EXPLAIN THAT!

GCE 'O' LEVEL CHEMISTRY

EXAMINER-STYLE ANSWER PHRASINGS TO MUST-KNOW QUALITATIVE QUESTIONS

ARNOLD K H TAN

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Explain That! is a series of comprehensive guides designed to help students master the skill of answering qualitative questions. Each title comprises a well-curated selection of questions which covers a variety of key ideas and concepts. These books train students to construct their explanations using examiner-style phrasing, giving them greater confidence before and during the examinations.

What's Inside?

- ☑ A collection of common must-know qualitative questions
- ☑ Concise reference answers with examiner-style phrasing
- ☑ Clear diagrams for better visualisation and understanding

Arnold K H Tan holds a Bachelor of Science in Biochemistry and Microbiology from NUS. In 2002, he qualified for membership with Mensa, the high IQ society. He also attained the Silver Award at the 12th Youth Science Fortnight (Biology Section). Currently, he is a full-time tutor and a tutor at Eton Tuition Centre. He specialises in equipping his students with concise and pertinent facts that can be used to craft accurate explanations at the GCE 'O' Level Chemistry examinations.

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Preface

Since my first tutoring assignment which started in June 1992, I knew that I would always be involved in the field of education. Today, I still keep in touch with that first student, as well as many other students whom I have taught over the years. These are the people who have taught me that every student is unique in their learning ability, aptitude, attitude and commitment.

Explain That! GCE 'O' Level Chemistry is inspired by the many common questions which I have had to explain in depth. It is also motivated by the need for a concise and handy reference to common questions that students have. To help students gain a better insight into the understanding of 'killer' topics in Chemistry, the explanations in this book have been simplified and presented with a suitable level of detail. The questions have been arranged by topic to make it easier for students to navigate through this book.

To help me improve this book for future editions, I would like to hear your feedback and suggestions. You can get in touch with me by sending an email to **bugline@gmail.com**. I would like to thank Tan Jun Wei (author of Explain That! Physics) and Tan Wei Jie (editor) for their help in making the publication of this book possible. Most importantly, I would like to thank you for reading this book, and I sincerely hope that this book will help to ease your journey in Chemistry.

Arnold K H Tan

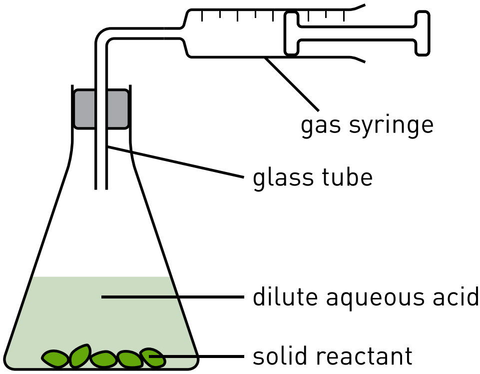
About the Author

Arnold K H Tan graduated with a Bachelor of Science, majoring in Biochemistry and Microbiology, from the National University of Singapore and is an alumnus of Raffles Junior College. During his student years, he has participated in a number of science competitions at the national level and has won the Silver Award at the 12th Youth Science Fortnight (Biology Section). Arnold qualified for membership with Mensa (the high IQ society) in 2002. Currently, Arnold is a full-time tutor and a tutor at Eton Tuition Centre. He specialises in equipping his students with concise and pertinent facts that can be used to craft accurate explanations at the GCE 'O' Level Chemistry examinations.

1 Experimental Chemistry

1.1 Experimental Design

001 **What apparatus should I use to collect a gas and measure its volume?**

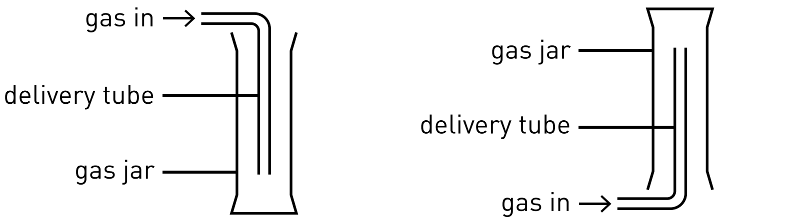


The simplest way to collect a gas is to connect a gas syringe to a conical flask using a delivery tube and a rubber stopper. If you need to measure the volume of gas collected, you can use a graduated gas syringe with volume markings on it.

002 **What properties of a gas should I consider when choosing a method to collect the gas?**

The method chosen to collect a gas depends on the physical properties of the gas, such as its relative molecular mass compared to air and its solubility in water.

