Idea Calculations 09/8/2023 - James Amidei

Excercise 1:

For gamma decay, what are the changes in mass number, atomic number, and the number of neutrons?

Answer:

No change in the atomic number, number of neutrons, and by definition no change in the atomic mass number.

Excercise 2:

For alpha decay what are the changes in mass number, atomic number, and the number of neutrons?

Answer:

The mass number will reduced by four and the number of protons (the atomic number) and neutrons will decrease by two each.

Excercise 3:

For each type of beta decay what are the changes in mass number, atomic number, and the number of neutrons?

Answer:

In each type of beta decay, there is no change in the atomic mass number, the atomic number goes down by one, and the number of neutrons increases by one.

Excercise 4:

How much time does it take for a collection of neutrons to decay where only 1% remain?

Answer:

Formula for half life:

$$N(t) = N_0(0.5)^{t/t_{1/2}}$$

Half life of free neutron: 14.64 minutes

$$log_{1/2}\frac{N_f}{N_0} = \frac{t}{t_{1/2}}$$

$$t = t_{1/2}log_{1/2}\frac{N_f}{N_0}$$

In [12]:

```
import numpy as np

N_0 = 100 # initial number of neutrons
t_half = 14.64 # minutes
N_f = 1 # number of neutrons after time t

log_bh = np.log(N_f/N_0)/np.log(0.5) # base 0.5 log of final number over initial

print('The the amount of time it takes for a collection of neutrons to decay to 1% of their original quantity is', t_half*log
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The the amount of time it takes for a collection of neutrons to decay to 1% of their original quantity is 97.26605461830196
minutes.
```

Excercise 5:

Calculate the range in of energies for visible light photons in eV. Compare these to energies of IR, radio, UV, X-ray, and Gamma ray energies and the rest energies of the electron, neutron and proton.

Answer:

$$\text{Rest Energy: } E = mc^2$$

$$\text{Energy: } E = \frac{hc}{\lambda}$$

$$\text{Wavelength: } \lambda = \frac{hc}{E}$$

Wavelengths:

- IR: $2.5\ \mu$m to $25\ \mu$m $\rightarrow$ 2500 nm to 25000 nm
- Radio: >1mm $\rightarrow$ > 1×10^6 nm
- UV: 1 nm to 400 nm
- X-ray: 1 pm to 1 nm $\rightarrow$ 0.001 nm to 1 nm
- Gamma Ray: < 10^{-12} m $\rightarrow$ 10^{-3} nm

In [7]:

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d of light)


wer wavelength for Radio)

ower wavelength for IR)
upper wavelength for IR)

er wavelength for visible light)
er wavelength for visibile light)

r wavelength for UV)
per wavlength for UV)

ower wavelength for x-ray)
 wavelength for x-ray)

per wavelength for gamma)

pectrum for radio wavelengths is greater than', hc/r_i ,'eV or', hc/r_i * 10**-6,'MeV.')

pectrum for infrared wavelengths is between', hc/ir_f, 'and', hc/ir_i,'eV or',hc/ir_f*10**-6, 'and',hc/ir_i*10**-6,'MeV.')

pectrum for visible wavelengths is between', hc/v_f, 'and', hc/v_i,'eV or',hc/v_f*10**-6, 'and', hc/v_i*10**-6,'MeV.')

pectrum for ultraviolet wavelengths is between', hc/uv_f, 'and', hc/uv_i,'eV or',hc/uv_f*10**-6, 'and',hc/uv_i*10**-6,'MeV.')

pectrum for x-ray wavelengths is between', hc/x_f, 'and', hc/x_i,'eV or',hc/x_f*10**-6, 'and',hc/x_i*10**-6,'MeV.')

pectrum for gamma ray wavelengths is up to ', hc/g_f ,'eV or',hc/g_f*10**-6,'MeV.')
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The energy spectrum for radio wavelengths is greater than 372000.0 eV or 0.372 MeV.

The energy spectrum for infrared wavelengths is between 14880000.0 and 148800000.0 eV or 14.879999999999999 and 148.79999999
999998 MeV.

The energy spectrum for visible wavelengths is between 496000000.0 and 930000000.0 eV or 496.0 and 930.0 MeV.

The energy spectrum for ultraviolet wavelengths is between 930000000.0 and 372000000000.0 eV or 930.0 and 372000.0 MeV.

The energy spectrum for x-ray wavelengths is between 372000000000.0 and 372000000000000.0 eV or 372000.0 and 372000000.0 Me
V.

The energy spectrum for gamma ray wavelengths is up to  372000000000000.0 eV or 372000000.0 MeV.
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In [43]:

```
m_p = 938.27 # MeV/c^2 (mass of proton)
m_n = 939.57 # MeV/c^2 (mass of neutron)
m_e = 0.511 # MeV/c^2 (mass of electron)

print('The rest energy of a proton is', m_p,'MeV, or',m_p*10**6,'eV.')
print()
print('The rest energy of a neutron is', m_n,'Mev, or', m_n*10**6,'eV.')
print()
print('The rest energy of an electron is', m_e,'MeV, or', m_e*10**6,'eV.')
```

```
The rest energy of a proton is 938.27 MeV, or 938270000.0 eV.

The rest energy of a neutron is 939.57 Mev, or 939570000.0 eV.

The rest energy of an electron is 0.511 MeV, or 511000.0 eV.
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In [ ]:

In [ ]: