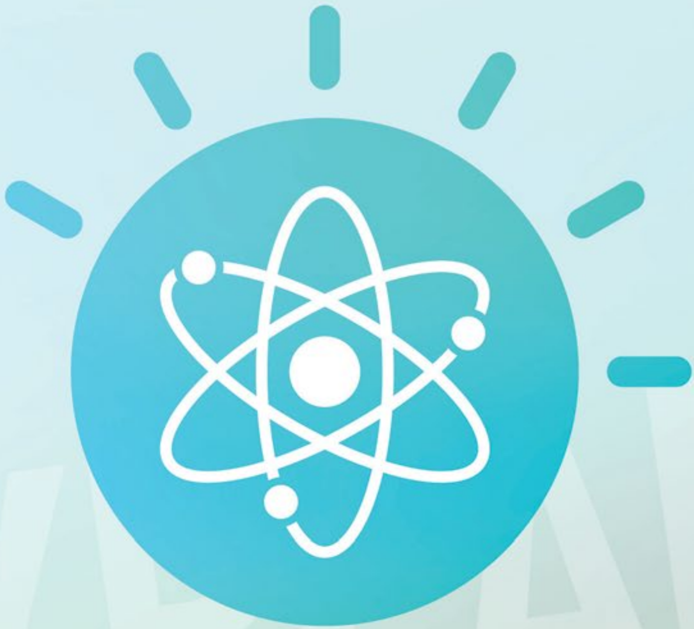
# EXPLAIN THAT!



## GCE 'O' LEVEL
# SCIENCE
## (PHYSICS/CHEMISTRY)

### EXAMINER-STYLE ANSWER PHRASINGS TO MUST-KNOW QUALITATIVE QUESTIONS

TAN JUN WEI     ARNOLD K H TAN

# EXPLAIN THAT!

## GCE 'O' LEVEL SCIENCE (PHYSICS/CHEMISTRY)

*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

**Tan Jun Wei** graduated with a Bachelor of Engineering with First Class Honours in Electrical Engineering. Currently, he trains the Junior Physics Olympiad Team at several top institutions in Singapore, and is the director of Eton Tuition Centre. His strengths lie in helping students build a strong foundation in Physics and teaching them how to apply what they have learnt to real world scenarios.

**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. 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 Science examinations.

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# Chemistry Section

# Preface

**by Tan Jun Wei**

Through years of interaction, one of the observations I made as an educator was that most students were unable to answer qualitative questions efficiently and effectively. Most books, notes – and even "summaries" – focus on elaborating concepts to instill understanding. However, the detailed paragraphs are often too lengthy to be used in an examination.

**Explain That! GCE 'O' Level Science (Physics/Chemistry)** is packed with suggested solutions for a wide variety of qualitative questions from the Physics and Chemistry sections of the GCE 'O' Level Science syllabus. It helps students identify key ideas and concepts which are sufficient for answering qualitative questions, especially when the clock is ticking by the second.

One of the early methods which I have employed as an educator was to develop worksheets for common qualitative questions. These questions were largely inspired by hundreds of local and overseas examination papers, ranging from school preliminary examinations to the GCE 'O' Level examinations. What I have gathered is that most qualitative questions are formed from pieces of information which I refer to as "building blocks", and different "building blocks" can be combined to create a new qualitative question. With the contributions of my past and present students, my worksheets have improved over the years. Soon, I realised that the growing collection of questions had the potential to become a book containing just the right amount of information.

Another thing I noticed was that students were often confused when faced with a question which has never appeared in the annals of ten-year series and test papers from other schools. This book aims to bridge the gap by including some innovative questions to inspire students to apply their knowledge to new problems. Each question was carefully selected to cover as many concepts as the syllabus dictates without turning this book into an encyclopedia (and subsequently a paperweight). Always remember that the list of questions is not exhaustive, and this book is meant as a reference to help students master the art of answering qualitative questions.

Students are advised to understand and modify the suggested answers when attempting similar questions during exams. This book should be used in conjunction with existing educational resources that students are already using. It does not cover every last piece of information that you will find in the course outline. Content which is not required in answering qualitative questions is most likely expunged from this compendium.

Due to human error (just like what happens in an experiment), controversies may arise from time to time. In such a situation, please send an email to **enquiries@examworld.com.sg** to let us know. A list of errors and corrections will be maintained on our website at http://www.examworld.com.sg .

