Chemistry Revision Notes
By
Johnathan Reynolds

Leaving Certificate – Chemistry (Higher & Ordinary Level)

Points to note about the Chemistry examination:

1. Higher & Ordinary Level comprises of a **100%** Written Examination in June of the Leaving Certificate
2. The paper at both levels equates to **400** marks
3. **8 q**uestions to be answered in total (At Least **2** questions must be answered from section **A**).
4. The chemistry exam is **3** hours in total.

Subject Content

Leaving Certificate Chemistry is comprised of all the essential and relevant topics within general chemistry. The major topics involved include the following:

1. Atomic structure
2. Volumetric analysis
3. Organic chemistry
4. Water chemistry
5. Reaction mechanisms.

There also is an option to be taken as part of the course which involves the study of atmospheric and industrial chemistry or the study of materials and electrochemistry.

Experimental investigations are an essential part of the leaving certificate course. Each student must complete **at least 28** experiments over the duration of the course.

Experimental work is examined as part of the leaving cert exam and forms the basis for a minimum of three questions on the exam paper.

Exam Structure

The leaving cert exam is three hours in duration. Each candidate must answer at least two questions from **Section A** (experimental section) and a maximum of six questions from **Section B**.

There are **eleven** questions in total on the exam paper, each carrying **fifty** marks.

There is no element of continuous assessment but experimental copies must be available for inspection by the State Examinations Commission. Students taking chemistry have to memorize the chemical components of a series of prescribed experiments. They will need to present the elements of four such experiments in their exam.

<u>Written exam:</u> 100% or 400 marks

Structure of the paper – Higher Level

There are 11 questions on the paper you **must** answer 8.

- **Question 1:** Titration – Volumetric Analysis – 50 Marks
- **Question 2:** Organic Chemistry – Preparation – 50 Marks
- **Question 3**: ANY OTHER OF THE 28 MANDATORY PRACTICALs – 50 Marks
- **Question 4**: Mixture of topics from throughout the course – 50 Marks
- **Question 5:** Atomic Structure and its history – 50 Marks
- **Question 6:** Organic Chemistry (Thermochemistry with calculations) – 50 Marks
- **Question 7:** Either/usually Organic mechanisms OR Rates of reactions OR Water, Acids & Bases OR Chemical Equilibrium
- **Question 8:** SEE Q7
- **Question 9:** SEE Q7
- **Question 10 & 11:** 3 parts answer **ANY** 2 – **Usually;** Redox reactions, radioactivity, chromatography, atomic structure and Stoichonometry (The Mole)

Structure of the paper – Ordinary Level

There are 11 questions on the paper you **must** answer 8.

- **Question 1:** Organic Chemistry – Preparation – 50 Marks
- **Question 2:** Titration – Volumetric Analysis – 50 Marks
- **Question 3**: ANY OTHER OF THE 28 MANDATORY PRACTICALs – 50 Marks
- **Question 4**: Mixture of topics from throughout the course – 50 Marks
- **Question 5:** Atomic Structure and its history – 50 Marks
- **Question 6:** Organic Chemistry (Thermochemistry with calculations) – 50 Marks
- **Question 7:** Either/usually Organic mechanisms OR Rates of reactions OR Water, Acids & Bases OR Chemical Equilibrium
- **Question 8:** SEE Q7
- **Question 9:** SEE Q7
- **Question 10 & 11:** 3 parts answer **ANY** 2 – **Usually;** Redox reactions, radioactivity, chromatography, atomic structure and Stoichonometry (The Mole)

<u>Author:</u>

- These notes were brought to you by Jonathan Reynolds. Jonathan is a graduate of the University of Limerick in Science Education and has experience in teaching in various schools around the country. Jonathan is currently a Junior Certificate Science and Leaving Certificate Biology & Chemistry teacher at Ramsgrange Community School, New Ross, Co. Wexford. Jonathan has been teaching Chemistry for six years as of 2013. He also corrects mocks and sets mock papers in Agricultural Science for Mocks.ie. Jonathan has had experience in teaching in well established schools such as Yeats College Waterford were he dedicated his time on study skills and helping pupils adapt to the examination environment and criteria.

