Atomic Spectra & the Quantum Atom (ch. 13.6 & 13.7)

Correct description of the observed atomic "spectra" and the observed **quantized atomic energy levels** – one of the earliest triumphs of Quantum Physics in the 1920s.

Essential topics:

Spectroscopy, particularly line spectra

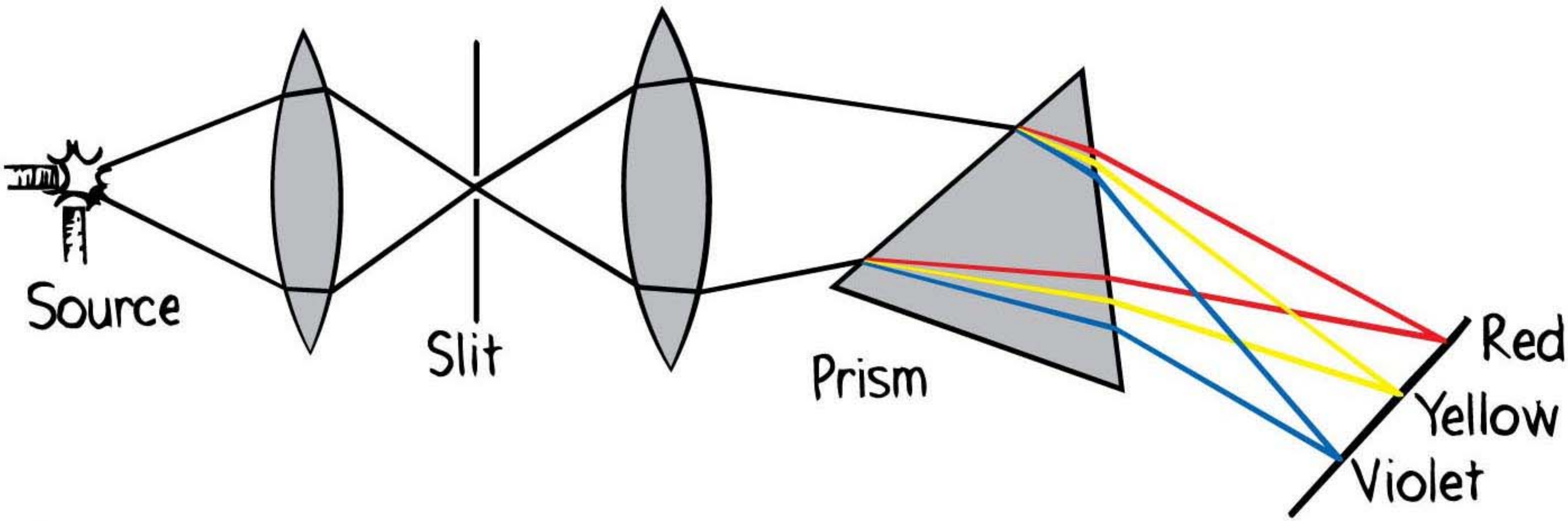
Energy quantization in hydrogen (atoms in general)

Quantum jumps – emission & absorption of photons

Probability distributions for the electron in H (hydrogen)