003 **When collecting a gas sample, should I use the upward or downward displacement method?**



upward displacement of air (downward delivery)

downward displacement of air (upward delivery)

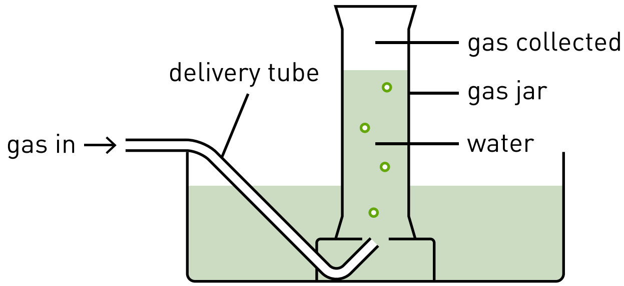
Air contains around 78% nitrogen (N_2), 21% oxygen (O_2) and 1% other gases. The approximate relative molecular mass (M_r) of air is (M_r of $N_2 \times 0.78$) + (M_r of $O_2 \times 0.21$) $= 28 \times 0.78 + 32 \times 0.21 = 28.56$.

Gases which have a significantly lower M_r than air can be collected by the downward displacement method. Examples include hydrogen (H_2), ammonia (NH_3) and methane (CH_4).

Gases which have a significantly higher M_r than air can be collected by the upward displacement method. Examples include sulfur dioxide (SO_2) and carbon dioxide (CO_2).

Gases such as oxygen (O_2), nitrogen (N_2), carbon monoxide (CO), ethene (C_2H_4) and ethane (C_2H_6) cannot be collected by either method because their M_r is too close to 28.56. Air is a mixture, so the composition of air may vary.

004 **Under what circumstances is it possible to use the setup below to collect a gas?**



The method of displacing water can be used when the gas to be collected is insoluble or sparingly soluble in water. The gas is delivered into a gas jar containing water using a delivery tube, displacing water out of the gas jar.

005 **Which drying agent should I use for a gas?**

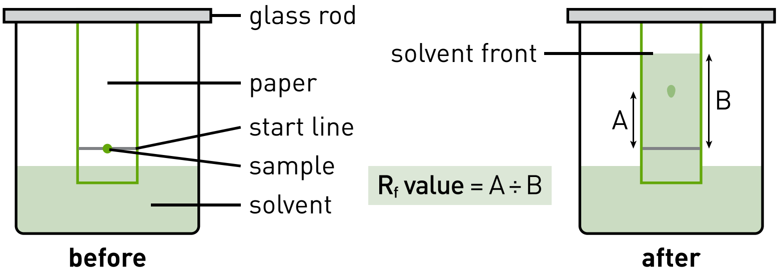
The simplest drying agent for most gases except ammonia is concentrated sulfuric acid (H_2SO_4). A suitable drying agent for ammonia gas (NH_3) is calcium oxide (CaO) pellets.

1.2 Methods of Purification and Analysis

006 **Do I need a locating agent for paper chromatography?**

A locating agent is needed when the substances being separated are colourless, such as amino acids. The locating agent reacts with the substances to produce coloured spots on the chromatogram.

007 Why must the start line be drawn using a pencil in a paper chromatography experiment?



Pencil lines are insoluble in water and organic solvents.

008 Why must the start line of the chromatography paper be above the solvent level?

If the start line is below the solvent level, the sample will dissolve and get washed away in the solvent.

009 Should I use simple distillation or fractional distillation?

Simple distillation is used to separate and collect the solvent from a mixture made from a solid dissolved in a liquid. An example is seawater, which contains salt dissolved in water.

Fractional distillation is used to separate components of a miscible liquid mixture. Examples include a mixture of alcohol and water, and crude oil.

010 How can I increase the yield of a salt collected during crystallisation?

Reduce the temperature of the saturated solution by placing it in an ice bath. The lower the temperature, the lower the solubility of the salt, causing more salt to crystallise.

011 **How do I separate a mixture of sawdust and iron filings?**

Since iron is a magnetic material, we can use a bar magnet to separate the iron filings from the sawdust.

012 **How do I obtain pure copper(II) sulfate from a sample containing impurities which are insoluble in water?**

Dissolve the sample in water and pour the contents through a filter paper to remove the impurities. Water evaporates when the filtrate is heated, resulting in a warm saturated solution. Pure $CuSO_4$ crystals are formed upon cooling.

013 **What test should I use to determine if a sample is pure?**

Pure substances have fixed melting and boiling points, and they melt and boil at fixed temperatures. Mixtures melt and boil over a range of temperatures.

1.3 Identification of Ions and Gases

014 **Why is nitric acid added for a number of tests for anions, such as the tests for chloride (Cl^-), iodide (I^-) and sulfate (SO_4^{2-}) ions?**

Nitric acid (HNO_3) is used to dissolve any insoluble base or insoluble carbonate present as impurities, which gives a false positive result. Nitric acid also removes any excess hydroxide ions (OH^-) present, preventing the formation of insoluble metal hydroxides which are visible as precipitates.