Contents

History of the Periodic Table & The atom

Introduction: History

1) **The Greeks:**
   - They were the first to propose that matter was composed of small **indivisible** particles called atoms.
   - There was no evidence to support this theory as the Greeks did not carry out experiments.

2) **John Dalton (1808):**
   - He put forward the **atomic theory**:

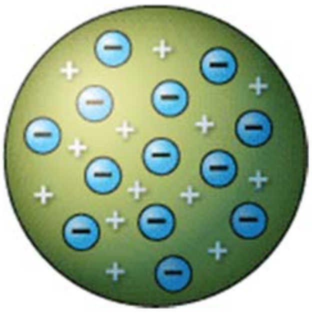
Main points:

- Matter is made up of small particles called atoms (carried out experiments)
- Atoms are indivisible and indestructible
- Atoms cannot be created or destroyed.
- Atoms of different elements vary in mass.

Note:
John Dalton's atomic theory was widely accepted then, but towards the end of the 19^{th} Century, his picture of the atom was questioned by other scientists.

3) **JJ Thompson**
   - He put forward the plum pudding model of the atom.

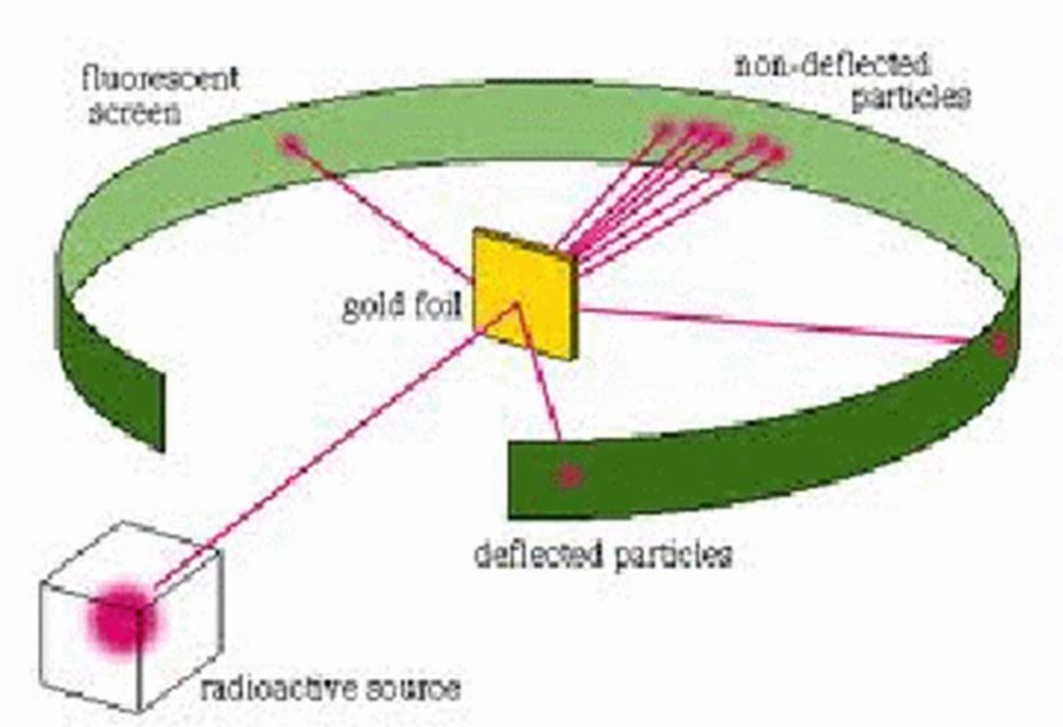
- An atom was a sphere of positive charge.
- Negatively charged electrons were embedded throughout this sphere.
- An atom is neutral because it contains the same number of positives as negatives.



- His theory was soon afterwards shown to be inadequate.

