

انسابير\\nQuantum Theory of Light, Atomic Models, and Nuclear Physics



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف الثاني عشر المتقدم ← المناهج ← الفصل الثالث ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 2026-06-13 20:58:15

ملفات اكتب للمعلم اكتب للطالب ا اختبارات الكترونية ا اختبارات ا حلول ا عروض بوربوينت ا أوراق عمل
منهج انجليزي ا ملخصات وتقارير ا مذكرات وبنوك ا الامتحان النهائي للمدرس

المزيد من مادة
المناهج:

إعداد: Atef Mohamed

التواصل الاجتماعي بحسب الصف الثاني عشر المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة المناهج في الفصل الثالث

انسابير Quantum Theory of Light, Atomic Models, and Nuclear Physics

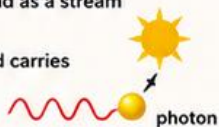
1



QUANTUM THEORY OF LIGHT & MATTER WAVES

1 QUANTUM NATURE OF LIGHT

- Light can behave as a wave and as a stream of particles called photons.
- A photon has no rest mass and carries quantized energy.



PHOTON ENERGY

$$E = hf$$

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

where:

h = Planck's constant (6.63×10^{-34} J·s)

f = frequency (Hz)

λ = wavelength (m)

c = speed of light (3.00×10^8 m/s)



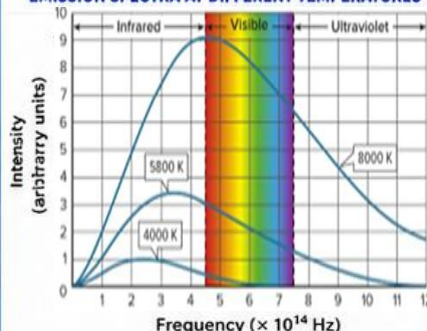
CONVENIENT RELATION

$$E(\text{eV}) = \frac{1240}{\lambda(\text{nm})}$$

2 BLACKBODY RADIATION

- Hot bodies emit a continuous spectrum of electromagnetic radiation.
- Classical theory failed at high frequencies (ultraviolet catastrophe).
- Planck explained this by assuming energy is emitted in discrete quanta.

EMISSION SPECTRA AT DIFFERENT TEMPERATURES

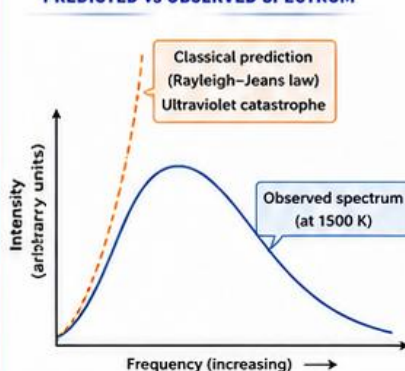


As temperature increases:

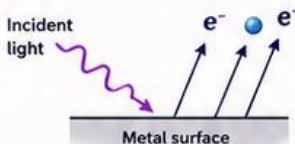
↑ Peak intensity increases.

← Peak shifts to higher frequency (shorter wavelength).

PREDICTED vs OBSERVED SPECTRUM



3 PHOTOELECTRIC EFFECT



Electrons are emitted from a metal surface only if the light frequency exceeds a threshold frequency f_0 .

KEY CONDITIONS

- If $f > f_0$ → electrons are emitted.
- If $f = f_0$ → emitted electrons have zero kinetic energy.
- If $f < f_0$ → no emission occurs.

EINSTEIN'S PHOTOELECTRIC EQUATION

$$KE_{\text{max}} = hf - W$$

where $W = hf_0$ (work function)

Therefore: $KE_{\text{max}} = hf - hf_0$



Increasing the intensity of light increases the number of emitted electrons.

Below threshold frequency ($f < f_0$), no electrons are emitted regardless of intensity.

STOPPIN'S POTENTIAL (V_0)

When a retarding potential just stops the fastest electrons:

$$eV_0 = KE_{\text{max}} \Rightarrow V_0 = \frac{KE_{\text{max}}}{e}$$

Thus, stopping potential measures the maximum kinetic energy.

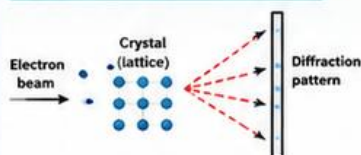
6 WAVE-PARTICLE DUALITY



Every particle has wave properties, and every wave has particle-like behavior.

Wave and particle aspects are complementary, not exclusive.