Tan Jun Wei

# Preface

**by Arnold K H Tan**

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 Science (Physics/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 the Chemistry section, 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 my co-author Tan Jun Wei and editor Tan Wei Jie 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 Science.

Arnold K H Tan

# About the Authors

**Tan Jun Wei** founded Examworld, an educational consultancy firm which provides students with quality Olympiad training. He graduated with a Bachelor of Engineering with First Class Honours in Electrical Engineering from the National University of Singapore, and has achieved the NUS Innovation Award (Merit). He represented Singapore in the 2001 Asian Physics Olympiad and is ranked Top 39 in Asia. In the same year, he received the Excellence in 'A' Level Physics Award which is given to the top ten performers at the GCE 'A' Level Physics examinations. Currently, he trains students for the Junior Physics Olympiad at several top institutions in Singapore, and is the director of Eton Tuition Centre.

*Tan Jun Wei is the author of the Physics Section of this book.*

**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 Science examinations.

*Arnold K H Tan is the author of the Chemistry Section of this book.*

# 1 Measurement

## 1.1 Physical Quantities, Units and Measurement

001 **Distinguish between scalar and vector quantities and give examples for each.**

| Scalar Quantities | Vector Quantities |
|---|---|
| Has magnitude only | Has both magnitude and direction |
| Examples:<br>• distance<br>• speed<br>• time<br>• mass<br>• temperature<br>• energy | Examples:<br>• displacement<br>• velocity<br>• acceleration<br>• weight<br>• force<br>• moment of a force |

002 **Suggest why a driver takes a longer time to stop a lorry in reality, compared to the theoretically calculated time.**

Due to human reaction time, the driver delays for a short moment before applying the brakes.

## 003 What are the different prefixes?

| Prefix | Symbol | Factor |
|---|---|---|
| giga | G | $10^9$ |
| mega | M | $10^6$ |
| kilo | k | $10^3$ |
| deci | d | $10^{-1}$ |

| Prefix | Symbol | Factor |
|---|---|---|
| centi | c | $10^{-2}$ |
| milli | m | $10^{-3}$ |
| micro | μ | $10^{-6}$ |
| nano | n | $10^{-9}$ |

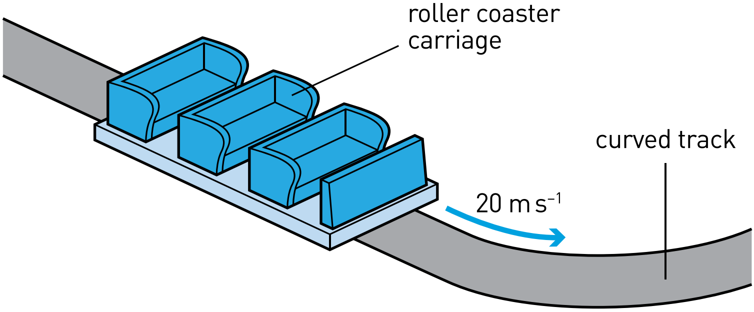
## 004 What are the orders of magnitudes of various objects?

| Object | Order of Magnitude / m |
|---|---|
| Diameter of atom | $10^{-10}$ |
| Diameter of virus | $10^{-8}$ to $10^{-7}$ |
| Wavelength of visible light | $10^{-7}$ |
| Diameter of human hair | $10^{-4}$ |
| Thickness of paper | $10^{-4}$ |
| Thickness of coin | $10^{-3}$ |
| Diameter of golf ball | $10^{-2}$ |
| Length of shoe | $10^{-1}$ |
| Height of man | $10^0$ |
| Length of saloon car | $10^0$ |
| Length of bus | $10^1$ |
| Height of Mount Everest | $10^3$ to $10^4$ (it is 8848 m) |
| Width of Singapore | $10^4$ |
| Diameter of Moon | $10^6$ |
| Diameter of Earth | $10^7$ |
| Distance from Earth to Moon | $10^8$ |

# Newtonian Mechanics

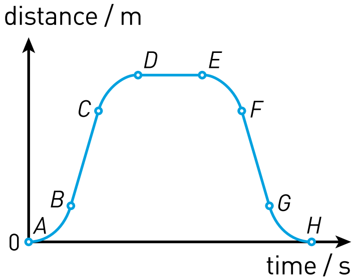
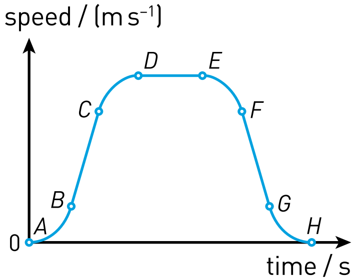
## 2.1 Kinematics

