CHEM 1110
KWANTLEN UNIVERSITY COLLEGE

NUCLEAR CHEMISTRY PROBLEM SET

1. Write the equations for the following nuclear processes:

   (a) ^{228}Th undergoing α decay
   (b) ^{110}In undergoing positron emission
   (c) ^{110}In undergoing EC
   (d) ^{127}I(p,7n)**X** and identify **X**
   (e) ^{10}B(**X**,p)^{10}Be and identify **X**
   (f) **X**(n,α)^{7}Li and idenitfy **X**
   (g) ^{95}Mo(p,**X**)^{95}Tc and identify **X**

2. Complete the following natural radiactive decay reactions:

   (a) $^{222}Rn \rightarrow {}^{218}Po + ?$
   (b) $^{234}Pa \rightarrow \beta^- + ?$
   (c) $^{11}C \rightarrow \beta^+ + ?$
   (d) $? \rightarrow {}^{90}Y + \beta^-$
   (e) $^{15}O \rightarrow \beta^+ + ?$
   (f) $^{218}Po \rightarrow \alpha + ?$
   (g) $^{23}Mg \rightarrow {}^{23}Na + ?$

3. (a) Calculate the mass defect of ^{23}Na if the measured mass is 22.9898 amu?
   NOTE: *Use the following masses for these calculations and all other calculations needing these masses.*

   m_{proton} = 1.007277 amu $m_{neutron}$ = 1.008665 amu $m_{electron}$ = 0.0005486 amu

   (b) What is the nuclear binding energy in joules per atom, Mev per atom and joules per mole of Na-23?

4. Each of the following nuclides is radioactive. Predict the mode of decay and write the balanced nuclear equation for the first decay step in each case:

   (a) ^{132}Sn (all isotopes of tin with A > 124 are unstable)
   (b) ^{226}U
   (c) ^{26}Si (the stable isotopes of Si have mass numbers of 28,29, and 30)
   (d) ^{19}N

5. The reaction for the first fusion bomb was ^{7}Li(p,α).
   (a) Write the complete reaction for the process and identify the other product.
   (b) The atomic masses are 1.007825 amu for ^{1}H, 4.00260 amu for ^{4}He and 7.01600 amu for ^{7}Li. Calculate the energy for the reaction of one atom of Li in Mev.

6. Rutheford's first nuclear transformation can be represented by the shorthand notation $^{14}N(\alpha,p)^{17}O$.
   (a) Write the corresponding nuclear equation for this process.
   (b) The respective atomic masses are 14.00307 amu for ^{14}N, 4.00260 amu for ^{4}He, 1.007825 amu for ^{1}H, and 16.99913 amu for ^{17}O. Calculate the energy required (in Mev)for this reaction to occur.

7. Calculate the binding energy per nucleon for the following isotopes:
   (a) ^{15}O with an atomic mass of 15.00300 amu
   (b) ^{16}O with an atomic mass of 15.99491 amu
   (c) ^{19}O with an atomic mass of 19.0035 amu

   Which of these would you expect to be the most stable?

8. What is the decay constant (k) for iridium-186 if the radiation emission drops to 25% of its original value after 3.4 hours?

9. What is the half-life of radium-226 if the radiation emission rate drops to 95% of its original value after 118.4 years?

10. What fraction of the original radiactive material remains after:

    (a) $t_{1/2}$ (b) $2t_{1/2}$ (c) $3t_{1/2}$ (d) $4t_{1/2}$ (e) $5t_{1/2}$

11. A freshly picked leaf with 20g of total carbon gives off 20,000 counts per hour due to its carbon-14 content. What is the age of an ancient wood sample that has 10 g of total carbon and emits 2500 counts per hour? Half-life of C-14 is 5730 years.