Energy Levels and Photon Emission

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First, a challenge...

In this room, there are enough sweets labelled with your names for everyone to win a sweet. However, to do this, you must correctly work out its gravitational potential energy, i.e. how much energy would be released if it fell to the floor?

$$\text{G.P.E.} = mgh,$$

where

$$m = \text{mass} = 5\,\text{g},$$

$$g = 9.81\,\text{m s}^{-2}.$$

Lesson Objectives

1. Understand what happens to electrons when atoms become excited.
2. Check understanding of the photoelectric effect.
3. Be able to calculate the energy of emitted / absorbed photons.

Textbook pp. 36–38

Specification Requirement

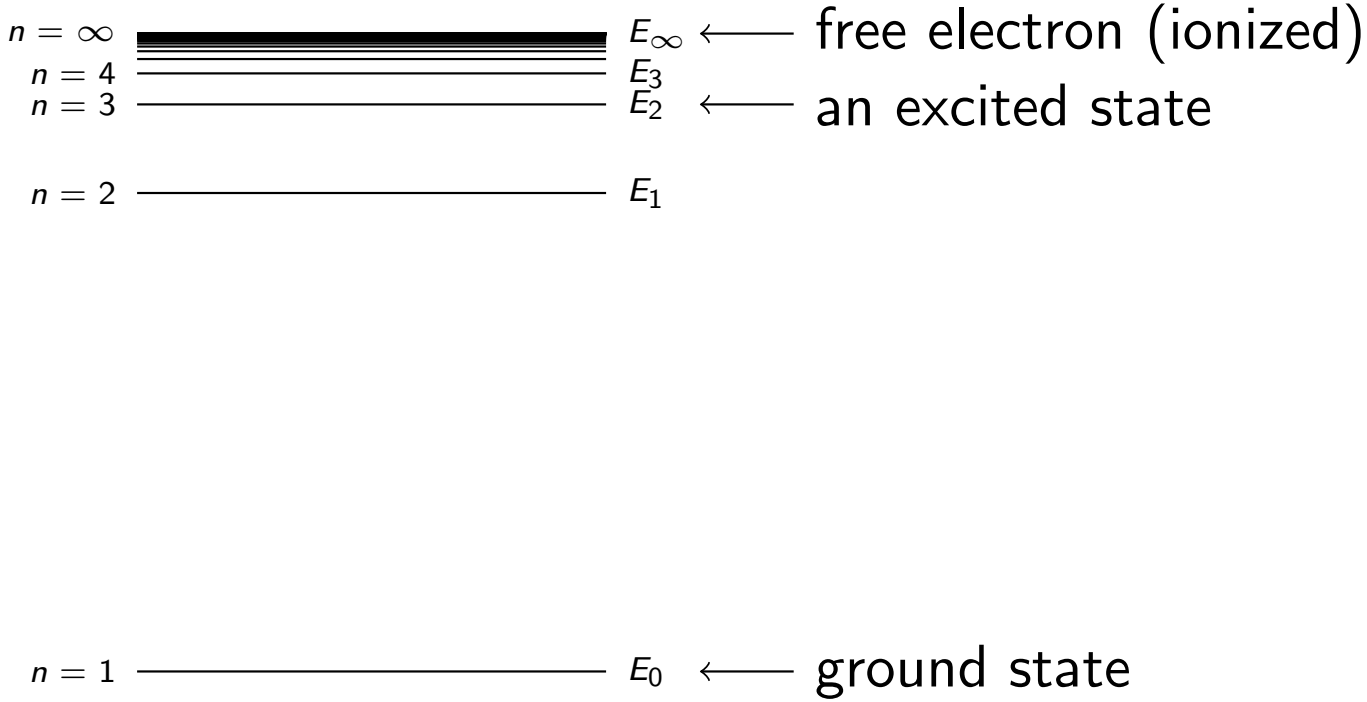
Line spectra (e.g. of atomic hydrogen) as evidence of transitions between discrete energy levels in atoms.

$$hf = E_1 - E_2$$

[AQA GCE AS and A Level Specification Physics A, 2009/10 onwards]

