Determine the number of electrons, protons, and neutrons in iron $^{56}_{26}Fe$.

protons=26 , neutrons=30 , electrons=26

Activity (as in *radioactivity*) of a radioisotope source = rate of decay over time =

source disintegration rate = $\frac{dN}{dt}_{decay} = -\lambda N$

$N =$ # of radioactive nuclei

$\lambda = decay\ constant$

For radium, $\lambda = 1\ curie = 1\ Ci = 3.7 * 10^{10}$ disintegrations / second

1 disintegration / second = $1\ becquerel = 1\ Bq = 2.703 * 10^{-11}\ Ci$

$$N = N_0 e^{-\lambda t}$$

Not necessarily the same measurement as emission rate of produced radiation…

-Only SOME decay events lead to one specific emitted radiation

-Isotopes have known decay schemes which could help in gathering that data

-some decay progeny may also give off more radiation almost immediately

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Specific activity = $\frac{activity}{mass} = \frac{\lambda N}{N(M/A_v)} = \lambda A_v/M$

$M = molecular\ weight,\ A_v = 6.02 * 10^{23}\ nuclei/mole$

-This could be used if you had a pure sample to weigh

-Isotopes are most easily stored with stable nuclei

Half-life $= t_{1/2} = ln(2)/\lambda = \tau ln(2)$

Mean lifetime $= \tau = t_{1/2}/ln(2) = 1.44 * t_{1/2}$

$\tau = 1/\lambda$

Energy of radiation:
Units of joules (J) or electron volts (eV)

1 eV = kinetic energy an e^{-} gains through a 1 V potential difference

$1\ eV = 1.609 * 10^{-19} J$

$1\ fJ = 10^{-15} J = 6.241 * 10^{3}\ eV$

For electromagnetic radiation:

$E = hv,\ h = planck\ constant = 6.626 * 10^{-34} J * s = 4.135 * 10^{-15} eV * s,\ v = frequency$

$\lambda\ (m) = 1.24 * 10^{-6} / E\ (eV),$ easy conversion to wavelength if given photon energy in eV

Charged radiation:
-fast electrons
    -beta particles emitted in nuclear decay
    -energized electrons from any other processes
-heavy charged particles (anything > 1 a.m.u. and some charge)
    -alpha particles
    -protons
    -fission & nuclear decay products

Uncharged radiation:
-electromagnetic radiation
    -x rays coming from electron shell rearrangement
    -gamma rays coming from nuclear transitions
-neutrons
    -slow neutrons
    -fast neutrons

Which is ‘hard’ and which is ‘soft’?

Fast electron sources:
-beta decay

$${}^{A}_{Z}\mathrm{X} \rightarrow {}_{Z+1}^{\ \ A}\mathrm{Y} + \beta^{-} + \bar{\nu}$$

-internal conversion
Normally, an energetic nucleus de-excites by releasing a gamma ray
Also possible to convert this energy to an orbital electron

$$E_{e^{-}} = E_{ex} - E_{b}$$

-Auger electrons

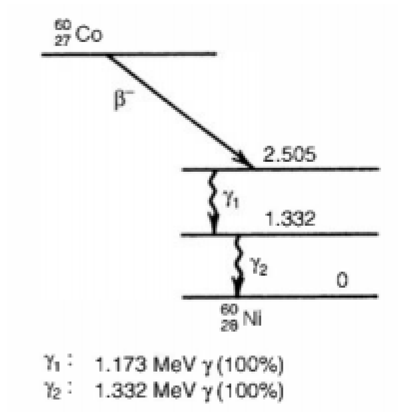
Atomic analogue to the nuclear internal conversion, atomic energy transfers to an outer e^{-}

Heavy charged particle sources:
-alpha decay

$$^{A}_{Z}\mathrm{X} \rightarrow {}^{A-4}_{Z-2}\mathrm{Y} + {}^{4}_{2}\alpha$$

-spontaneous fission
Only source of radiation more massive than alpha decay

Electromagnetic radiation sources:
-gamma ray following beta decay



-annihilation radiation
β^+ decay exists, positron-electron annihilate quickly and produce 2 .511 MeV photons

-gamma ray following nuclear reaction

-bremmsstrahlung

-characteristic x-rays
Orbital electron transitions (filling a vacancy) produce x-rays, energy must match the transition

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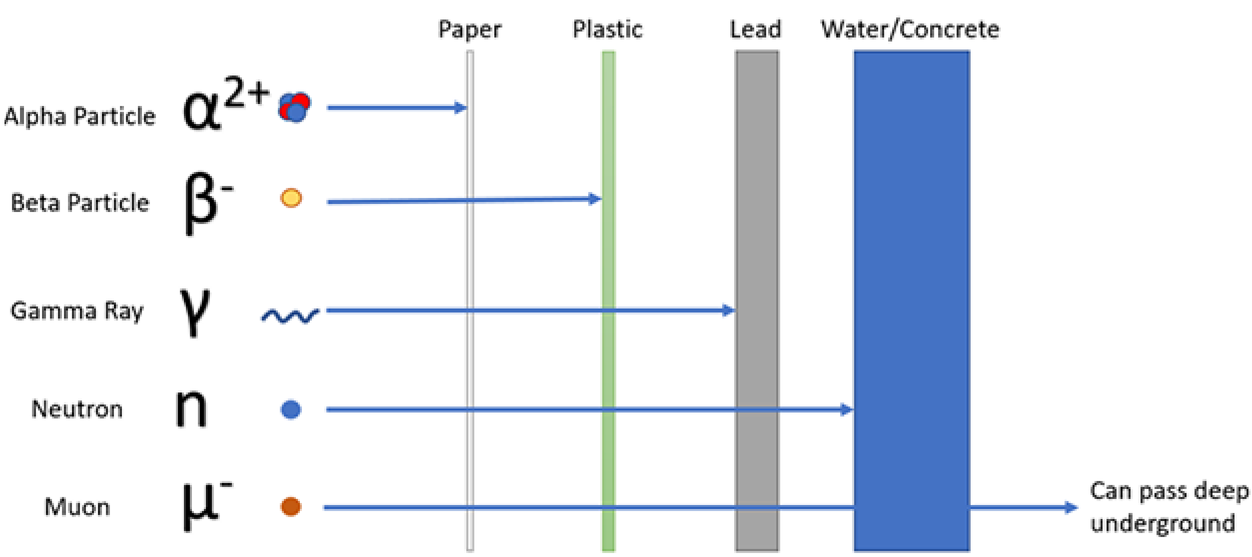
neutron sources:
Fission and using the right target with alpha particles



What is the specific activity of pure tritium ($^{3}H,\ M = 3\ g/mol$) which has a half life of 12.26 years?

Radon gas has a half life of 3.83 days. If 3 g of radon is present at t=0, what mass of radon remains after 1.5 days have passed?

Binding energy E_b:

Total energy of a nucleus is less than combined energies of separated nucleons

$E = mc^2$, replace ‘energy’ with ‘mass’

The difference in the energies = binding energy of the nucleus, energy needed to break it

The nucleus of a deuterium atom (a deuteron) consists of a proton and a neutron. Calculate the deuteron’s binding energy in MeV given the atomic mass of deuterium = 2.014 u.

($m_{proton} = 1.007\,u,\ m_{neutron} = 1.008\,u,\ 1\,u = 931.5\,MeV = unified\ mass\ unit$)
