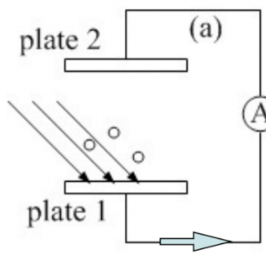
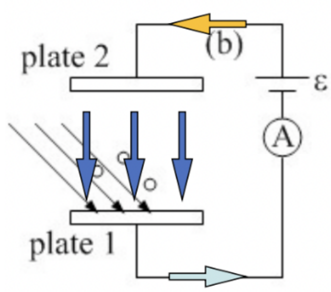
CAS PY 106

Lecture Note 35

1. Stopping potential

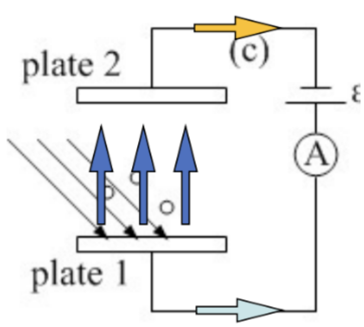
a. 

b. Direction of the current due to the ejected electrons?

c. 

d. Direction of the current due to the battery?

e. Direction of the electric field in between the plates? → accelerate more

f. 

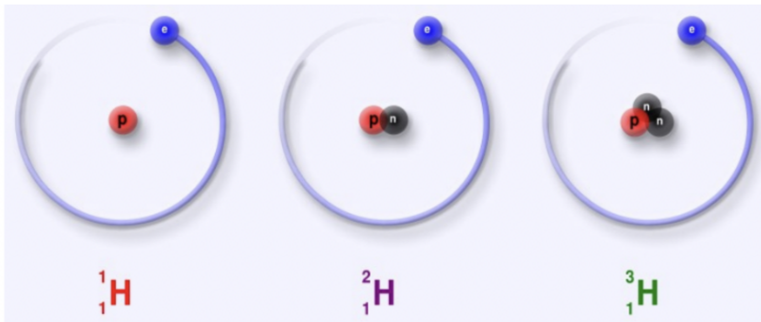
g. Direction of the current due to the battery?

h. Direction of the electric field in between the plates? → stop!

2. Isotopes

    a. Not all atoms of a given element are the same

    b. For example, hydrogen H has three different isotopes

    c. 

    d. **Isotope notation $^{A}_{Z}X$**

    e. X = symbol of element (H, He, Li, etc)

    f. Z = atomic number (number of protons)

    g. A = atomic mass number (number of protons + number of neutrons)

3. Mass of the particles making up atoms

    a.

Particle	Charge	Mass (kg)	Mass (u)	Mass (MeV/c²)
Neutron	0	1.674929×10^{-27} kg	1.008664	939.57
Proton	$+e$	1.672623×10^{-27} kg	1.007276	938.28
Electron	$-e$	9.109390×10^{-31} kg	0.00054858	0.511

    b. Mass of atoms, protons, neutrons, etc. are typically given not in kg but in "atomic mass units" (symbol u)

    c. 1 u = 1/12 (mass of neutral 12C6 atom) = 1.66 * 10^-27 kg

4. Total mass of one carbon-12 atom (12C6)

    a. Mass of one carbon-12 atom = 6 neutrons + 6 protons + 6 electrons bound together into one 12C6 atom: 12.0 u

    b. Total mass of 6 neutrons, 6 protons, and 6 electrons, unbound: 12.0989u

c. When combining protons + neutrons + electrons, some of the mass is converted into the binding energy: E = mc^2

d. Difference = mass defect = the binding energy

e. For this example, (12.0989u - 12u) * 931.5 MeV = 91.58 MeV

5. What holds the nucleus together?

    a. Electrostatic force pushes the protons away from each other (Coulomb's Law)

    b. F = k*q1*q2/r^2 = k*e^2/r^2 = 231 N where e = 1.602*10^-19 C and r = 10^-15 m

    c. Gravitational forces between protons are too small (can be neglected)

    d. F = G*mass of proton*mass of proton/r^2 = 1.9*10^-34N where G = 6.67 * 10^11 N * m^2/kg^2 and mass of proton = 1.67*10^-27 kg

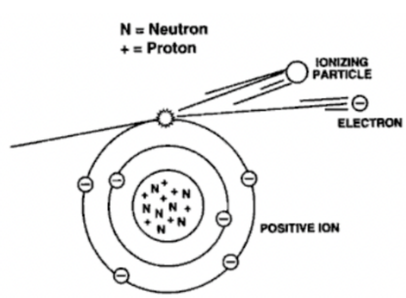
    e. There is a 3rd force (called nuclear force) that causes an attraction between protons/protons, neutrons/neutrons, as well as protons/neutrons which must balance out the electrostatic force of proton-proton repulsions

