NE 39A Midterm Solutions

March 17, 2004.

Good Luck!!!!

$N_A = 6.02x10^{23}$ [atoms/mol]
1 eV = $1.602x10^{-19}$ J
1 u = $1.66054\ x10^{-27}$ kg

1 b = 10^{-24} cm^2
1 W = 1 J/s

Essay Question:
(25 minutes)

50 points

1) Scientific and technological advances can often result in dividing society into two groups: one for and one against the technology (e.g. Nukes and Anti-Nukes). Explain what you think causes this bifurcation. Do you feel that our society is equipped to handle these controversial technological advances reasonably, or that our scientific and technological advances have outstripped society's ability to deal with them? Do social values need adjusting in order to properly accommodate technology? Or does technology need to accommodate to society's values? Use specific examples from lecture, discussion and/or elsewhere to support your arguments.

Short Answers:
(25 minutes total)

2) Determine the activity in Bq of ^{204}Pb in 1 kg of natural lead. The isotopic abundance of ^{204}Pb is 1.4%, the molar mass of Pb is 207.2 g/mol, and the half-life or ^{204}Pb is $1.4x10^{17}$ years.

$A = N\lambda \quad \lambda = \frac{\ln 2}{t_{1/2}} \quad t_{1/2} = 4.418\times10^{24}s$

$\lambda = 1.569\times10^{-25}s^{-1}$

8 pts

$N = \frac{10^3 g\ Pb}{207.2 g/mol} N_A \cdot .014 = 4.069\times10^{22}$

$A = 6.384\times10^{-3}\ Bq$

3a) Determine the values for A and Z in the following reaction:

$^{1}_{0}n + ^{208}_{92}Pb \rightarrow ^{4}_{2}\alpha + ^{A}_{Z}Bi$

$A = 205$
$Z = 90$

4 pts

b) Calculate the Q value for the reaction given the following atomic masses:

n	1.0086649 u
^{4}He	4.0026032 u
^{208}Pb	207.9766359 u
^{A}Bi	204.9773747 u

8 pts

$Q = c^2(207.9766359 + 1.0086649 - 4.0026032 - 204.9773747)$

$= (5.3229\times10^{-3}u)c^2$

$(1u)c^2 = 931.49\ MeV$

so $Q = 4.958\ MeV = 7.94\times10^{-13}J$

4a) Assuming that 200MeV of thermal energy is released per fission of ^{239}Pu, determine the fission rate of ^{239}Pu in a 100 MW_{th} Plutonium-fueled nuclear reactor.

$$100 \frac{MJ}{s} \cdot \frac{1\ MeV}{1.602\times10^{-19}\ MJ} \cdot \frac{1\ \text{fission}}{200\ MeV} = 3.12\times10^{18}\ s^{-1}$$

$$= 1.872\times10^{20}\ min^{-1}$$

4 pts

$$= 1.123\times10^{22}\ hr^{-1}$$

$$= 2.696\times10^{23}\ day^{-1}$$

b) Given a thermal neutron flux of 10^{13} n/cm^2 s and a thermal neutron-induced fission cross section of 698.3 b, determine the mass of ^{239}Pu that would be present in the reactor to generate this power.

$$\text{Rxn Rate} = n\sigma\phi \qquad 698.3b = 6.983\times10^{-22}\ cm^2$$

$$n = \frac{3.12\times10^{18}\ s^{-1}}{6.983\times10^{-22}\ cm^2 \cdot 10^{13}\ cm^{-2}\ s^{-1}} = 4.468\times10^{26}\ \text{atoms}\ ^{239}Pu$$

10 pts

$$\frac{4.468\times10^{26}}{N_A}\ 239\ g/mol = 1.773\times10^{5}\ g\ Pu = 177.3\ kg$$

5) Describe how Generation IV nuclear plants will produce Hydrogen and why current Generation III plants are unable to perform such production.

(5) Gen IV plants will operate at much higher temperatures, this extra heat is brought to a thermochemical of hydrolysis H-production facility.

8 pts

(3) Gen III plants don't get hot enough to drive these reactions.

8 pts

6) Circle which of the following radiological properties are desirable for SPECT:

- Long half-life
- Short half-life
- No charged particle emission
- Heavy Charged Particle Emission
- Gamma ray energies high enough to easily penetrate 20 cm of human flesh
- Gamma ray energies high enough to easily penetrate 20 cm of lead
- Easy production of the radionuclide.
- Cheap production of the radionuclide.