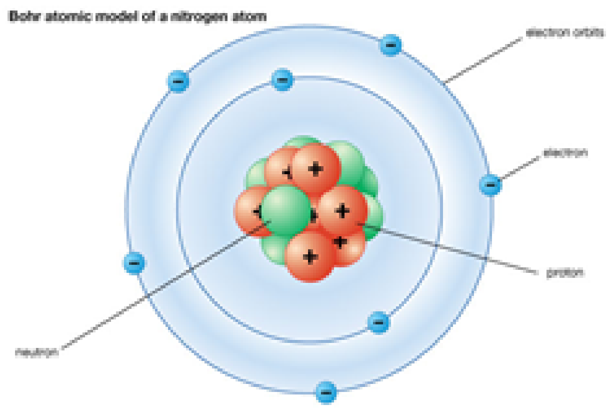
This is pages 8 - 11. It is a continuation of the regents level information and practice problems.

Atomic & Nuclear Forces



3. What force holds electrons in orbit around the nucleus?

   Electromagnetic

4. What force holds nucleons together?

   Protons & neutrons

   Strong Force

5. Draw and label the forces between the particles on the diagram at right.

Nucleons are protons and neutrons (think back to chemistry)

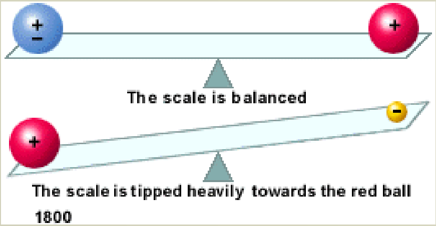
The EM force tries to repel the protons but the strong force keeping them together is stronger.

Atomic & Nuclear Forces

Name	Property	Type	Range	Strength
Gravitational	Force between objects with mass (energy)	Attractive	Long range	4
Electromagnetic (Electrostatic, Coulomb)	Force between charged objects	Attractive or repulsive	Long range	2
Strong Force	Holds protons and neutrons together in nucleus	Attractive	Short range	1
Weak Force	Involved in radioactive decay	Repulsive	Short range	3

Atomic & Nuclear Structure

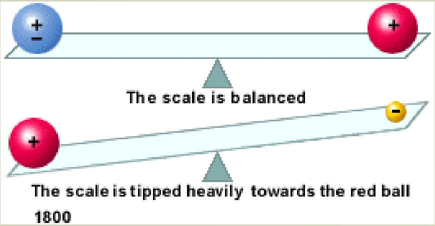
- Universal Mass unit – (u) – an atomic mass unit defined as 1/12th the mass of an atom of carbon-12



This is used in atomic and nuclear physics because of its convenient size, better than kilograms.

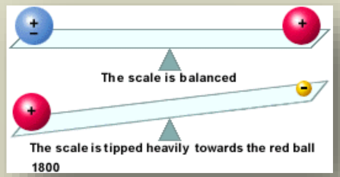
Atomic & Nuclear Structure

In kilograms the proton and neutron are the same (3 s.f.), but in u, the neutron is slightly more massive (5 s.f.)



Particle	Electric Charge (C)	Mass in Kilograms (kg)	Mass (u)
Electron	-1.60×10^{-19}	9.11×10^{-31}	5.49×10^{-4}
Proton	$+1.60 \times 10^{-19}$	1.67×10^{-27}	1.0073
Neutron	0	1.67×10^{-27}	1.0087

Atomic & Nuclear Forces



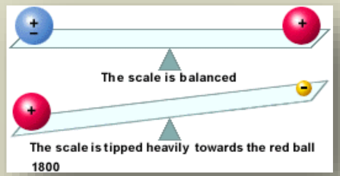
Particle	Electric Charge (e)	Electric Charge (C)	Mass		Equivalent Energy	
			(kg)	(u)	(J)	(MeV)
Electron	-1	-1.60×10^{-19}	9.11×10^{-31}	0.000549		
Proton	+1	$+1.60 \times 10^{-19}$	1.67×10^{-27}	1.0073		
Neutron	0	0	1.67×10^{-27}	1.0087		

$$\boxed{1\ \text{u} = 931\ \text{MeV}}$$

Use $E = mc^2$ convert

Calculate the energy in J using $E=mc^2$ and then convert u to MeV.

Atomic & Nuclear Forces



Particle	Electric Charge (e)	Electric Charge (C)	Mass		Equivalent Energy	
			(kg)	(u)	(J)	(MeV)
Electron	-1	-1.60×10^{-19}	9.11×10^{-31}	0.000549	8.2×10^{-14}	0.511
Proton	+1	$+1.60 \times 10^{-19}$	1.67×10^{-27}	1.0073	1.5×10^{-10} J	938
Neutron	0	0	1.67×10^{-27}	1.0087	1.5×10^{-10} J	939

$$\boxed{1\ \text{u} = 931\ \text{MeV}}$$

Use $E = mc^2$ convert

Notice how the neutron has slightly more energy in MeV

Atomic Spectra

A deuterium nucleus has a mass that is 1.53×10^{-3} universal mass units less than the mass of its components. How much energy does this represent?

This is a unit conversion between u and MeV

Atomic Spectra

A deuterium nucleus has a mass that is 1.53 x 10^{-3} universal mass units less than the mass of its components. How much energy does this represent?

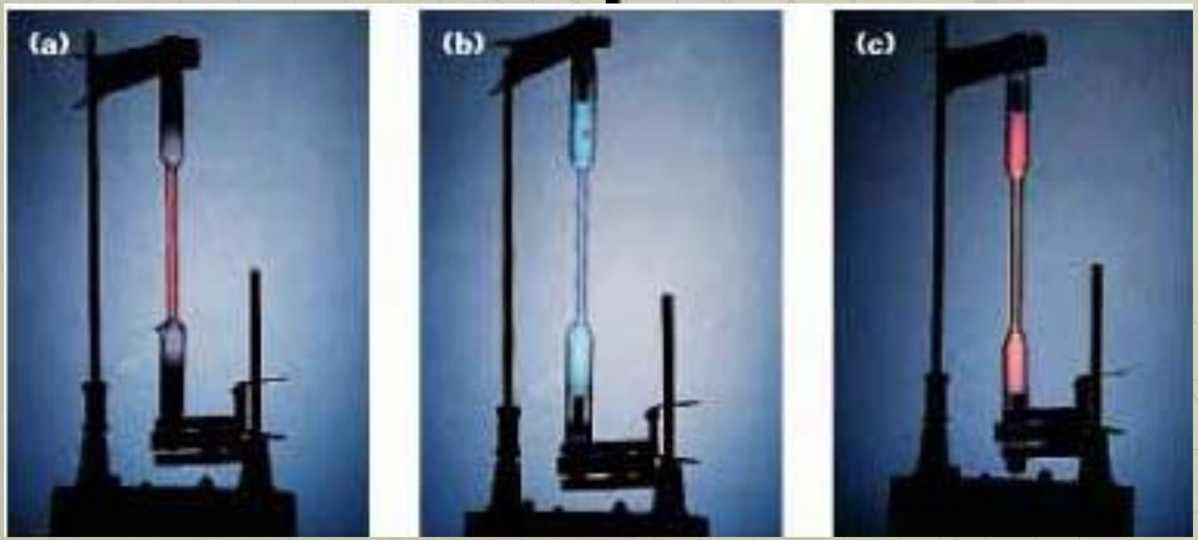
$$1.53\times10^{-3}\text{u}\left(\frac{9.31\times10^{2}\text{MeV}}{1\text{u}}\right)=1.42\text{ MeV}$$

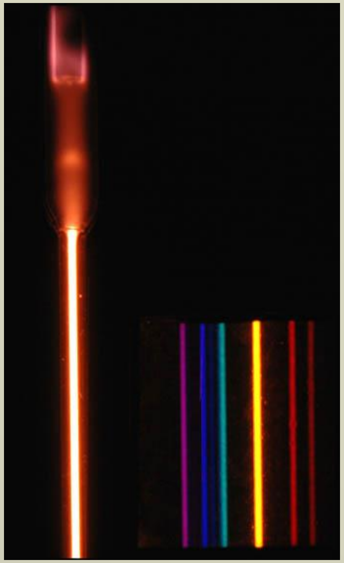
Sigh. If we were in class, I would take out a glass tube filled with atomic gas, zap it with electricity and watch it glow. We'd then use spectroscopes to view the light and see the components.