7 ELECTRON DIFFRACTION



Electron diffraction through crystals provides clear evidence for the wave nature of electrons. Davisson-Germer experiment (1927) confirmed this.

4 PHOTON MOMENTUM



Even though photons have no rest mass, they carry momentum.

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

5 de BROGLIE WAVES (MATTER WAVES)



de Broglie proposed that matter particles such as electrons have wave nature.

de Broglie wavelength:

$$\lambda = \frac{h}{p}$$

where p = momentum of the particle

All moving particles have a wavelength, but it is noticeable mainly for very small particles (large momentum).

COMPLEMENTARY NATURE



8 IMPORTANT NOTES / QUICK FACTS

- Photon energy increases with frequency: $E \propto f$.
- Photon energy is inversely proportional to wavelength: $E \propto \frac{1}{\lambda}$.
- Threshold frequency (f_0) depends on the metal (its work function).
- At threshold ($f = f_0$), emitted electrons have zero kinetic energy.
- Increasing light intensity increases the number of photoelectrons (but not their maximum kinetic energy).
- de Broglie wavelength decreases as momentum increases: $\lambda \propto \frac{1}{p}$.

9 KEY CONSTANTS

$h = 6.63 \times 10^{-34}$ J·s
(Planck's constant)

$c = 3.00 \times 10^8$ m/s
(speed of light)

$1 \text{ eV} = 1.60 \times 10^{-19}$ J
(electron volt)



ATOMIC MODELS & ELECTRONS

KEY CONCEPTS & FORMULAS

ENERGY LEVELS

- Energy of an electron in the n^{th} orbit:

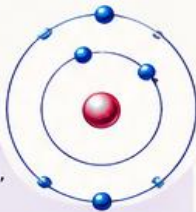
$$E_n = -\frac{13.6}{n^2} \text{ eV}$$

Where:

- $n = 1, 2, 3, \dots$
- n is the principal quantum number.
- As n increases $\rightarrow$ radius increases, energy less negative (higher).
- Radius of the n^{th} orbit:

$$r_n = n^2 r_1$$

Where $r_1 = 0.053 \text{ nm}$ (Bohr radius)

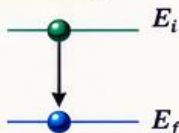


BOHR ENERGY TRANSITIONS

When an electron moves from level E_i to E_f , it absorbs or emits energy:

$$E_{\text{photon}} = \Delta E = E_f - E_i = hf$$

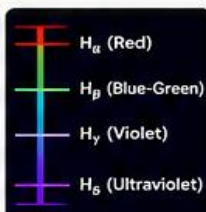
- If $E_f < E_i \rightarrow$ emits photon.
- If $E_f > E_i \rightarrow$ absorbs photon.



HYDROGEN SPECTRUM (BALMER SERIES)

Visible lines in hydrogen spectrum (Balmer series):

Line Level	Final Level (n_f)	Series Name
$n_f = 1$	Lyman	Ultraviolet
$n_f = 2$	Balmer	Visible
$n_f = 3$	Paschen	Infrared
$n_f > 3$	Higher series	Infrared



- As n_f increases, the lines get closer together.
- All lines in a series correspond to transitions ending at the same final level.
- Moving from a higher orbit to a lower orbit $\rightarrow$ emission of energy.

ELECTRON WAVE PROPERTIES

- Electrons behave like waves.
- De Broglie's wavelength:

$$\lambda = \frac{h}{p}$$

Where p = momentum of the particle.

- Wave nature of electrons explains their interference and diffraction.
- When electrons pass through slits, they interfere and form a pattern, proving they have wave nature.



ATOMIC MODELS OVERVIEW

- All gases behave similarly, so a spectroscope is used to study their line spectra.

1 Continuous Models

- Predict continuous spectra.
- Cannot explain the stability of atoms or line spectra.

2 Discontinuous (Quantized) Models

- Electrons can only have specific energies.
- Transitions between levels emit or absorb photons.

3 Spectroscopic Models (Quantized)

- Based on spectral lines of gases.
- Explain discrete energy levels.
- Help analyze the atomic structure.

PURPOSE OF SPECTROSCOPY

Used to:

- Identify elements.
- Determine composition of a sample.
- Study the structure of atoms.

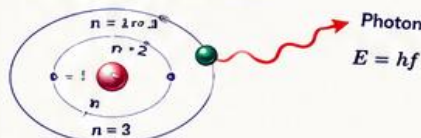
SPECTRAL LINE PATTERNS

- Continuous spectrum $\rightarrow$ hot dense gas.
- Bright line spectrum $\rightarrow$ excited gas at low pressure.
- Dark line spectrum $\rightarrow$ cooler gas in front of a hot source.
- Each element has a unique spectral fingerprint.



