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How to Pass SQA ADVANCED HIGHER Chemistry

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Contents

Introduction

Welcome to *How to Pass Advanced Higher Chemistry*. This book follows the updated 2019 SQA arrangements for the Advanced Higher Chemistry course.

Using this book

The content of this guide is designed to help you prepare for the SQA Advanced Higher Chemistry exam. It provides a complete summary of the Advanced Higher course and offers the following features to aid understanding and improve recall of important points.

Key points

Key points !

- Key point summaries at the start of each chapter detail the knowledge and skills required by the SQA.
- Once you have read the chapter and completed the questions, go back and check the key points to ensure that you have gained the required knowledge from this chapter.
- Using the key points and the study questions, you should be able to test your knowledge of the topic.

Hints & tips

Hints & tips

This feature gives you extra hints and tips and draws your attention to particular things to think about and remember for each topic.

Examples

Examples

Throughout the book, you will find sets of worked examples to test your knowledge of the concepts in each chapter and show how to answer the questions at Advanced Higher level.

Before looking at the exemplar answer provided, try to recollect how to answer such questions from the information you have read in the chapter. It is essential for your learning to make every effort to recall information; this effort of mentally searching for an answer helps to strengthen your memory and will boost your ability to learn. Review your answer against the exemplar provided.

Study questions

Study questions ?

Study questions are found at the end of each chapter. They should be used to test your knowledge and understanding of the chemistry covered. The questions included have been selected carefully and some are modelled on those found in previous SQA Advanced Higher examinations. Like the worked examples, you should always try to answer the question using your own recall of the topic before checking the answers given in the book.

Glossary

Electronegativity: Electronegativity is a measure of the attraction an atom involved in a bond has for the electrons of the bond.
Frequency: This is the number of wavelengths that pass a fixed point in one unit of time.

A glossary of key words is included at the end of each unit. Once you've completed a unit, review the glossary for the key words that you should be familiar with, and ensure you know the definitions too.

Exam-style questions

At the end of each unit you will find a number of exam-style questions to work through. Answers to these can be found, along with answers to all the Study questions, at the end of the book.

Additional features of the Advanced Higher Chemistry exam

This section appears at the end of the book and offers advice on how to tackle two important features of the Advanced Higher Chemistry exam: numeracy and open-ended questions. Both are explored in detail and are supported with worked examples and study questions. Again, you should practise the exemplars and study questions before comparing them against the worked examples.

The Advanced Higher Chemistry course

The Advanced Higher Chemistry course comprises four areas which are covered in the four units of this *How to Pass* guide.

Key area	Topics covered
Inorganic chemistry	Electromagnetic radiation and atomic spectra, atomic orbitals; electronic configurations and the Periodic Table; transition metals
Physical chemistry	Chemical equilibrium; reaction feasibility; kinetics
Organic chemistry and instrumental analysis	Molecular orbitals; synthesis; stereochemistry; experimental determination of a structure; pharmaceutical chemistry
Researching chemistry	Common chemical apparatus; skills involved in experimental work; stochiometric calculations; gravimetric analysis; volumetric analysis; practical skills and techniques

Advanced Higher Chemistry assessment

There are two parts to the Advanced Higher Chemistry assessment:

- project
- examination paper.

Project

The project is worth 25 marks. This is scaled by SQA to represent 25% of the overall marks for the course assessment. The project allows you to carry out an in-depth investigation of a chemistry topic of your choosing and produce a project report. You will be required to plan and carry out a chemistry investigation on your own, after discussing potential topics with your teacher or lecturer to ensure you do not waste time researching unsuitable topics. You will need to work autonomously, making independent and rational decisions based on evidence and interpretation of scientific information, by analysing and evaluating your results. This will help develop and enhance your scientific literacy skills, and offers challenge by requiring you to apply skills, knowledge and understanding in a new context.

Examination question paper

The question paper has 110 marks. This is scaled by SQA to represent 75% of the overall marks for the course assessment.