You may have done something similar in Chem. Remember the glowing glass tubes and spectral lines? That's what we're talking about here.

This is how neon lights work.

Determine the elements by their spectral lines.

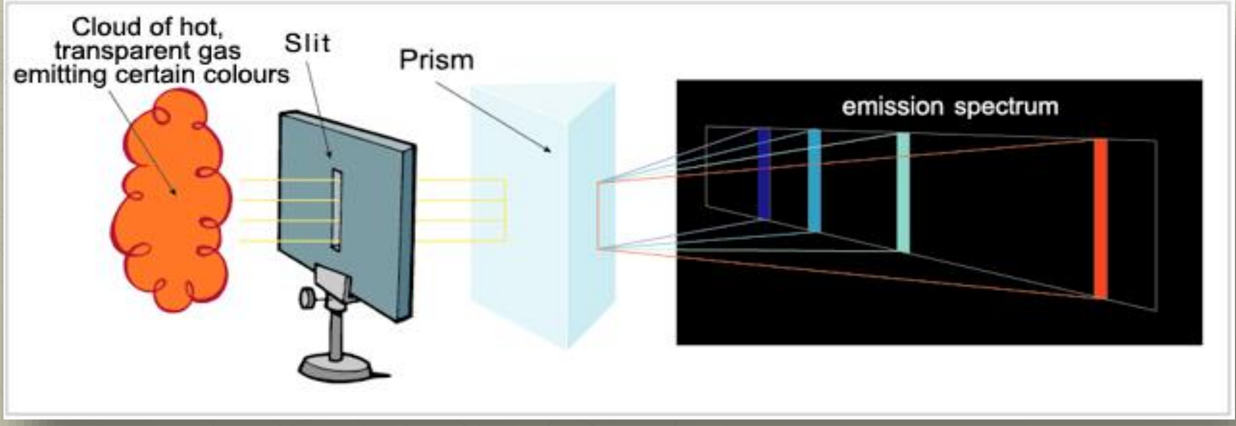




Production of Emission Spectra

- Low pressure gas is energized by applying a potential difference across it causing it to heat up.
-

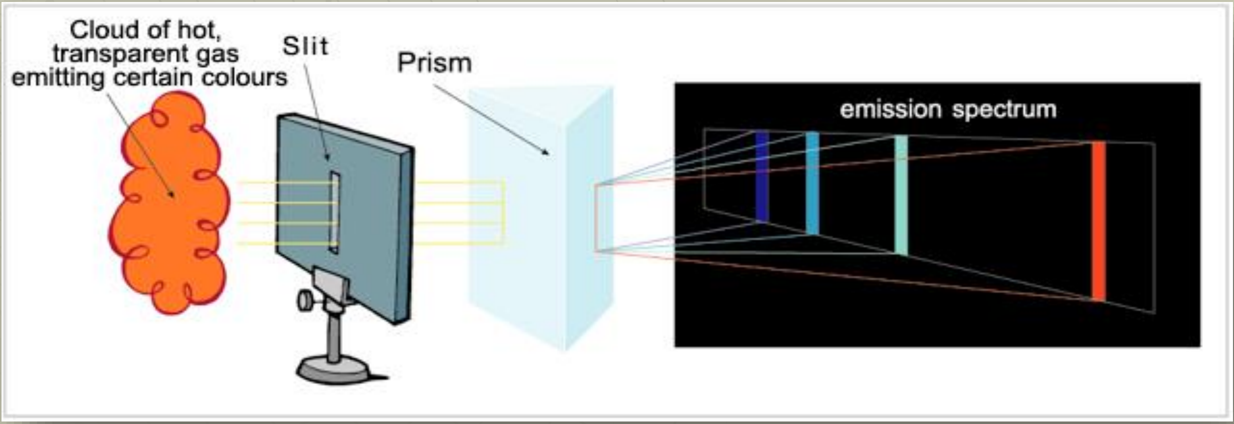
Zap a gas with electricity, excites the atoms



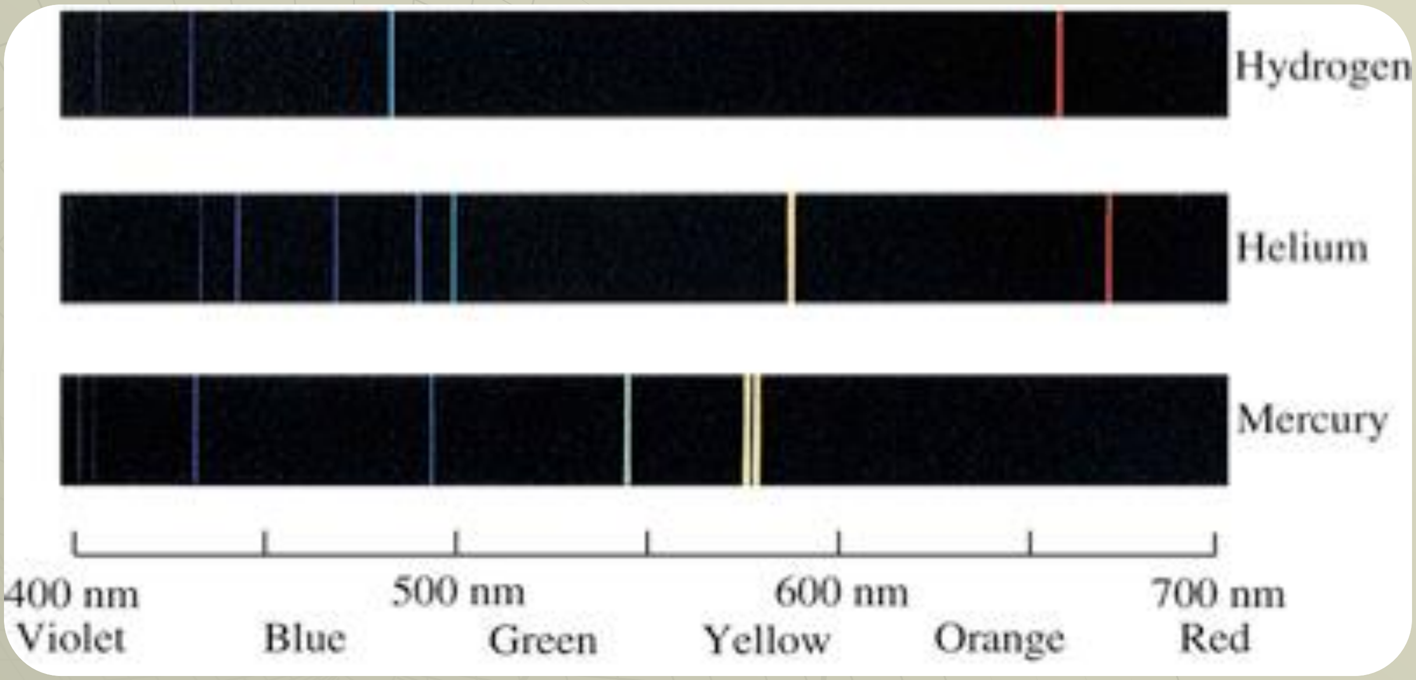
Production of Emission Spectra

- The hot gas emits light energy only at certain well-defined frequencies, as seen through a diffraction grating or prism.

When the electrons relax to a lower energy level they emit light – very specific frequencies.



