100 Nuclear Chemistry Questions (106 really, but who's counting?)

1. Which product of nuclear decay has mass but no charge?
   1. alpha particles 2. neutrons 3. gamma rays 4. beta positrons

2. Which type of emission has the highest penetrating power?
   1. alpha 2. beta 3. positron 4. gamma

3. Which radioisotope is a beta emitter? 1. Sr-90 2. Fr-220 3. K-37 4. U-218

4. An electron has a charge of
   1. -1 and the same mass as a proton
   2. +1 and the same mass as a proton
   3. -1 and a smaller mass than a proton
   4. +1 and a smaller mass than a proton

5. Which of these types of nuclear radiation has the greatest penetrating power?
   1. alpha 2. neutron 3. beta 4. gamma

6. Alpha particles and beta particles differ in
   1. mass, only 2. charge, only 3. both mass + charge 4. neither mass nor charge

7. The stability of an isotope is based on its
   1. number of neutrons, only
   2. number of protons, only
   3. ratio of neutrons to protons
   4. ratio of electrons to protons

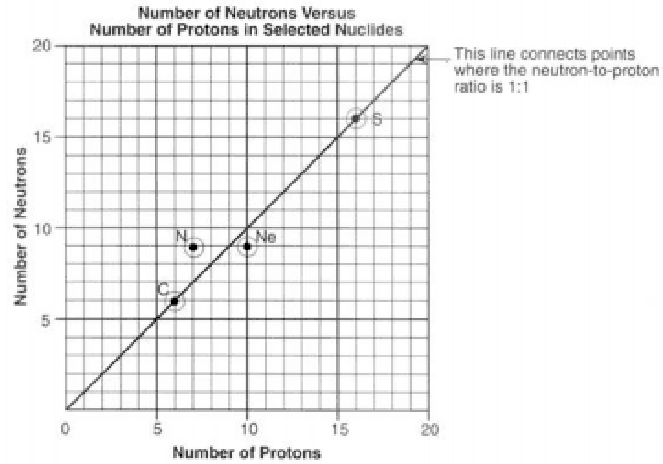
8. Which of these particles has the greatest mass? 1. alpha 2. beta 3. neutron 4. positron

9. Which of these types of radiation has the greatest penetrating power?
   1. alpha 2. beta 3. gamma 4. positron

10. Which statement best describes gamma radiation?
    1. It has a mass of 1 and a charge of 1.
    2. It has a mass of 0 and a charge of –1.
    3. It has a mass of 0 and a charge of 0.
    4. It has a mass of 4 and a charge of +2.

11. For most atoms with an atomic number less than 20, nuclear stability occurs when the ratio of neutrons to protons is 1:1. Which of the following atoms would be most likely to have an unstable nucleus? 1. 4-He 2. 12-C 3. 16-N 4. 24-Mg

Base your answers to questions 12 - 15 on the information at right, which relates the numbers of neutrons and protons for specific nuclides of C, N, Ne, and S.



12. Using the point plotted on the graph for neon, what is the neutron-to-proton ratio of this nuclide?

13. skip this one

14. Explain, in terms of atomic particles, why S-32 is a stable nuclide.

15. Using the point plotted on the graph for nitrogen, what is the neutron-to-proton ratio of this nuclide?

16. Exactly how much time must elapse before 16 grams of potassium-42 decays, leaving 2 grams of the original isotope?
    1. 8 x 12.4 hours 2. 2 x 12.4 hours 3. 3 x 12.4 hours 4. 4 x 12.4 hours

17. As a sample of the radioactive isotope 131-I decays, its half-life
    1. decreases 2. increases 3. remains the same 4. unknown

18. According to Reference Table N, which radioactive isotope will retain only one-eighth its original radioactive atoms after approximately 43 days?
    1. gold-198 2. iodine-131 3. phosphorus-32 4. radon-222

19. After 32 days, 5 milligrams of an 80-milligram sample of a radioactive isotope remains unchanged. What is the half-life of this element?
    1. 8 days 4. 2 days 3. 16 days 4. 4 days

20. Based on Reference Table N, what fraction of a sample of gold-198 remains radioactive after 2.69 days? 1. 1/4 2. 1/2 3. 3/4 4. 7/8

Base your answers to questions 21—23 on the reading passage below and on your knowledge of chemistry.