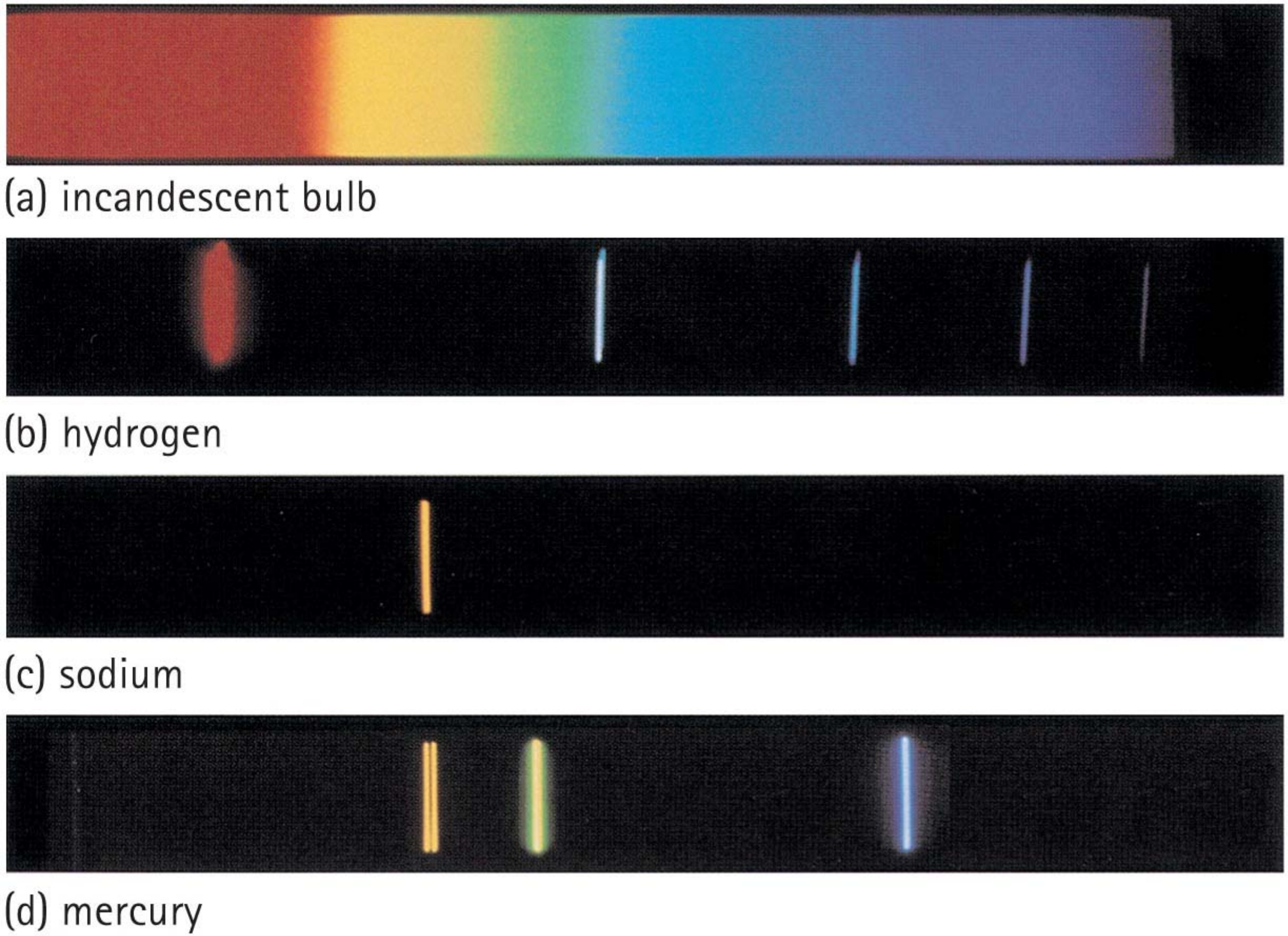
Various types of "*spectroscopy*", one of *the* most important tools in physics & chemistry & astronomy!

One example, prism spectrograph:



(→ raindrops leading to rainbows!)

Continuous vs. Line Spectra: glowing solids/liquids vs. gases at low pressure (inter-atomic interactions vs. isolated atoms): demo!



Quiz # 99: A hot plate that is warming up, but not yet visibly glowing, will emit

(a) uv radiation (b) no radiation (c) visible light (d) x-rays
(e) infrared radiation

As an object heats up more & more, and its glow changes from "red hot" to bluish/white, is that apparent color change consistent with what we learned about photons, incl. Planck's $E = hf$?