4) **Ernest Rutherford – model of an atom – 1910**
   - He carried out the famous: **Alpha Particle scattering experiment**
   - From this experiment he proposed:

- The **mass** of an **atom** is concentrated in a small **dense area** called the **nucleus**.
- This **nucleus contains** the positive charges or **protons**.
- An atom is mostly empty space.
- The **electrons move around** the **nucleus** in this empty space.



- He bombarded/hit a sheet of gold foil with alpha particles.

He expected:

- Most of the alpha particles should pass straight through the gold foil or be deflected slightly (when they encounter a positive proton).

He observed:

- Most of the alpha particles passed straight through as expected.
- Some of the particles were deflected slightly
- **To his surprise some of the alpha particles were reflected at large angles.**
- They encountered a dense area **(the nucleus)**

Background to his experiment:

Q) What is an alpha particle?

- This is a positively charged particle emitted from the nucleus of a radioactive substance.
- Consists of two protons and two neutrons, similar to a helium nucleus

Q) From what was the metal foil in the experiment he used?

- Gold
- He bombarded the gold foil with alpha particles.

Niels Bohr Model of an atom

The arrangement of the electrons in the electron cloud proposed in 1913 by Bohr, pictured on the right, was consistent with the hydrogen emission spectrum.

- Bohr suggested **how electrons move around the nucleus of an atom**.
- <u>He suggested:</u>
- Electrons revolve around the nucleus in **fixed paths or orbits**.
- While in a particular orbit, the electrons have a fixed or discrete amount of energy called an **energy level**.
- **The electrons travel in precise paths and at a precise distance from the nucleus.**
- When the electrons gain energy, they are promoted to a higher energy level (excited state).
- This excited state is temporary and unstable, the electrons fall back to the lower **energy levels by emitting energy as light.**
- The energy emitted is equal to the energy difference between two energy levels ($E_2 - E_1$).
- This emitted energy has a definite frequency and wavelength and can be calculated using the following formula **(Planck's constant)**

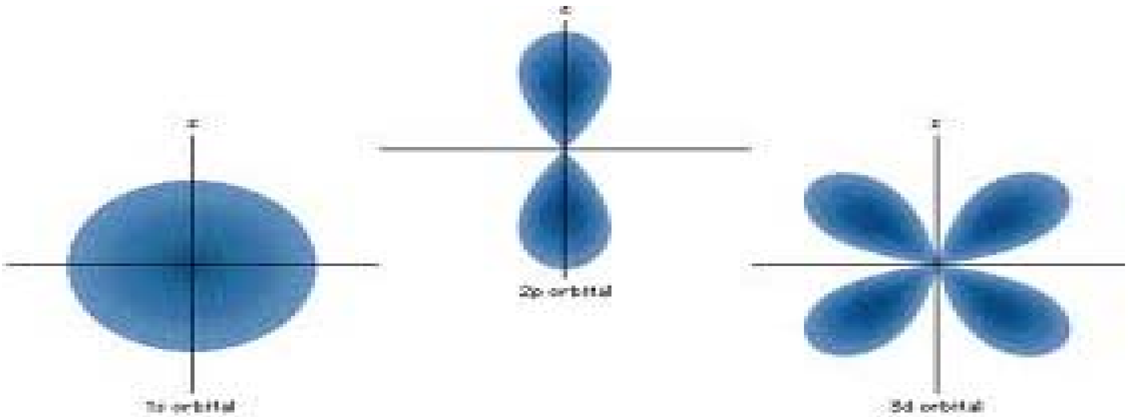
  $$E_2 - E_1 = hf$$

<u>Two limitations of Bohr's theory that led to its modification:</u>
- **Electrons** like all moving particles **have** a **wave motion (<u>De Broglie</u>)**
- As a result, the electrons do not travel in precise paths and at a fixed distance from the nucleus.
- **<u>Heisenberg</u>** showed that it is not possible to determine the exact position and speed of an electron at the same time **(Heisenberg's Uncertainty Principle).**

<u>Note:</u>
Because of the **uncertainty** with regard to **the exact location** of an **electron** in an atom at a **particular time**, scientists now refer to the probability of finding an electron in a particular position/ area **<u>(atomic orbitals)</u>**

<u>Atomic orbital</u>: This is an area around the nucleus of an atom where there is a high probability (99%) of finding an electron.

