



國立清華大學
ESS 201000 核工原理
(Principle of Nuclear Engineering)

Homework #2

- The radioisotope generator SNAP-9 was fueled with 475 g of ^{238}PuC (plutonium-238 carbide), which has a density of 12.5 g/cm^3 . The ^{238}Pu has a half-life of 89 years and emits 5.6 MeV per disintegration, all of which may be assumed to be absorbed in the generator. The thermal to electrical efficiency of the system is 5.4%. Calculate
 - the fuel efficiency in curies per watt (thermal);
 - the specific power in watts (thermal) per gram of fuel;
 - the power density in watts (thermal) per cm^3 ;
 - the total electrical power of the generator.
- Show that if the half-life of B is much shorter than the half-life of A, then the activities of A and B in Problem 2.39 eventually approach the same value. In this case, A and B are said to be in *secular equilibrium*.
- Radon-222, a highly radioactive gas with a half-life of 3.8 days that originates in the decay of ^{234}U (see the chart of nuclides), may be present in uranium mines in dangerous concentrations if the mines are not properly ventilated. Calculate the activity of ^{222}Rn in Bq per metric ton of natural uranium.
- Using atomic mass data, compute the average binding energy per nucleon of the following nuclei:
 - ^2H
 - ^4He
 - ^{12}C
 - ^{51}V
 - ^{138}Ba
 - ^{235}U
- It has been proposed to use uranium carbide (UC) for the initial fuel in certain types of breeder reactors, with the uranium enriched to 25 w/o. The density of UC is 13.6 g/cm^3 .
 - What is the atomic weight of the uranium?
 - What is the atom density of the ^{235}U ?

6. Compute the atom densities of ^{235}U and ^{238}U in UO_2 of physical density 10.8 g/cm^3 if the uranium is enriched to 3.5 w/o in ^{235}U .
7. Long-lived ^{232}Th ($T_{1/2} = 14.05 \times 10^9$ years) decays through a series of much shorter lived daughters to the stable isotope ^{208}Pb . The number of ^{208}Pb atoms in a geological rock sample, assuming no initial inventory of ^{208}Pb in the sample, equals the number of initial ^{232}Th atoms that have decayed since the rock was formed. The number of decayed ^{232}Th atom in the form of intermediate daughters, which are in secular equilibrium and have not reached ^{208}Pb , is negligible small. What is the age of a rock sample is found to have 1.37 gram of ^{232}Th and 0.31 g of ^{208}Pb ?
8. Charcoal found in a deep layer of sediment in a cave is found to have an atomic $^{14}\text{C}/^{12}\text{C}$ ratio only 30% that a charcoal sample from a higher level with a known age of 1850 year. What is the age of deep layer?