An atom with the energy levels shown is initially in the ground (n=1) state. Which of the following is the most complete set of photon energies that can be absorbed by the atom?

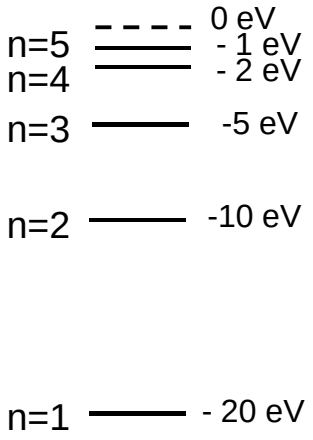
(A) 1 eV

(B) 1 eV, 4 eV, 9 eV, 19 eV

(C) 2 eV, 5 eV,10 eV, 20 eV

(D) 10 eV, 15 eV, 18 eV

(E) 10 eV, 15 eV, 18 eV, 25 eV



Directly after a collision with a free electron an atom with the energy levels shown is in the n=5 state. Which of the following is the most complete set of photon energies that can be emitted by the atom?

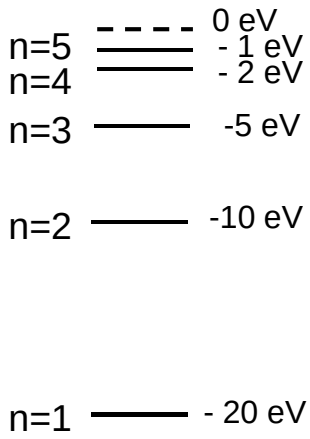
(A) 1 eV

(B) 1 eV, 4 eV, 9 eV, 19 eV

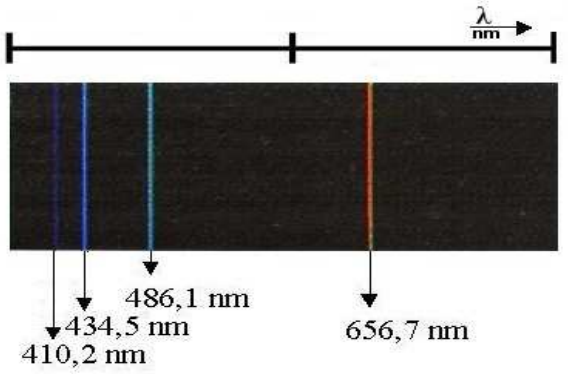
(C) 2 eV, 5 eV,10 eV, 20 eV

(D) 10 eV, 15 eV, 18 eV

(E) 10 eV, 15 eV, 18 eV, 25 eV



# Hydrogen atom: Balmer series




Balmer (1885) noticed that hydrogen lines follow a pattern:

$$\lambda = \frac{91.19\text{nm}}{\frac{1}{2^2} - \frac{1}{n^2}}$$

where $n$ = 3, 4, 5, …

As n gets larger, the wavelength of the light …

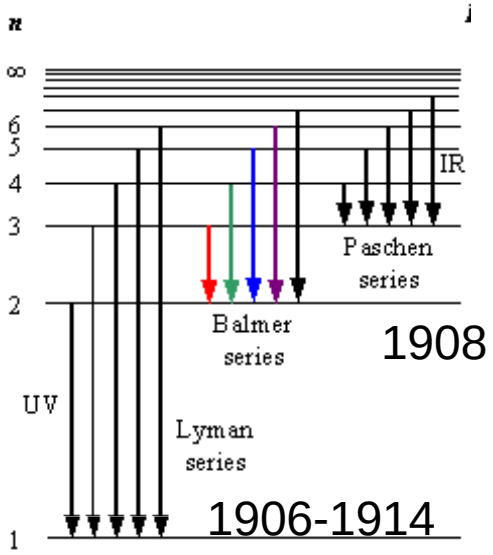
(A) gets larger and larger without limit

(B) gets larger and larger, but approaches a maximum

(C) gets smaller and smaller until it reaches zero

(D) get smaller and smaller, but approaches a minimum

# Hydrogen atom: Line series




Balmer's formula can be generalized for *all* hydrogen lines

$$\lambda = \frac{91.19\text{nm}}{\frac{1}{m^2} - \frac{1}{n^2}}$$

with m = 1, 2, 3, 4, … and n > m

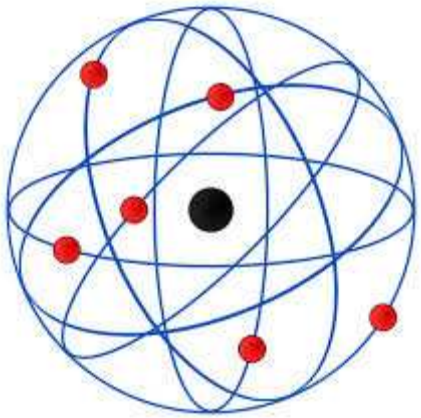
Lyman (m=1), Balmer (m=2), Paschen (m=3)