A Glow in the Dark, and Scientific Peril

The [Marie and Pierre] Curies set out to study radioactivity in 1898. Their first accomplishment was to show that radioactivity was a property of atoms themselves. Scientifically, that was the most important of their findings; because it helped other researchers refine their understanding of atomic structure.

More famous was their discovery of polonium and radium. Radium was the most radioactive substance the Curies had encountered. Its radioactivity is due to the large size of the atom, which makes the nucleus unstable and prone to decay, usually to radon and then lead, by emitting particles and energy as it seeks a more stable configuration.

Marie Curie struggled to purify radium for medical uses, including early radiation treatment for tumors. But radium's bluish glow caught people's fancy, and companies in the United States began mining it and selling it as a novelty: for glow-in-the-dark light pulls, for instance, and bogus cure-all patent medicines that actually killed people.

What makes radium so dangerous is that it forms chemical bonds in the same way as calcium, and the body can mistake it for calcium and absorb it into the bones. Then, it can bombard cells with radiation at close range, which may cause bone tumors or bone-marrow damage that can give rise to anemia or leukemia.

— Denise Grady, The New York Times, October 6, 1998

21. State one risk associated with the use of radium.

22. Using Reference Table N, complete the equation for the nuclear decay of 226-Ra. Include both atomic number and mass number for each particle.

23. Using information from the Periodic Table explain why radium forms chemical bonds in the same way as calcium does.

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24. If a scientist purifies 1.0 gram of radium-226, how many years must pass before only 0.50 gram of the original radium-226 sample remains unchanged?

25. Based on Reference Table N, what fraction of a radioactive 90-Sr sample would remain unchanged after 56.2 years? 1. 1/2 2. 1/4 3. 1/8 4. 1/16

26. What is the half-life and decay mode of Rn-222?
    1. 1.91 days and alpha decay
    2. 1.91 days and beta decay
    3. 3.82 days and alpha decay
    4. 3.82 days and beta decay

27. What is the half-life of sodium-25 if 1.00 gram of a 16.00-gram sample of sodium-25 remains unchanged after 237 seconds? 1. 47.4 s 2. 59.3 s 3. 79.0 s 4. 118 s

Radioactive Decay - Practice with Table N

Fill in atomic number, look up decay mode, write out isotope each nuclide transmutes into in last column.

#	Nuclide		Decay mode		Transmutes into
28	^{198}Au	$\rightarrow$		+	
29	^{37}Ca	$\rightarrow$		+	
30	^{222}Rn	$\rightarrow$		+	
31	^{85}Kr	$\rightarrow$		+	
32	^{131}I	$\rightarrow$		+	
33	^{220}Fr	$\rightarrow$		+	
34	^{19}Ne	$\rightarrow$		+	
35	^{53}Fe	$\rightarrow$		+	
36	^{233}U	$\rightarrow$		+	
37	^{235}U	$\rightarrow$		+	
38	^{3}H	$\rightarrow$		+	
39	^{60}Co	$\rightarrow$		+	

For each problem, write the decay reaction as shown in the example below.

	From a sentence like this	Write a decay reaction
Ex	The alpha decay of radon 198	$^{198}_{86}Rn \rightarrow ^{4}_{2}He + ^{194}_{84}Po$
40	The beta decay of uranium 237	
41	The positron emission from Si-26	
42	Polonium-214 undergoes alpha decay	
43	Es-253 emits an alpha particle	
44	Ar-37 transmutes into Cl-37	
45	Na-22 transmutes into neon-22	
46	Pm-142 transmutes into Nd-142	
47	Cs-137 transmutes into barium 137	
48	Strontium-90 undergoes beta decay	
49	Carbon-14 emits a beta particle	
50	Rn-222 and an alpha particle transmute from what radioisotope?	

51. Write the nuclear equation for the decay of Po-210 if it undergoes 2 consecutive alpha decays followed by a beta decay followed by another alpha decay.

52. Selenium-83 has a half-life of 25.0 minutes. How many minutes would it take for a 10.0 g sample to decay and have only 1.25 g of it remain?

53. Element-106 has a half-life of 0.90 seconds. If 1,000,000 atoms of it were prepared, how many atoms would remain after 4.5 seconds?

