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Name: _____ Class: _____ Date: _____

SECONDARY 3 · CHEMISTRY · EXPERIMENTAL CHEMISTRY

Experimental Chemistry

Theory and worked examples

Measuring time, temperature and mass

Chemists take measurements to describe what happens in an experiment. Every measurement needs a suitable piece of apparatus (the equipment used) and a unit. Time, temperature and mass are measured with the same apparatus in almost every experiment.

WORDS TO KNOW

apparatus	the equipment used in an experiment
accurate	close to the true value; a more accurate piece of apparatus gives a reading closer to the true value

Quantity	Apparatus	Unit	Notes
time	stopwatch (stopclock)	s, min	start it when the reaction starts, as you add the last reactant
temperature	thermometer	°C	keep the bulb in the liquid, not touching the glass
mass	(electronic) balance	g	put the empty container on first and press zero (tare)

TRY THIS

Name the apparatus used to measure the mass of a solid and state its unit.

Answer: A balance; the mass is measured in grams (g).

Measuring the volume of a liquid

Several pieces of apparatus measure the volume of a liquid. They are not equally accurate, so you must choose the right one. A beaker only holds liquid. A pipette and a burette are used in titration, where a solution is added slowly until a reaction is just complete.

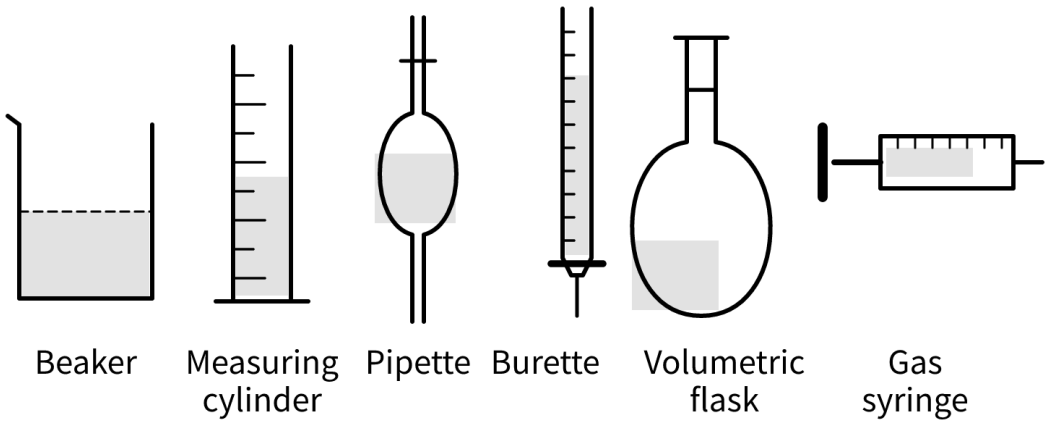
KEY IDEA

Pipette and volumetric flask: one fixed volume. Burette: any volume, added slowly. Measuring cylinder: any volume, less accurate.

WORDS TO KNOW

volume	the amount of space a liquid or gas takes up, measured in cm^3 or dm^3
titration	an experiment in which one solution is added from a burette to a measured volume of another until the reaction is just complete
titre	the volume of solution added from the burette: final reading – initial reading

Apparatus	What it does	Accuracy
beaker	holds or pours liquids; its markings are only a rough guide	least accurate
measuring cylinder	measures any volume of liquid (for example 38 cm^3) up to its size; also the volume of a small irregular solid by water displacement	about ±1 cm^3
pipette	measures out ONE fixed volume only (for example 25.0 cm^3) of a liquid	very accurate
burette	delivers any volume you choose, drop by drop, through a tap; read to the nearest 0.05 cm^3	very accurate
volumetric flask	makes up ONE fixed volume of solution (for example 250 cm^3)	very accurate
gas syringe	measures the volume of a gas, in cm^3 (see Collecting gases and Measuring gas volumes)	accurate



WORKED EXAMPLE

A pupil does a titration four times. The burette readings are in the table (all in cm³). Calculate the titre of run 1 and the mean titre. The rough run (run R) is not used in the mean.

Run	Final reading / cm³	Initial reading / cm³	Titre / cm³
R (rough)	25.80	1.20	24.60
1	24.65	1.20	?
2	25.30	1.75	23.55
3	27.10	3.60	23.50

1. Titre = final reading – initial reading. Run 1: 24.65 – 1.20 = 23.45 cm³.
2. Leave out the rough run (24.60 cm³). It is a trial and is not close to the others.
3. Use only titres that agree within 0.10 cm³ of each other (concordant titres): 23.45, 23.55 and 23.50 cm³.
4. Mean titre = (23.45 + 23.55 + 23.50) ÷ 3 = 70.50 ÷ 3 = 23.50 cm³.

