115 - 25 = 90

Nucl Eng 535/Chem 580: Radiochemistry

First Examination **Friday, 17 February 2017**

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1. Consider ^{85}Rb. Give complete symbols for an isotope $^{86}_{37}Rb$ **, an isotone** $^{86}_{38}Sr$ **,**

an isobar $^{85}_{38}Sr$ **, and an isomer** $^{85m}_{37}Rb$ **. (3 each)**

2. The equation for the surface of a sphere is S = 4πR^2 where R is the radius. The second term of the binding energy equation is -17.23A$^{2/3}$. Do not write beyond the lines provided. (4 each)

Clearly explain why the term is negative. the nucleons at the surface are less tightly bound

From where does 17.23 come? It is empirically measured

Why is A to the 2/3 power? the radius is proportional to $A^{\frac{1}{2}}$ $A^{1/3}$ meaning the surface area $\propto (A^{\frac{1}{3}})^2$ -4

3. Bromine has two stable isotopes: ^{79}Br with a mass of 78.91835 mu and an abundance of 50.54%, and ^{81}Br with a mass of 80.91634 mu. On the back, calculate the average weighted mass of Br, and place the answer here. 79.9066 u **(6)**

4. There are 5 stable nuclides with odd Z and odd N. What is the smallest atomic number below which four of them are located? < 8 ($^{2}_{1}H$, $^{6}_{3}Li$, $^{10}_{5}B$, $^{14}_{7}N$) **(3)**

5. Beyond what element are there no stable radionuclides? beyond ~~Pb~~ Bi **(3)** -3

6. Write the complete decay equation for ~~^{86}Sc~~ ^{86}Sr. Assume no gamma emission. $^{86}_{38}Sr \rightarrow$ stable **(9)**

7. Write the most probable decay equation for ^{69}As. Assume no gamma emission. $^{69}_{33}As \rightarrow {}^{69}_{32}Ge^{-} + {}^{0}_{-1}\beta^{+} + {}^{0}_{0}\nu^{0}$ **(9)**

8. ^{81}Kr decays by electron capture. ^{81}Kr weighs 80.91660 mu, ^{81}Br weighs 80.91634 mu, ^{81}Rb weighs 80.91901 mu, and the electron weighs 0.00055 mu. On the back calculate the decay energy and place the answer here. 2.24 MeV produced **(9)** -9

9. ^{259}No is produced by bombardment of ^{248}Cm with ^{18}O. On the back, calculate the coulomb barrier and place the answer here. 102.7 MeV **(9)**

10. On the reverse, calculate the reaction energy for ^{14}N(n,p$^+$)----. Masses in mu are ^{14}N ~~(13.003074)~~ 14.0063074, n (1.00867), ^{1}H(1.00783), ^{14}O(14.00860), ^{14}C(14.00324).

Place answer here. 1.95 MeV lost -0.63 MeV **(9)** -9

11. A nuclide with a half-life T of 22 days has an activity of 12,441 c/m. How long will it take for the count to drop to 4077 c/m?

Calculate on the back, and place answer here. 35.43 days 5 **(10)**

12. ^{247}Cm has a half-life T = 1.6 x 10^7 years. What is the activity in c/m for 27 g of CmF$_3$ if the detector has an efficiency of 9.00 %? Avogadro number = 6.022 x 10^{23}.

Calculate on the back and place the answer here. 3.97×10^{8} cpm **(9)**

3. $\dfrac{f_{79} M_{79} + f_{81} m_{81}}{100} = \dfrac{50.54 * 78.91835\,u + 49.46 * 80.91634}{100} = \boxed{79.9066\,u}$

8. $^{81}_{36}Kr^{+} \quad + \quad ^{0}_{-1}e^{-1} \longrightarrow \; ^{81}_{35}Br \quad + \quad ^{0}_{0}\nu^{0}$

$(80.91660\,u - \cancel{0.00055\,u}) \quad + \quad \cancel{0.00055\,u} \qquad 80.91901\,u \qquad 0\,u$

$E = m_d - m_p$

$= [80.91901\,u - (80.91660\,u)] * 931\ MeV/u$

$= -0.00241\,u * 931\ MeV/u$

$= -2.24371\ MeV$

9. $E_c = 1.11 \dfrac{A + A'}{A} \dfrac{ZZ'}{A^{\frac{1}{3}} + A'^{\frac{1}{3}}}$

$= 1.11 \dfrac{(248 + 18)}{248} * \dfrac{96 * 8}{248^{1/3} + 18^{1/3}}$

$= 102.696$

10. $^{14}_{7}N \quad + \quad ^{1}_{0}n^{0} \longrightarrow \; ^{14}_{6}C \quad + \quad ^{1}_{1}H$

$14.0003074\,u \quad + \quad 1.00867\,u \qquad 14.00324\,u \quad + \quad 1.00783\,u$

$(\Sigma m_d - \Sigma m_p)\, 931 = E$

$E = 931 \frac{MeV}{u} * [(14.00324\,u + 1.00783) - (14.0003074 + 1.00867)]$

$E = 1.95\ MeV$

11. $A = A_0 * e^{-\lambda t}, \qquad \lambda = \dfrac{\ln 2}{T_{1/2}} = \dfrac{0.693}{22\,d} = 0.0315\ d^{-1}$

$\log A - \log A_0 = -0.434 \lambda t \longrightarrow t = \dfrac{\log A - \log A_0}{-0.434\,\lambda} = \dfrac{\log(4077) - \log(12441)}{-0.434 * 0.0315\,d^{-1}}$