005 **A roller coaster carriage travelling at a uniform speed of 20 m $s^{-1}$ approaches a curve along the track. Explain why the carriage accelerates upon entering the curved segment of the track even though its speed remains at 20 m $s^{-1}$.**




Although the roller coaster carriage is moving at a uniform speed of 20 m $s^{-1}$, its direction changes as it travels along the curved segment of the track. Since velocity consists of both magnitude and direction, there is a change in velocity, hence the carriage is accelerating.

## 006 Describe the motion of an object based on its distance-time graph or speed-time graph.

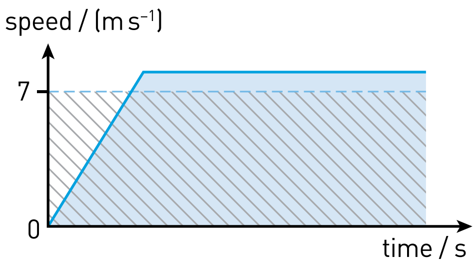
| | Distance-Time Graph | Speed-Time Graph |
|---|---|---|
| |  Points *A* and *H* are at zero displacement. |  Points *A* and *H* are at rest. |
| ***AB*** | non-uniform increasing speed<br>(object moving away from 0) | non-uniform increasing acceleration |
| ***BC*** | uniform speed | uniform acceleration |
| ***CD*** | non-uniform decreasing speed | non-uniform decreasing acceleration |
| ***DE*** | at rest | uniform speed<br>(zero acceleration) |
| ***EF*** | non-uniform increasing speed<br>(object moving towards 0) | non-uniform increasing deceleration |
| ***FG*** | uniform speed | uniform deceleration |
| ***GH*** | non-uniform decreasing speed | non-uniform decreasing deceleration |

007 **A student wants to show that a toy car is moving at a constant speed. Describe how he can show that the speed is constant and state the measurements to be made.**

1. Using a metre rule, make three markings *A*, *B* and *C* on the ground in a straight line one metre apart.
2. Using a stopwatch, measure the time taken for the toy car to move between markings *A* and *B*, and between markings *B* and *C*.
3. The toy car is moving at a constant speed if the two time intervals are the same.

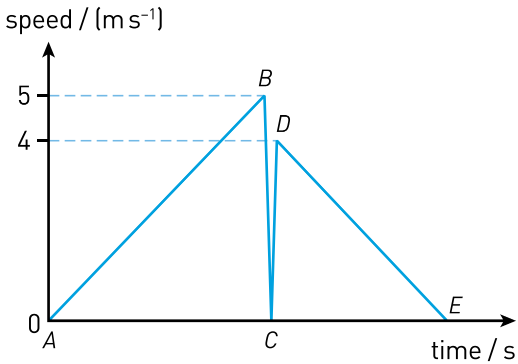
008 **A sprinter competes in a 100-metre race along a straight track. If the sprinter runs at an average speed of 7 m s$^{-1}$, suggest why his speed must exceed 7 m s$^{-1}$ at some point during the race.**

The average speed is given by the total distance travelled over the total time taken. The sprinter accelerates from rest, so it is unlikely that he runs at a constant speed throughout the race. Hence, the speed of the sprinter is below 7 m s$^{-1}$ at some times and above 7 m s$^{-1}$ at other times.




Note: The area under the speed-time graph (▭) represents the distance travelled (100 metres), which is equal to the area bounded by the dashed line (average speed of 7 m s$^{-1}$) and the horizontal axis (▨) for the same time period.

009 **The diagram below shows the speed-time graph of a ball that is dropped from a height. State the change in velocity after the ball bounces off and explain your answer based on the graph.**




After the ball bounces off the ground, the change in velocity is 9 m $s^{-1}$ upwards.

