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

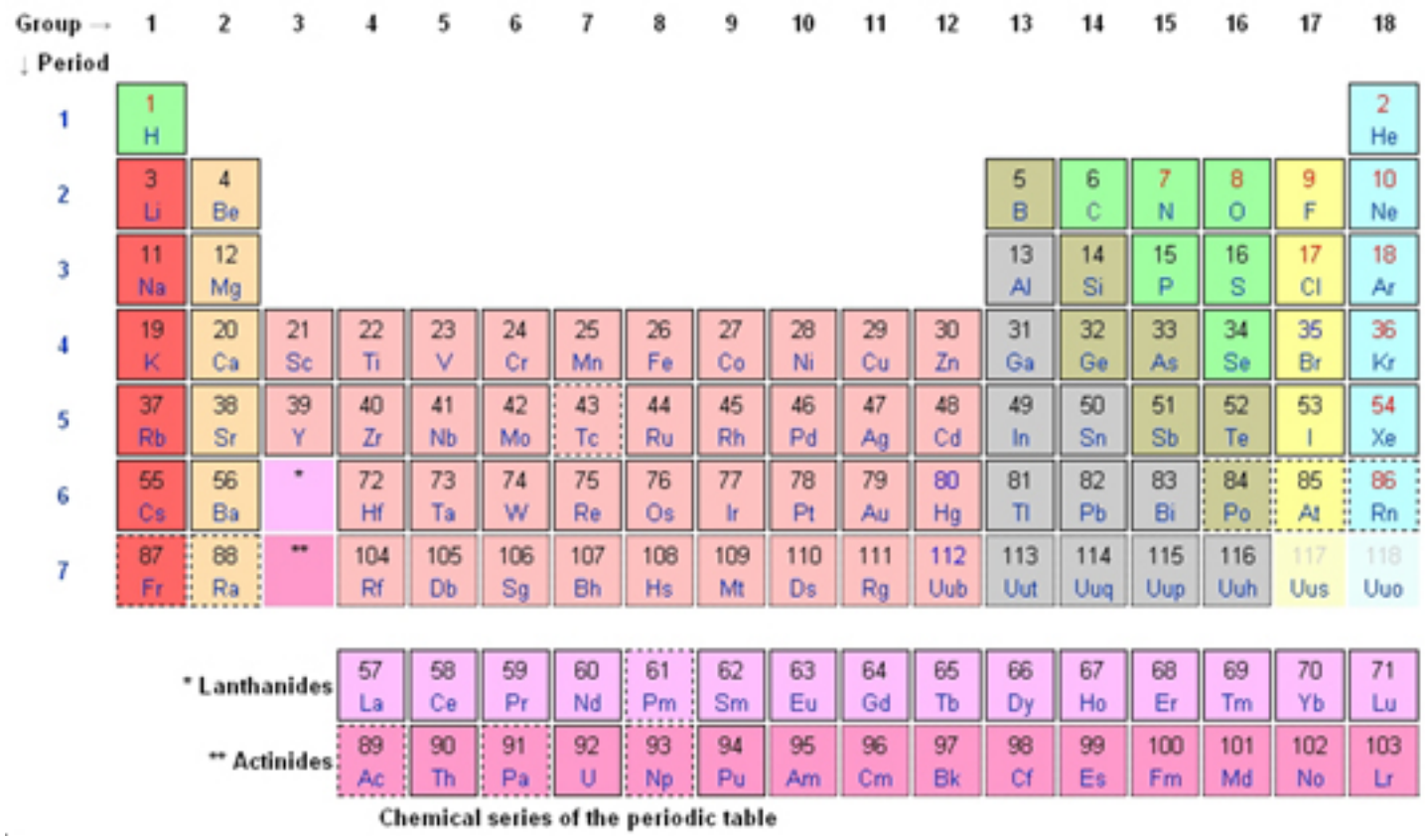
4. (30 points)
A meteorite lands in your back yard. You immediately take it to an analytical lab for elemental analysis. From measurements on a single crystal in the center of the meteorite they tell you the following: "the number of ^{40}K atoms is ***exactly equal*** to the number of ^{40}Ar atoms".

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



Source: Wikipedia