$= \boxed{35.43\ days}$

12. $A(cpm) = \varepsilon * \lambda N = \varepsilon \dfrac{\ln 2}{T_{1/2}} N = \varepsilon \dfrac{\ln 2}{T_{1/2}} N_{cm} = 0.09 * \dfrac{0.693}{8.42 \times 10^{12}\ min} * 5.35 \times 10^{22}$

$N_{cm} = \dfrac{1\,cm}{1\,CmF_3} \dfrac{27_g * N_A}{m_{CmF_3}} * = 5.35 \times 10^{22} \qquad T(min) = T(yr) \dfrac{365.241\,d}{yr} * \dfrac{24\,h}{1\,d} * \dfrac{60\,m}{1\,h} = 8.42 \times 10^{12}\ min$

$A = \lambda N = 3.97 \times 10^{8}\ cpm$

chem580 exam 1

Binding Energy

surface Coulomb N/Z Pairing

$$B = 15.56A - 17.23A^{2/3} - 0.72Z^2A^{-1/3} - 23.285\,(A-2Z)^2\,A^{-1} + 11A^{-1/2} \quad (1)$$

nuclear

+ for even even

$$B = 931\,(1.00783Z + 1.00867N - M) \quad (2)$$

- for odd odd

0 for even/odd

Nuclear Radius

$$R(\text{cm}) = 1.4 \times 10^{-13}A^{1/3} \quad (3)$$

Magic Numbers

2, 8, 20, 28, 50, 82, 126 (also 118 for p^+)

AMU

1 u=931 MeV

36
38
48

Coulomb Barrier

target beam

$$E_C = 1.11\frac{(A+A')}{A}\frac{ZZ'}{(A^{1/3}+A'^{1/3})} \quad (4)$$

Specific Activity

A is mass number, T is half-life in days

$\frac{\text{mCi}}{\text{mg}}$

$\frac{1.3 \times 10^8}{AT}$

$\frac{\text{MBq}}{\text{mg}}$

$\frac{4.8 \times 10^6}{AT}$

Beta Recoil

$$E_{Max} = E_m\frac{m_e}{m_e + M_D} \quad (5)$$

^{14}N

^{3}Li

$^{1}_{1}H$

Periodic Table of the Elements

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.0079 Hydrogen																	2 He 4.0026 Helium
3 Li 6.941 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.0067 Nitrogen	8 O 15.9994 Oxygen	9 F 18.9984 Fluorine	10 Ne 20.1797 Neon
11 Na 22.9898 Sodium	12 Mg 24.3050 Magnesium											13 Al 26.9815 Aluminum	14 Si 28.0855 Silicon	15 P 30.9738 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.4527 Chlorine	18 Ar 39.948 Argon
19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.9559 Scandium	22 Ti 47.867 Titanium	23 V 50.9415 Vanadium	24 Cr 51.9961 Chromium	25 Mn 54.9380 Manganese	26 Fe 55.845 Iron	27 Co 58.9332 Cobalt	28 Ni 58.6934 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.61 Germanium	33 As 74.9216 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
37 Rb 85.4678 Rubidium	38 Sr 87.62 Strontium	39 Y 88.9059 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.9064 Niobium	42 Mo 95.96 Molybdenum	43 Tc (97.907) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.9055 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.8682 Silver	48 Cd 112.411 Cadmium	49 In 114.818 Indium	50 Sn 118.710 Tin	51 Sb 121.760 Antimony	52 Te 127.60 Tellurium	53 I 126.9045 Iodine	54 Xe 131.29 Xenon
55 Cs 132.9054 Cesium	56 Ba 137.327 Barium	57 La* 138.9055 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.9488 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.2 Osmium	77 Ir 192.22 Iridium	78 Pt 195.084 Platinum	79 Au 196.9666 Gold	80 Hg 200.59 Mercury	81 Tl 204.3833 Thallium	82 Pb 207.2 Lead	83 Bi 208.9804 Bismuth	84 Po (208.98) Polonium	85 At (209.99) Astatine	86 Rn (222.02) Radon
87 Fr (223.02) Francium	88 Ra (226.0254) Radium	89 Ac** (227.0278) Actinium	104 Rf (261.11) Rutherfordium	105 Db (262.11) Dubnium	106 Sg (263.12) Seaborgium	107 Bh (262.12) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 Ds (281) Darmstadtium	111 Rg (272) Roentgenium							

*Lanthanide Series	58 Ce 140.115 Cerium	59 Pr 140.9076 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (145.91) Promethium	62 Sm 150.36 Samarium	63 Eu 151.965 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.9253 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.9303 Holmium	68 Er 167.26 Erbium	69 Tm 168.9342 Thulium	70 Yb 173.54 Ytterbium	71 Lu 174.9668 Lutetium
**Actinide Series	90 Th 232.0381 Thorium	91 Pa 231.0388 Protactinium	92 U 238.0289 Uranium	93 Np (237.0482) Neptunium	94 Pu (244.664) Plutonium	95 Am (243.061) Americium	96 Cm (247.07) Curium	97 Bk (247.07) Berkelium	98 Cf (251.08) Californium	99 Es (252.08) Einsteinium	100 Fm (257.10) Fermium	101 Md (258.10) Mendelevium	102 No (259.10) Nobelium	103 Lr (262.11) Lawrencium

Values in parentheses are atomic masses or mass numbers of the most stable isotope of an element.