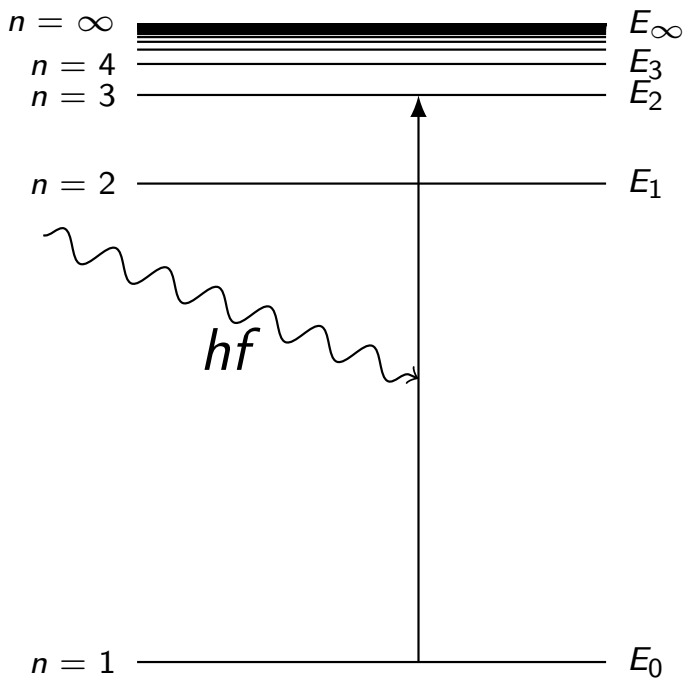
Energy levels

The sweets could only take certain levels of energy, fixed by the levels of the horizontal surfaces available in the room. Similarly, electrons in atoms can only have certain energy states, determined by their interaction with the electric field around the nucleus.



Excitation

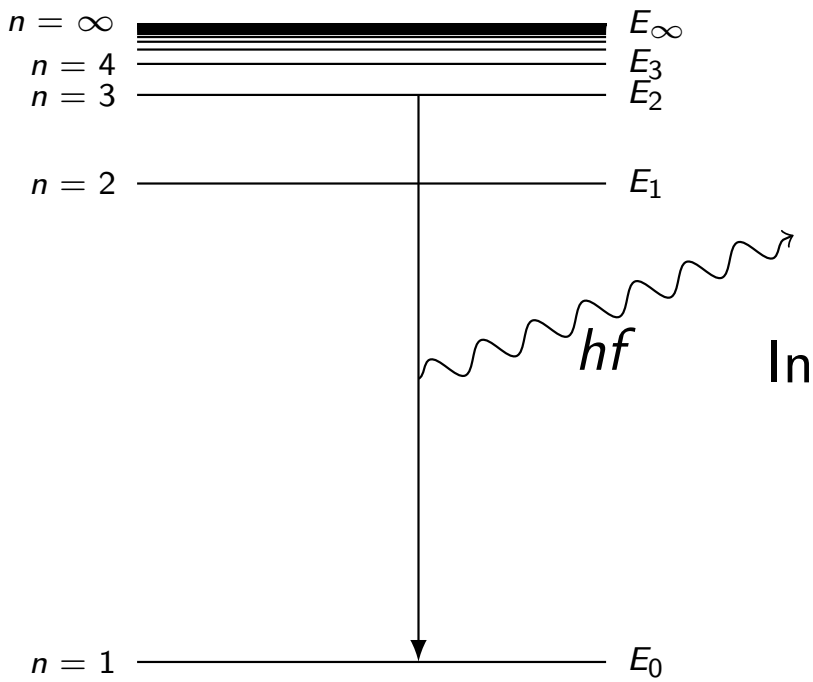
An electron can move up from the lowest energy level (the **ground state**) to a higher energy level as follows:



- The energy hf of the photon must exactly equal the difference in energy of the energy levels.
- There must be a vacancy in the higher energy state (as electrons cannot normally occupy the same state).

De-excitation

An electron in an excited state can 'settle' into a vacancy in a state of lower energy or the ground state by emitting a photon to carry away **exactly** the excess energy.