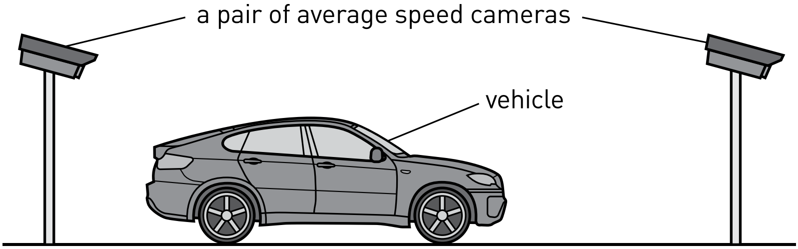
Note: The change in velocity of the ball should include both the magnitude (9 m $s^{-1}$) and direction (upwards).

From *A* to *B*, the ball is falling from a height. From *D* to *E*, the ball is travelling upwards after it bounces off. *BCD* refers to the time when the ball is in contact with the ground.

This means that the velocity of the ball is 5 m $s^{-1}$ downwards before the ball bounces off the ground, and 4 m $s^{-1}$ upwards after the ball bounces off the ground. Hence, the change in velocity is 4 – (–5) = 9 m $s^{-1}$ upwards.

Note: Change in velocity is equal to final velocity (*v*) – initial velocity (*u*). We use –5 to represent 5 m $s^{-1}$ downwards since the ball travels at 4 m $s^{-1}$ in the opposite direction (upwards) after it bounces off the ground.

010 **The diagram shows a pair of average speed cameras that can be used to determine the average speed of a vehicle travelling between two points along a road.**




**(i) Suggest the measurements that can be made in order to determine the average speed of a vehicle travelling between two points along a road.**

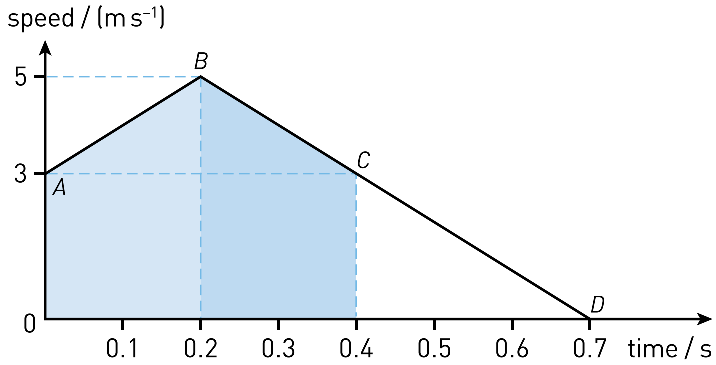
**(ii) Explain how this setup can be used to identify vehicles which have been travelling above the speed limit along a road, even if the instantaneous speed of the vehicle is below the speed limit in front of the two cameras.**

**(i)** Measure the distance between the two cameras along the road. Find the difference between the two recorded times to determine the time taken by the vehicle to travel between the two cameras. The average speed of the vehicle is the distance divided by the time taken.

**(ii)** The average speed refers to the total distance travelled divided by the total time taken. If the average speed of the vehicle calculated in **(i)** is higher than the speed limit, the vehicle must have been travelling above the speed limit at some point between the two cameras, even if the instantaneous speed of the vehicle is below the speed limit in front of the two cameras. Hence, the setup can be used to identify vehicles which have been speeding along a stretch of road.

011 **A student throws a ball vertically downwards. The ball leaves her hand at a speed of 3 m $s^{-1}$ and hits the ground 0.2 seconds later, changing its direction of motion.**

**Assuming that no energy is lost when the ball hits the ground or due to air resistance, draw a speed-time graph for the ball's journey, from the point where the ball leaves the student's hand to the point where the ball reaches its maximum height. Explain the shape of your graph.**

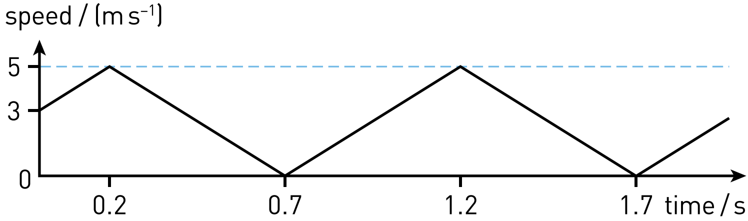



At point *A*, the ball is travelling downwards with an initial speed of 3 m $s^{-1}$. At point *B*, the ball hits the ground with a speed of 5 m $s^{-1}$ (acceleration due to gravity is 10 m $s^{-2}$ downwards) and bounces off at the same speed since the kinetic energy remains constant (principle of conservation of energy). At point *C*, the ball passes its initial position and continues travelling upwards. At 0.7 seconds, the ball is momentarily at rest when it reaches its highest point *D*.

