

Name \_\_\_\_\_

Physics 111 Quiz #5, November 13, 2015

*Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.*

*I affirm that I have carried out my academic endeavors with full academic honesty.*

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Strontium-90 is chemically similar to calcium and if ingested can replace calcium in bones leading to health problems.  $^{90}_{38}\text{Sr}$  is produced as a nuclear fission product of uranium and  $^{90}_{38}\text{Sr}$  has too many neutrons to be stable and thus decays with a half-life of about 29yr.

1. How long would you have to wait for the amount of  $^{90}_{38}\text{Sr}$  on the Earth's surface to reach 1% of its current level, assuming no new material is scattered about?

From the half-life we calculate the decay constant:

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{29\text{yr}} = 0.024\text{yr}^{-1}$$

Then the time to reach this amount is:

$$m = 0.01m_o = m_o e^{-\lambda t} \rightarrow t = -\frac{\ln(0.01)}{\lambda} = -\frac{\ln(0.01)}{0.024\text{yr}^{-1}} = 192.7\text{yr}$$

2. What is the decay reaction and what is the maximum kinetic energy available to the decay particle? (See table 1 on the back of the page for pertinent data.)

Too many neutrons mean that this is a beta-minus decay. We have:  $^{90}_{38}\text{Sr} \rightarrow ^0_{-1}e + ^{90}_{39}\text{Y} + \bar{\nu}_e$

The maximum kinetic energy available to the beta particle is (assuming that the  $^{90}_{39}\text{Y}$  is at rest after the decay) and the electron's mass is included in the rest mass of Yttrium:

$$KE_{\max} = (m_{\text{Sr}} - m_{\text{Y}})c^2$$
$$KE_{\max} = \left[ (89.90773u - 89.90585u) \times \left( \frac{931.5 \frac{\text{MeV}}{c^2}}{1u} \right) \right] c^2 = 1.75\text{MeV}$$

3.  $^{90}_{38}\text{Sr}$  has 38 protons in its nucleus. Why doesn't the strontium nucleus break apart?
  - a. The repulsive Coulomb force doesn't act inside of the nucleus.
  - b. The force of gravity overpowers the repulsive Coulomb force inside of the nucleus.
  - c. The negatively charged neutrons balance the positively charged protons.
  - d. Protons lose some of their positive charge inside the nucleus.
  - ☒ e. The strong nuclear force holds the nucleus together.

GROUP

1

IA

1

1.0079

H

HYDROGEN

2

9.0122

He

HELIUM

3

6.941

Li

LITHIUM

4

9.0122

Be

BERYLLIUM

11

22.990

Na

SODIUM

12

24.305

Mg

MAGNESIUM

19

39.098

K

POTASSIUM

20

40.078

Ca

CALCIUM

21

44.956

Sc

SCANDIUM

22

47.867

Ti

TITANIUM

23

50.942

V

VANADIUM

24

51.996

Cr

CHROMIUM

25

54.938

Mn

MANGANESE

26

55.845

Fe

IRON

27

58.933

Co

COBALT

28

58.693

Ni

NICKEL

29

63.546

Cu

COPPER

30

65.38

Zn

ZINC

31

69.723

Ga

GALLIUM

32

72.64

Ge

GERMANIUM

33

74.922

As

ARSENIC

34

78.96

Se

SELENIUM

35

79.904

Br

BROMINE

36

83.798

Kr

KRYPTON

37

85.468

Rb

RUBIDIUM

38

87.62

Sr

STRONTIUM

39

88.906

Y

YTRIUM

40

91.224

Zr

ZIRCONIUM

41

92.906

Nb

NIOBIUM

42

95.96

Mo

MOLYBDENUM

43

(98)