Emission Spectra



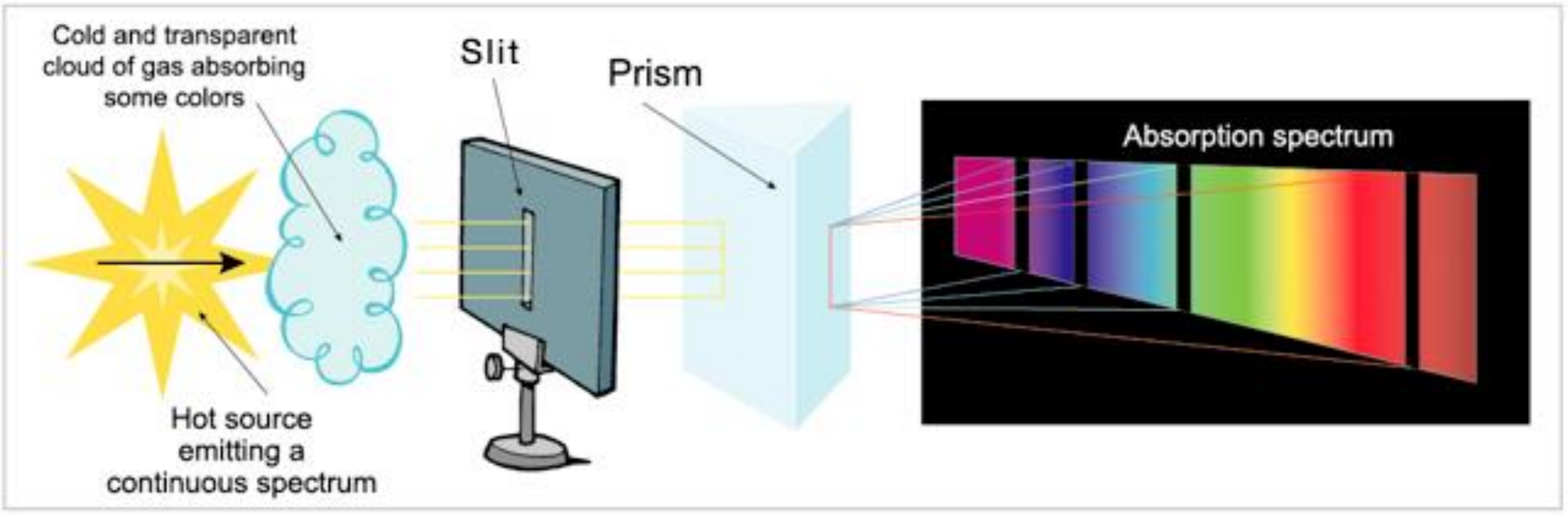
The **spectral lines** produced (emission or absorption) are characteristic of the particular element producing them.

Every element is unique, like a fingerprint

Production of Absorption Spectrum

- Light is shone through a cool low pressure gas.

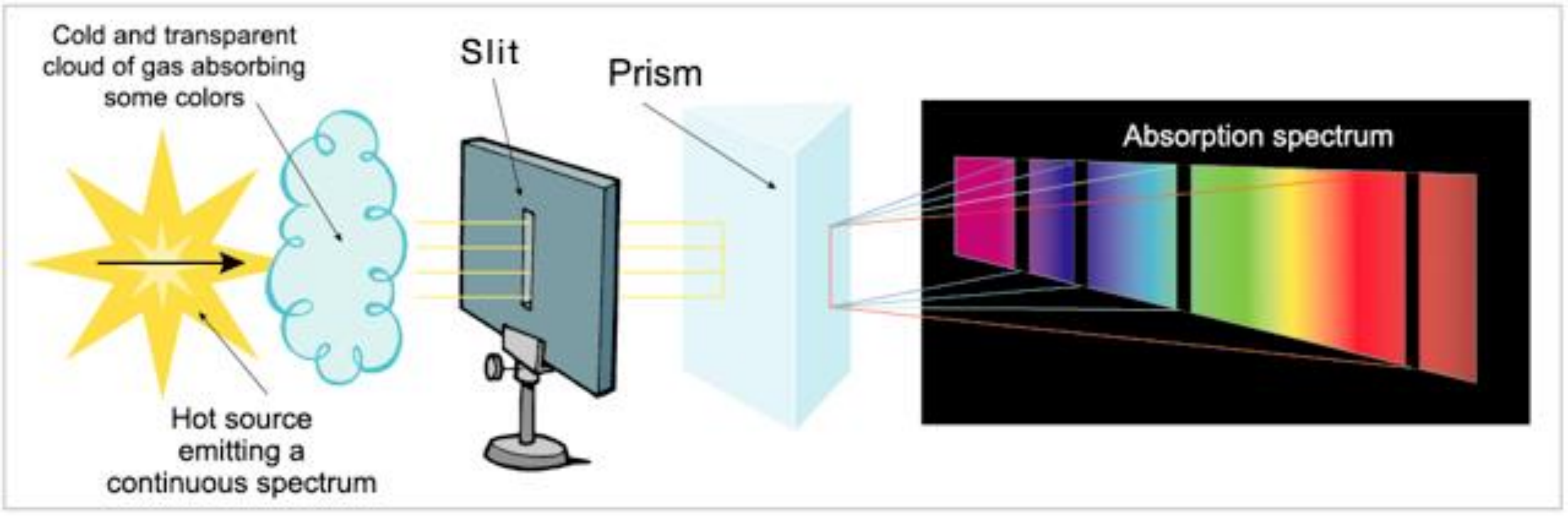
Shine light through a gas and it will absorb certain frequencies.



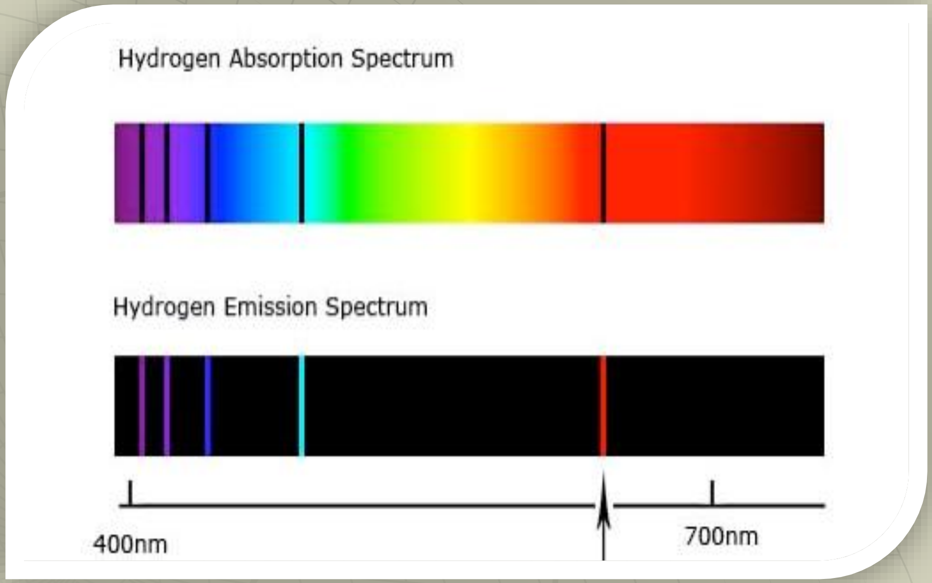
Production of Absorption Spectrum

- A diffraction grating or prism is used to determine what frequencies pass through the gas and which are absorbed.

There are dark lines where the light was absorbed.