Notes:

1 The area between *AB* and the horizontal axis represents the distance travelled downwards, from the point where the ball leaves the student's hand to the point where the ball hits the ground. This area is equal to the area between *BC* and the horizontal axis.

**2** Beyond the highest point *D*, the ball starts falling towards the ground. Its speed increases from 0 m $s^{-1}$ to 5 m $s^{-1}$ in 0.5 seconds and the shape of the graph repeats.




# 2.2 Dynamics

### 012 What do you understand by the resultant force on a body?

The resultant force on a body is due to a non-zero vector sum of two or more forces acting on the body. It results in an acceleration which can be determined by the relationship resultant force = mass × acceleration ($F = ma$).

### 013 Explain why an object moving in a circle at a uniform speed experiences a resultant force.

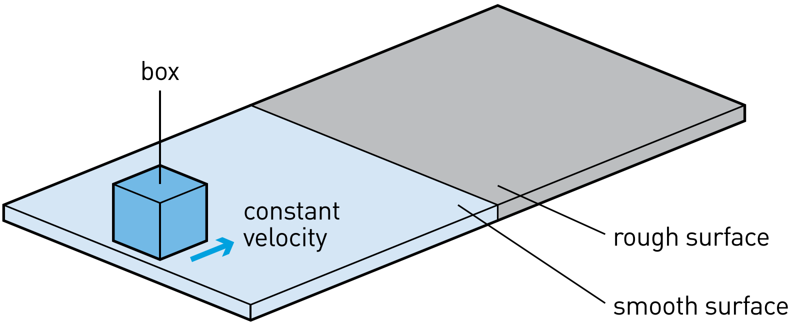
When an object is moving in a circle at a uniform speed, the magnitude of its velocity does not change, but the direction of its velocity changes constantly. Since velocity is changing, there is an acceleration. Since $F = ma$, there is a resultant force on the object.

014 **Explain, in terms of the forces acting on a driver, how the seat belt acts as a safety device to prevent the driver from moving forwards abruptly when the car brakes suddenly.**

OR **Using ideas about acceleration, explain how an airbag reduces the force on a driver during a car crash.**

A seat belt or an airbag increases the length of time it takes for the driver to come to rest. Since the change in velocity remains the same, the magnitude of deceleration decreases, hence the force on the driver decreases.

015 **Initially, a box is moving across a smooth surface with a constant velocity. A few seconds later, the box continues moving in the same direction across a rough surface. State and explain what happens to the box when it moves along the rough surface.**

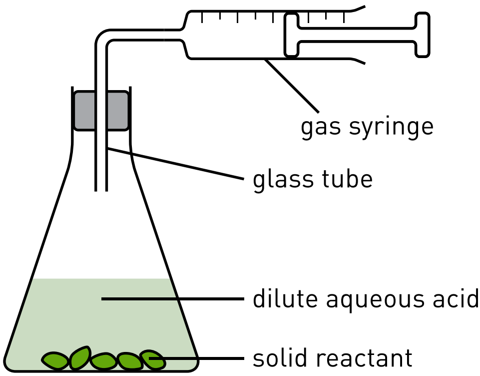



When the box moves across the rough surface, it slows down and eventually stops. This is due to friction acting on the box backwards by the rough surface. This gives a resultant force backwards, so the box decelerates until it eventually comes to a stop.

# Experimental Chemistry

## 7.1 Experimental Design

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

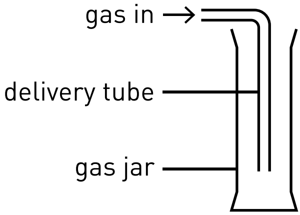



The simplest way to collect a gas is to connect a gas syringe to a conical flask using a delivery tube and a rubber stopper. If you need to measure the volume of gas collected, you can use a graduated gas syringe with volume markings on it.

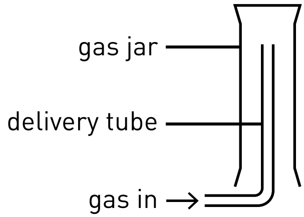
## 142 What properties of a gas should I consider when choosing a method to collect the gas?

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.