015 Is there an easy way to memorise the tests for cations using sodium hydroxide and aqueous ammonia?

Sodium hydroxide (NaOH)	Aqueous ammonia (NH_4OH)
Remember ZAP – Zn, Al, Pb	Remember CuZn – Cu, Zn like a short form of 'cousin'
These metal hydroxides are soluble when excess sodium hydroxide is added	These metal hydroxides dissolve in excess aqueous ammonia

016 How do I test for the presence of a particular gas?

The table below shows the various tests which can be used to identify the presence of common gases.

Gas	Test
Hydrogen (H_2)	When a lighted splint is placed inside a test tube containing hydrogen, a distinctive 'pop' sound is heard.
Oxygen (O_2)	When a glowing splint is placed inside a test tube containing oxygen, the splint relights.
Carbon dioxide (CO_2)	When carbon dioxide is passed through some limewater, a white precipitate is formed. The precipitate dissolves in excess carbon dioxide.
Ammonia (NH_3)	The presence of ammonia gas causes a piece of moist red litmus paper to turn blue.
Chlorine (Cl_2)	The presence of chlorine gas causes a piece of moist blue litmus paper to turn red. The litmus paper becomes bleached after a while.

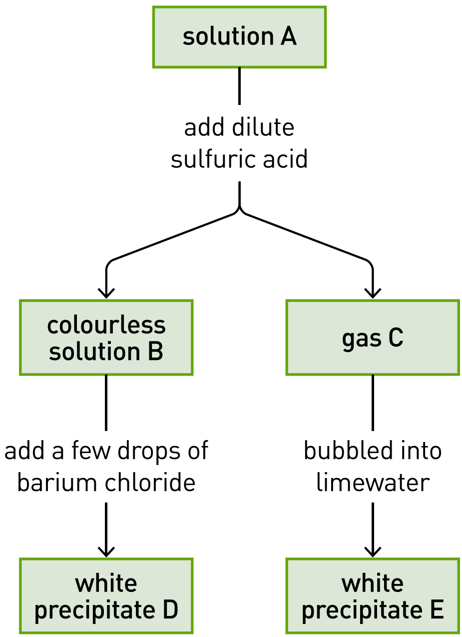
For **qualitative analysis questions** that involve a flowchart, you may begin by looking out for specific tests for cations (positive ions), anions (negative ions) or gases to determine the substance formed. After identifying some substances on the flowchart, you can work backwards to determine the starting substances.

017 **Solution A is a mixture of two potassium salts.**

(i) **Name substances C, D and E.**

(ii) **The formation of white precipitate D shows that sulfate ions are present in solution B. Explain why this does not mean that sulfate ions are present in solution A.**

(iii) **How can the procedure be modified to confirm that sulfate ions are present in solution A?**



(i) C: carbon dioxide
D: barium sulfate
E: calcium carbonate

Note: When asked to **name** a substance, the name of the substance must be spelt out in full. When asked to **identify** a substance, either the name or the chemical formula of the substance can be accepted.

White precipitate D must be barium sulfate as barium chloride is used to test for the presence of sulfate ions, with a white precipitate indicating a positive result.

We can deduce that white precipitate E is calcium carbonate because limewater is used to test for carbon dioxide and a white precipitate is formed, indicating a positive result. Working backwards, gas C must be carbon dioxide. From this, we can only conclude that solution A contains potassium carbonate. The identity of the second potassium salt in A cannot be confirmed.

(ii) When dilute sulfuric acid is added to solution A, the resulting solution will contain sulfate ions. We cannot conclusively determine whether solution A contains sulfate ions since sulfate ions were added before the test for sulfate ions.

(iii) Add excess nitric acid to 1 cm^3 of solution A to remove the carbonate ions. Add a few drops of barium chloride to the resulting solution. Sulfate ions are present if a white precipitate is formed.

Note: If barium chloride is added to a small sample of solution A without removing the carbonate ions, the white precipitate formed would be barium carbonate, leading to a false positive result.

2 Atomic Structure and Stoichiometry

2.1 Kinetic Particle Theory

018 **Iodine exists as a solid at r.t.p. but sublimes when it is heated. Use the kinetic particle theory to explain this.**

Iodine molecules (I_2) have higher molecular masses and hence stronger intermolecular forces than other covalent molecules with smaller molecular masses. When heated, the iodine molecules gain kinetic energy and sublimes when the intermolecular forces of attraction are overcome.

019 **A solid melts when it is heated. Use the kinetic particle theory to explain why the temperature of the substance remains constant at the melting point for some time.**

The temperature of the solid rises until it reaches the melting point. At this point, the temperature remains constant as energy is used to overcome the attractive forces between the particles. At this temperature, the substance exists as a mixture of solid and liquid.