Titre of run 1 = 23.45 cm³; mean titre = 23.50 cm³

TRY THIS

A pupil pours 50 cm³ of water into a measuring cylinder. A small stone is lowered in and the level rises to 68 cm³. What is the volume of the stone?

Answer: 68 – 50 = 18 cm³

Collecting gases

A gas made in a reaction must be collected in a suitable way. The method depends on two properties of the gas: does it dissolve in water, and is it denser or less dense than air? Gas collected in a gas jar is used for tests, for example a burning splint test.

KEY IDEA

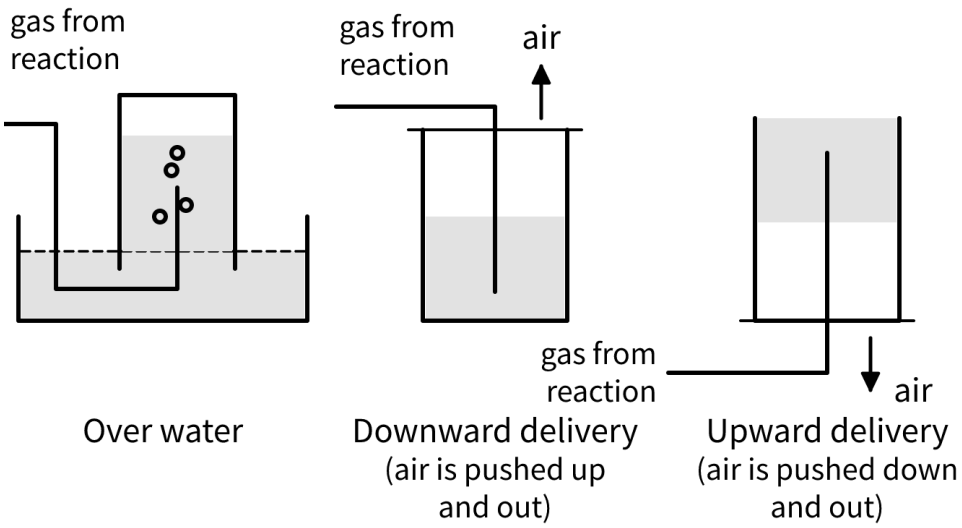
Choose by solubility first, then by density: soluble and denser than air, use downward delivery; soluble and less dense, use upward delivery.

- Ammonia, sulfur dioxide and hydrogen chloride are very soluble in water, so they are never collected over water.
- The delivery tube must reach the bottom of an upright jar (downward delivery) and the top of an upside-down jar (upward delivery).

WORDS TO KNOW

denser	heavier for the same volume; a gas denser than air sinks in air
soluble	able to dissolve in a liquid such as water

Method	Use it for a gas that is	Examples
over water (gas pushes water out of an inverted jar)	insoluble (or almost insoluble) in water	hydrogen, oxygen
downward delivery (gas jar upright, gas sinks and pushes air up and out)	denser than air	carbon dioxide, chlorine, sulfur dioxide, hydrogen chloride
upward delivery (gas jar upside down, gas rises and pushes air down and out)	less dense than air	hydrogen, ammonia, methane



WORKED EXAMPLE

Chlorine is a gas that dissolves in water and is denser than air. Name the best way to collect a gas jar of chlorine and give a reason.

1. Chlorine dissolves in water, so collection over water is not suitable.
2. Chlorine is denser than air, so it sinks and pushes the air out of the top of an upright gas jar.

Downward delivery (upward displacement of air), because chlorine is denser than air.

TRY THIS

Hydrogen is insoluble in water and much less dense than air. Name two ways to collect it.

Answer: Over water, or by upward delivery (jar upside down).

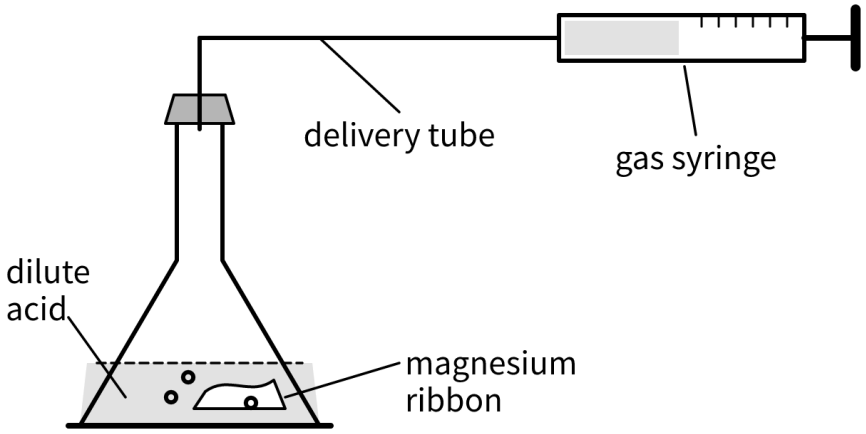
Measuring gas volumes and the rate of a reaction