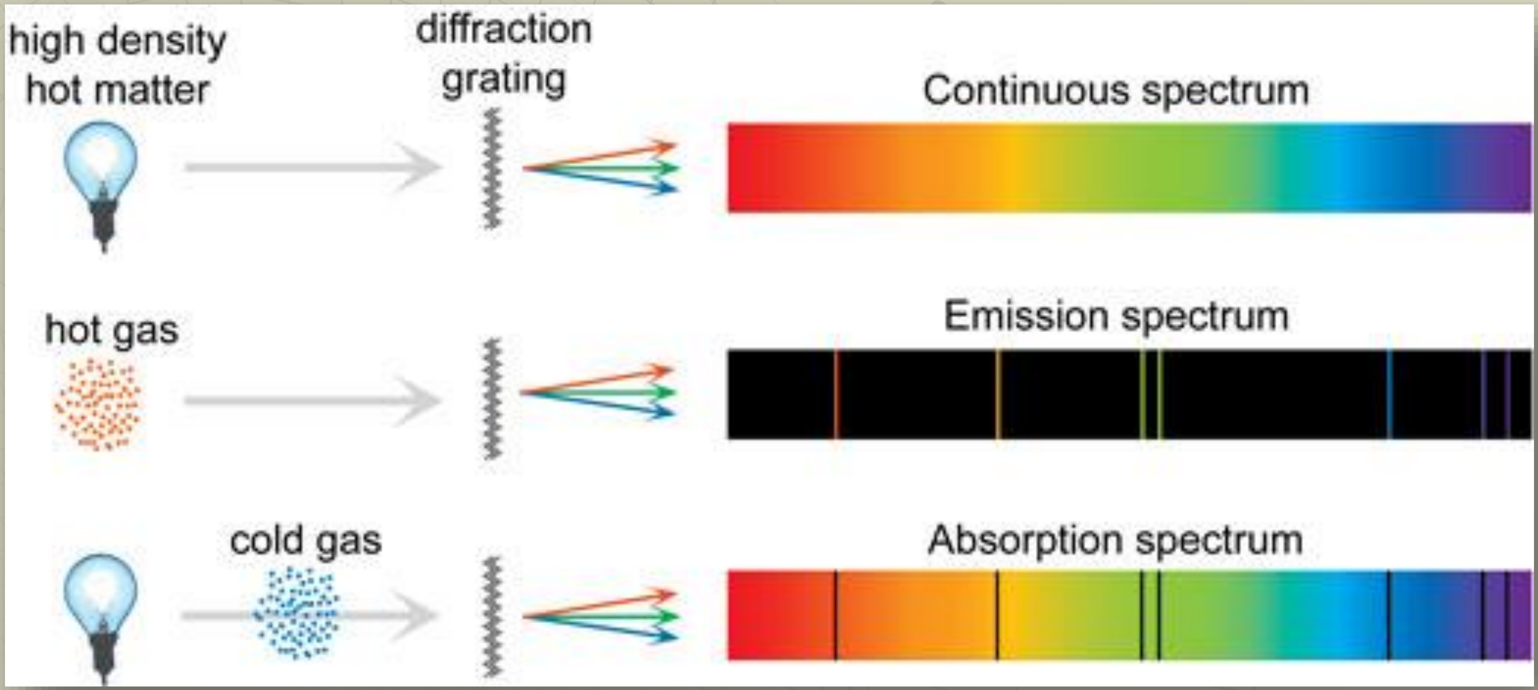


Atomic Emission & Absorption Spectra



- Note that emission and absorption spectral lines occur at the same locations for the same element.

Atomic Emission & Absorption Spectra

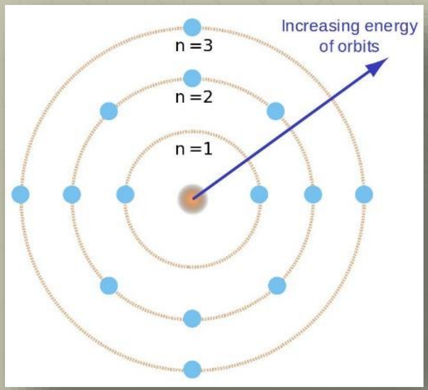


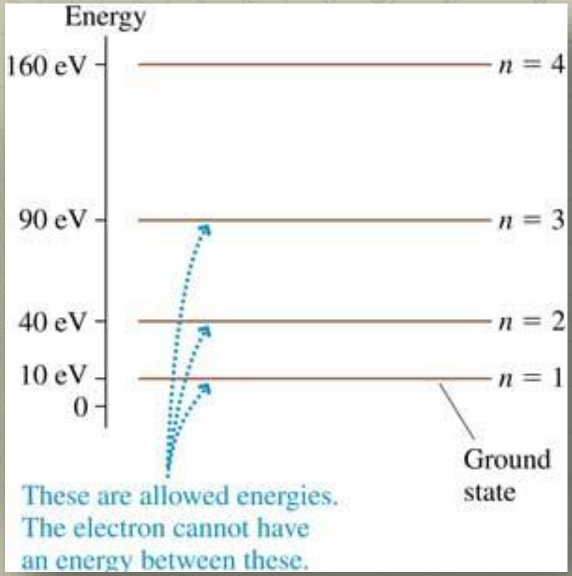
A gas can only absorb when it emits and only emit what it absorbs

Scientists needed an explanation for what they were observing. Bohr came up with the best explanation. You may remember Bohr from the Chemistry orbitals – p, q, etc. These are different. They are energy levels the electrons can jump to.

Postulates of the Bohr Model of the Atom

I. Electrons in an atom can only exist in certain well-defined (discrete) stationary states called energy levels or energy states.

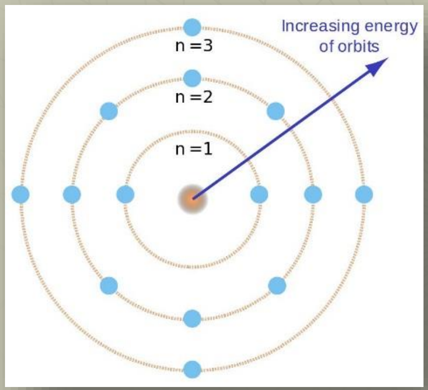


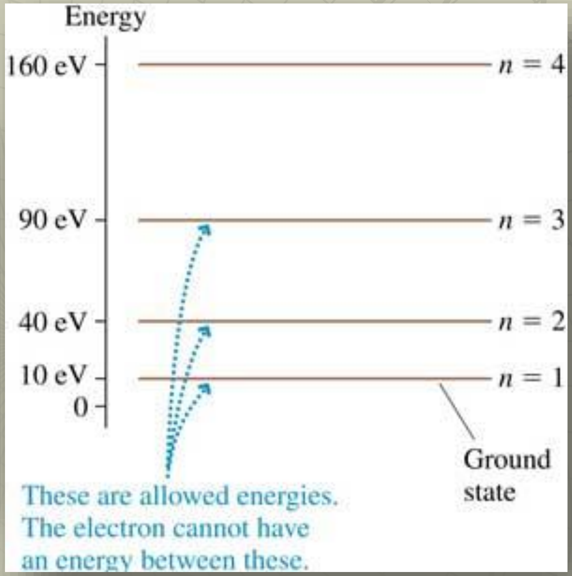


Electrons can only jump to certain energy levels. They can't go anywhere in between.

Postulates of the Bohr Model of the Atom

I. Electrons in an atom can only exist in certain well-defined (discrete) stationary states called energy levels or energy states.



