RDCH 702 Name:_____

Quiz 1

Assigned 5 Sep 12, Due 17 Sep 12

Chart of the nuclides (up to and including page 1-13 of the lecture notes)

Use the chart of the nuclides, the readings on the chart of the nuclides, table of the isotopes, and web links from lecture 1 to answer the following questions.

1. (10 Points)Using the chart of the nuclides find 4 isotopes where the metastable state is longer lived that the ground state.

Examples are below

Isotope	Metastable half life	Ground state half life	Isotope	Metastable half life	Ground state half life
^{34}Cl	**32.2 minutes**	**1.53 seconds**	**^{169}Re**	**16 seconds**	**8.1 seconds**
^{42}Sc	**1.03 minutes**	**682 ms**	**^{177}Lu**	**160.7 days**	**6.65 days**
^{44}Sc	**2.442 days**	**3.93 hours**	**^{180}Ta**	**>1.2E15 years**	**8.15 hours**
^{50}Mn	**1.74 minutes**	**283.2 ms**	**^{184}Re**	**165 days**	**38 days**
^{54}Co	**1.46 minutes**	**193.2 ms**	**^{186}Re**	**2E5 years**	**3.718 days**
^{80}Br	**4.42 hours**	**17.66 minutes**	**^{192}Ir**	**24e1 years**	**73.83 days**
^{81}Se	**57.3 minutes**	**18.5 minutes**	**^{194}Ir**	**171 days**	**19.3 hours**
^{95}Tc	**61 days**	**20.0 hours**	**^{195}Hg**	**1.73 days**	**10.53 hours**
^{102}Rh	**3.74 years**	**207 days**	**^{195}Ir**	**3.9 hours**	**2.5 hours**
^{104}Rh	**4.36 minutes**	**42.3 seconds**	**^{200}Au**	**18.7 hours**	**48.4 minutes**
^{106}Rh	**2.18 hours**	**29.9 seconds**	**^{210}Bi**	**3E6 years**	**5.01 days**
^{106}Ag	**8.28 d**	**24.0 m**	**^{212}Po**	**45 seconds**	**0.298 microseconds**
^{108}Ag	**438 years**	**2.39 minutes**	**^{222}Ac**	**63 seconds**	**5 seconds**
^{110}Ag	**249.8 days**	**24.6 seconds**	**^{242}Am**	**141 years**	**16.02 hours**
^{114}In	**49.51 days**	**1.198 minutes**	**^{248}Bk**	**>9 years**	**23.7 hours**
^{115}Cd	**44.6 days**	**2.228 days**	**^{265}Sg**	**18 seconds**	**8 seconds**
^{118}Sb	**5 hours**	**3.6 minutes**			
^{119}Te	**4.69 days**	**16.0 hours**			
^{121}Te	**164 days**	**19.1 days**			
^{121}Sn	**44 years**	**1.128 days**			
^{131}Te	**1.36 days**	**25.0 minutes**			
^{148}Pm	**41.3 days**	**5.37 days**			
^{162}Ho	**1.12 hours**	**15 minutes**			
^{166}Ho	**1200 years**	**1.118 days**			

2. (10 Points) The cross section data generally have two values. As an example the cross section data the absorption of a neutron and emission of a photon for ^{147}Nd is
σ_γ=4E2, 2E2

   Why are there two values and what is the cross section unit. Define the different types of cross sections presented by the data.

The cross section data is for the thermal neutron and resonance integral for the production of ^{148}Nd. The resonance integral is the reaction over a large energy range above thermal energy. The data is presented as 4E2, 4E2 in barns, where a barn= 10^{-24} cm^2. The data represents the following:

^{147}Nd(n,γ)X	Thermal cross section (barns)	Resonance Integral (barns)
^{148}Nd	4E2	4E2

3. (5 Points) Name 5 elements lighter than uranium that were found during the discovery of fission.

From page 11 in the chart of the nuclides elements found during fission include barium, lanthanum, cerium, molybdenum, rubidium, antimony, and iodine.

