N&R EXAM QUESTIONS 2003-04

1. Which of the following values, in MeV, is closest to the maximum energy of the positron released in the decay of $^{13}_{7}N$ to $^{13}_{6}C$?

A. 0.511
B. 0.686
C. 1.197
D. 1.708
E. 2.220

Nucleus	ATOMIC Mass (u)
$^{13}_{7}N$	13.005 738
$^{13}_{6}C$	13.003 355

2. 10 kg of the isotope tritium, which has a half-life of 12.3 years, is produced at a reactor. Which of the following values, in kg, is closest to the mass of tritium that will remain after 30 years?

A. 7.5
B. 1.8
C. 0.9
D. 6.6
E. 2.3

3. X-rays of wavelength 0.1 nm are required for a particular medical procedure. Which of the following values is closest to the minimum potential difference that must be applied to the X-ray tube?

A. 10 kV
B. 12kV
C.19kV
D.120V
E. 190V

4. By definition, a Roentgen produces 2.58×10^{-4} Coulombs of positive charge per kilogram of dry air at STP. How many ion pairs does 1.5 R produce in a volume of 0.5 cubic metres? (The density of dry air at STP is 1.29 $kg.m^{-3}$).

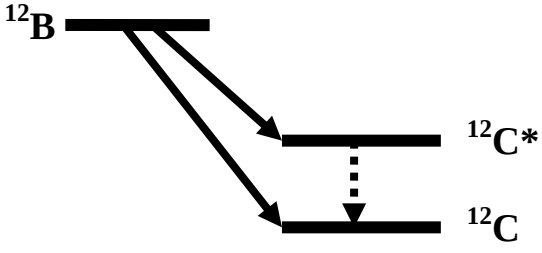
A. 2.6×10^{-4}
B. 1.0×10^{15}
C. 1.6×10^{15}
D. 1.7×10^{-4}
E. 3.8×10^{14}

N&R EXAM QUESTIONS 2005-2006

1. The level of radiation close to an X-ray machine is 1R. If the linear attenuation coefficient for lead is 9.4 cm^{-1}, what is the thickness of the lead shield in cm that will reduce this exposure to 10^{-4} R at the same distance from the machine?

A. 9.2 B. 0.4 C. 5.6 D. 1.0 E. 9.4

2. $^{12}_{5}B$ decays via two different paths, each emitting an electron. One decay, with an endpoint energy of 9.00 MeV, leaves the daughter, $^{12}_{6}C$, in an excited state ($^{12}_{6}C^*$). The other possible decay leaves the $^{12}_{6}C$ in its ground state, as shown in the diagram.



Nucleus	ATOMIC Mass (u)
$^{12}_{5}B$	12.014 352

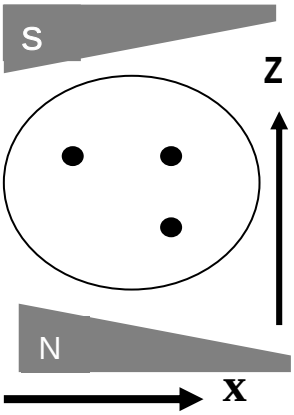
The $^{12}_{6}C^*$ subsequently decays to the $^{12}_{6}C$ ground state. Which of the following values is closest to the energy of the gamma ray, in fm?

Neglect any effects of nuclear recoil.

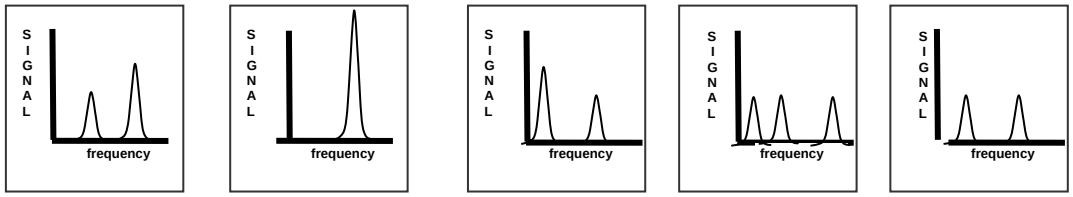
A. 254 B. 284 C. 230 D. 321 E. 62.6

3. A patient is given an injection of a radioisotope of half-life 2.30 hours. 5 ml blood samples are taken after 12 hours and again after 24 hours. Both samples are counted 30 hours after injection; the measured activities, corrected for background, are 160 Bq and 98 Bq respectively. Which of the following answers is closest to the effective half-life in hours of the radioisotope in the body?

A. 0.495 B. 1.18 C. 2.03 D. 1.75 E. 16.6



4. A laboratory sample used for MRI research, containing three capsules of water (indicated by the three black dots in the diagram), is placed in a magnetic field. The magnetic field is constant and uniform in the +z direction; $B_z(z) = B_0$. The field has a gradient in the +x direction; it decreases in the +x direction according to $B_z(x) = B_0 - xG$, where G is a constant greater than zero, as shown in the diagram to the left. The graphs below show the result of the measurement of the Larmor frequencies of the protons in each capsule. The values of frequency are plotted along the x-axis, and the strength of the signal is plotted on the y-axis. Which of the graphs most closely approximates the frequency spectrum you would expect to see?