3 types of atomic Orbital's you need to be familiar with: S, P and D
1) **S – orbital** (has a spherical shape, holds **two** electrons) – 2 electrons in total
2) **P – orbital** (have a dumb – bell shape, each orbital can hold two electrons) – 6 in total
3) **D – Orbital** (there are 5 D – orbitals and each can hold 2 electrons.
4) **F – orbital** (can hold up to 14 electrons)



Note: A sub – level: is a group of atomic orbital's with similar energy (px, py, pz)

Energy Levels:

- This is the discrete or fixed amount of energy which an electron in an orbital can have.
- **Ground state of an atom: Stable state** of an atom. All the electrons occupy the **lowest available energy levels**.

Series of lines:
N = 1: Balmer Series
N = 2: Lyman Series

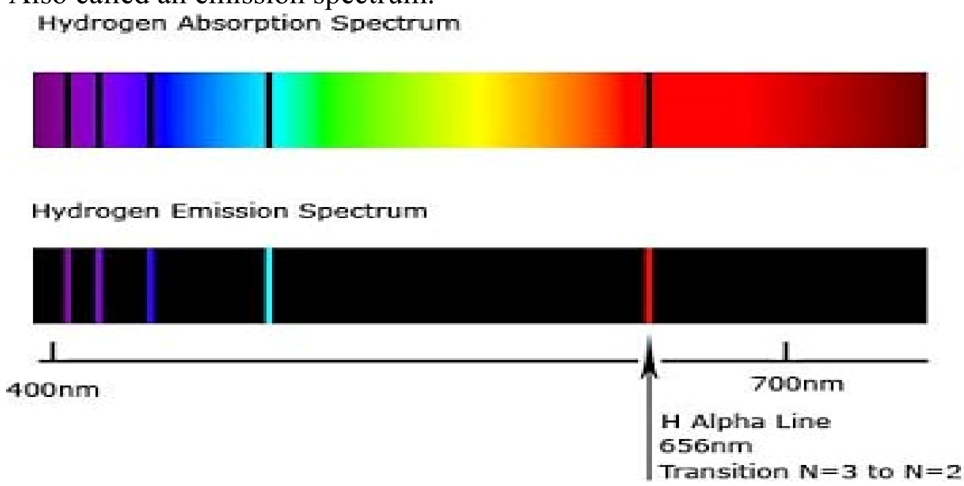
Note: When an atom in a ground state is given energy (Heat) the electrons absorb energy and are promoted to higher energy levels i.e. excited state.

Q) How did Bohr discover energy levels and orbitals?

- Bohr was studying the line spectra which excited atoms producing coloured lines.

Q) What are line spectra?

- This type of spectrum is obtained by passing the light emitted from an excited atom into a spectroscope.
- It consists of coloured lines of definite wavelength against a dark background
- Also called an emission spectrum.



Note:

- Every element produces a unique line spectrum; therefore other elements can be identified using line spectra.
- A continuous spectrum is obtained by analysing white light in a spectroscope, **a continuous band of colours are obtained.**

Q) How did Bohr explain a line spectrum?

- He suggested each line in the spectrum represents a definite amount of energy.

How is the line produced?

- **Electrons** in an atom are **usually** in the **ground state.**
- When an atom is given energy e.g. heated by a Bunsen burner, the **electrons** in the atom **absorb energy (photons), jump** to **higher energy levels** i.e. excited state.
- The **excited state** is **unstable**
- As a result, the **electrons fall back** to the lower energy levels
- As they do so, they **emit energy** as **coloured light**.
- **The energy emitted is equal to the energy difference between E1 and E2**.
- The **emitted energy** has a **definite frequency** and produces a line in the spectrum
- $E2 - E1 = hf$.