## 143 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)**

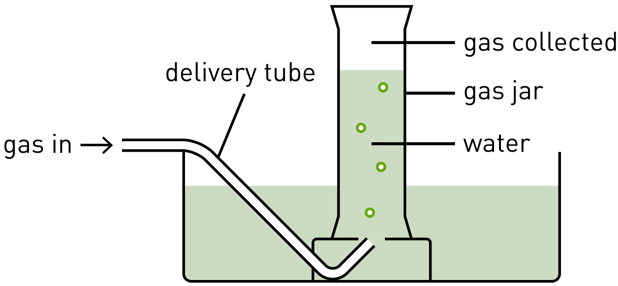
Air contains around 78% nitrogen ($N_2$), 21% oxygen ($O_2$) and 1% other gases. The approximate relative molecular mass ($M_r$) of air is ($M_r$ of $N_2 \times 0.78$) + ($M_r$ of $O_2 \times 0.21$) $= 28 \times 0.78 + 32 \times 0.21 = 28.56$.

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.

144 **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.

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

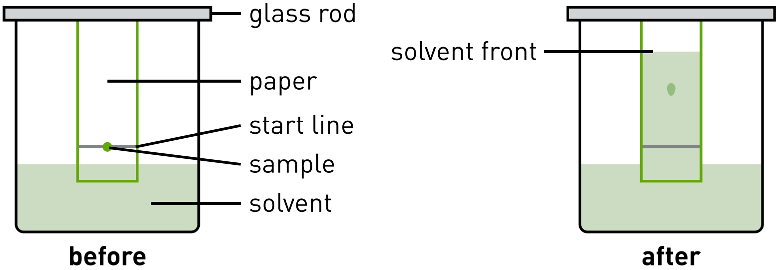
The simplest drying agent for most gases except ammonia is concentrated sulfuric acid ($H_2SO_4$). A suitable drying agent for ammonia gas ($NH_3$) is calcium oxide (CaO) pellets.

# 7.2 Methods of Purification and Analysis

146 **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.

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




Pencil lines are insoluble in water and organic solvents.

148 **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.

149 **How can I increase the mass 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.

150 **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.

### 151 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.

### 152 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.

## 7.3 Identification of Ions and Gases

### 153 Why is nitric acid added for a number of tests for anions, such as the tests for chloride ($Cl^-$) 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.

## 154 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 |

## 155 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. |

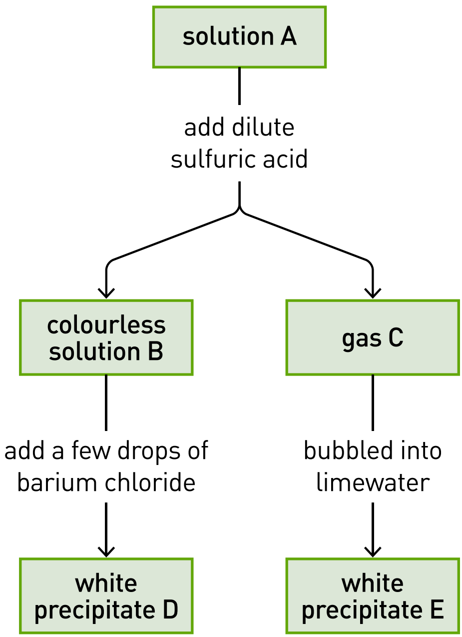
For **qualitative analysis questions** that involve a flowchart, you may begin by looking out for specific tests for cations (positive ions), anions (negative ions) or gases to determine the substance formed. After identifying some substances on the flowchart, you can work backwards to determine the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

156 **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. The chemical formula of the substance will not 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.