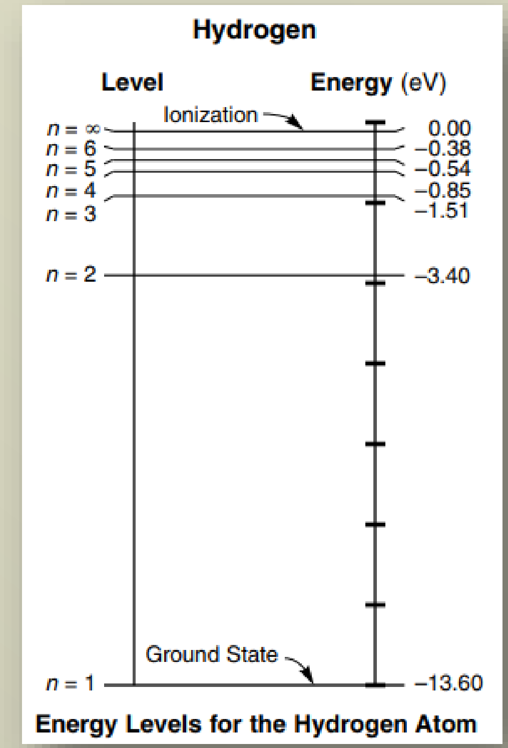


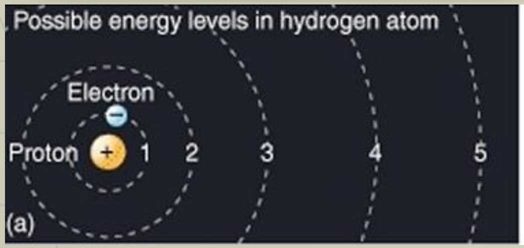
What does each energy level represent?

an allowed stable orbit for the electron

- **Ground state–** closest to nucleus – lowest energy
  - n = 1 E_1 = -13.6 eV for hydrogen

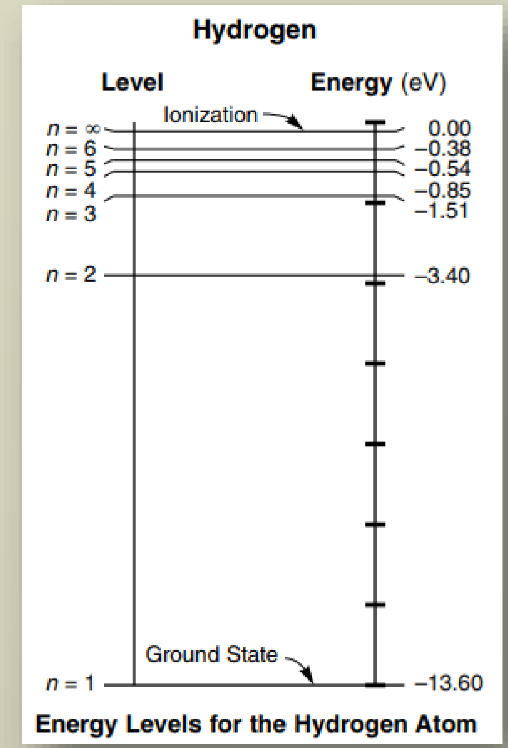
The ground state is like "home base" – where they are naturally/regularly/without being zapped



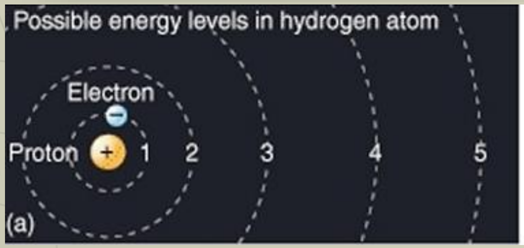


- **Excited state level –** farther from nucleus – more energy
  - n = 2 E_2 = -3.40 eV
  - n = 3 E_3 = -1.51 eV
  - Etc.

All of the middle levels are called excited states, they have different energy values

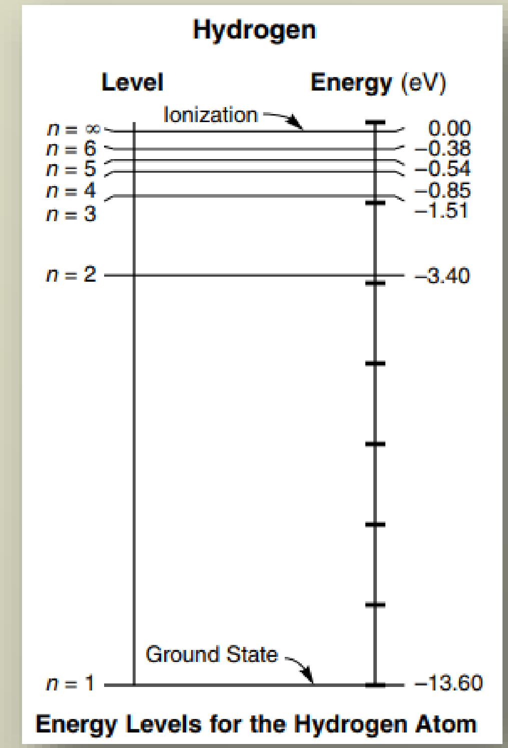


Energy Levels for the Hydrogen Atom

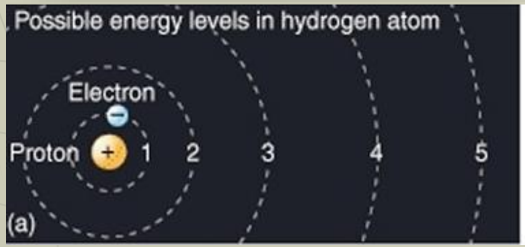


- **Ionization state –** electron removed from atom – most energy
  - n = ∞   E = 0 eV

This is at the top of the chart. Since it is set to zero, all other levels have negative values.

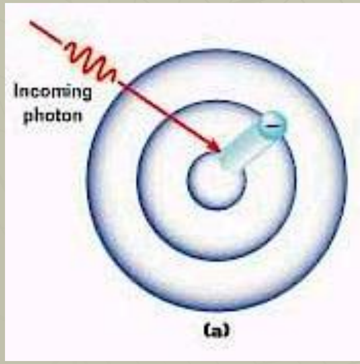


Energy Levels for the Hydrogen Atom



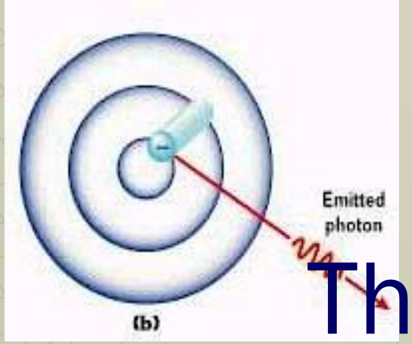
Postulates of the Bohr Model of the Atom

II. **Electrons may move from one stationary state to another by emitting or absorbing a quantum of radiation (photon) whose energy equals the difference in the two states.**



When a photon (energy) is absorbed. . .

The electron jumps to higher energy level

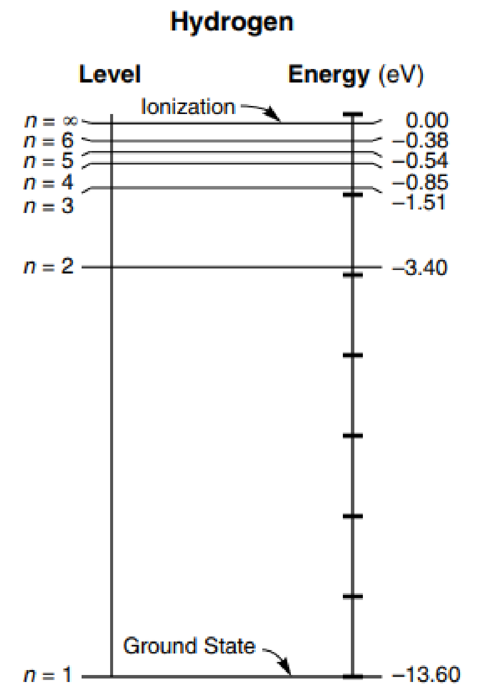


When a photon (energy) is emitted. . .

The electron relaxes to lower energy level

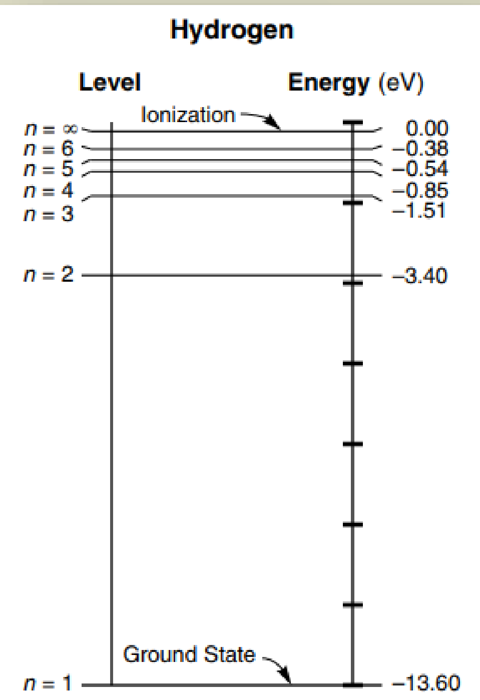
- An electron in the n = 4 state relaxes to the n = 2 state and emits a photon. How much energy does the photon have?