BOHR'S MODEL (KEY POINTS)

- Electrons move in fixed circular orbits around the nucleus.
 - Electrons do not radiate energy while in a stable orbit.
 - Energy is emitted or absorbed only during transitions between orbits.
 - Electrons cannot exist between orbits.
 - Orbits have specific (quantized) energies.
 - Orbit radius increases as n increases.
- Lowest energy level ($n = 1$) is closest to the nucleus.
 - Higher energy levels are farther from the nucleus.



STATIONARY STATE

Electrons in orbits have stable energy.

- In low-energy orbits (close to nucleus), energy is the lowest (most negative).
- In higher-energy orbits (farther), energy is higher (less negative).

EXCITED STATE

When an electron absorbs energy, it jumps to a higher energy level.

- The atom is in an excited state.
- It later returns to a lower level by emitting a photon.



BOHR MODEL (1)

- Electron orbits the nucleus in fixed circular paths.
- Each orbit has a specific radius.
- Energy is quantized in each orbit.
- Orbit radii increase by a factor of $\sim 10,000$ from one level to the next.
- During an orbit, electrons do not emit energy.
- Atoms with electrons in lower energy levels are more stable.
- Excited atoms have electrons in higher orbits.
- When an electron drops to a lower orbit, it emits a photon.
- The photon's energy equals the difference between the two levels.
- Higher orbits $\rightarrow$ bigger size.



NUCLEAR MODEL

Definition:

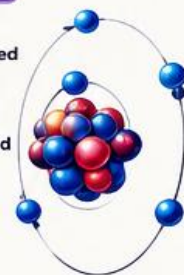
The positive charge is concentrated in a tiny central nucleus.

Formed by protons and neutrons.

The nucleus is very small compared to the atom.

Electrons orbit the nucleus in highly organized patterns.

Electrons have high speed and revolve in stable orbits.



EXPERIMENTAL EVIDENCE FOR ORBITS

Bohr model is supported by:

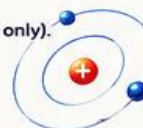
- Electron diffraction (de Broglie waves).
- Electrons cannot exist between two orbits.
- Electrons have a fixed total energy in an orbit.
- When excited, electrons jump to higher orbits.
- When they return to lower orbits, they emit photons.



BOHR MODEL (2): CONDITIONS

This model is valid only for:

- Hydrogen-like atoms (one electron only).
- Specific (quantized) orbits.
- Discrete energy levels only.



MECHANICS SUMMARY

Definition:

The study of an object's properties using its motion.

Benefits:

- Explaining new phenomena and laws of physics.
- Developing new tools.
- Building advanced technologies.



STAY CURIOUS!

Physics explains the hidden rules of nature. The more you understand, the more you can discover! ⚡



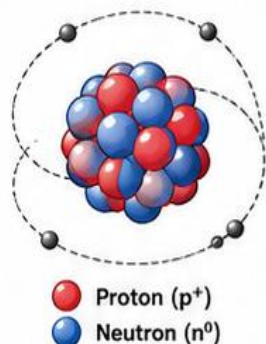


NUCLEAR PHYSICS



Key Concepts, Equations & Reactions

1 STRUCTURE OF THE NUCLEUS



- The nucleus is a very small, dense region at the center of an atom containing protons and neutrons (nucleons).
- Atomic number (Z):** number of protons.
- Mass number (A):** number of protons + neutrons.
- Number of neutrons (N):**
 $N = A - Z$

NUCLEAR NOTATION



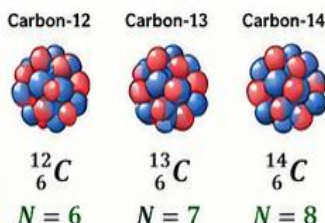
EXAMPLE: ${}_{6}^{12}\text{C}$

- $Z = 6$ (protons)
- $A = 12$ (protons + neutrons)
- $N = A - Z = 12 - 6 = 6$ (neutrons)

2 ISOTOPES

Atoms of the same element have the same atomic number (Z) but different numbers of neutrons (N).

Different isotopes differ in their mass number (A).



