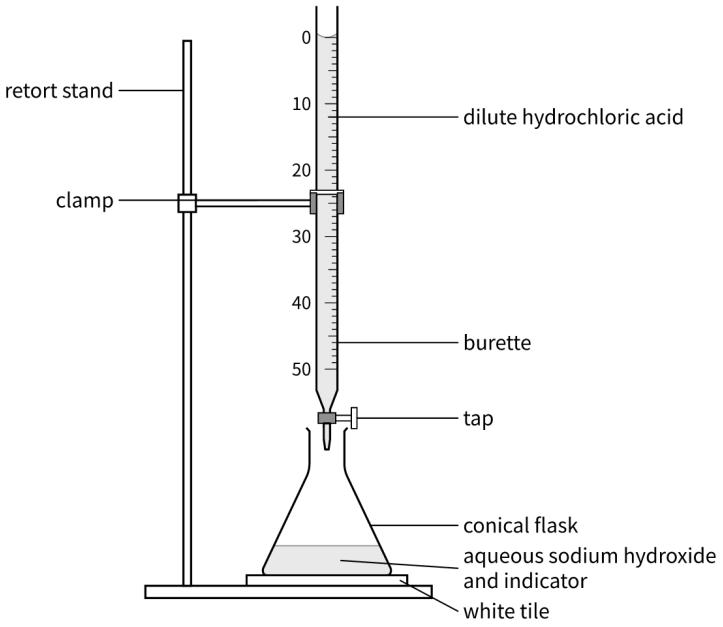
Name the apparatus you would use to measure (a) 2.36 g of a solid, (b) exactly 25.0 cm³ of an alkali, (c) 48 cm³ of a gas.

Answer: (a) electronic balance (b) pipette (c) gas syringe

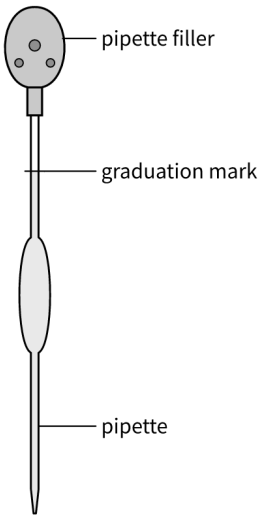
Using a pipette and a burette accurately

In a titration a pipette delivers a fixed volume of one solution into a conical flask, and a burette adds the other solution until the indicator changes colour. Small mistakes in handling change the volume, so each step has a reason. The most important idea is rinsing: a piece of apparatus that MEASURES a solution is rinsed with that same solution, so that no water is left inside to dilute it. The conical flask is different: it is rinsed with distilled water only, because water in the flask does not change the number of moles of alkali that the pipette puts in.

Step	Reason
Rinse the pipette with the alkali it will measure, and the burette with the acid it will hold.	Water left inside would dilute the solution and change the volume needed.
Fill the pipette with a pipette filler, never by mouth.	The solution may be corrosive or poisonous.
Bring the bottom of the meniscus to the graduation mark at eye level.	Avoids parallax error, so exactly 25.0 cm³ is delivered.
Remove the filter funnel from the burette before reading it.	Drops from the funnel would run in and change the reading.
Run a little acid through the tap so the jet has no air bubble.	An air bubble that leaves the jet makes the reading too large.
Put the flask on a white tile and swirl it; add acid drop by drop near the end-point.	The colour change is easy to see; one drop changes the colour at the end-point.
Repeat until two titres agree within 0.10 cm³ (concordant results).	Shows the results are reliable; average the concordant titres.



titration set-up



pipette and filler

WORKED EXAMPLE

Kumar rinsed his burette with distilled water and then filled it with dilute sulfuric acid without rinsing it with the acid. He titrated 25.0 cm³ of aqueous sodium hydroxide. Explain how this mistake affects his titre.

1. Find the mistake: water was left in the burette.
2. Effect on the acid: the water dilutes the acid, so each cm³ contains fewer moles of H_2SO_4.
3. Effect on the volume: the same number of moles of acid is still needed to neutralise the alkali, so a larger volume must be added.

The water left in the burette dilutes the acid, so the acid is less concentrated. A larger volume of acid is needed to neutralise the 25.0 cm³ of alkali, so his titre is too large.

TRY THIS

Why must the conical flask NOT be rinsed with the alkali before the pipette is emptied into it?

Answer: Alkali left in the flask would add extra moles of alkali, so more acid would be needed and the titre would be too large.

