INKPHYSICS FLASHCARDS

Quantum phenomena

Year 12 · 16 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Work function.

THE PHOTOELECTRIC EFFECT

DEFINITION

Define: Threshold frequency.

THE PHOTOELECTRIC EFFECT

DEFINITION

Define: Photon.

THE PHOTOELECTRIC EFFECT

CHECK YOURSELF

Sodium has a work function of 2.3 eV. Light of frequency 7.0×10^{14} Hz falls on it. Find the maximum kinetic energy of the photoelectrons, in eV and in joules. ($h = 6.63 \times 10^{-34}$ J s.)

Hint: Find the photon energy in joules first, then run the budget.

THE PHOTOELECTRIC EFFECT

SPOT THE ERROR

Say what is wrong with this claim:

Brighter light gives the electrons more energy.

THE PHOTOELECTRIC EFFECT

DEFINITION

Define: The electronvolt.

COLLISIONS OF ELECTRONS WITH ATOMS

DEFINITION

Define: Excitation.

COLLISIONS OF ELECTRONS WITH ATOMS

DEFINITION

Define: Ionisation.

COLLISIONS OF ELECTRONS WITH ATOMS

DEFINITION

The minimum frequency of radiation that will release electrons from a surface: hf_0 equals the work function.

THE PHOTOELECTRIC EFFECT

DEFINITION

The minimum energy needed to release an electron from the surface of a metal.

THE PHOTOELECTRIC EFFECT

CHECK YOURSELF

Photon energy: $E = hf = 6.63 \times 10^{-34} \times 7.0 \times 10^{14} = 4.64 \times 10^{-19}$ J = 2.9 eV.

Budget: $E_k(\text{max}) = hf - \varphi = 2.9 - 2.3 = 0.6$ eV.

In joules: $0.6 \times 1.60 \times 10^{-19} = 9.6 \times 10^{-20}$ J. A photon either pays the 2.3 eV toll or nothing happens; brightness never enters the calculation.

THE PHOTOELECTRIC EFFECT

DEFINITION

A discrete packet of electromagnetic energy: $E = hf$.

THE PHOTOELECTRIC EFFECT

DEFINITION

The energy gained by an electron accelerated through a potential difference of one volt: 1 eV = 1.60×10^{-19} J.

COLLISIONS OF ELECTRONS WITH ATOMS

SPOT THE ERROR

Brightness sets how many photons arrive, not how much energy each carries. One electron absorbs one photon, so only frequency — through $E = hf$ — decides whether electrons escape and how fast. Below the threshold frequency, no brightness will do it.

THE PHOTOELECTRIC EFFECT

DEFINITION

An electron gaining enough energy to leave the atom entirely, forming an ion.

COLLISIONS OF ELECTRONS WITH ATOMS

DEFINITION

An atomic electron gaining exactly the energy needed to jump to a higher energy level.

COLLISIONS OF ELECTRONS WITH ATOMS

CHECK YOURSELF

In a fluorescent tube, describe the energy story that turns the kinetic energy of a free electron into visible light. Name each process.

Hint: There are four hand-offs, and the ultraviolet step is the one candidates forget.

COLLISIONS OF ELECTRONS WITH ATOMS

SPOT THE ERROR

Say what is wrong with this claim:

Any collision can nudge an atom just a little.

COLLISIONS OF ELECTRONS WITH ATOMS

DEFINITION

Define: Ground state.

ENERGY LEVELS AND PHOTON EMISSION

CHECK YOURSELF

In hydrogen, an electron falls from the -3.4 eV level to the -13.6 eV ground state. Find the frequency of the emitted photon. ($h = 6.63 \times 10^{-34}$ J s.)

Hint: Gap first, in eV; then joules; then h.

ENERGY LEVELS AND PHOTON EMISSION

SPOT THE ERROR

Say what is wrong with this claim:

An atom can emit any colour it likes.

ENERGY LEVELS AND PHOTON EMISSION

DEFINITION

Define: De Broglie wavelength.

WAVE-PARTICLE DUALITY

CHECK YOURSELF

An electron ($m = 9.11 \times 10^{-31}$ kg) moves at 3.3×10^{6} m s^{-1}. Find its de Broglie wavelength, and state what happens to the diffraction pattern if the electrons are accelerated to a higher speed.

Hint: Momentum first. Then remember what diffraction needs from a wavelength.

WAVE-PARTICLE DUALITY

SPOT THE ERROR

Say what is wrong with this claim:

Light is a wave, and electrons are particles.

WAVE-PARTICLE DUALITY

SPOT THE ERROR

Atomic energy levels are discrete, so an atom can only accept the exact energy of a gap between levels. A collision offering less than the smallest gap leaves the atom entirely unchanged: exact change or no sale.

COLLISIONS OF ELECTRONS WITH ATOMS

CHECK YOURSELF

The tube's pd accelerates a free electron, giving it kinetic energy. A collision excites a mercury atom, transferring one exact level gap.

The atom de-excites almost at once, emitting the gap as an ultraviolet photon (hf equal to the gap).

The phosphor coating absorbs the UV, and its own electrons de-excite in smaller steps, emitting visible photons. Kinetic energy became level gaps became light, in exact parcels the whole way.

COLLISIONS OF ELECTRONS WITH ATOMS

CHECK YOURSELF

Gap: $E_1 - E_2 = (-3.4) - (-13.6) = 10.2$ eV. The signs take care of themselves.

In joules: $10.2 \times 1.60 \times 10^{-19} = 1.63 \times 10^{-18}$ J.

Frequency: $f = E/h = 1.63 \times 10^{-18} / 6.63 \times 10^{-34} = 2.5 \times 10^{15}$ Hz, in the ultraviolet, as a drop to the ground state usually is.

ENERGY LEVELS AND PHOTON EMISSION

DEFINITION

The lowest energy level of an atom, in which its electrons normally sit.

ENERGY LEVELS AND PHOTON EMISSION

DEFINITION

The wavelength associated with a moving particle: $\lambda = h/p$, where p is the particle's momentum.

WAVE-PARTICLE DUALITY

SPOT THE ERROR

Each photon's energy must equal the gap between two discrete levels, and only certain gaps exist. That is why each element emits its own line spectrum, not a free choice of colours.

ENERGY LEVELS AND PHOTON EMISSION

SPOT THE ERROR

Light diffracts like a wave yet arrives in photons; electrons are particles yet diffract through crystals. Everything carries both behaviours — which one shows depends on the experiment, and $\lambda = h/p$ says when the wave side is visible.

WAVE-PARTICLE DUALITY

CHECK YOURSELF

Momentum: $mv = 9.11 \times 10^{-31} \times 3.3 \times 10^{6} = 3.0 \times 10^{-24}$ kg m s^{-1}.

Wavelength: $\lambda = h/mv = 6.63 \times 10^{-34} / 3.0 \times 10^{-24} = 2.2 \times 10^{-10}$ m, about an atomic spacing, which is why crystals diffract electron beams so well.

At higher speed the momentum grows, λ shrinks, and the electrons diffract less: the rings contract towards the centre.

WAVE-PARTICLE DUALITY