# Quantization of energy

Light consists of energy quanta (photon)
discrete “chunks of energy”

Electrons in atoms can have only
specific discrete energies
Each transition between energy levels
results in emission of photon of
certain frequency (color)

# Atom model (E. Rutherford)



not to scale

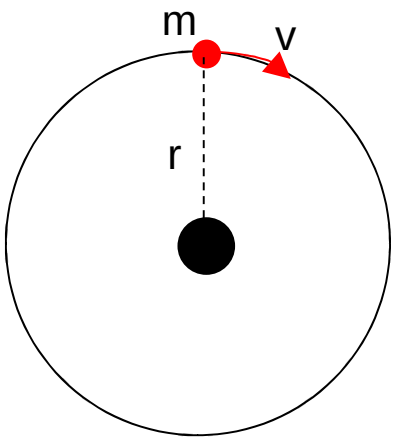
Planetary model:

A small massive positively charged nucleus surrounded by electrons in orbits

Two problems:

Why only discrete energies?
And …?

# Review: Planetary motion




What is the magnitude of the net force on an electron (planet) orbiting a proton (the sun)?

(A) m v

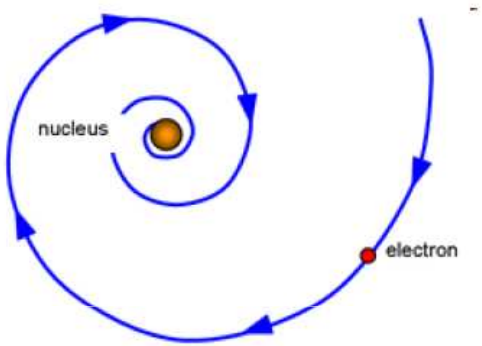
(B) m v r

(C) m $v^2$ / r

(D) 0 (no force)

(E) Don’t know/remember

# Atom model (E. Rutherford)




Force on electron

→ electron is accelerated

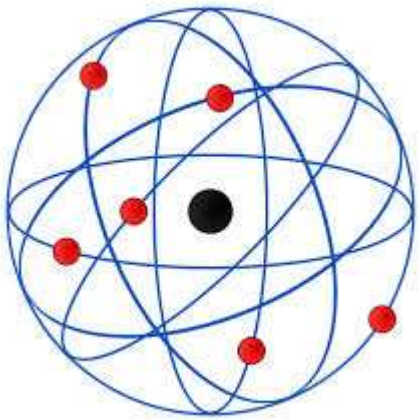
→ accelerated charges emit electromagnetic radiation

→ electromagnetic radiation carries energy

→ electron looses energy and falls into the nucleus

KABOOM !

# Atom model (E. Rutherford)



not to scale

Planetary model:

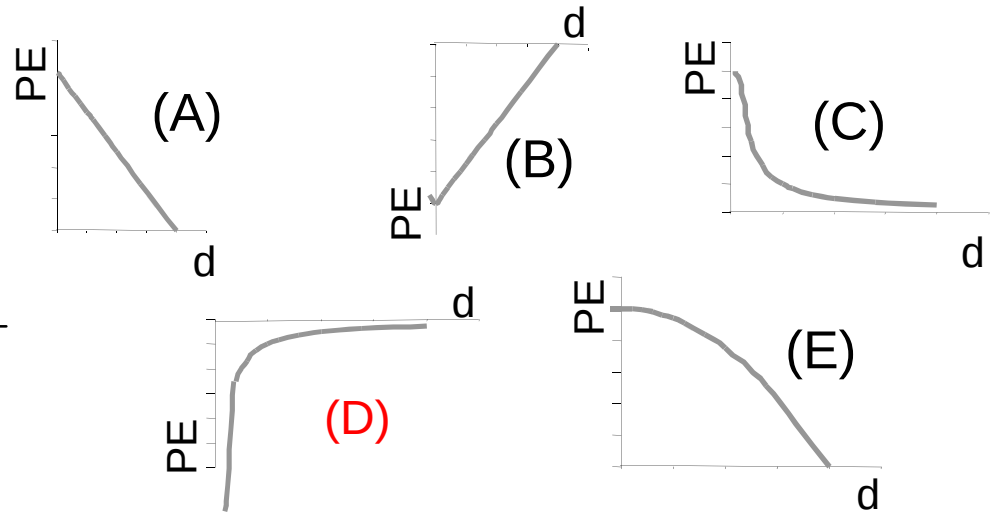
A small massive positively charged nucleus surrounded by electrons in orbits

Two problems:

Why only discrete energies?
Why are atoms stable?

# Potential energy in hydrogen atom

Predict shape of potential energy curve as function of distance from proton:.




$$PE = -\frac{ke^2}{d}$$