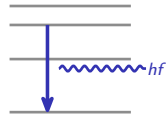


Modern Physics

AP Physics 2 ■ Unit 15

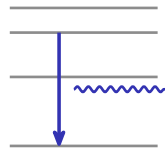
AP Physics 2



Modern Physics

What we will cover

- 1 Photons and wave-particle duality
- 2 The Bohr model and energy levels
- 3 Spectra and blackbody radiation
- 4 The photoelectric effect
- 5 Compton scattering
- 6 Nuclear physics



1

Photons & duality

Photons and wave-particle duality

Light comes in packets called **photons** 光子, each carrying:

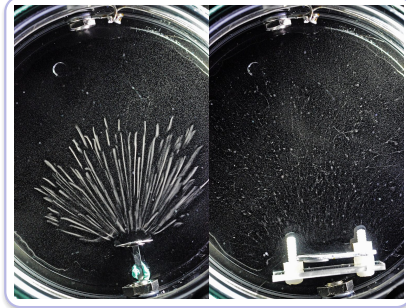
Photon energy

$$E = hf$$

Matter waves

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

the **de Broglie wavelength** 德布罗意波长.



Particles leave tracks of ionisation

2 Bohr model

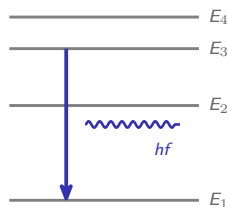
The Bohr model and energy levels

The **Bohr model** 玻尔模型: electrons occupy only certain **energy levels** 能级 – energy is **quantized**.

A jump emits or absorbs a photon

$$E = hf = E_i - E_f$$

Hydrogen $-3.4 \rightarrow -13.6$ eV: emits a 10.2 eV photon.



3 Spectra

Modern Physics
└ Spectra

Spectra and blackbody radiation

Discrete levels give sharp spectral lines – a **fingerprint** of each element:

- **emission** 发射光谱: bright lines (electrons drop)
- **absorption** 吸收光谱: dark lines in a rainbow (photons absorbed)

A hot **blackbody** 黑体 glows across all wavelengths; hotter $\Rightarrow$ peak shifts to **shorter** λ (**Wien's law** 维恩定律).



Nuclear energy is released from the nucleus

4 Photoelectric

The photoelectric effect

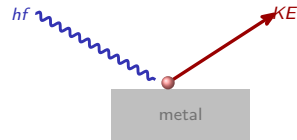
Light ejects electrons from a metal – only if each photon is energetic enough:

One photon, one electron

$$E = hf = \phi + KE_{\max}$$

work function 逸出功 ϕ = energy to escape.

Below the **threshold frequency** 截止频率, **no** electrons come out – however bright the light.



5 Compton

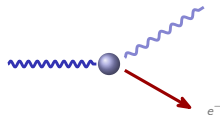
Compton scattering

A photon collides with an electron like two billiard balls – proof photons carry **momentum** 动量:

Photon momentum

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

The scattered photon loses energy, so it comes away with a **longer** wavelength. Both energy and momentum are conserved.



6

Nuclear

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└ Nuclear

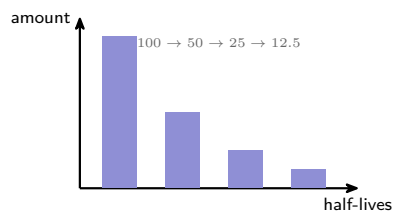
Nuclear physics

The nucleus releases huge energy when it changes – the lost **mass** becomes energy:

Mass-energy

$$E = mc^2$$

- **fission** 裂变: split a heavy nucleus
- **fusion** 聚变: join light nuclei (the Sun)
- **alpha** 阿尔法 / **beta** 贝塔 / **gamma** 伽马 decay – conserve nucleons & charge



Half-life 半衰期: time for half to decay.

Modern Physics
└ Nuclear

Nuclear physics

Nuclear physics

7

Recap

Unit 15 – key takeaways

1 Duality

$E = hf$, matter has $\lambda = h/p$; wave and particle both

2 Atoms

quantized levels; a jump gives $hf = E_i - E_f$ – sharp lines

3 Photoelectric

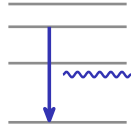
$hf = \phi + KE_{max}$; a threshold frequency, not brightness

4 Nuclear

fission, fusion, decay; $E = mc^2$; half-life

Check yourself

- 1 What sets a single photon's energy?
- 2 Why does an atom emit only certain colours?
- 3 Below the threshold frequency, does brighter light eject electrons?
- 4 After two half-lives, what fraction of a sample remains?



Answers 1. its frequency ($E = hf$) 2. quantized energy levels 3. no 4. one quarter