To follow how fast a reaction makes a gas, measure how the volume of gas changes with time. A gas syringe collects the gas and shows its volume on a scale in cm^3. A stopwatch measures the time. A measuring cylinder filled with water and turned upside down in a trough can also collect and measure a gas that is insoluble.

- Write down the syringe reading at regular times, for example every 30 seconds.
- If the gas simply escapes into the air, the rate can be found by the loss in mass on a balance. Put a loose plug of cotton wool in the neck so that no liquid spits out.
- The faster the gas is made, the faster the plunger moves out.

WORDS TO KNOW

rate of reaction	how fast a reaction happens, found by how quickly a product is made or a reactant is used up
gas syringe	a glass barrel with a plunger that is pushed out by the gas; its scale gives the volume of gas in cm^3



WORKED EXAMPLE

Magnesium reacts with dilute acid to give hydrogen gas. Suggest the apparatus needed to find how fast the hydrogen is made.

1. Use a conical flask for the reaction. Close it with a bung and a delivery tube so no gas escapes.
2. Connect the delivery tube to a gas syringe to measure the volume of hydrogen in cm^3.
3. Use a stopwatch and record the volume of gas at fixed times, for example every 30 s.

Conical flask with bung and delivery tube, a gas syringe, and a stopwatch.

TRY THIS

Carbon dioxide escapes from a flask during a reaction. Name the apparatus that can be used instead of a gas syringe to follow the reaction.

Answer: A balance (measure the loss in mass), plus a stopwatch.

CHAPTER 1

Practice Questions

Part 2: Experimental Chemistry



In the practice questions

24 questions, 77 marks. For each multiple-choice question, write the letter of the correct option in the brackets. Write your other answers on the lines given. The answers are on page 293.

- Section A: Multiple-Choice Questions: 14 questions, 14 marks
- Section B: Structured Questions: 8 questions, 43 marks
- Section C: Free-Response Questions: 2 questions, 20 marks

Name: _____ Class: _____ Date: _____

SECONDARY 3 · CHEMISTRY · EXPERIMENTAL CHEMISTRY

Experimental Chemistry

INSTRUCTIONS

- 24 questions, 77 marks in total.
- Answer all questions in the spaces provided.
- For multiple-choice questions, write the letter of the correct option in the brackets.
- Write your other answers on the lines given, in full sentences.

Section A: Multiple-Choice Questions

1 Which apparatus is the most suitable for measuring out exactly 25.0 cm^3 of a solution? ( ) [1]

(A) beaker
(B) measuring cylinder
(C) pipette
(D) conical flask

2 Which statements about melting points and boiling points are correct?
1: A pure solid has a sharp melting point.
2: An impure solid melts at a higher temperature than the pure solid.
3: An impure liquid boils over a range of temperatures. ( ) [1]

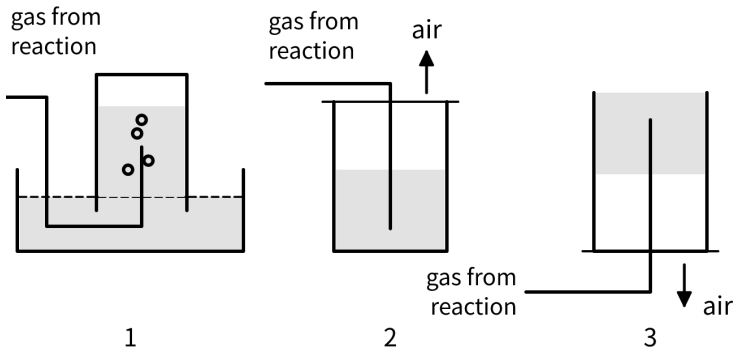
(A) 1 and 3 only (B) 1 and 2 only (C) 2 and 3 only (D) 1, 2 and 3

3 Which row correctly matches the apparatus with its use? ( ) [1]

	Apparatus	Use
A	volumetric flask	adds liquid drop by drop
B	gas syringe	measures the volume of a gas
C	beaker	measures exactly 25.0 cm^3 of liquid
D	measuring cylinder	gives one fixed volume of solution only

