Week 11 Nuclear 2, Kinetics, Energy, Fission

**QUESTION 1**

For each pair of isotopes below, choose the one that is the most stable isotope.

a. $^{24}\text{Mg}$ or $^{26}\text{Mg}$

b. $^{106}\text{Cd}$ or $^{113}\text{Cd}$

**QUESTION 2**

A wooden artifact from China has a $^{14}\text{C}$ activity of 24 counts/min as compared to an activity of 31.7 counts/min for modern wood. What is the age of the artifact? (The half-life for $^{14}\text{C}$ is 5700 years.)

A. 1700 years  
B. 2300 years  
C. 4600 years  
D. 3750 years  
E. 4340 years

**QUESTION 3**

The $^{14}\text{C}/^{12}\text{C}$ ratio in a wooden artifact is 1/8 the $^{14}\text{C}/^{12}\text{C}$ ratio in today's atmosphere. How old is the artifact? ($t_{1/2}$ for $^{14}\text{C}$ = 5700 years)

A. 45,600 years  
B. 17,100 years  
C. 700 years  
D. 1,900 years  
E. 11,400 years

**QUESTION 4**

The nuclear decay of $^{88}\text{Mo}$ is shown in the graph below. What is the rate constant for the decay?

A. 0.04 min$^{-1}$  
B. 0.05 min$^{-1}$  
C. 1.03 min$^{-1}$  
D. 0.09 min$^{-1}$  
E. 0.10 min$^{-1}$
QUESTION 5

The half-life of $^{239}$Pu is 24,000 years. What fraction of the $^{239}$Pu present in nuclear wastes generated in the year 2000 will be present in the year 3000?

A. 0.95
B. 0.92
C. 1.03
D. 0.97
E. 0.90

QUESTION 6

A rock contains 0.313 mg of $^{206}$Pb for each milligram of $^{238}$U. The half-life for the decay of $^{238}$U to $^{206}$Pb is $4.5 \times 10^9$ yr. How long ago was the rock formed?

A. $1.08 \times 10^9$ years
B. $1.39 \times 10^9$ years
C. $1.41 \times 10^9$ years
D. $1.56 \times 10^9$ years
E. $2.00 \times 10^9$ years

QUESTION 7

Potassium-40 decays to argon-40 with a half-life of $1.27 \times 10^9$ years. What is the age of a rock in which the mass ratio of argon-40 to potassium-40 is 3.6?

A. $-2.3 \times 10^9$ years
B. $2.8 \times 10^9$ years
C. $1.8 \times 10^9$ years
D. $1.2 \times 10^9$ years
E. $4.3 \times 10^9$ years

QUESTION 8

$^{36}$Cl is a $\beta$-emitter with a half-life of $3.00 \times 10^6$ yr. The $\beta$-activity of a sample of NaCl is 1.20 disintegrations per second. How many atoms of $^{36}$Cl are in the sample, assuming that $^{36}$Cl is the only source of $\beta$-decay?

A. $3.25 \times 10^{21}$
B. $9.81 \times 10^{17}$
C. $6.02 \times 10^{23}$
D. $1.64 \times 10^{13}$
E. 120

QUESTION 9

What is the mass defect in kilograms for the breaking of a single $^{21}$Ne nucleus into separated nucleons? (Masses: $^{21}$Ne = 20.98846 amu; $^1$H = 1.00728 amu; $^1$n = 1.00867 amu)

QUESTION 10

How much energy must be supplied to break a single $^6$Li nucleus into separated protons and neutrons? (Masses: $^6$Li = 6.01347 amu; $^1$H = 1.00728 amu; $^1$n = 1.00867 amu)

A. $3.09 \times 10^{12}$ J
B. $1.54 \times 10^{-3}$ J
C. $5.14 \times 10^{-9}$ J
D. $5.14 \times 10^{-12}$ J
E. $3.09 \times 10^{15}$ J
QUESTION 11

What is the binding energy of $^{60}_{27}$Co? The mass of a $^{60}_{27}$Co nucleus is 59.9338 amu.

A. $9.117 \times 10^{-28}$ J
B. $8.206 \times 10^{-11}$ J
C. $4.840 \times 10^{-13}$ J
D. $2.735 \times 10^{-19}$ J
E. $2.735 \times 10^{-16}$ J

QUESTION 12

The binding energy per nucleon of a U-238 nucleus is $1.21 \times 10^{-12}$ Joules. Is this nucleus more or less stable than a He-4 nucleus? The mass of a He-4 nucleus is 4.00150 amu.

QUESTION 13

Which of the following isotopes is most likely to undergo fusion?

A. Helium-4
B. Iron-56
C. Uranium-235
D. Uranium-238
E. Mendelevium-256

QUESTION 14

What is the final product of the nuclear disintegration series when Uranium-238 undergoes 5 alpha decay reactions and 2 beta decay reactions?

A. radon-226
B. lead-218
C. polonium-218
D. plutonium-244
E. radium-226

QUESTION 15

When $^{235}_{92}$U is bombarded with one neutron, fission occurs and the products are three neutrons, $^{94}_{36}$Kr and which other isotope?

A. $^{139}_{56}$Ba
B. $^{141}_{56}$Ba
C. $^{139}_{58}$Ce
D. $^{139}_{54}$Xe
E. $^{142}_{53}$I

QUESTION 16

Carbon-11 is used in medical imaging. The half-life of this radioisotope is 20.4 min. What percentage of a sample remains after 60.0 min?

A. 71.2 %
B. 5.28 %
C. 13.0 %
D. 34.0 %
E. 2.94 %
QUESTION 17

Which one of the following statements concerning the nuclear reactor is correct?

A. Pure $^{235}_{92}U$ is used as the fuel in the reactor.
B. If allowed to overheat, the reactor can explode like a nuclear bomb.
C. Water is never used as a coolant for the reactor core.
D. Heat is initially supplied to the reactor core to start the chain reaction.
E. The control rods present in the reactor absorb excess neutrons.