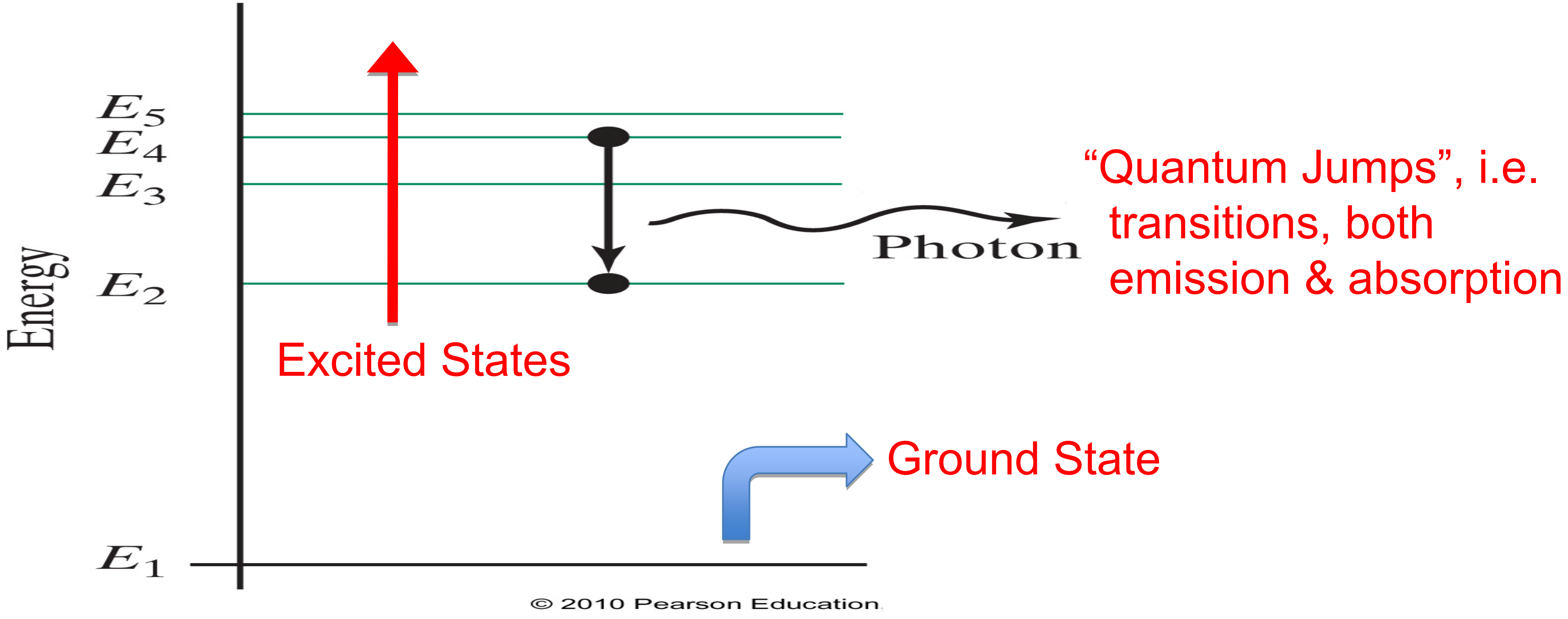
Quiz # 100: If you compare the spectra from two sodium (Na) vapor lamps, and then a sodium vapor lamp with a mercury (Hg) vapor lamp, apart from intensity differences, the spectra would be