Tc

TECHNETIUM

44

101.07

Ru

RUTHENIUM

45

102.91

Rh

RHODIUM

46

106.42

Pd

PALLADIUM

47

107.87

Ag

SILVER

48

112.41

Cd

CADMIUM

49

114.82

In

INDIUM

50

118.71

Sn

TIN

51

121.76

Sb

ANTIMONY

52

127.60

Te

TELLURIUM

53

126.90

I

IODINE

54

131.29

Xe

XENON

55

132.91

Cs

CAESIUM

56

137.33

Ba

BARIUM

57-71

La-Lu

Lanthanide

72

178.49

Hf

HAFNIUM

73

180.95

Ta

TANTALUM

74

183.84

W

TUNGSTEN

75

186.21

Re

RHENIUM

76

190.23

Os

OSMIUM

77

195.08

Ir

IRIDIUM

78

195.08

Pt

PLATINUM

79

196.97

Au

GOLD

80

200.59

Hg

MERCURY

81

204.38

Tl

THALLIUM

82

207.2

Pb

LEAD

83

208.98

Bi

BISMUTH

84

(209)

Po

POLONIUM

85

(210)

At

ASTATINE

86

(222)

Rn

RADON

87

(223)

Fr

FRANCIUM

88

(226)

Ra

RADIUM

89-103

Ac-Lr

Actinide

104

(267)

Rf

RUTHERFORDIUM

105

(268)

Db

DUBNIUM

106

(271)

Sg

SEABORGIUM

107

(272)

Bh

BOHRNIUM

108

(277)

Hs

HASSIUM

109

(276)

Mt

MEITNERIUM

110

(281)

Ds

DARMSTADTIUM

111

(280)

Rg

ROENTGENIUM

112

(285)

Cn

COPERNICIUM

113

(...)

Uut

UNUNTRIUM

114

(287)

Uuq

FLEROVIUM

115

(...)

Uup

UNUNPENTIUM

116

(291)

Lv

LIVERMORIUM

117

(...)

Uus

UNUNSEPTIUM

118

(...)

Uuo

UNUNOCTIUM

PERIOD

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2

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4

5

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7

RELATIVE ATOMIC MASS (1)

13

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(1) Pure Appl. Chem., 81, No. 11, 2131-2156 (2009)

Relative atomic masses are expressed with five significant figures. For elements that have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element. However three such elements (Th, Pa and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

LANTHANIDE														
57 138.91 <b>La</b> LANTHANUM	58 140.12 <b>Ce</b> CERIUM	59 140.91 <b>Pr</b> PRASEODYMIUM	60 144.24 <b>Nd</b> NEODYMIUM	61 (145) <b>Pm</b> PROMETHIUM	62 150.36 <b>Sm</b> SAMARIUM	63 151.96 <b>Eu</b> EUROPIUM	64 157.25 <b>Gd</b> GADOLINIUM	65 158.93 <b>Tb</b> TERBIUM	66 162.50 <b>Dy</b> DYSPROSIUM	67 164.93 <b>Ho</b> HOLMIUM	68 167.26 <b>Er</b> ERBIUM	69 168.93 <b>Tm</b> THULIUM	70 173.05 <b>Yb</b> YTTERBIUM	71 174.97 <b>Lu</b> LUTETIUM

  

ACTINIDE														
89 (227) <b>Ac</b> ACTINIUM	90 232.04 <b>Th</b> THORIUM	91 231.04 <b>Pa</b> PROTACTINIUM	92 238.03 <b>U</b> URANIUM	93 (237) <b>Np</b> NEPTUNIUM	94 (244) <b>Pu</b> PLUTONIUM	95 (243) <b>Am</b> AMERICIUM	96 (247) <b>Cm</b> CURIUM	97 (247) <b>Bk</b> BERKELIUM	98 (251) <b>Cf</b> CALIFORNIUM	99 (252) <b>Es</b> EINSTEINIUM	100 (257) <b>Fm</b> FERMIUM	101 (258) <b>Md</b> MENDELEVIUM	102 (259) <b>No</b> NOBELIUM	103 (262) <b>Lr</b> LAWRENCIUM

<http://www.chemizzle.com/p/chemistry.html>

Element	$^{90}_{38}\text{Sr}$	$^{90}_{39}\text{Y}$	$^{87}_{37}\text{Rb}$	$^{94}_{40}\text{Zr}$	$^{86}_{36}\text{Kr}$	$^4_2\text{He}$	$^0_{-1}\text{e}$ or $^0_{+1}\text{e}$
Mass (unified mass units)	89.90773	89.90585	86.90918	93.90632	86.91062	4.00260	0.00055