In this case,

$$hf = E_2 - E_0.$$

Concept questions: the photoelectric effect

A xenon arc lamp is covered with an interference filter that only transmits light of 400 nm wavelength. When the transmitted light strikes a metal surface, a stream of electrons emerges from the metal. If the intensity of the light striking the surface is doubled,

1. more electrons are emitted in a given time interval
2. the electrons that are emitted are more energetic
3. both of the above
4. neither of the above

Concept questions: the photoelectric effect (2)

A xenon arc lamp is covered with an interference filter that only transmits light of 400 nm wavelength. When the transmitted light strikes a metal surface, a stream of electrons emerges from the metal. The interference filter is then replaced with one transmitting at 300 nm and the lamp adjusted so that the intensity of the light striking the surface is the same as it was for the 400 nm light. With the 300 nm light,

1. more electrons are emitted in a given time interval
2. the electrons that are emitted are more energetic
3. both are true
4. both are false

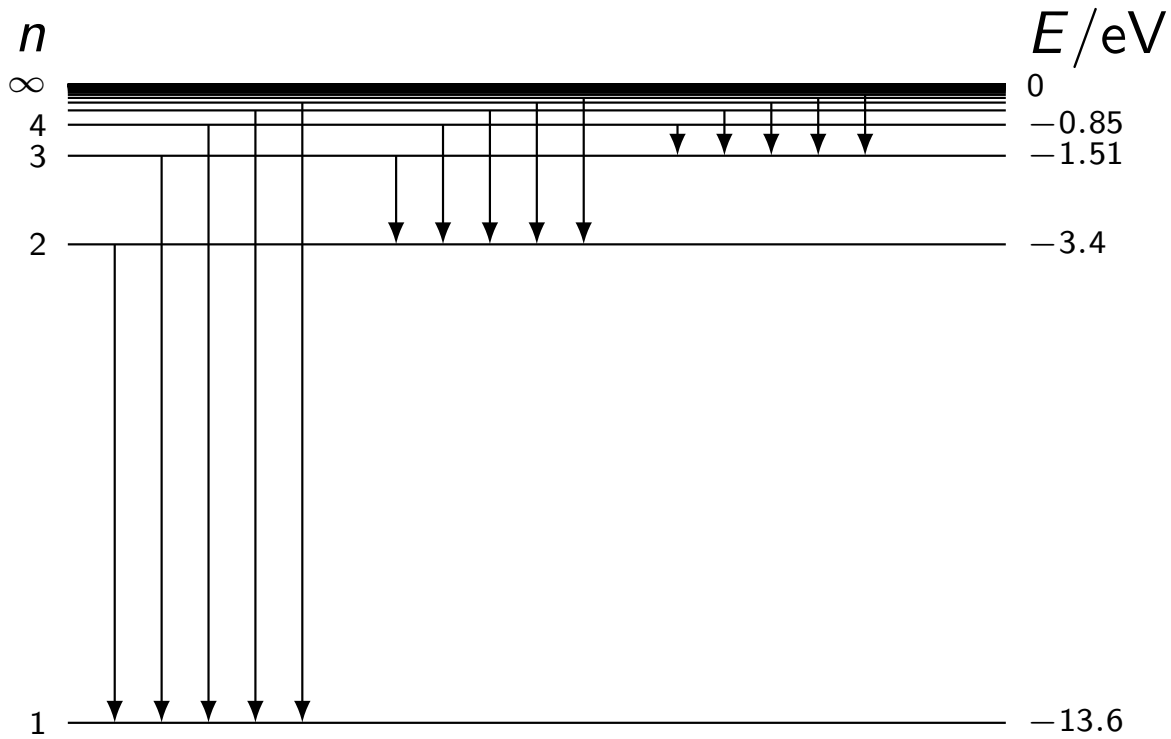
Concept question: the photelectric effect (3)

Which of the following experimental observations of the photoelectric effect are inconsistent with classical electromagnetism?

(a) The ammeter current increases proportionally to the light intensity on the cathode.
(b) Independent of the intensity, the ammeter current goes to zero when the wavelength of the light exceeds a certain value.
(c) The measured maximum kinetic energy of the emitted electrons does not change with the incident light intensity.
(d) As the light intensity incident on the cathode is decreased to very low values, there is never any evidence of a threshold intensity below which no photoelectrons are produced.
(e) The maximum kinetic energy of the emitted electrons is different for different metals, other conditions being the same.

1. a, b, and c
2. b, c, and d
3. c, d, and e
4. a, d, and e

Hydrogen Line Spectrum



Flourescence