The question paper has two sections. Section 1 contains multiple-choice questions and is worth 25 marks. Section 2 contains restricted-response and extended-response questions and is worth a total of 85 marks. This written exam lasts for 3 hours.

Advice for all Advanced Higher Chemistry students

Advanced Higher Chemistry requires you to have a great deal of knowledge and understanding of the topics studied, as well as the confidence to answer standard questions that may be asked in the exam. This book presents you with all the chemical knowledge you will need in summarised form and includes likely question types you will be asked.

The difficult part is learning and understanding this knowledge and remembering how to do the standard questions. Try to get into the habit of reviewing the relevant chapters at the same time as you are studying the concepts in class. To ‘review’ means to read and test your understanding and recall. Using the worked examples and study questions in this book will help to reinforce the information you have read. The more you retrieve the information, the more easily knowledge will come to you. In other words, you need to review and attempt the questions in each chapter several times.

Make sure to space out revision over a long time period to ensure maximum retrieval from long-term memory. Research has shown that it is a more effective strategy than simply doing the same questions over and over. Once you have mastered one chapter and checked your understanding, you should move on to another chapter and repeat the process. You should then return to the original chapter a week or two later and test your understanding again. You may well have forgotten some knowledge and so will have to review the questions again. This will work to reinforce the information in your memory.

Specific advice is given at the back of the book for tackling numeracy and open-ended questions. These are questions which most students avoid tackling when revising or in the final exam. To achieve greater success, it is necessary to practise answering these types of questions when revising. This helps to build confidence and the skills needed to face these questions in an examination setting.

I hope that this book will help you during your final chemistry studies at school. Even if you do not choose to pursue chemistry at university level, it is hoped that this course will have given you a greater understanding of the use of chemistry in everyday life from medicines to food production.

Unit 1 Inorganic chemistry

Chapter 1
Electromagnetic spectrum

Key points

- Electromagnetic radiation can be described as a wave (with a wavelength and frequency) and as a particle; it is said to have a dual nature.
- The relationship between wavelength (λ) and frequency (f) is given by:

  $$c = f \times \lambda$$

  where c is the speed of light in a vacuum, 3.00×10^{8} m s^{-1}.
- When electromagnetic radiation is absorbed or emitted by matter, it behaves like a stream of particles; these particles are known as photons. The equation

  $$E = hf$$

  where h is Planck's constant, 6.63×10^{-34} J s, can be used to calculate the energy associated with a single photon. The energy associated with one mole of photons is given by

