1/ Complete the following decay reactions (you'll need a periodic table for this);

$^{226}Rn \longrightarrow {}^{222}Po + ?$

$^{239}Pu \longrightarrow ? + \alpha$

$^{14}C \longrightarrow ? + \beta$

2/ The half-life of ^{106}Rh is 30s. Calculate the decay constant for ^{106}Rh. Calculate the activity of a body of 1.2×10^{12} atoms of ^{106}Rh. Express your answer in Bequerels and in Curies. How many atoms of ^{106}Rh are left after 100 s ?

[0.0231 disint.s^{-1}, 2.77 x 10^{10} Bq, 0.75 Ci, 1.19 x 10^{11}]

3/ ^{232}Th decays with a half-life of 1.41×10^{10} years (4.45×10^{17} s), emitting alpha particles of energy 4 MeV. Calculate the activity of a source of 5×10^{19} atoms of ^{232}Th. Calculate the amount of energy per second being emitted by this source. Calculate the absorbed dose in Grays if all this emitted energy is deposited in 30 kg of tissue. Calculate this dose in Sieverts / year.

[77.8 disint.s^{-1}, 5 x 10^{-11} Js^{-1}, 1.66 x10^{-12} Gy, 1.05 mSv / year]

4/ The mass of a nucleus of ^{208}Pb is 207.9316746amu. If the mass of a free proton is 1.00728 amu and a free neutron is 1.008665 amu

- calculate, using E = mc2, the binding energy for the 208Pb nucleus in Joules (note, one amu = 1.6605x10-27kg, c=3x108m/s).
- express this energy in MeV
- calculate the binding energy per nucleon.

[2.63 x 10^{-10} J, 1641MeV, 7.89MeV]

5/ In a smoke detector, ^{241}Am decays to ^{237}Np by emitting an alpha particle. The respective masses are ^{241}Am = 241.056827amu, ^{237}Np = 237.048172amu, and ^{4}He = 4.002603amu

- Find the total energy released in the decay
- Assume all this energy goes to the alphas, the speed of the alpha particle?
- What is this in terms of c, the speed of light?

[9.1x10^{-13}J, 16.5x10^{6}m/s, 5.5%]

6/ An old wooden sample of 500g of carbon produces 41 Bq.

- How many atoms of carbon in the sample?
- Given a half-life of 5730 years, convert this to seconds and calculate the decay constant of ^{14}C.
- Given the radiation of our sample, how many atoms of ^{14}C does it contain?
- What is ratio of ^{14}C to ^{12}C in our sample?
- Atmospheric carbon has 1.5 ^{14}C per 10^{12} atoms of C. By what fraction is this ratio lower in our sample?
- Use this to calculate the age of our sample.

[2.51×10^{25}, 3.83×10^{-12} s^{-1}, 1.07×10^{13}, 4.27×10^{-13}, 0.284, 10,400 years]

7/ A patient is being treated for a thyroid disorder by radioactive iodine 131. They receive a dose of 2.4×10^{-3}Ci.

- Calculate the the equivalent dose in Bequerel is.
- Each 131I disintegration releases 0.61MeV). Convert this to Joules.
- If the patient weights 73kg calculate the whole body radiation dose in Grays.
- Given that 131I is a beta particle emitter and that the RBE for beta particles is 1, calculate the radiation dose in Sievert per second.
- If the treatment continues for four days calculate the total dose received.

[8.88x107Bq, 9.77x10-14J, 1.19x10-7Gy, 1.19x10-7Sv/sec, 41mSv]

8/ The legal limit for Radon in a private house is 200Bq/m^3. The energy of the α particles emitted from ^{222}Rn to have an energy of 5.48MeV and a half life of 3.825 days.

- Calculate the decay constant for ^{222}Rn.
- Calculate the energy of one of these a particles in Joules
- What is the corresponding limit for number of atoms of ^{222}Rn per m^3?
- If a person has a tidal volume of 400mL, how many disintegrations per second of ^{222}Rn do they experience in their lungs?
- If this person has a mass of 55kg, what is the dose in Gray they receive every second?
- What is this dose in Sieverts per second?
- How many Sieverts do they get in one day?

[2.097×10^{-6} s^{-1}, 8.77×10^{-13}J, 9.54×10^{7} m^{-3}, $0.08s^{-1}$, 1.27×10^{-15}Gy/s, 2.55×10^{-14}Sv/s, 0.0022μSv]