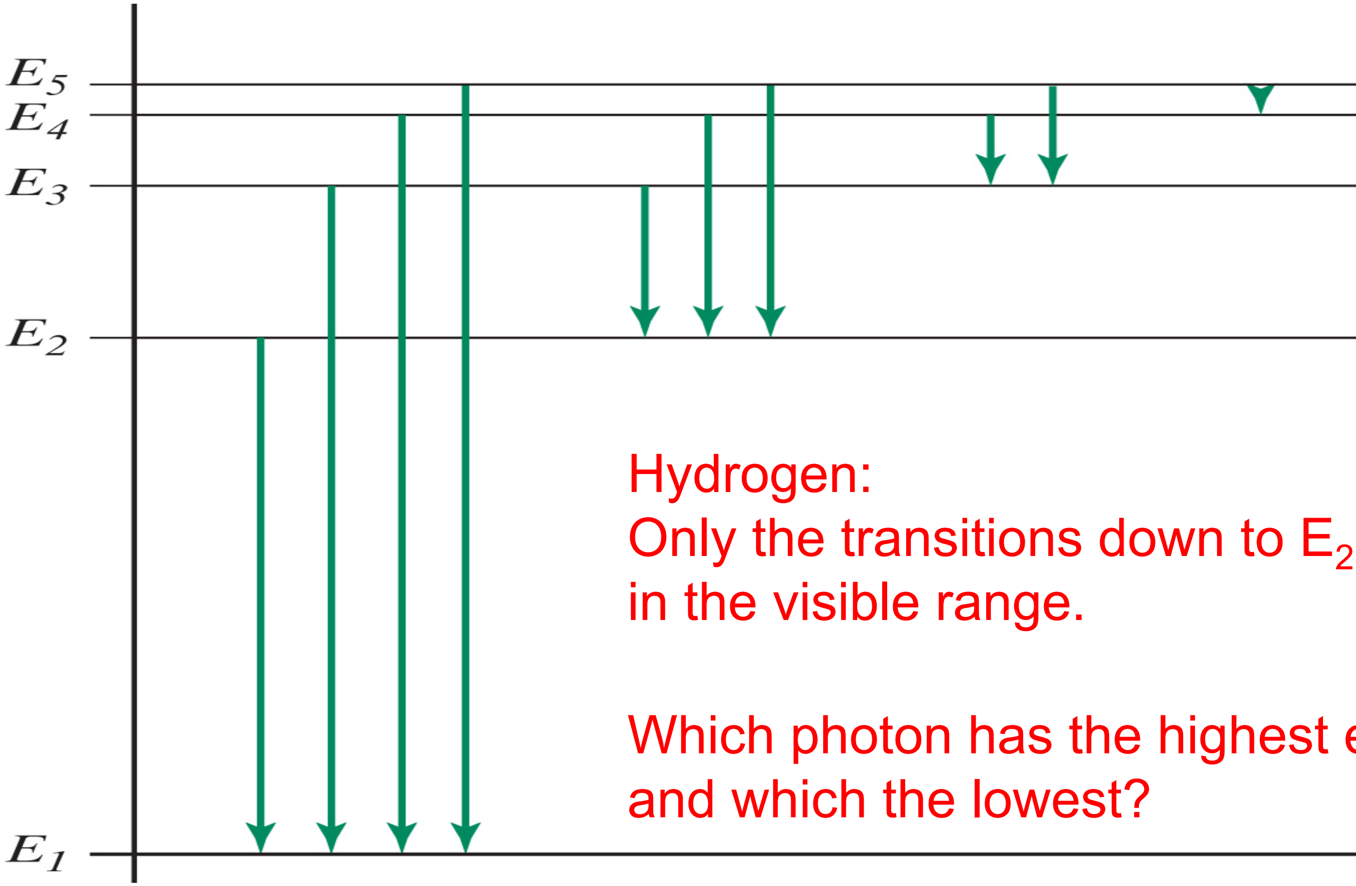
(a) the same (two Na), and also the same for Na & Hg
(b) different in both cases
(c) the same (two Na), but different for Na & Hg
(d) different (two Na), but the same for Na & Hg

Most important fact about the quantum atom, i.e. the quantum mechanically correct description of atoms:

Electron energy level ("atomic states") are severely restricted, i.e. $E_{electron}$ is **quantized** !