54. In which list can all particles be accelerated by an electric field?
1. alpha particles, beta particles, and neutrons
2. alpha particles, protons, and neutrons
3. alpha particles, beta particles, and protons
4. beta particles, protons, and neutrons

55. C-14 $\rightarrow$ N-14 + X   Which particle could be represented by the X?
1. alpha   2. beta   3. neutron   4. proton

56. Artificial transmutation is brought about by using accelerated particles to bombard an atom's
1. nucleus   2. valence shells   3. occupied sublevels   4. inner principal energy levels

57. The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called
1. natural transmutation
2. artificial transmutation
3. natural decay
4. radioactive decay

58. The spontaneous decay of an atom is called
(1) ionization   (2) crystallization   (3) combustion   (4) transmutation

59. Co-60 $\rightarrow \beta^-$ + Ni-60   This reaction is an example of
(1) fission   (2) fusion   (3) artificial transmutation   (4) natural transmutation

60. Given the nuclear equation: Cu-58 $\rightarrow$ Ni-58 + X   What nuclear particle is represented by X?

61. Neon-19 $\rightarrow$ X + Fluorine-19   What nuclear particle is represented by X?

62. Cs-137 $\rightarrow$ X + Ba-56   What nuclear particle is represented by X?

Artificial transmutation is when an isotope is forced to transmute because it's bombarded by another particle. Sometimes there is one product, often two or three.

	Artificial Transmutation	Plus what?
EX	$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + X$	X = $^{1}_{1}He$
63	$^{27}_{13}Al + ^{4}_{2}He \rightarrow X + ^{1}_{0}n$	X =
64	$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U \rightarrow ^{239}_{93}Np + X$	X =
65	$^{249}_{98}Cf + ^{18}_{8}O \rightarrow ^{263}_{106}Sg + 4X$	X =
66	$^{239}_{94}Pu + 2\,^{1}_{0}n \rightarrow ^{241}_{94}Pu \rightarrow ^{241}_{95}Np + X$	X =

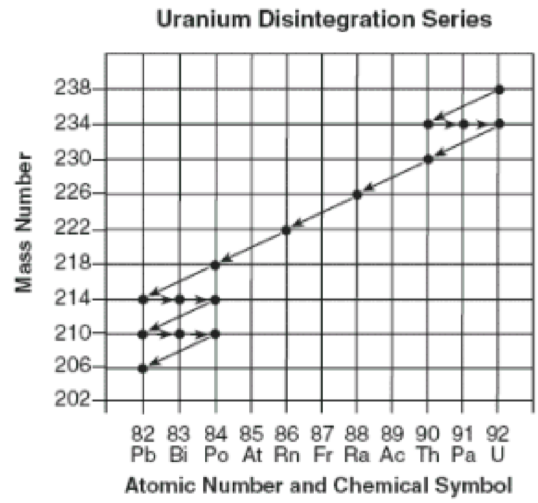
67. Positrons are spontaneously emitted from the nuclei of
    1. potassium-37 2. radium-226 3. nitrogen-16 4. thorium-232

68. According to Reference Table N, which pair of isotopes spontaneously decays?
    1. C-12 and N-14 2. C-12 and N-16 3. C-14 and N-14 4. C-14 and N-16

69. In a fusion reaction, reacting nuclei must collide. Collisions between two nuclei are difficult to achieve because the nuclei are
    1. both negatively charged and repel each other 2. oppositely charged and attract each other
    3. both positively charged and repel each other 4. oppositely charged and repel each other

70. During a fission reaction, which type of particle is captured by a nucleus?
    1. deuteron 2. electron 3. neutron 4. proton

A U-238 atom decays to a Pb-206 atom through a series of steps. Each point on the graph here represents a nuclide and each arrow represents a nuclear decay mode.



71. Based on this graph, what particle is emitted during the nuclear decay of a Po-218 atom?

72. Explain why the U-238 disintegration series ends with the nuclide Pb-206.

73. Given the reaction $^{2}H + ^{2}H \rightarrow ^{4}He$ + energy. The process is called
1. fission 2. fusion 3. artificial transmutation 4. alpha decay

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3\,^{1}_{0}n$$

74. The reaction at right can best be described as
1. nuclear fusion 2. nuclear fission 3. natural transmutation 4. decomposition

75. The sum of the masses of the products is slightly less than the sum of the masses of the reactants. Explain this loss of mass.