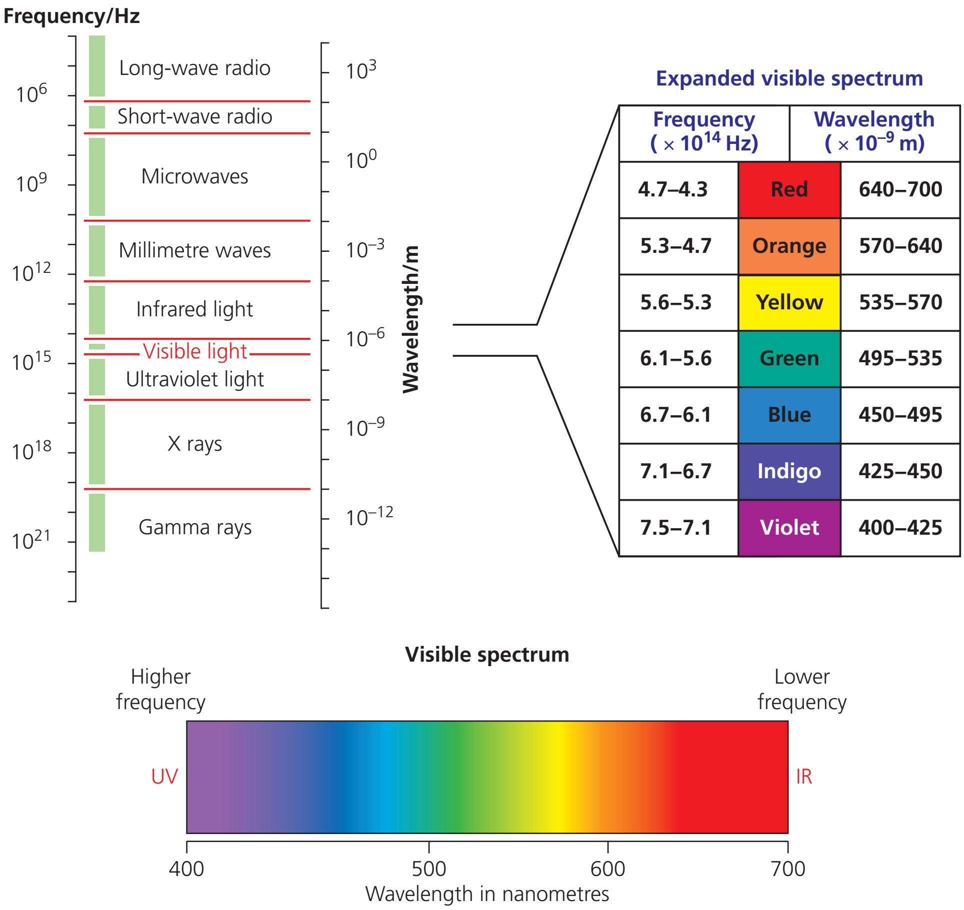
  $$E = \frac{Lhc}{\lambda}$$

  where L is Avogadro'sconstant, 6.02×10^{23} mol^{-1}.
- The energy is often given in units of kJ mol^{-1}.
- When a photon is absorbed or emitted, the electrons within the substance gain or lose energy.
- Photons in high-frequency radiation transfer more energy than photons in lower-frequency radiation.
- In emission spectroscopy, high temperatures are used to excite the electrons within atoms in the sample and as the electrons drop to lower energy levels, photons are emitted and measured. An emission spectrum of a sample is produced by measuring the intensity of light emitted at different wavelengths.
- When photons of light energy are absorbed by atoms, electrons move from a lower energy level to a higher one. As this happens, an absorption spectrum is produced. The difference between the intensity of absorbed light and the transmitted light gives the spectrum, and it varies with wavelength.
- Each element produces a unique pattern of frequencies of radiation in both its emission and absorption spectra, and these can be used to identify and quantify the elements present within a sample.
- The concentration of an element within a sample is related to the intensity of light emitted or absorbed and this can be used to determine unknown concentrations of an element.

Electromagnetic radiation

Electromagnetic radiation is a form of energy. The **electromagnetic spectrum** consists of many bands of electromagnetic radiation which differ in terms of energy (E), wavelength (λ) and frequency (f). Visible light is only a small part of the electromagnetic spectrum. Visible light is split into seven different colours that have different wavelengths and frequencies.

Electromagnetic radiation can be described as a wave and as a particle and is said to have a **dual nature**.



Frequency ($\times 10^{14}$ Hz)		Wavelength ($\times 10^{-9}$ m)
4.7–4.3	Red	640–700
5.3–4.7	Orange	570–640
5.6–5.3	Yellow	535–570
6.1–5.6	Green	495–535
6.7–6.1	Blue	450–495
7.1–6.7	Indigo	425–450
7.5–7.1	Violet	400–425

Figure 1.1 The electromagnetic spectrum

Hints & tips

The colour order in the visible light electromagnetic spectrum can be remembered from the mnemonic ROY G BIV.

Hints & tips

Frequency and wavelength are inversely proportional: as frequency increases, wavelength decreases and vice versa.