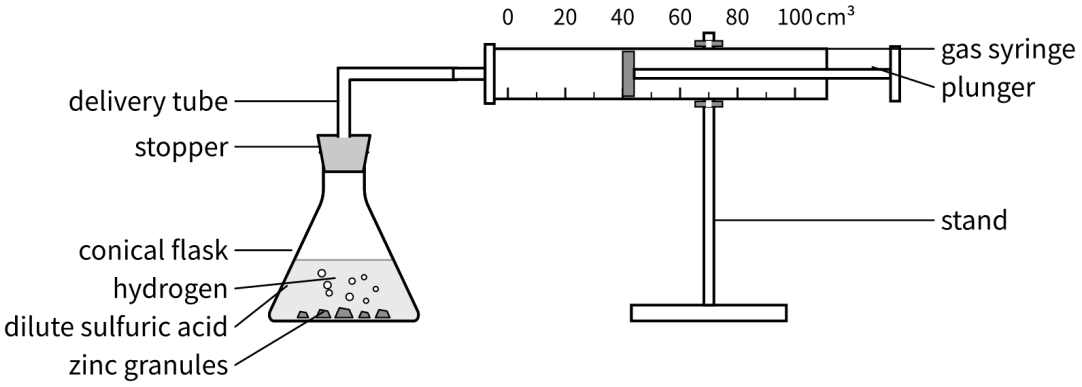
Measuring the volume of a gas and following a reaction

The volume of a gas is measured with a gas syringe, or by collecting it over water in an inverted measuring cylinder or burette. A gas syringe works for any gas, while collecting over water works only for gases that are insoluble or only slightly soluble in water. To follow how fast a reaction goes (its rate),

measure the volume of gas at regular time intervals with a stopwatch, or measure the loss in mass of the flask on an electronic balance as the gas escapes. Rates of reaction are studied in detail in Secondary 4; here you only need to choose the apparatus.

- In the mass-loss method, the cotton wool plug lets the gas out but stops acid spray escaping, which would add to the loss in mass.

Method	What is measured	Best for	Not suitable when
gas syringe	volume of gas at each time	any gas	the volume is more than the syringe holds (about 100 cm^3)
inverted measuring cylinder or burette over water	volume of gas at each time	insoluble or slightly soluble gases (H_2, O_2)	the gas is very soluble (NH_3, HCl, SO_2)
flask on a balance with a cotton wool plug	loss in mass at each time	a dense gas such as CO_2 (M_r 44)	the gas is very light, such as H_2 (M_r 2): the loss is too small to measure



WORKED EXAMPLE

Zinc granules react with dilute sulfuric acid to give hydrogen.

$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

(a) Suggest the apparatus needed to follow how the volume of hydrogen changes with time.

(b) Explain why following the loss in mass of the flask would not work well for this reaction.

1. What is measured: a gas volume against time, so a gas syringe and a stopwatch.
2. Loss in mass: depends on the mass of gas given off. Hydrogen has M_r 2, so even 100 cm^3 of it has a mass of under 0.01 g.
3. An electronic balance reads to 0.01 g, so it cannot show the change.

CHAPTER 1

Practice Questions

Part 2: Experimental Chemistry



In the practice questions

23 questions, 69 marks. For each multiple-choice question, write the letter of the correct option (A, B, C or D) in the brackets. Write your other answers on the lines given. The answers are on page 418.

- Section A: Multiple-Choice Questions: 15 questions, 15 marks
- Section B: Structured Questions: 6 questions, 34 marks
- Section C: Free-Response Questions: 2 questions, 20 marks

Name: _____ Class: _____ Date: _____

SECONDARY 3 · CHEMISTRY · EXPERIMENTAL CHEMISTRY

Experimental Chemistry

INSTRUCTIONS

- 23 questions, 69 marks in total.
- Answer all questions in the spaces provided.
- For MCQs, write the letter (A, B, C or D) in the brackets.
- Write your other answers on the lines given, in full sentences.