Find the difference between the n = 4 and the n = 2 levels



Energy Levels for the Hydrogen Atom

- An electron in the n = 4 state relaxes to the n = 2 state and emits a photon. How much energy does the photon have?

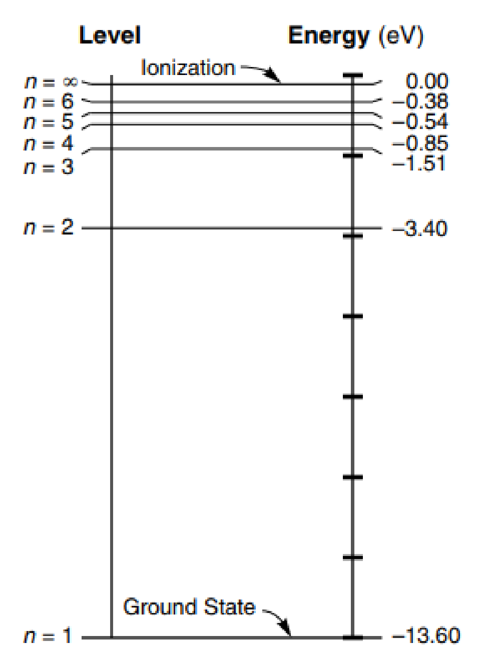


Energy Levels for the Hydrogen Atom

Find the difference between the n = 4 and the n = 2 levels.

We'll learn the official equation shortly.

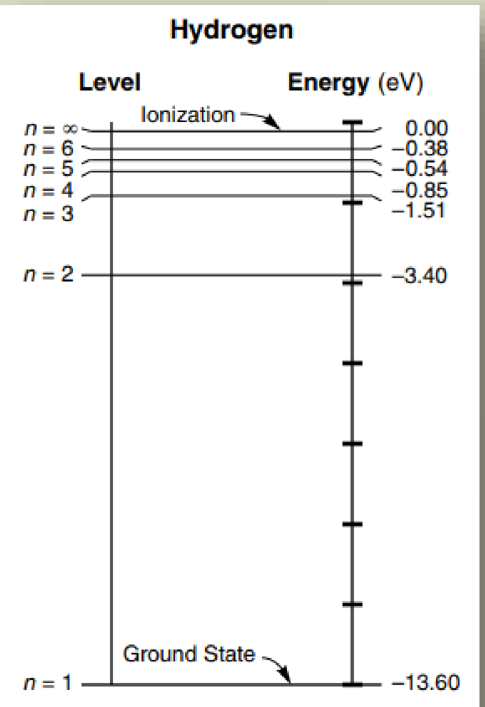
- An electron in the n = 4 state relaxes to the n = 2 state and emits a photon. How much energy does the photon have?



Energy Levels for the Hydrogen Atom

2.55 eV

- A photon whose energy is 1.13 eV is <u>emitted</u> from a hydrogen atom. Determine the energy level transition that this represents.



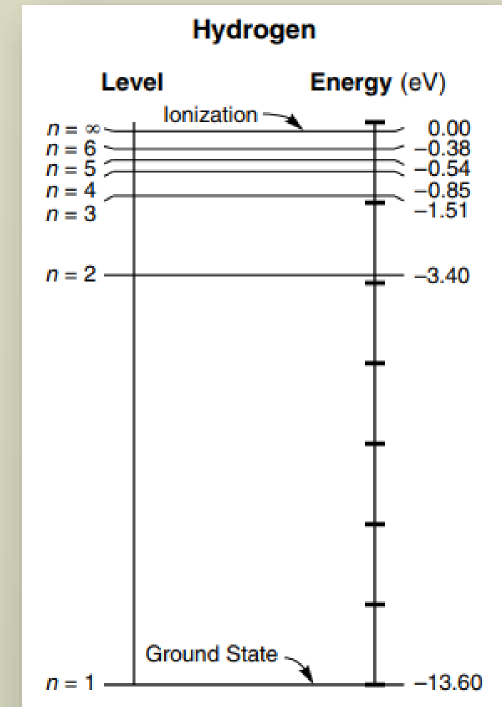
Energy Levels for the Hydrogen Atom

Find which two are separated by exactly 1.13 eV.

There is no equation.

The emitted gives a clue which way they go.

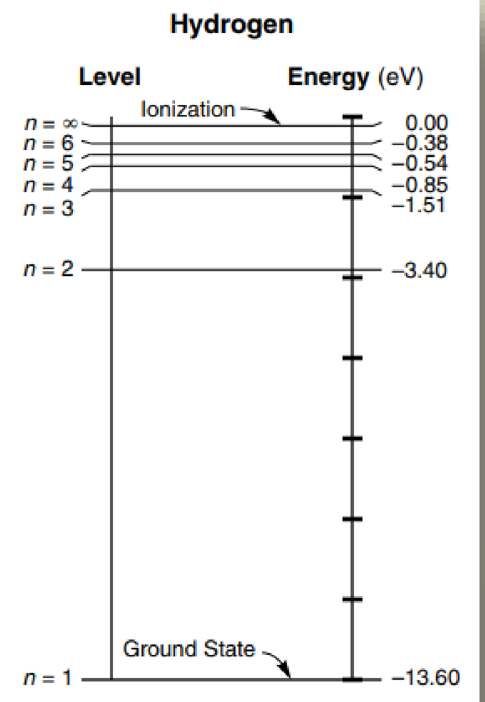
- A photon whose energy is 1.13 eV is <u>emitted</u> from a hydrogen atom. Determine the energy level transition that this represents.



Energy Levels for the Hydrogen Atom

n = 6 to n = 3

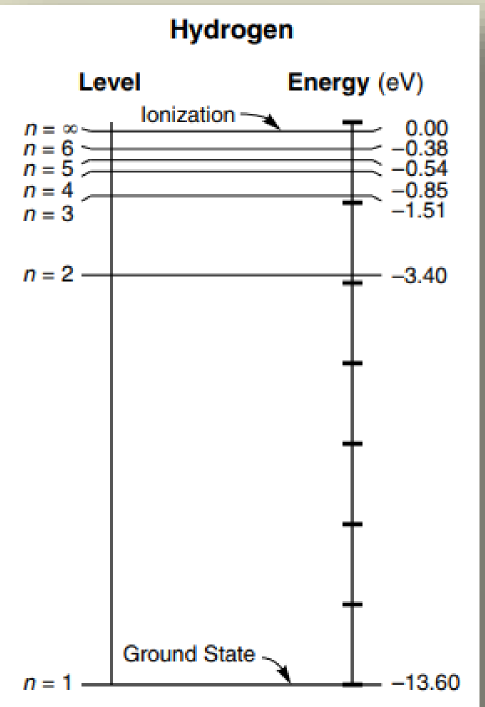
- How much energy is needed to ionize an atom in the ground state of hydrogen?