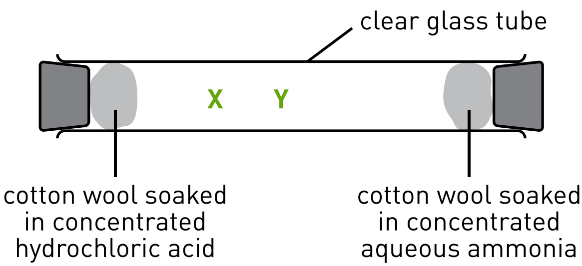
020 **Large amounts of solid methane hydrate have been found underground in high-pressure regions with temperatures below −5 °C. Methane hydrate has a similar structure to ice, and is formed from methane and water. When it is extracted, large volumes of methane are released.**

Suggest why methane hydrate decomposes when it is extracted at r. t. p.

At r. t. p, methane hydrate immediately starts to melt and the pressure decreases to atmospheric pressure. The weak forces between the simple covalent methane molecules and the water molecules are overcome when methane hydrate decomposes to produce water and methane gas.

021 **A piece of cotton wool soaked in concentrated hydrochloric acid and a piece of cotton wool soaked in concentrated aqueous ammonia are placed at the two ends of a clear glass tube.**

After some time, white fumes are observed at point X even though hydrogen chloride fumes and ammonia gas are colourless.



(i) Name the compound formed at point X and explain the observation using the kinetic particle theory.

The experiment was repeated using methylamine (CH_3NH_2) solution instead of concentrated aqueous ammonia.

(ii) Name the compound formed and explain why the white fumes appear at point Y instead.

(iv) The hydrochloric acid and aqueous ammonia from the cotton wool evaporate to form hydrogen chloride (HCl) gas and ammonia (NH_3) gas respectively. The gas particles are in constant random motion and diffusion occurs. Ammonia gas which has a smaller molecular mass diffuses faster than hydrogen chloride, so the white fumes of ammonium chloride (NH_4Cl) are formed at point X.

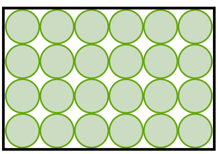
(v) The relative molecular masses (M_r) of hydrogen chloride gas, methylamine and ammonia gas are 36.5, 31 and 17 respectively. Since the M_r of methylamine is closer to the M_r of hydrogen chloride gas, the methylamine diffuses slower than ammonia gas but slightly faster than hydrogen chloride gas. Hence, the white fumes of methylamine chloride (CH_3NH_3Cl) are formed at point Y.

022 **An open bottle of perfume is placed at one side of a room. Use the kinetic particle theory to explain why a person sitting at the other side of the room can smell the perfume.**

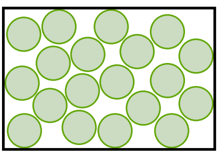
Perfume particles with enough energy leave the liquid during evaporation as the weak forces of attraction between the perfume particles are overcome. The constant random motion of the perfume gas particles causes the perfume to diffuse across the room.

023 **What are the common properties of solids, liquids and gases, in terms of motion, arrangement and forces of attraction between particles?**

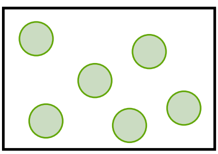
Property	Solid	Liquid	Gas
Arrangement of particles	Ordered, regularly arranged	Not ordered, irregularly arranged	Not ordered
Distance between particles	Closely packed	Less closely packed	Large distance between molecules
Forces of attraction between molecules or particles	Very strong	Strong	Very weak
Motion of particles	Particles vibrate randomly and remain in their fixed positions	Particles slide over other particles randomly and move to take the shape of its container	Particles move about randomly at high speeds and expand to fill the container



solid



liquid



gas

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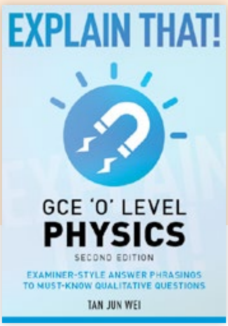

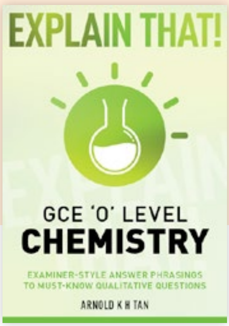

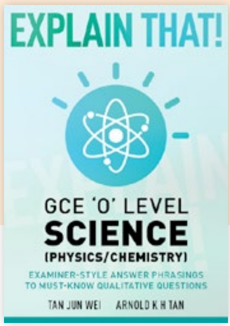

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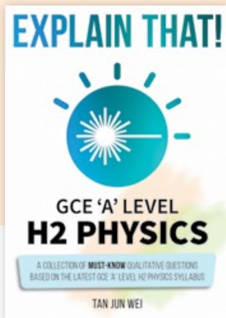

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