Same $Z = 6$
Different N and A

3 MASS DEFECT & BINDING ENERGY

- Mass defect (Δm) is the difference between the total mass of separate nucleons and the actual mass of the nucleus.

$$\Delta m = (Zm_p + Nm_n) - M$$

where m_p = mass of proton
 m_n = mass of neutron
 M = actual mass of nucleus

- Binding energy (E) is the energy that holds the nucleus together.

$$E = \Delta m c^2$$

- If mass is in atomic mass units (u):

$$\text{Binding Energy (MeV)} = \Delta m \times 931.49$$

- Binding energy per nucleon: $\frac{E}{A}$

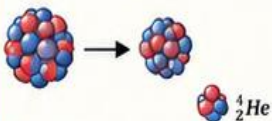
★ Larger E/A means greater nuclear stability.

4 RADIOACTIVITY & NUCLEAR DECAY

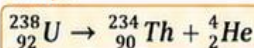
- Some nuclei are unstable and emit radiation spontaneously.
- This process is random and is NOT affected by ordinary chemical changes, temperature, or pressure.

ALPHA (α) DECAY

Emits an alpha particle (${}^4_2\text{He}$).
Mass number decreases by 4.
Atomic number decreases by 2.

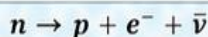


Example:

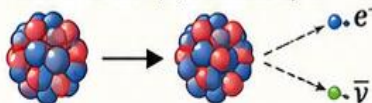


BETA MINUS (β^-) DECAY

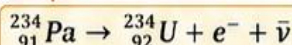
A neutron transforms into a proton, emitting an electron and an anti-neutrino.



Mass number (A) unchanged.
Atomic number (Z) increases by 1.

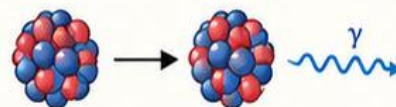


Example:



GAMMA (γ) DECAY

An excited nucleus emits a gamma photon (γ) and moves to a lower energy state.

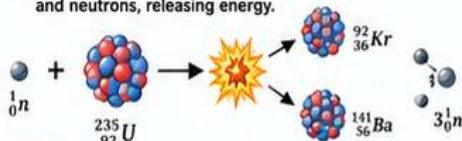


Mass number (A) unchanged.
Atomic number (Z) unchanged.

5 NUCLEAR REACTIONS

FISSION

A heavy nucleus splits into smaller nuclei and neutrons, releasing energy.

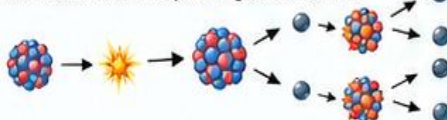


Example:



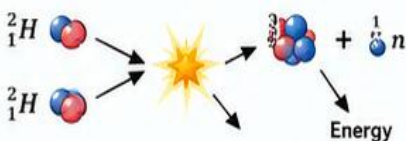
CHAIN REACTION

- Neutrons released in one fission can strike other nuclei and cause more fissions, producing a chain reaction.

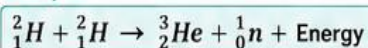


FUSION

Light nuclei combine to form a heavier nucleus and release large energy.



Example:



FUSION IN THE SUN

Hydrogen fusion is the ultimate energy source in the Sun and stars.



6 ADVANTAGES & CHALLENGES

FISSION

- Very high energy output.
- Produces radioactive waste that remains hazardous for long periods.

FUSION

- High energy with cleaner by-products.
- Requires extremely high temperature and advanced confinement to occur.

7 DETECTION OF RADIATION

GEIGER COUNTER



Detects ionizing radiation via electrical pulses.

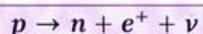
CLOUD CHAMBER



Visualizes charged particle tracks as tiny vapor trails.

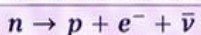
8 NUCLEON CONVERSIONS

BETA PLUS (β^+) CONCEPT



A proton converts to a neutron, emitting a positron and a neutrino.

BETA MINUS (β^-) CONCEPT



A neutron converts to a proton, emitting an electron and an anti-neutrino.

OPTIONAL NOTE (QUANTIZATION)

Bohr Quantization Condition

In the Bohr model, electron motion in orbits is quantized:

$$mvr = \frac{nh}{2\pi}$$

$$2\pi r = n\lambda$$

where $n = 1, 2, 3, \dots$

9 QUICK FACTS

- ✓ The nucleus is tiny, dense, and contains protons and neutrons.
- ✓ Isotopes have the same Z but different numbers of neutrons.
- ✓ Mass defect leads to binding energy: higher $\frac{E}{A} \Rightarrow$ more stable nucleus.
- ✓ Alpha decay lowers both A (-4) and Z (-2).
- ✓ Beta minus decay increases Z by 1; A remains the same.
- ✓ Gamma decay changes energy state only; A and Z do not change.