## Physics 111 Equation Sheet

### Electric Forces, Fields and Potentials

$$\vec{F} = k \frac{Q_1 Q_2}{r^2} \hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k \frac{Q}{r^2} \hat{r}$$

$$PE = k \frac{Q_1 Q_2}{r}$$

$$V(r) = k \frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

### Magnetic Forces and Fields

$$F = qvB \sin\theta$$

$$F = IlB \sin\theta$$

$$\tau = NIAB \sin\theta = \mu B \sin\theta$$

$$PE = -\mu B \cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\mathcal{E}_{\text{induced}} = -N \frac{\Delta\phi_B}{\Delta t} = -N \frac{\Delta(BA \cos\theta)}{\Delta t}$$

### Constants

$$g = 9.8 \frac{m}{s^2}$$

$$1e = 1.6 \times 10^{-19} C$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{C^2}{Nm^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{Nm^2}{C^2}$$

$$1eV = 1.6 \times 10^{-19} J$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$$

$$c = 3 \times 10^8 \frac{m}{s}$$

$$h = 6.63 \times 10^{-34} Js$$

$$m_e = 9.11 \times 10^{-31} kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67 \times 10^{-27} kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69 \times 10^{-27} kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66 \times 10^{-27} kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02 \times 10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

### Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR = I \left( \frac{\rho L}{A} \right)$$

$$R_{\text{series}} = \sum_{i=1}^N R_i$$

$$\frac{1}{R_{\text{parallel}}} = \sum_{i=1}^N \frac{1}{R_i}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$Q = CV = \left( \frac{\kappa \epsilon_0 A}{d} \right) V = (\kappa C_0) V$$

$$PE = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{Q^2}{2C}$$

$$Q_{\text{charge}}(t) = Q_{\text{max}} \left( 1 - e^{-\frac{t}{RC}} \right)$$

$$Q_{\text{discharge}}(t) = Q_{\text{max}} e^{-\frac{t}{RC}}$$

$$C_{\text{parallel}} = \sum_{i=1}^N C_i$$

$$\frac{1}{C_{\text{series}}} = \sum_{i=1}^N \frac{1}{C_i}$$

### Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{\text{max}} = hf - \phi = eV_{\text{stop}}$$

$$\Delta\lambda = \frac{h}{m_e c} (1 - \cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{\text{total}} = KE + E_{\text{rest}} = \gamma mc^2$$

$$E_{\text{total}}^2 = p^2 c^2 + m^2 c^4$$

$$E_{\text{rest}} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

### Geometry

$$\text{Circles: } C = 2\pi r = \pi D \quad A = \pi r^2$$

$$\text{Triangles: } A = \frac{1}{2} bh$$

$$\text{Spheres: } A = 4\pi r^2 \quad V = \frac{4}{3} \pi r^3$$

### Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

$$S(t) = \frac{\text{energy}}{\text{time} \times \text{area}} = c\epsilon_0 E^2(t) = c \frac{B^2(t)}{\mu_0}$$

$$I = S_{\text{avg}} = \frac{1}{2} c\epsilon_0 E_{\text{max}}^2 = c \frac{B_{\text{max}}^2}{2\mu_0}$$

$$P = \frac{S}{c} = \frac{\text{Force}}{\text{Area}}$$

$$S = S_o \cos^2\theta$$

$$v = \frac{1}{\sqrt{\epsilon\mu}} = \frac{c}{n}$$

$$\theta_{\text{inc}} = \theta_{\text{refl}}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{\text{total}} = \prod_{i=1}^N M_i$$

$$S_{\text{out}} = S_{\text{in}} e^{-\sum \mu_i x_i}$$

$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

### Nuclear Physics

$$E_{\text{binding}} = (Zm_p + Nm_n - m_{\text{rest}})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

### Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\Delta(m\vec{v})}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m \frac{v^2}{R} \hat{r}$$

$$W = \Delta KE = \frac{1}{2} m (v_f^2 - v_i^2) = -\Delta PE$$

$$PE_{\text{gravity}} = mgy$$

$$PE_{\text{spring}} = \frac{1}{2} ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1} \left( \frac{A_y}{A_x} \right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{r} = \vec{r}_i + \vec{v}_i t + \frac{1}{2} \vec{a}t^2$$