Energy Levels for the Hydrogen Atom

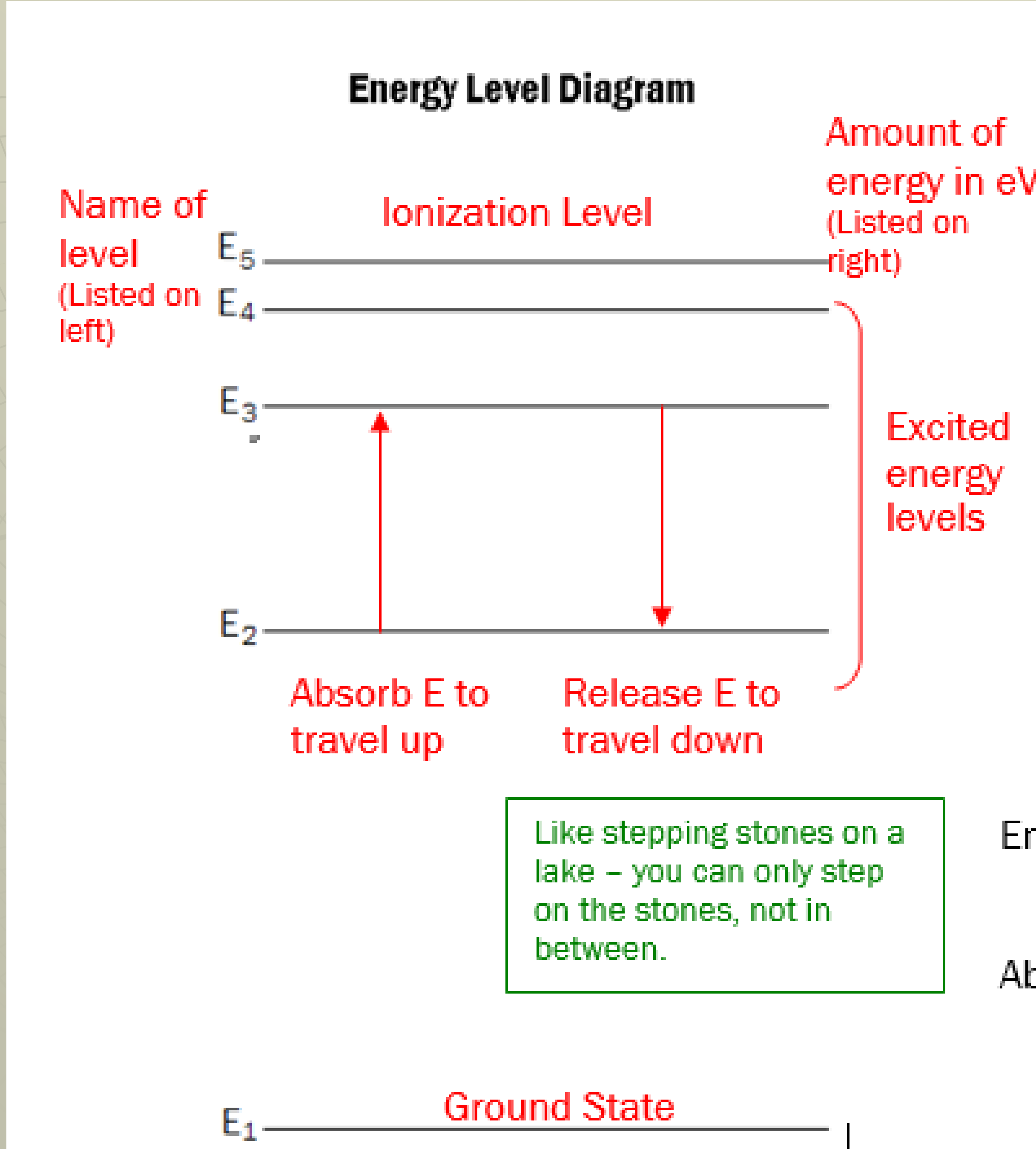
If the final level is zero (ionization) how much difference is there between the level and ionization?

- How much energy is needed to ionize an atom in the ground state of hydrogen?



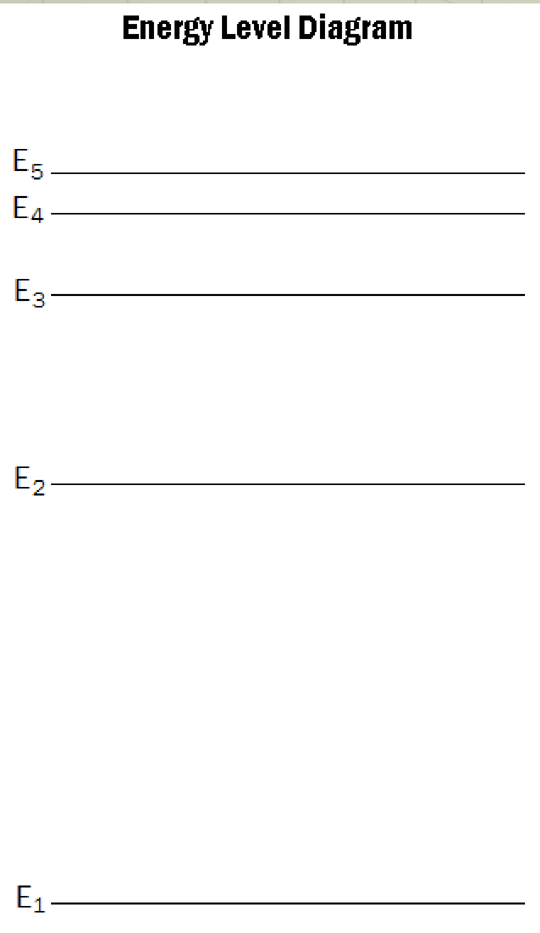
Energy Levels for the Hydrogen Atom

-13.60 eV



Energy Level Diagram
Amount of energy in eV (Listed on right)
Name of level (Listed on left)
Ionization Level
E_5
E_4
E_3
E_2
E_1
Excited energy levels
Absorb E to travel up
Release E to travel down
Like stepping stones on a lake – you can only step on the stones, not in between.
Ground State

Energy Levels

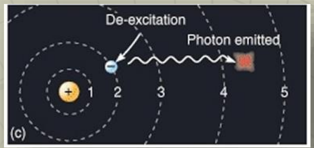


$$E_{photon} = E_i - E_f$$

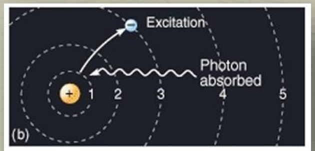
This equation is on your reference tables. INITIAL minus FINAL, which is a change from delta meaning final minus initial. If you mix them up, you get the wrong sign.

Energy Levels

- Emitted photons have positive energy values.

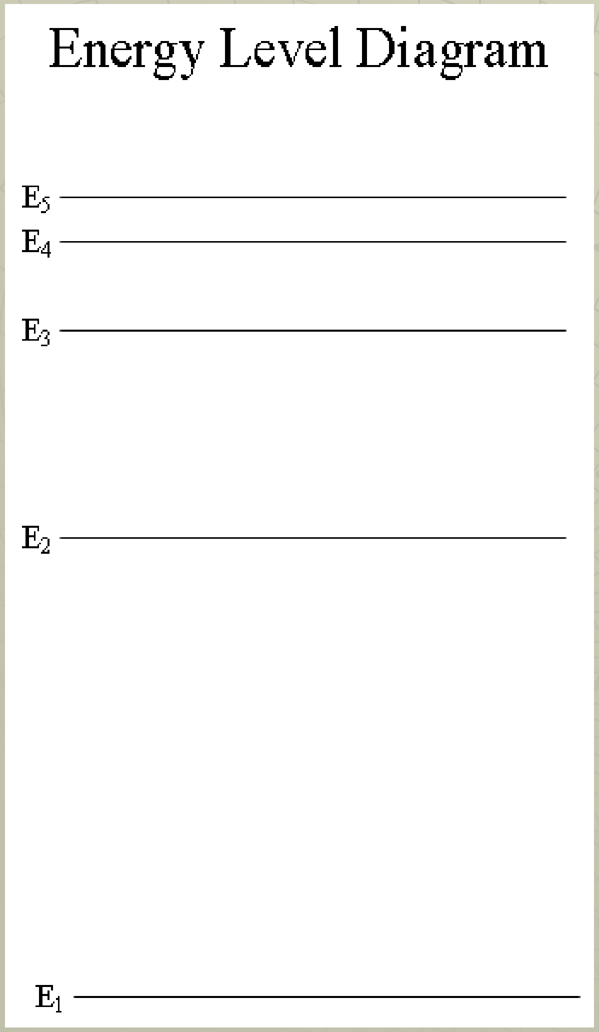


- Absorbed photons have negative energy values.