When using the wave model to describe electromagnetic radiation, the waves can be specified by their wavelength and frequency:

- The **wavelength** of a wave (given the symbol lambda, λ) is the distance between adjacent crests or adjacent troughs and in chemistry is typically measured in nanometres ($1\,nm = 1 \times 10^{-9}\,m$).
- The **frequency** (symbol, f) is determined by the number of wavelengths which pass a fixed point in one second. This is measured as the reciprocal of time (s^{-1}) which is also called hertz (Hz).

All electromagnetic radiation travels at the same velocity. This constant is the speed of light (symbol, c) and, in a vacuum, it is approximately equal to $3.00 \times 10^8\,m\,s^{-1}$. Frequency and wavelength are related by the formula:

$$c = \text{wavelength} \times \text{frequency}$$

or

$$c = f \times \lambda.$$

Examples

1 Electromagnetic radiation is found to have a wavelength of 1100 nm. Calculate the frequency of this radiation. (Give your answer to three significant figures.)

Answer

$c = f \times \lambda$

Rearrange this formula to find f.

$f = \frac{c}{\lambda}$

$f = \frac{3.00 \times 10^8}{1100 \times 10^{-9}} = \mathbf{2.73 \times 10^{14}\,Hz}$

2 Electromagnetic radiation is found to have a frequency of 6×10^{12} Hz. Calculate the wavelength of this radiation. (Give your answer to three significant figures.)

Answer

$c = f \times \lambda$

Rearrange this formula to find λ.

$\lambda = \frac{c}{f}$

$\lambda = \frac{3.00 \times 10^8}{6 \times 10^{12}} = \mathbf{5 \times 10^{-5}\,m}$

Electromagnetic radiation is useful in chemistry as it can be both absorbed and emitted. When electromagnetic radiation is absorbed or emitted it behaves like a stream of particles (so we have to use the particle model rather than the wave model). These particles are called **photons**. When a photon is emitted or absorbed, energy is lost or gained by the electrons in the sample being studied. Photons which are at high frequencies transfer larger amounts of energy than photons in lower frequencies.

So there is a relationship between the energy (E) carried by a photon and its frequency. This relationship is given by the equation:

$$E = hf$$

where h is Planck's constant and has the value 6.63×10^{-34} J s. In chemistry, we use kJ not J so to convert J to kJ, the number value must be divided by 1000.

To obtain the quantity of energy in kJ mol^{-1}, the relationship of E has to take into account the moles present, so uses Avogadro's constant (L), 6.02×10^{23} mol^{-1}. So the energy in kJ mol^{-1} is given by the equation:

$$E = \frac{Lhf}{1000}$$

When relating energy to wavelength, the equation to use is

$$E = \frac{Lhc}{10000\lambda}$$

Hints & tips

That violet/UV is high energy is easily remembered by the fact that UV radiation from the Sun causes sunburn and skin cancers.

Hints & tips

The values of Planck's constant (h), the speed of light in a vacuum (c) and Avogadro's constant (L) are provided on the back page of the data booklet along with SI prefixes and multiplication factors.

Example

3 Calculate the wavelength, in nm, of light required to break 1 mole of H—Cl bonds. Use the bond enthalpy data from the data booklet.

Answer

H–Cl bond enthalpy = 432 kJ mol^{-1}

$$E = \frac{Lhc}{1000\lambda}$$

Rearrange this formula to find λ.

$$\lambda = \frac{Lhc}{1000E}$$

$\lambda = (6.02 \times 10^{23} \times 6.63 \times 10^{-34} \times 3.00 \times 10^{8})/(1000 \times 432)$

$= 2.77 \times 10^{-7}$ m

The question asks for the answer in nm so multiply by 10^9.

$\lambda = 2.77 \times 10^{-7} \times 10^{9} =$ **277 nm**

Atomic emission spectra

When a beam of white light is passed through a prism or from a diffraction grating onto a screen, a continuous spectrum is visible.

When white light from a source passes through a sample being heated, the spectrum turns out not to be a continuous spectrum, but a series of lines of different wavelengths and thus of different colours. Each line corresponds to the energy given out when excited electrons move down to a lower energy level, generating photons of various frequencies.