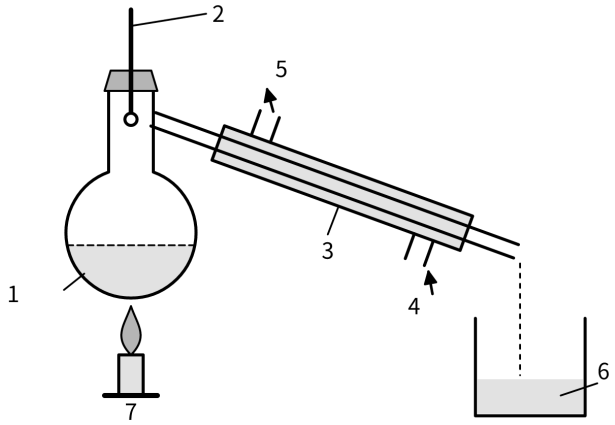
(A) A (B) B (C) C (D) D

4 Hydrogen is insoluble in water and is less dense than air. Which of the methods shown in the diagram can be used to collect it? ( ) [1]



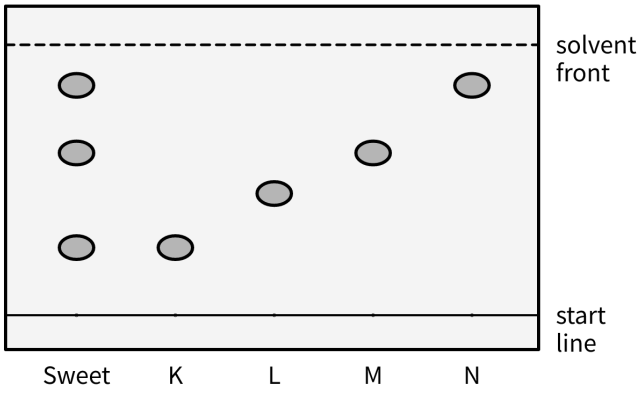
(A) 1 only (B) 2 only (C) 3 only (D) 1 and 3 only

5 Sea water is heated in the apparatus shown. Which number shows where cold water LEAVES the condenser? ( ) [1]



(A) 5 (B) 4 (C) 7 (D) 6

6 A chromatogram of a green sweet and four dyes K, L, M and N is shown. Which dyes are in the sweet? ( ) [1]

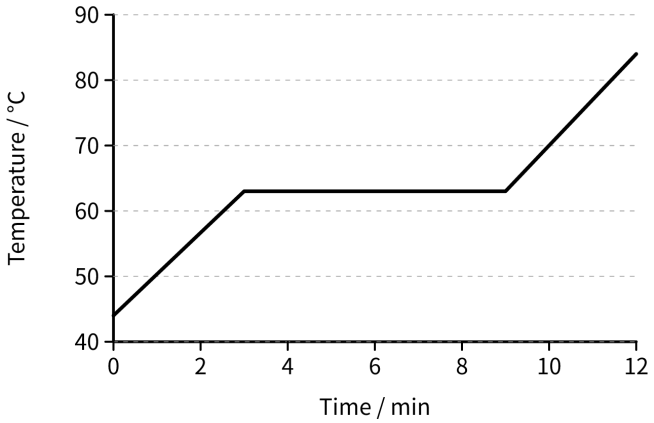


(A) K and L only (B) L, M and N (C) K, M and N (D) K, L, M and N

7 Which mixture can NOT be separated by adding water, stirring and filtering? ( ) [1]

(A) salt and sand
(B) sugar and chalk powder
(C) salt and charcoal powder
(D) sand and chalk powder

8 A solid S is heated and its temperature is recorded every minute. The graph is shown. Which conclusion is correct? ( ) [1]



(A) S is a mixture.
(B) S is pure and its melting point is 63 °C.
(C) S is pure and its boiling point is 63 °C.
(D) S is impure and melts at 63 °C.

9 The table shows the melting points and boiling points of four pure liquids W, X, Y and Z. A sample melts from 2 °C to 4 °C and boils from 81 °C to 84 °C. Which pure substance is it an impure sample of? ( ) [1]

Substance	Melting point / °C	Boiling point / °C
W	17	118
X	−7	59
Y	6	80
Z	−95	56

(A) W (B) X (C) Y (D) Z

10 Why is a fractionating column filled with glass beads? ( ) [1]

(A) to give a large surface area for repeated condensing and vaporising
(B) to stop the liquid from bumping
(C) to cool the vapour so that it turns to liquid
(D) to prevent the thermometer from breaking