6. Ionizing radiation

    a. Visible light is also a form of radiation… but nothing much happens when these photons hit an atom

    b. However: alpha radiation, beta radiation, and gamma radiation can ionize an atom

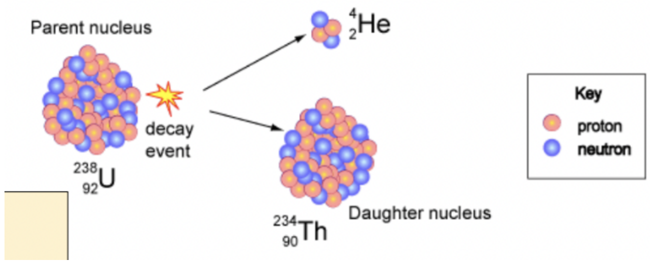
    c. These types are therefore called ionizing radiation

    d. 

7. Unstable nuclei

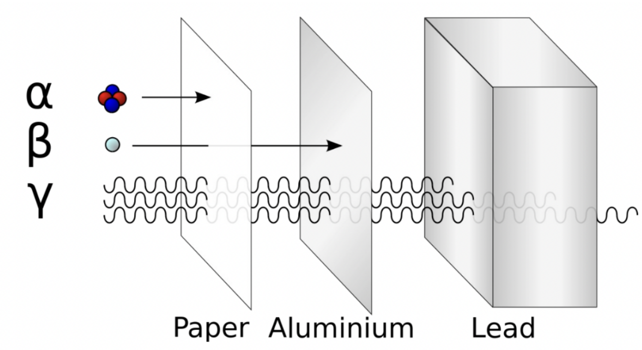
    a. Sometimes there are too many or too few neutrons, and the nucleus can fall apart

    b. This is called radioactive decay

    c. 

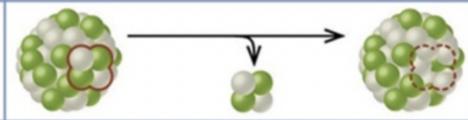
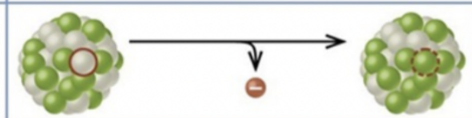
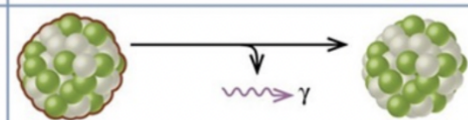
    d. There are 3 main types:
    - emission of $^{4}_{2}\mathrm{He}$ (α-radiation)
    - emission of electron (β-radiation)
    - emission of photon (γ-radiation)

8. Strength of ionizing radiation

    a. 

9. Summary of radioactive decay

a.

Type	Nuclear equation	Representation	Change in mass/atomic numbers
alpha decay	$\boxed{{}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y^{-2} + {}^{4}_{2}\mathrm{He}^{+2}}$		A: decrease by 4 Z: decrease by 2
beta-minus decay	$\mathrm{n} \rightarrow \mathrm{p}^{+} + \mathrm{e}^{-} + \bar{\upsilon}_e$ $\boxed{{}^{A}_{Z}X \rightarrow {}_{Z+1}^{\;\;A}Y^{+} + \mathrm{e}^{-} + \bar{\upsilon}_e}$		A: unchanged Z: increase by 1
beta-plus decay	$\mathrm{p}^{+} \rightarrow \mathrm{n} + \mathrm{e}^{+} + \upsilon_e$ $\boxed{{}^{A}_{Z}X \rightarrow {}_{Z-1}^{\;\;A}Y^{-} + \mathrm{e}^{+} + \upsilon_e}$		A: unchanged Z: decrease by 1
gamma decay	$\boxed{{}^{A}_{Z}X^{*} \rightarrow {}^{A}_{Z}X + \gamma}$	 Excited nuclear state	A: unchanged Z: unchanged

10. Example

a. Consider the B+ decay: 23Mg12 → 23Na11 + e + v_e

- Step 1: find the difference in the mass before and after the decay, called delta m (this mass is the energy released via E = mc^2)
- Step 2: convert the delta mass to energy (E = mc^2) by using the fact that 1u = 931.5 MeV/c^2