These lines correspond to certain specific frequencies and wavelengths found in the visible or ultraviolet spectrum. Each element creates its own unique spectrum, something like a chemical fingerprint, with its own specific frequencies and wavelengths.

Atomic absorption spectroscopy

When a beam of continuous radiation like white light is directed through a gaseous sample, it can cause an atom to make a transition from its ground state to an excited state. If the frequency of the light, and therefore the energy of the photon, corresponds to an excitation energy of the atom, then the photon of light is absorbed. The radiation that emerges will therefore have certain wavelengths missing. These show up as dark lines on a continuous spectrum called an **atomic absorption spectrum** (Figure 1.2).

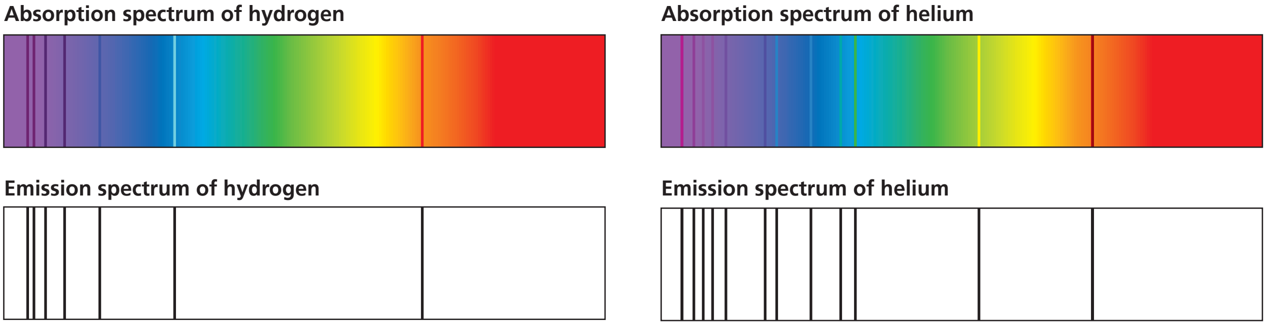


Figure 1.2 Absorption and emission spectra for hydrogen and helium

Both emission and absorption spectroscopy can be used to determine whether a certain species is present in a sample and how much of it is present, since the intensity of the transmitted or absorbed radiation can be measured.

A calibration graph is first made using known concentrations of the species being analysed. The radiation absorbed or emitted by the species in these samples is then plotted against concentration. When the unknown sample is analysed, the concentration of the species can be found from the graph by reading off the concentration of the known sample with the same absorbance.

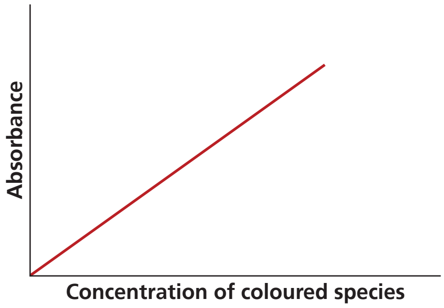


Figure 1.3 A calibration graph of absorbance against concentration

Study questions ?

1 Electromagnetic radiation is found to have a wavelength of 900 nm. Calculate the frequency of this radiation. (Give your answer to three significant figures.) [3 marks]

2 Electromagnetic radiation is found to have a frequency of 5×10^9 Hz. Calculate the wavelength of this radiation. (Give your answer to three significant figures.) [3 marks]

3 A line in the visible spectrum is caused by an electron transition with an associated energy of 264 kJ mol^{-1}. Calculate the wavelength of this line in nanometres. [3 marks]

4 Strontium is an element discovered on the west coast of Scotland. When strontium is placed in a flame, a red colour is observed which has a very prominent line in the spectrum.

a) Refer to your data booklet to determine the wavelength of this line. [2 marks]

b) Calculate the energy, in kJ mol^{-1}, of the electron transition related to this line. [2 marks]