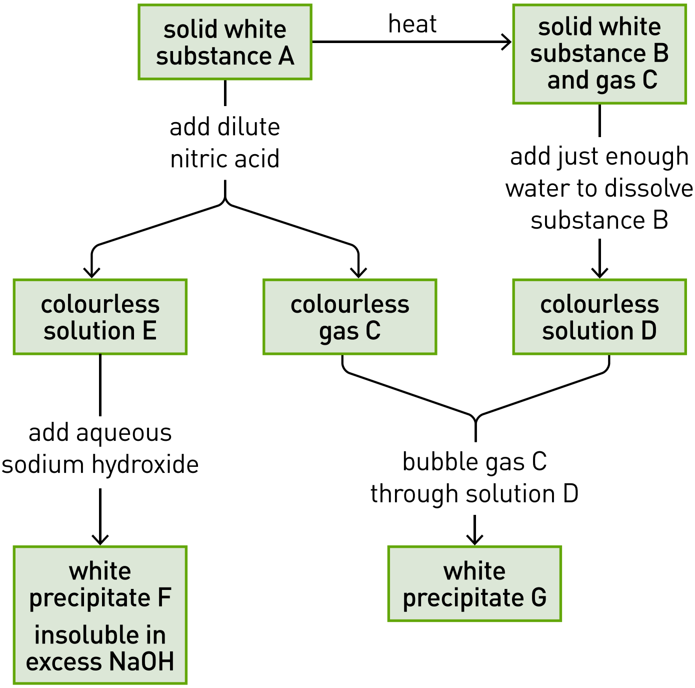
**(iii)** Add excess nitric acid to 1 $cm^3$ of solution A to remove the carbonate ions. Add a few drops of barium chloride to the resulting solution. Sulfate ions are present if a white precipitate is formed.

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.

157 **Study the following flowchart carefully.**

**(i) Identify substances A to G.**

**(ii) Write down the balanced equation with state symbols for any one of the changes in the flowchart.**




(i) A: calcium carbonate or $CaCO_3$

B: calcium oxide or $CaO$

C: carbon dioxide or $CO_2$

D: calcium hydroxide or $Ca(OH)_2$

E: calcium nitrate or $Ca(NO_3)_2$

F: solid calcium hydroxide or solid $Ca(OH)_2$

G: calcium carbonate or $CaCO_3$

Note: When asked to **identify** a substance, the chemical name or the chemical formula can be accepted.

Substance A can be thermally decomposed to produce substance B and gas C. At the same time, substance A reacts with dilute nitric acid to produce gas C. From these two reactions, we can conclude that gas C is carbon dioxide, so substance B must be a metal oxide.

White precipitate G is calcium carbonate because it is the result of a positive test for carbon dioxide gas. Hence, solution D must be saturated calcium hydroxide (limewater). Working backwards, substance B can be identified as calcium oxide.

Sodium hydroxide is used to test for cations. Since only calcium ions form a white precipitate that does not dissolve in excess sodium hydroxide, white precipitate F is solid calcium hydroxide. Working backwards, we can conclude that substance A is calcium carbonate and solution E is calcium nitrate.

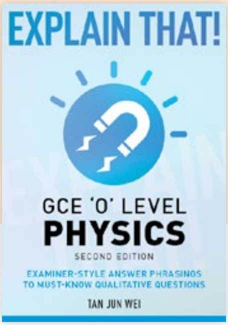
**(ii)** The equations with state symbols for the changes in the flowchart are as follows:

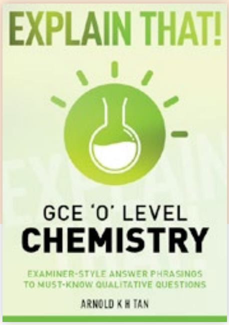
| **Reaction** | **Equation** |
|---|---|
| A → B + C | $CaCO_3$ (s) → $CaO$ (s) + $CO_2$ (g) |
| A → C + E | $CaCO_3$ (s) + 2 $HNO_3$ (aq) → $Ca(NO_3)_2$ (aq) + $CO_2$ (g) + $H_2O$ (l) |
| E → F | $Ca(NO_3)_2$ (aq) + 2 $NaOH$ (aq) → $Ca(OH)_2$ (s) + 2 $NaNO_3$ (aq) |
| C + D → G | $Ca(OH)_2$ (aq) + $CO_2$ (g) → $CaCO_3$ (s) + $H_2O$ (l) |

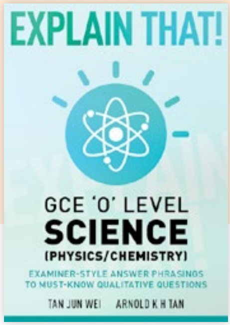
# EXPLAIN THAT!

***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.

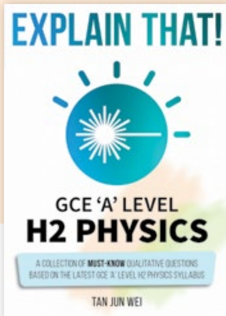
## GCE 'O' LEVEL




## GCE 'A' LEVEL

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