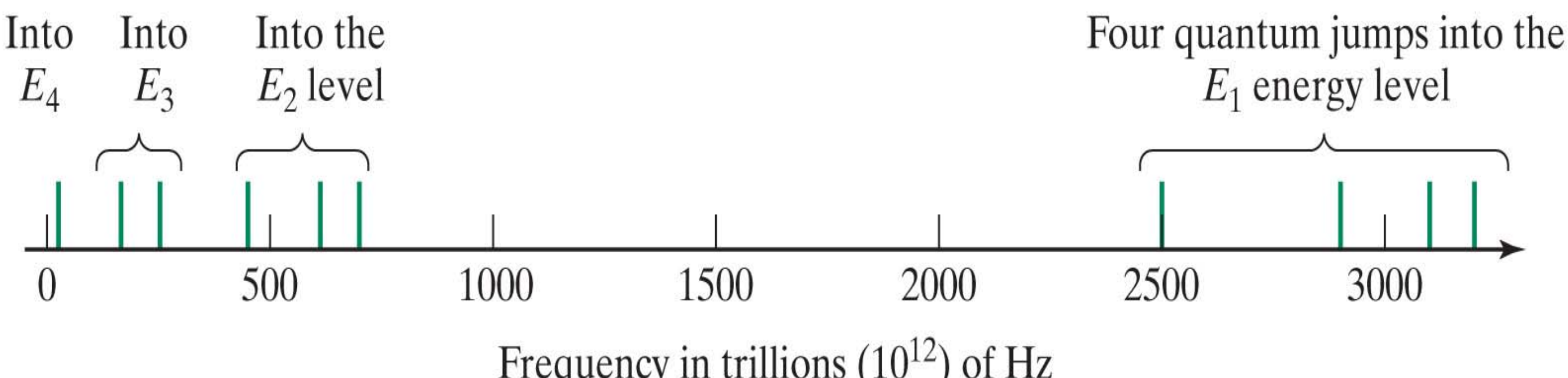
→ There is a *lowest* level, the *ground state*, and then a sequence of *excited states*. Only in these states (and in principle combos thereof) can the atom exist - ever!





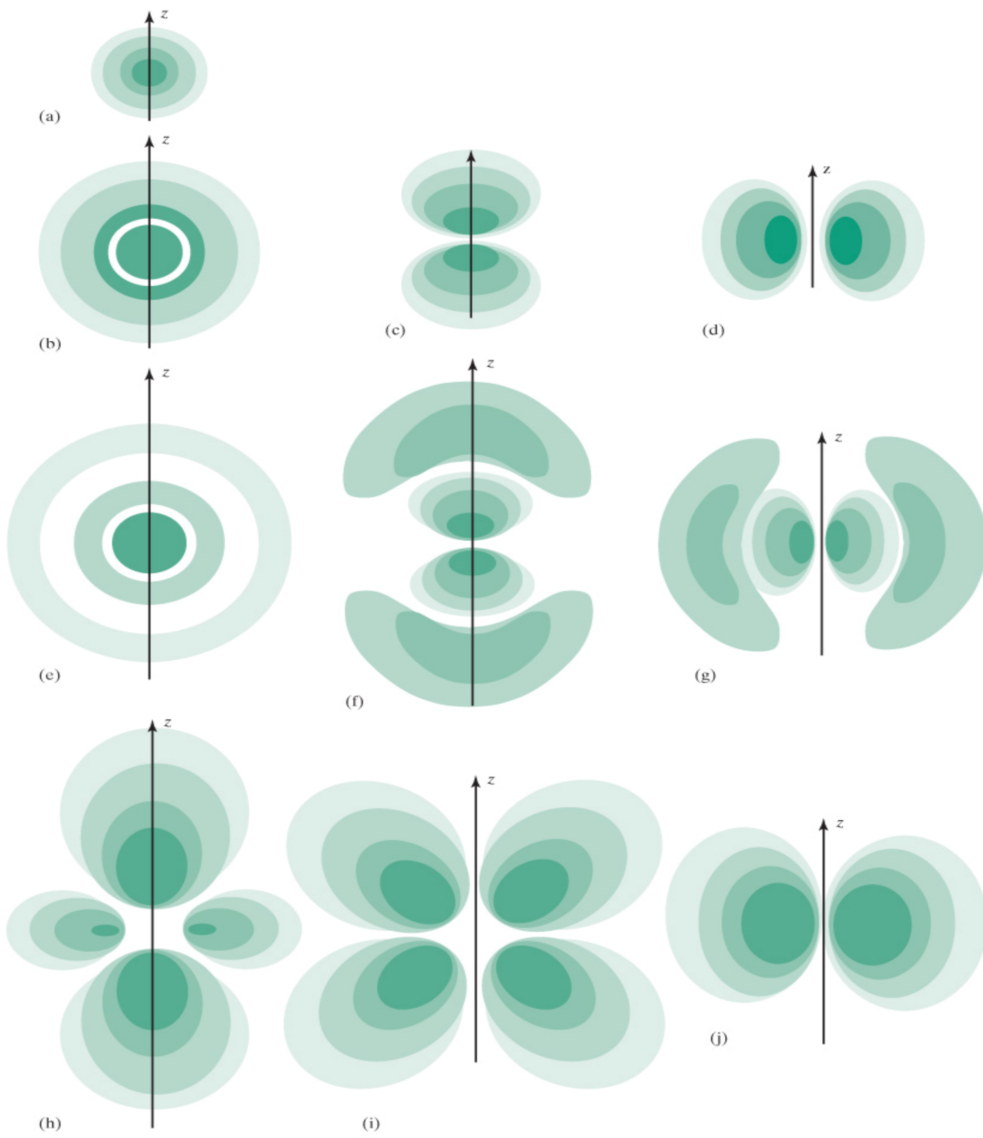
Hydrogen:
Only the transitions down to E_2 are in the visible range.

