AP PHYSICS 2 • HOLIDAY HOMEWORK 假期作业

15 Photons and the atom – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
quanta	量子			
photons	光子			
Wave–particle duality	波粒二象性			
energy levels	能级			
photoelectric effect	光电效应			
work function	逸出功			

Recall

You have heard some surprising ideas about light and atoms:

- Light comes in tiny packets called photons, not just a smooth wave.
- Atoms give off particular colours –think of the orange glow of a street lamp.
- Shining light on some metals can knock electrons out.

This sheet makes these quantum ideas exact. Each idea has a worked example.

New ideas

■ 1 Photons

At tiny scales, energy comes in packets called **quanta** 量子. Light is carried by **photons** 光子, each with energy set by its frequency:

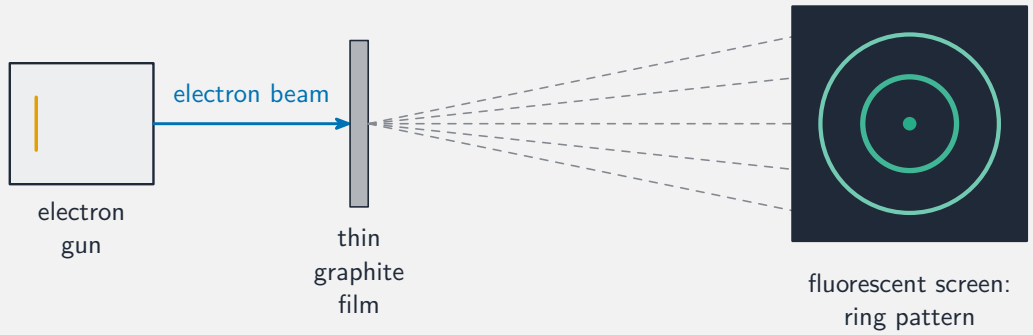
$$E = hf,$$

where $h = 6.63 \times 10^{-34}$ J s is Planck's constant. Higher-frequency light means higher-energy photons.

Worked example. A green-light photon of frequency 5.0×10^{14} Hz carries $E = hf = 6.63 \times 10^{-34} \times 5.0 \times 10^{14} = 3.3 \times 10^{-19}$ J.

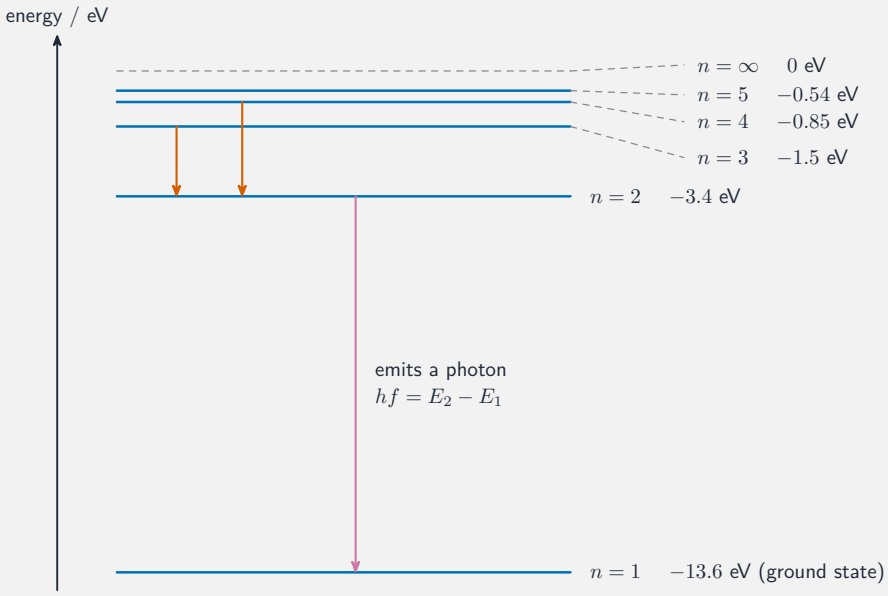
2 Wave–particle duality

Wave–particle duality 波粒二象性 means light (and even matter) shows **both** wave behaviour (interference, diffraction) and particle behaviour (photons, single hits).



3 Energy levels

An atom's electrons can sit only in certain **energy levels** 能级. An electron jumps between levels by absorbing or emitting a photon whose energy exactly matches the gap. Because the gaps are fixed, each element gives off its own set of colours –a fingerprint.



■ 4 The photoelectric effect

Shining light on a metal can eject electrons –the **photoelectric effect** 光电效应–but only if the photon's frequency is high enough. The escaping electron's energy is

$$K_{\max} = hf - \phi,$$

where ϕ is the **work function** 逸出功 (the energy needed to free an electron).

Watch out: below the threshold frequency, **no** electrons come out, no matter how bright the light. Brightness adds more photons, but each one must individually be energetic enough.

Practice

Try these in order. The methods are all above.

2.1 Find the energy of a photon of frequency 4.0×10^{14} Hz ($h = 6.63 \times 10^{-34}$ J s). [2]

2.2 State what "wave–particle duality" means, in one sentence. [1]

2.3 An electron drops between two energy levels, emitting a photon. State what decides

the photon's energy. [1]

2.4 Light of frequency 9.0×10^{14} Hz hits a metal with work function $\phi = 4.0 \times 10^{-19}$ J. Find the maximum kinetic energy of an ejected electron. [3]

2.5 A very bright red light shines on a metal but ejects no electrons, while a dim blue light does. Explain why. [2]