4. (10 Points) Provide 5 elements that have at least 5 metastable isotopes? Are there any trends in the population of isotopes with metastable states? (consider the number of neutrons and protons)

   A partial list includes: Os, Hf, Lu, Ir, Au, Co, Br, Nb, Ce, Se, Y, Rh, Tc, Ag, Ba, Cs, Sb, In, Sn, Te, Rb, Po

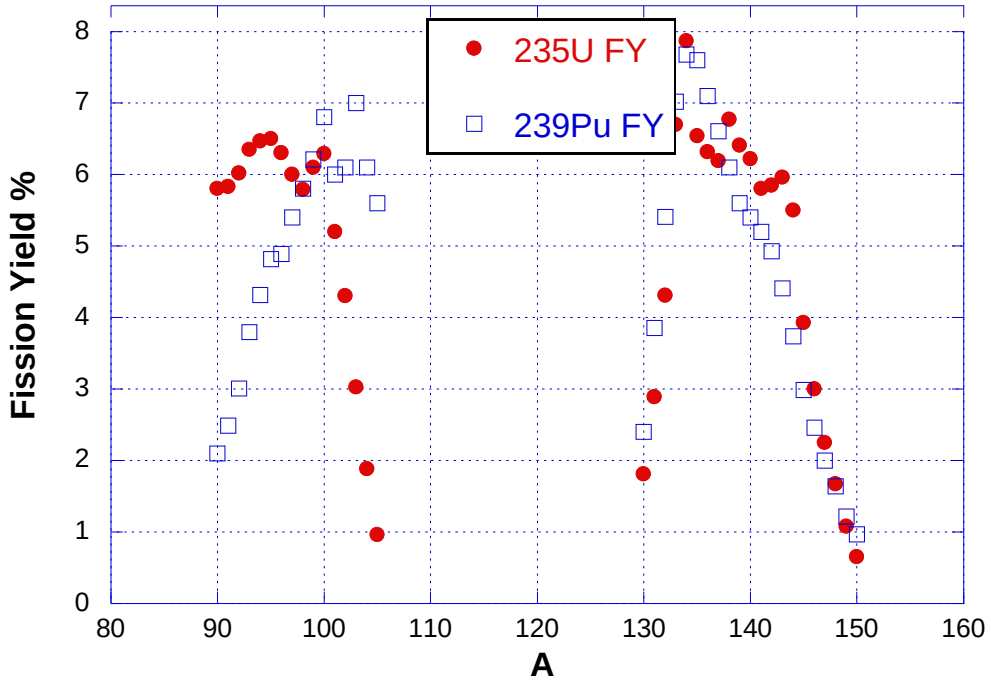
   Metastable isotopes tend to be heavy and have an unpaired nucleon. The lightest metastable isotopes are ^{24m}Na, ^{26m}Al, ^{34m}Cl, ^{38m}Cl and ^{38m}K, all of which have an odd number of protons and neutrons. Cobalt (Z=27) is the lightest element with at least 5 metastable states. Elements with even Z (i.e., Ge with Z=32) that have at least 5 metastable states manifest the metastable states with odd N. For Ge the metastable isotopes are ^{71m}Ge, ^{75m}Ge, ^{77m}Ge, ^{79m}Ge, and ^{81m}Ge. The generalized trends for metastable isotopes are that they are heavy (Z above 26), and have at least one unpaired nucleon, primarily the proton. Even-even metastable isotopes tend to be populated by beta decay.