Which photon has the highest energy and which the lowest?



Note how the total # of possible transitions is simply a function of the total # of energy levels that exist.

→ Classically atoms should ***NOT*** exist, should not be stable! Why?

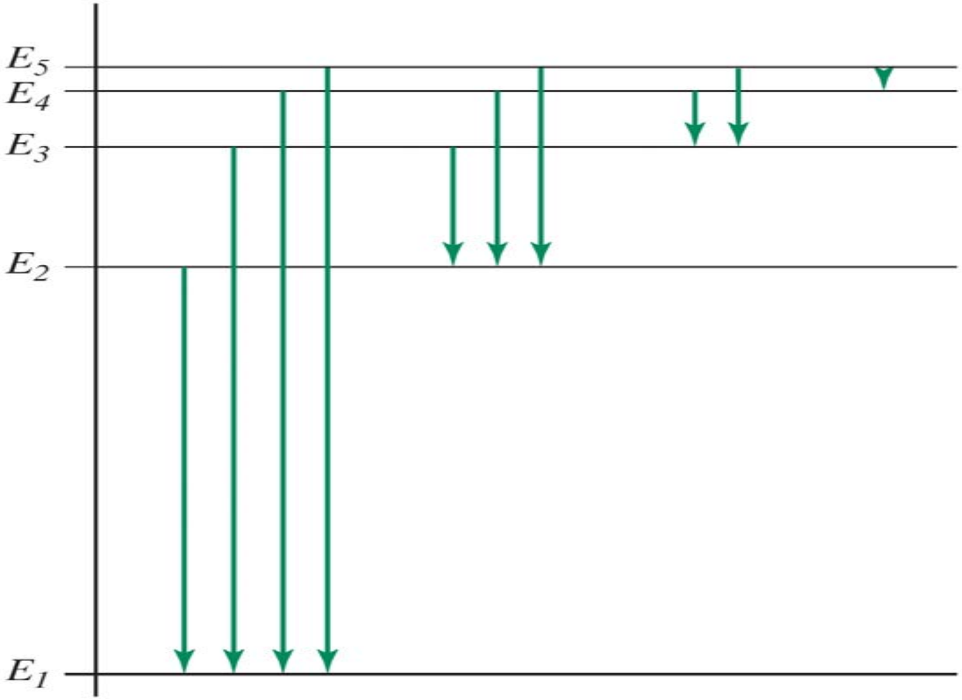


Position probabilities of the electron in the H-atom. (careful: need to rotate these around the z-axis – it's a 3-dimensional problem, after all.)

http://hyperphysics.phy-astr.gsu.edu/hbase/hydwf.html

Quiz # 101: In a very accurate measurement of an atom's mass would you find a *mass difference* between the atom in an excited state and the same atom in its ground state?

(a) Yes, more massive in its excited state.
(b) No, same mass.
(c) Yes, more massive in its ground state.
(d) Depends on the kind of atom.



Quiz # 102: Considering only transitions to the ground state, the longest λ (not frequency!) emitted, would be

(a) E_2 to E_1
(b) E_3 to E_2
(c) E_4 to E_1
(d) E_5 to E_2
(e) E_5 to E_1