Q) What evidence do the line emission spectra provide for the existence of energy levels in atoms?

- Each line emission spectrum represents a definite amount of energy
- This energy was emitted by an electron returning to a lower energy level.
- **The emitted energy has a fixed or definite frequency.**
- Since it has a definite frequency, the electrons must be restricted or occupy certain energy levels.

Q) Why does each element have a unique line emission spectrum?

Each element has;

- A different set of energy levels
- A different electron configuration

As a result: different electron transitions will occur.

- **The energy emitted will have a different frequency; hence, the lines in the spectrum will occur at different frequencies.**

Q) Why is it possible for line emission spectra to be used to distinguish between different elements?

- Every element produces a **unique line spectrum**.

Reason:

- Each element has a different set of energy levels
- Contain different numbers of electrons
- Different electron transitions will occur.

Q) Give an everyday example of electron transitions.

a) Fireworks: Several different metallic compounds are heated e.g. Na (yellow), K (lilac), Ba (red), Sr (Green). Each emits a distinct colour of light.

b) Neon lights

Flame Tests:

- When salts of different metals are heated in a Bunsen burner, different colours are observed.

Na - Yellow
K - Lilac
Sr - Red
Ba – Green
Cu – Blue – Green

Q) Outline what's involved in flame tests.

- Soak some wooden splints in water overnight.
- Put a small sample of the salt to be tested on a clean clock glass.
- Dip the soaked splint in the salt to be tested.
- Place the splint in the splint in the flame of the Bunsen burner and note the colour given off
- Repeat this for all of the other salt samples.

Absorption Spectrum

- This is the spectrum which is observed when white light is passed through an element.
- Consists of dark lines against a coloured background.
- Each dark line represents a wavelength of light (colour) which has been absorbed by the background.

Note: Every element represents a unique absorption spectrum.

Q) What use is made of an absorption spectrum?

- The concentration of a particular element can be determined by measuring the amount of light which has been absorbed by the element.
- Carried out the in an instrument called an atomic absorption spectrometer (AAS)

Q) What happens in an atomic absorption Spectrometer?

- White light is passed through a sample (river water).
- The elements in the water e.g. Pb, (lead) and Hg (Mercury) will absorb certain characteristic wavelengths of light.
- The amount of light absorbed is directly proportional to the concentration of the element in the sample.

Q) On what principle does an atomic absorption spectrometer work?

Every element: 1) absorbs a particular wavelength of light. 2) amount of light absorbed is proportional to the concentration of the element

Q) Explain the differences between a line spectrum and an atomic emission spectrum.

Line Emission	**Atomic Emission**
Consists of coloured lines against a black background.	Consists of dark lines against a coloured background.
Obtained by analysing light by excited atoms.	Obtained by analysing wavelengths of atoms absorbed.

Sub Atomic Particles

The sub atomic particles are:

- Neutrons
- Protons
- Electrons

Properties of the three sub atomic particles

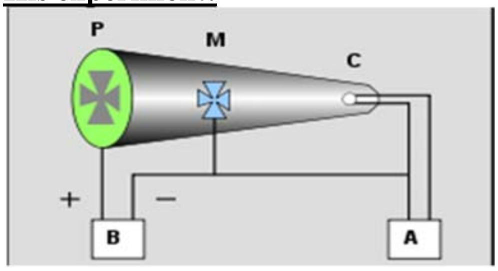
	Location	Mass	Charge
Proton	Nucleus	1 a.m.u.	+1
Neutron	Nucleus	1 a.m.u.	0
Electron	Orbiting Nucleus	1/1840 a.m.u.	-1

1) The Electron

William Crooke's development to atomic theory

- Discovered cathode rays i.e. invisible rays were emitted from negative cathode
- Suggested that the invisible rays contained small particles.

His experiment:



He observed:

- A shadow of the cross on the florescent screen.

He concluded:

- Invisible rays were emitted from negative cathode (cathode rays).
- When these rays hit the fluorescent screen, a shadow of the cross was formed.
- Cathode rays contain small particles.