22.01 Introduction to Ionizing Radiation Name:_____
Fall 2003
Professor Coderre
Quiz #1
September 29, 2003

You have 50 minutes to complete this quiz.
This quiz is closed book.
Please show all work on the attached sheets.

Supplemental information is attached at the back.

This quiz consists of 4 questions worth a total of 100 points.

The point values for each question are indicated in parentheses next to the question number.

1. (15 points)
Identify the daughter products (by specifying A, Z, and the chemical element) of the following radionuclides, given their mode(s) of decay.
(A periodic table is attached at the back)

a) $^{147}_{61}Pm$ (β^-)

b) $^{238}_{92}U$ (α)

c) $^{22}_{11}Na$ (β^+)

d) $^{78}_{35}Br$ (β^+, EC)

e) $^{99m}_{43}Tc$ (γ)

2. (25 points)
a) Calculate the energy released (Q value) by the following reaction:

$$^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + {}^{7}_{3}Li + 0.48\,MeV\,\gamma \qquad (94\%)$$

b) Calculate the kinetic energy of the alpha particle.

c) What is the recoil energy of the lithium ion?

d) In the other 6% of these reactions, no gamma ray is produced. What would be the energy of that alpha particle?

Assume that the ^{10}B is at rest and that the kinetic energy of the neutron is negligible.

	mass difference (Δ)
$^{10}_{5}B$	12.052 MeV
$^{1}_{0}n$	8.0714 MeV
$^{4}_{2}He$	2.4248 MeV
$^{7}_{3}Li$	14.907 MeV

3. (30 points)
The human body contains 0.2% potassium (K) by weight. The natural abundance of ^{40}K (i.e., fraction of total K that is ^{40}K) is 0.0118%. The decay scheme and half-life of ^{40}K are given below. Calculate the gamma activity (in Bq) in an adult human weighing 75 kg.

^{40}K $t_{1/2} = 1.28 \times 10^9$ years
Decay scheme:

$^{40}_{19}K$	β^- (89%)	β^-: 1.312 MeV (max)
	EC (11%)	γ: 1.461 MeV (11%); Ar X rays

4. (30 points)
A meteorite lands in your back yard. You immediately take it to an analytical lab for elemental analysis. From measurements on a single crystal in the center of the meteorite they tell you the following: "the number of ^{40}K atoms is ***exactly equal*** to the number of ^{40}Ar atoms".

How old is this meteorite?

State any assumptions you make in this calculation.

^{40}K $t_{1/2} = 1.28 \times 10^9$ years
Decay scheme:

$^{40}_{19}K$	β^- (89%)	β^-: 1.312 MeV (max)
	EC (11%)	γ: 1.461 MeV (11%); Ar X rays

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	—— VII ——	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	1 H															2 He
2	3 Li	4 Be									5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg									13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110								

* Lanthanide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr