<u>Chem 1105-2015 Summer Problem Set #3</u>

1. Write the equation for the alpha decay of radon-222.

2. Classify each reaction as alpha decay, beta decay, positron emission, electron capture, spontaneous fission, or neutron emission.
a) $^{96}_{41}Nb \rightarrow \ ^{96}_{42}Mo + \ ^{0}_{-1}e$
b) $^{90}_{41}Nb \rightarrow \ ^{90}_{40}Zr + \ ^{0}_{+1}e$
c) $^{228}_{93}Np \rightarrow \ ^{89}_{38}Sr + \ ^{135}_{55}Cs + \ 4^{1}_{0}n$
d) $^{196}_{84}Po \rightarrow \ ^{192}_{82}Pb + \ ^{4}_{2}He$
e) $^{90}_{41}Nb + \ ^{0}_{-1}e \rightarrow \ ^{90}_{40}Zr$
f) $^{223}_{86}Rn \rightarrow \ ^{223}_{87}Fr + \ ^{0}_{-1}e$
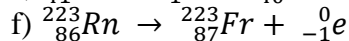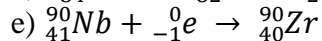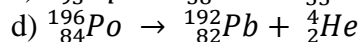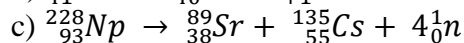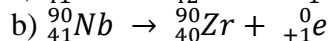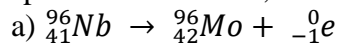
3. Complete each equation:
a) $^{139}_{58}Ce + \ ^{0}_{-1}e \rightarrow ?$
b) $^{23}_{12}Mg \rightarrow ? + \ ^{0}_{+1}e$
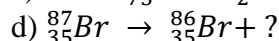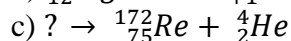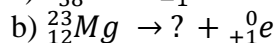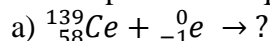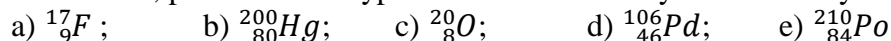c) $? \rightarrow \ ^{172}_{75}Re + \ ^{4}_{2}He$
d) $^{87}_{35}Br \rightarrow \ ^{86}_{35}Br + ?$
e) $^{141}_{56}Ba \rightarrow ? + \ ^{0}_{-1}e$
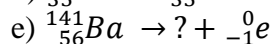
4. How do the modes of decay differ for a neutron-rich nuclide and a proton-rich nuclide?

5. Predict which of the following nuclides are probably stable. For the nuclides that are probably radioactive, predict which type of radioactive decay is most likely. Explain your answers.
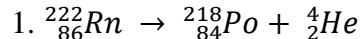a) $^{17}_{9}F$;   b) $^{200}_{80}Hg$;   c) $^{20}_{8}O$;   d) $^{106}_{46}Pd$;   e) $^{210}_{84}Po$

6. What is the specific activity in Ci/g if 1.65 mg of an isotope emits 1.56×10^{6} alpha particles per second?

7. The half-life for the radioactive decay of iridium-192 is 73.8 days. Calculate the amount in grams of Ir-192 that will be left from a 1.36 g sample after a) 221.4 d and b) 192.4 d.

8. A rock contains 270 µmol of U-238($t_{1/2}$ = 4.5×10^{9} yr) and 110 µmol of Pb-206. Assuming that all the Pb-206 comes from decay of the U-238, estimate the rock's age.

9. The half-life for the beta decay of osmium-194 is 6.0 y. a) How many disintegrations per second will be observed from a sample that contains 8.2 pg of osmium-194? b) How many atoms of osmium-194 are required to give 5.0×10^{7} disintegrations per second? c) What mass of osmium-194 is required to give 5.0×10^{7} disintegrations per second? Express the mass in the most appropriate units that do not require a power of -10 term.

1. $^{222}_{86}Rn \rightarrow \ ^{218}_{84}Po + \ ^{4}_{2}He$

2.a) beta decay; b) positron emission; c) spontaneous fission; d) alpha decay; e) electron capture; f) beta decay

3.a) $^{139}_{57}La$; b) $^{23}_{11}Na$; c) $^{176}_{77}Ir$; d) $^{1}_{0}n$; e) $^{141}_{57}La$
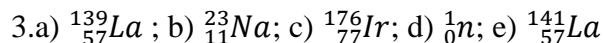
4. A neutron-rich nuclide undergoes beta-decay. A neutron-poor nuclide undergoes positron emission or electron capture.

5.a) The atomic mass of fluorine-17 is lower than the atomic mass of naturally occurring fluorine(18.9984 amu). Fluorine-17 has too few neutrons. Fluorine-17 is more likely to decay by emitting positrons than by electron capture.
b) The atomic mass of mercury-200 is close to the atomic mass of naturally occurring mercury(200.59 amu). Mercury-200 has even numbers of both protons and neutrons(80p and 120n) and is probably stable.
c) The atomic mass of oxygen-20 is higher than the atomic mass of naturally occurring oxygen(15.9994 amu). Oxygen-20 has too many neutrons and will probably be radioactive and decay by beta emission.
d) The atomic pass of palladium-106 is about the same as the atomic mass of naturally occurring palladium(106.42 amu). Palladium-106 has even numbers of both protons and neutrons(46p and 60n) and is probably stable.
e) The atomic number of polonium(84) is greater than 83. No nuclides with atomic number > 83 are stable. Polonium is beyond the band of stability and will probably decay by alpha emission.

6. 2.56×10^{-2} Ci/g

7.a) 0.17 g; b) 0.22 g

8. 2.2×10^{9} yr

9.a) 93 events/s; b) 1.4×10^{16} atoms; c) 4.4 µg