76. This process releases greater energy than an ordinary chemical reaction does. Name another type of nuclear reaction that releases greater energy than an ordinary chemical reaction.

77. Nuclear fusion differs from nuclear fission because nuclear fusion reactions
1. form heavier isotopes from lighter isotopes 2. form lighter isotopes from heavier isotopes
3. convert mass to energy 4. convert energy to mass

78. In a nuclear fusion reaction, the mass of the products is
1. less than the mass of the reactants because some of the mass has been converted to energy
2. less than the mass of the reactants because some of the energy has been converted to mass
3. more than the mass of the reactants because some of the mass has been converted to energy
4. more than the mass of the reactants because some of the energy has been converted to mass

79. Which change takes place in a nuclear fusion reaction?
1. Matter is converted to energy.
2. Ionic bonds are converted to covalent bonds.
3. Energy is converted to matter.
4. Covalent bonds are converted to ionic bonds.

80. Types of nuclear reactions include fission, fusion, and
1. single replacement 2. neutralization 3. oxidation-reduction 4. transmutation

81. State one possible advantage of using nuclear power instead of burning fossil fuels.

82. State one possible risk of using nuclear power.

83. If animals feed on plants that have taken up Sr-90, the Sr-90 can find its way into their bone structure. Explain one danger to the animals.

84. According to Table N, which radioactive isotope is best for determining the actual age of Earth?
1. U-238 2. Sr-90 3. Co-60 4. C-14

85. Which statement explains why nuclear waste materials may pose a problem?
1. They frequently have short half-lives and remain radioactive for brief periods of time.
2. They frequently have short half-lives and remain radioactive for extended periods of time.
3. They frequently have long half-lives and remain radioactive for brief periods of time.
4. They frequently have long half-lives and remain radioactive for extended periods of time.

In the 1920s, paint used to inscribe the numbers on watch dials was composed of a luminescent (glow-in-the-dark) mixture. The powdered-paint base was a mixture of radium salts and zinc sulfide. As the paint was mixed, the powdered base became airborne and drifted throughout the workroom causing the contents of the workroom, including the painters' clothes and bodies, to glow in the dark.

The paint is luminescent because radiation from the radium salts strikes a scintillator. A scintillator is a material that emits visible light in response to ionizing radiation. In watch-dial paint, zinc sulfide acts as the scintillator. Radium present in the radium salts decomposes spontaneously, emitting alpha particles. These particles can cause damage to the body when they enter human tissue.

Alpha particles are especially harmful to the blood, liver, lungs & spleen because they can alter genetic information in the cells. Radium can be deposited in the bones because it substitutes for calcium.

86. Write the notation for the alpha particles emitted by radium in the radium salts.

87. How can particles emitted from radioactive nuclei damage human tissue?

88. Why does radium substitute for calcium in bones?

Radioactivity at home

You may be surprised to learn that you do not need to visit a nuclear power plant or a hospital Xray laboratory to find sources of radioactivity. They are all around us. In fact, it is likely that you'll find a few at home. Your front porch may incorporate cinder blocks or granite blocks. Both contain uranium. Walk through the front door, look up, and you'll see a smoke detector that owes its effectiveness to the constant source of alpha particle emissions from Americium-241. As long as the gases remain ionized within the shielded container, electricity flows, and all is calm. When smoke enters the chamber, it neutralizes the charges on these ions. In the absence of these ions, the circuit breaks and the alarm goes off.

Indicator lights on your appliances may use Krypton-85; electric blankets, promethium-147; and fluorescent lights, thorium-229. Even the food we eat is radioactive. The more potassium-rich the food source, the more potassium-40 (a radioactive isotope that makes up about 0.01% of the natural supply of this mineral) is present. Thus, brazil nuts, peanuts, bananas, potatoes, and flour, all rich in potassium, are radiation sources.