Section A: Multiple-Choice Questions

1 A pupil must add exactly 18.65 cm^3 of dilute acid to a flask. Which apparatus should she use? ( ) [1]

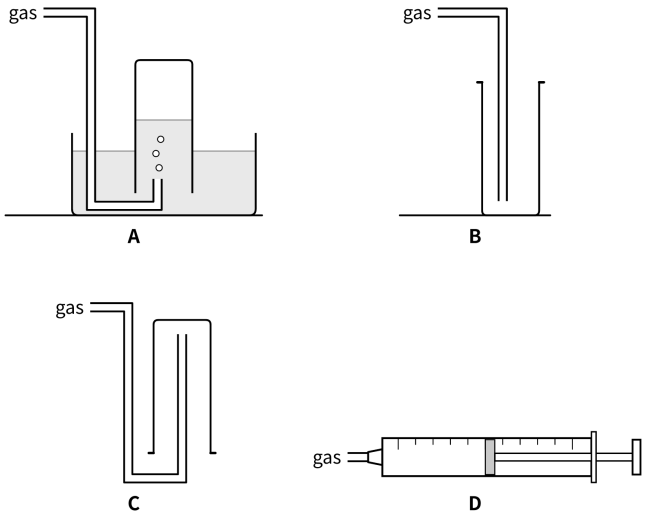
(A) beaker
(B) measuring cylinder
(C) pipette
(D) burette

2 Which row is correct? ( ) [1]

	Quantity	Apparatus	Can be read to
A	mass of a beaker	electronic balance	0.01 g
B	volume of a gas	measuring cylinder	0.05 cm^3
C	temperature of a solution	thermometer	0.05 °C
D	25.0 cm^3 of an alkali	burette	1 cm^3

(A) A (B) B (C) C (D) D

3 Gas Y has M_r 17 and is very soluble in water. Which apparatus can be used to fill a gas jar with Y? ( ) [1]



Ⓐ A Ⓑ B Ⓒ C Ⓓ D

4 Which row shows a gas and a drying agent that can be used to dry it? ( ) [1]

	Gas	Drying agent
A	ammonia	concentrated sulfuric acid
B	carbon dioxide	fused calcium chloride
C	chlorine	calcium oxide
D	sulfur dioxide	calcium oxide

Ⓐ A Ⓑ B Ⓒ C Ⓓ D

5 The rate of a reaction can be followed by measuring the loss in mass of the flask on an electronic balance as a gas escapes. For which reaction is this method LEAST suitable? ( ) [1]

Ⓐ calcium carbonate and dilute hydrochloric acid

Ⓑ magnesium and dilute hydrochloric acid

Ⓒ sodium carbonate and dilute sulfuric acid

Ⓓ zinc carbonate and dilute nitric acid

6 Blue crystals of hydrated copper(II) sulfate are made by crystallisation, not by evaporating the solution to dryness. Which statements give correct reasons?

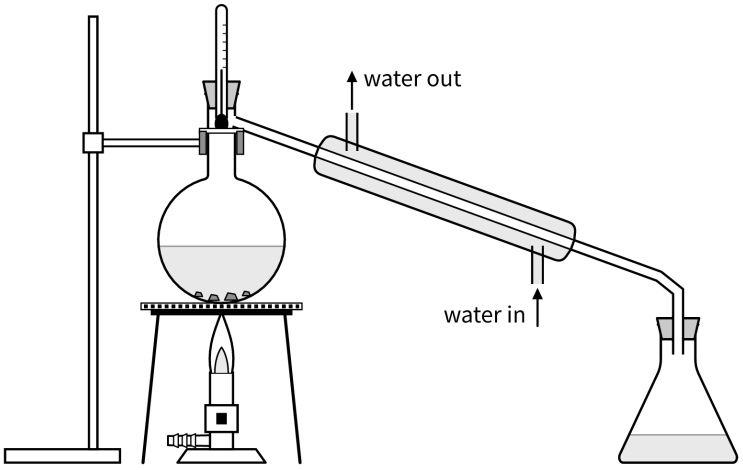
1 Strong heating removes the water of crystallisation.
2 Soluble impurities stay in the solution left after crystallisation.
3 Crystallisation also removes insoluble impurities. ( ) [1]

(A) 1 only (B) 2 only (C) 2 and 3 only (D) 1 and 2 only

7 Which mixture of two solids can be separated by sublimation? ( ) [1]

(A) iodine and zinc oxide
(B) copper(II) sulfate and sand
(C) sodium chloride and sugar
(D) zinc oxide and sand

8 A student uses this apparatus to collect water from a solution of a dye. What is the effect of the mistake in the set-up? ( ) [1]



(A) The distillate will contain the dye.
(B) The water vapour will not condense.
(C) Pressure will build up inside the apparatus, which could force the stoppers out or crack the glass.
(D) The thermometer will read a temperature above 100 °C.

9 Which mixture is best separated by fractional distillation? ( ) [1]

(A) methanol (b.p. 65 °C) and ethanol (b.p. 78 °C)
(B) hexane and water
(C) sand and water
(D) iodine and sand