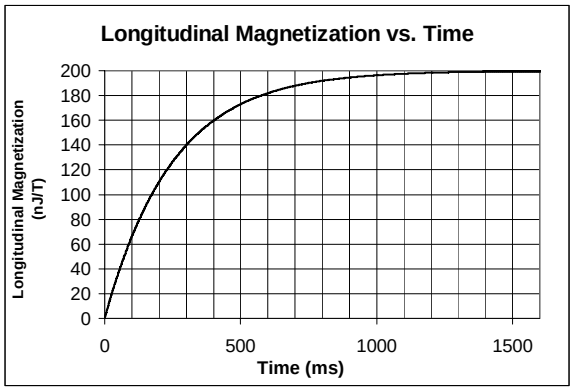


(A) **(B)** **(C)** **(D)** **(E)**

(diagram corrected from original).

N&R EXAM QUESTIONS 2006-07 (WITH analysis)

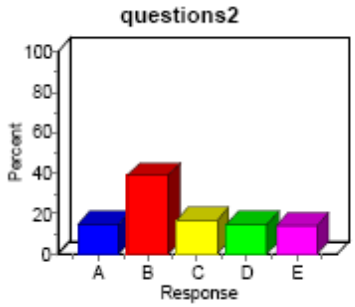
2. In an MRI study of an obese patient, a measurement of the relaxation of the longitudinal magnetization, M_z (the z component of the macroscopic magnetization), for a small volume of the patient's body, yields the data shown in the graph. Which of the following answers is closest to the value of the relaxation time in ms?



(A) 525 **(B) 250** **(C)** 370
(D) 175 **(E)** 400

Item Analysis: q2

Label	Value	Frequency	Percent
A	1	43	14.98
B	2	112	39.02
C	3	49	17.07
D	4	42	14.63
E	5	41	14.29
Total		287	100.00



7. A beam of 1.50 MeV photons strikes a slab of carbon of thickness 2.00 cm and density 2.25 g cm^{-3}. At this energy the mass energy absorption coefficient is 0.064 cm^2g^{-1}. The percentage of the energy of the beam that is transmitted through the slab is closest to:

(A) 93 **(B)** 14 **(C)** 25 **(D) 75**
(E) 86

Item Analysis: q7

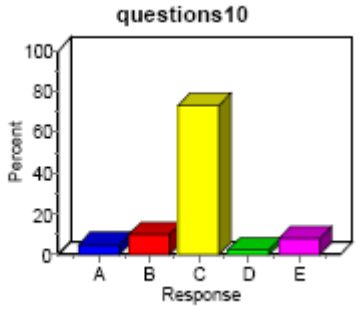
Label	Value	Frequency	Percent
A	1	14	4.88
B	2	15	5.23
C	3	63	21.95
D	4	174	60.63
E	5	21	7.32
Total		287	100.00

10. 1.20 x 10^5 Bq of ^{42}K, which has a nuclear half-life of 12.5 hours were injected into the body. 24.0 hours later some blood was taken; this sample had 0.150 g of stable potassium and 29.0 Bq of ^{42}K in it. Neglecting biological excretion (the biological half life is long), and assuming the potassium had fully mixed throughout the body, which of the following values is closest to the amount of stable potassium in the body in grams?

(A) 181 **(B)** 190 **(C) 164** **(D)** 101 **(E)** 152

Item Analysis: q10

Label	Value	Frequency	Percent
A	1	15	5.23
B	2	28	9.76
C	3	211	73.52
D	4	8	2.79
E	5	24	8.36
Total Missing	-1	1	0.35
Total		287	100.00

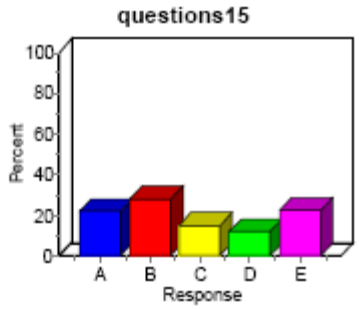


15. An air-filled lung has a density of 0.32 g cm^{-3} compared to 1.0 g cm^{-3} for a solid tumor. For diagnostic X-rays, the mass attenuation coefficient has a value of 0.25 cm^2g^{-1} for both lung and tumour. If a lung is 15 cm thick, what is the minimum size of tumour that can be resolved with these X-rays, if the film requires a ratio of intensities of less than 0.95 (i.e. greater than a 5% effect)? The following answers are in mm.

(A) 2.1 **(B) 3.0** **(C)** 33 **(D)** 0.75 **(E)** 4.3

Item Analysis: q15

Label	Value	Frequency	Percent
A	1	62	21.60
B	2	81	28.22
C	3	43	14.98
D	4	33	11.50
E	5	64	22.30
Total Missing	-1	4	1.39
Total		287	100.00



20. 8.0 x 10^6 Bq of the isotope of Iodine, ^{131}I, which has a nuclear decay constant of 0.086 $days^{-1}$, is administered orally to a patient. The biological half life for Iodine in the thyroid gland is 140 days. Which of the following values, in days, is closest to the effective half life of the ^{131}I in the thyroid?

(A) 11 **(B)** 9.0 **(C)** **7.6** **(D)** 12
(E) 13

Item Analysis: q20

Label	Value	Frequency	Percent
A	1	30	10.45
B	2	17	5.92
C	3	215	74.91
D	4	20	6.97
E	5	5	1.74
Total		287	100.00