—Chem Matters April 2000

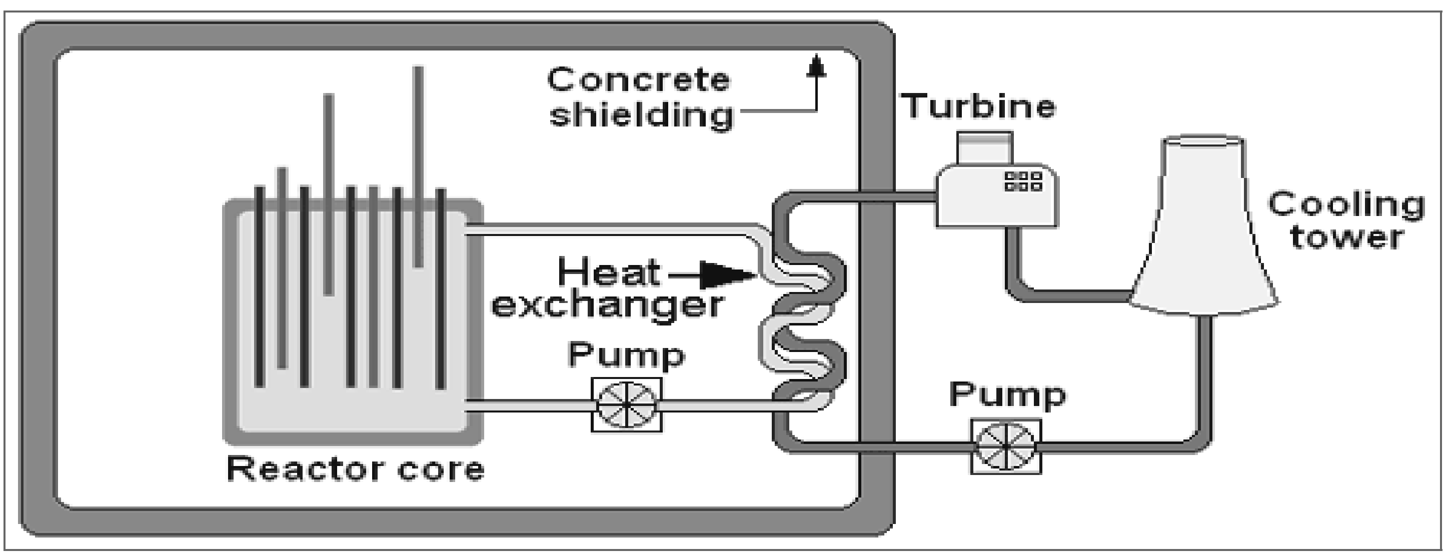
89. Write the equation for the alpha decay that occurs in a smoke detector containing Americium-241 (Am-241).

90. How is the radioactive decay of Krypton-85 different from the radioactive decay of Am-241?

91. State one benefit or useful application of radioactivity not mentioned in this article.

92. State one risk or danger associated with radioactivity.

93. Below is a diagram of a nuclear reactor. Describe in a full paragraph the reaction taking place in the core, the waste produced, why there are pipes both inside and outside the concrete shield, and what does a turbine do? What's with the 2 pumps? What's with the cooling tower, what does it do? If all works well, what are the only waste products released to the environment?



94. Cobalt-60 is used in medicine to deliver radiation, often used to treat some tumors. What is the half life of this radioisotope?

95. What sort of radiation is emitted by this element?

96. Of the types of radiation listed: alpha, beta, and gamma, which is strongest, which is weakest?

97. As far as penetrating power of these types of radiation, draw a diagram showing their relative penetrating power.

98. Explain in three or four sentences how radioactive carbon-14 dating works.

99. Why can't we date dinosaur fossils with carbon-14 but we can date frozen mastodons from the tundra of Asia

100. What is the name of the nuclear reaction that occurs inside of the Sun?

101. Why is it called "nuclear" chem anyway?

102. How can matter be created or destroyed in a nuclear reaction? What about that conservation of matter law?

103. What is the difference between natural and artificial transmutation?

104. Iodine-131 is used in diagnosing thyroid disorders. Explain how it's used, and why doesn't the exposure to this radioisotope pose a great danger to humans who are tested with it by injecting it into their veins?

105. When exposed to radioactive polonium you are at little risk unless you eat it. Why?

106. What techniques can be used to speed up, or slow down, or even to stop radioactive decay?