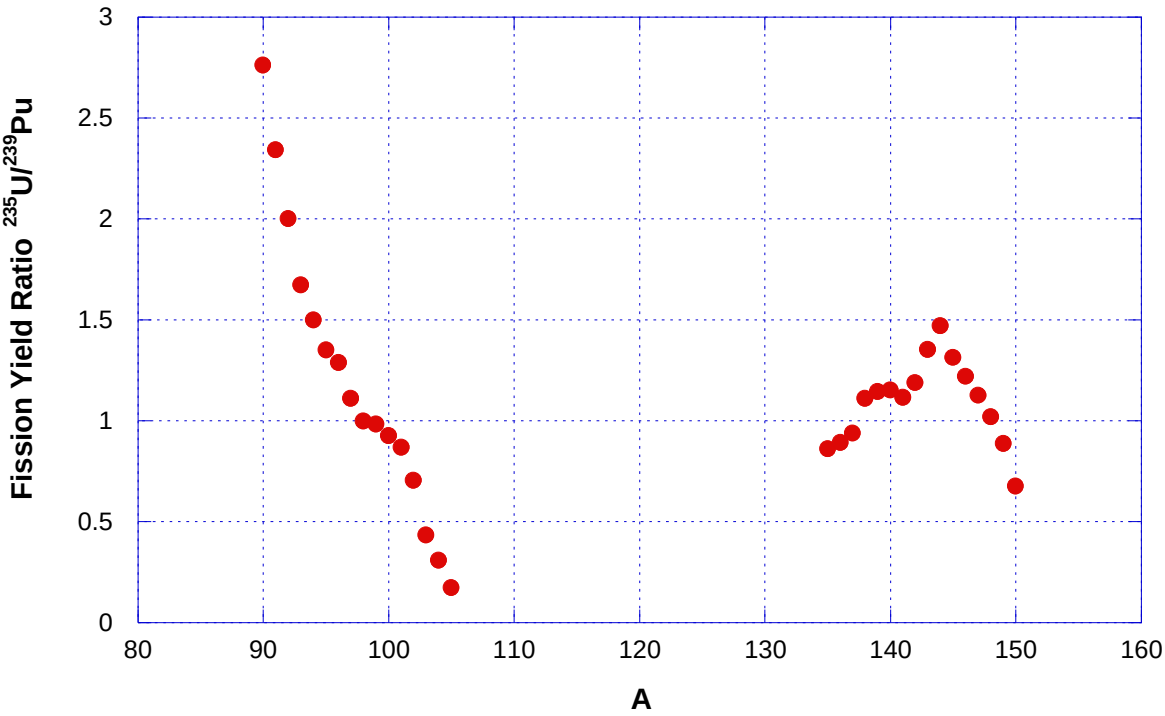
5. (10 Points) Provide the cumulative fission yields for the A isobars listed below.

A	^{233}U	^{235}U	^{239}Pu
116	**0.013**	**0.013**	**0.051**
95	**6.3**	**6.5**	**4.82**
72	**0.0004**	**0.000026**	**0.0001**
160	**0.0003**	**0.0003**	**0.010**

6. (15 Points) Plot the ratio of ^{235}U cumulative fission yield to ^{239}Pu cumulative fission yield for 90≤A≤105 and 135≤A≤150. (Use plotting software, provide on separate page).

What are the differences between the higher (135≤A≤150) and lower (90≤A≤105) A set? What accounts for this difference?





What are the differences between the higher and lower A set? What accounts for this difference?

The ratio of the higher A set is close to 1; there is not a large difference in the cumulative fission product yield for these isotopes for the fission of ^{235}U and ^{239}Pu. The main difference in the cumulative fission yields for ^{235}U and ^{239}Pu is in the lower area, with a large ratio near 90 and a small ratio above 105.

The similarity in the high A set is driven by the doubly magic ^{132}Sn (Z=50, N=82). This enhanced stability leads a tendency for the formation of isotopes in this region.

7. (15 Points) Describe the cross section data presented for ^{197}Au.

The cross section data is for the thermal neutron and resonance integral for the production of ^{198m}Au and ^{198}Au. The resonance integral is the reaction over a large energy range above thermal energy. The data is presented as (0 + 98.7), 155E1 in barns. The data represents the following:

^{197}Au(n,γ)X	Thermal cross section	Resonance Integral
^{198m}Au	0	
^{198}Au	98.7	155E1

8. (10 Points) Provide the main gamma decay energy and the gamma decay intensity for the following isotopes

Isotope	Main gamma decay energy (keV)	Gamma Intensity (%)
^{56}Ni	158.4, 811.8	98.8, 86.0
^{60}Co	1332.5, 1173.2	99.98, 99.97
^{127}Sb	685.7, 473.6	37, 25.8
^{137}Cs	661.6	85.1
^{183}Re	162.3, 46.5	23.3, 7.97
^{241}Am	59.6	35.9

9. (5 Points) Where was the location of the first man-made reactor?

Stagg field, University of Chicago under the direction of Enrico Fermi

10. (10 Points) Provide the spin, parity, and half-life for the isotopes below

Isotope	Spin	Parity	Half-life
^{208}Pb	0	+	Stable
^{107}Rh	7/2	+	21.7 minutes
^{99}Tc	9/2	+	2.13E5 years
^{148m}Pm	6	-	41.3 days
^{162}Dy	0	+	Stable
^{255}Fm	7/2	+	20.1 hour