Positive people share and give things away, negative people are selfish and take them in.

Quantum Leap



Quantum Leap

Energy Level Diagram

a) How many possible different photons may be emitted as the electrons relaxes back down to the ground state? Sketch them on the diagram.

6 photons (8 possible paths, 2 duplicate photons)

b) Which transition produces a photon with the most energy?

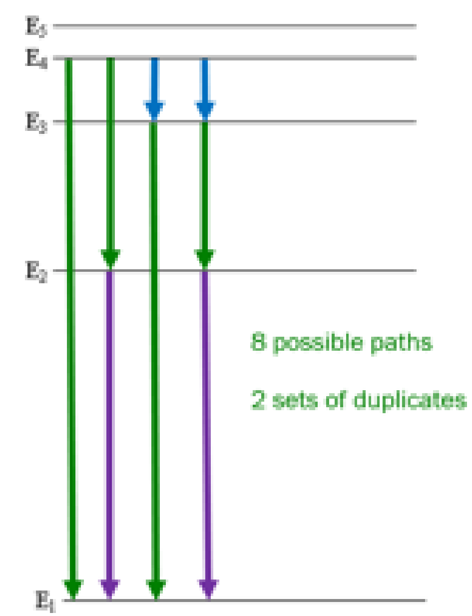
4 to 1

c) Which transition produces a photon with the highest frequency?

4 to 1

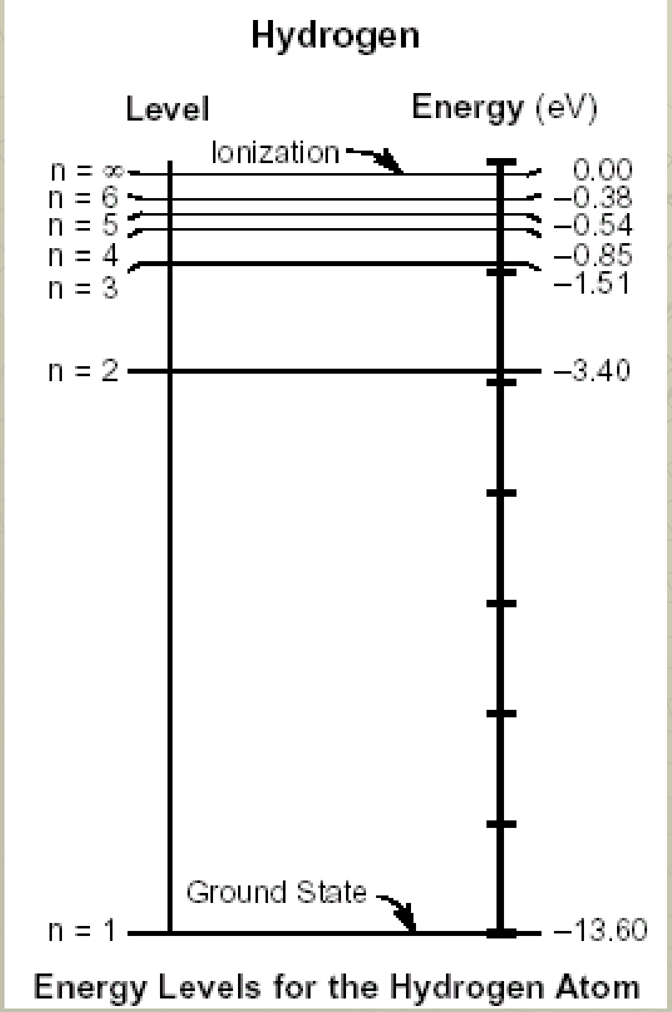
d) Which transition produces a photon with the longest wavelength?

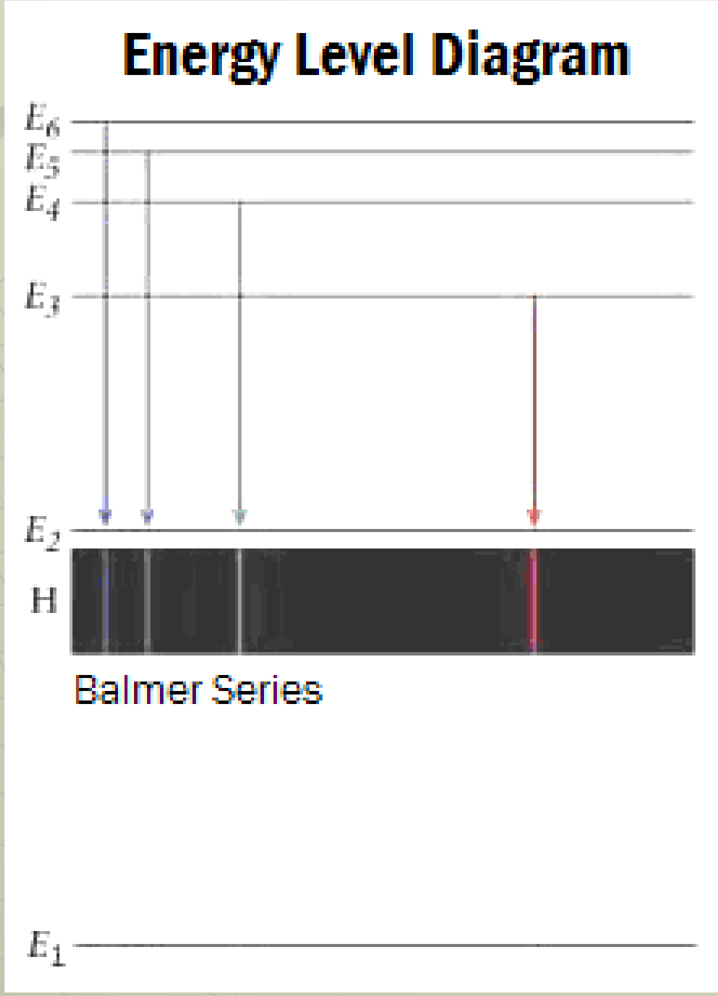
4 to 3



E_1

Quantum Leap





Quantum Leap

- What will happen if hydrogen gas in the ground state is illuminated with light whose photons have an energy of 10.20 eV?

This is asking which energy level will it jump to. You have E initial, they give you E photon (negative because absorbed), and you solve for E final.

Quantum Leap

- What will happen if hydrogen gas in the ground state is illuminated with light whose photons have an energy of 10.20 eV?

$$E_i - E_{photon} = E_f$$

$$(-13.60\ \text{eV}) - (-10.20\ \text{eV}) = -3.40\ \text{eV}$$

The electron will jump to the second energy level.

Quantum Leap

- What will happen if hydrogen gas in the ground state is illuminated with light whose photons have an energy of 11.40 eV?

Same question. Your turn.

Quantum Leap

- What will happen if hydrogen gas in the ground state is illuminated with light whose photons have an energy of 11.40 eV?

$$E_i - E_{photon} = E_f$$

$$(-13.60\ \text{eV}) - (-11.40\ \text{eV}) = -2.20\ \text{eV}$$

The electron will remain in its energy level because there is no 2.20 eV level.

Quantum Leap

- How much energy is needed for an electron to transition from the n = 2 to the n = 3 energy level? Is this energy absorbed or emitted? Will this result in a bright line or dark line in the atomic spectra?

Solve for E photon. Look at the direction for absorb or emit. If absorb it’s a dark lin. If emit it’s a bright line.

Quantum Leap

- How much energy is needed for an electron to transition from the n = 2 to the n = 3 energy level? Is this energy absorbed or emitted? Will this result in a bright line or dark line in the atomic spectra?

$$E_{photon} = E_i - E_f$$

$$= (-3.40\text{eV}) - (-1.51\text{eV}) = -1.89 \text{ eV}$$

Energy is absorbed.

Dark line on absorption spectra