Nuclear Chemistry Practice Sheet

Using your knowledge of nuclear chemistry, write the equations for the following processes:

1)   The alpha decay of iridium-174

2)   The beta decay of platinum-199

3)   Positron emission from sulfur-31

4)   Krypton-76 undergoes electron capture

5)   Write the symbols for an alpha particle, beta particle, gamma ray, and positron.

6)   If the half-life for the radioactive decay of zirconium-84 is 26 minutes and I start with a 175 gram sample, how much will be left over after 104 minutes?

7)   Why is it difficult to make a fusion reaction occur?

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

2. Alpha particles are emitted during the radioactive decay of
   (1) carbon-14   (3) calcium-37
   (2) neon-19   (4) radon-222

3. Which reaction represents natural nuclear decay?
   (1) $H^+ + OH^- \rightarrow H_2O$
   (2) $KClO_3 \rightarrow K^+ + ClO_3^-$
   (3) $^{235}_{92}U \rightarrow {}^4_2He + {}^{231}_{90}Th$
   (4) $^{14}_7N + {}^4_2He \rightarrow {}^{17}_8O + {}^1_1H$
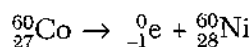
4. Which type of radiation is identical in mass and charge to a helium nucleus?
   (1) alpha   (3) positron
   (2) beta   (4) proton

5. When $^{226}_{88}Ra$ undergoes a natural transmutation reaction, it emits
   (1) an alpha particle   (3) a proton
   (2) a beta particle   (4) a neutron

6. Given the nuclear reaction:

   $$^{60}_{27}Co \rightarrow {}^0_{-1}e + {}^{60}_{28}Ni$$

   This reaction is an example of
   (1) fission
   (2) fusion
   (3) artificial transmutation
   (4) natural transmutation

7. When cobalt-60 undergoes nuclear decay, it emits
   (1) a positron   (3) a beta particle
   (2) a neutron   (4) an alpha particle

8. As ^{14}C decays to ^{14}N, the number of protons in the nucleus
   (1) decreases   (3) remains the same
   (2) increases

9. Which nuclear equation represents beta decay?
   (1) $^{27}_{13}Al + {}^4_2He \rightarrow {}^{30}_{15}P + {}^1_0n$
   (2) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^4_2He$
   (3) $^{14}_6C \rightarrow {}^{14}_7N + {}^0_{-1}e$
   (4) $^{37}_{18}Ar + {}^0_{-1}e \rightarrow {}^{37}_{17}Cl$

10. Which particle will be attracted to the positive electrode in an electric field?
    (1) an alpha particle   (3) a neutron
    (2) a beta particle   (4) a positron

11. Which type of radiation has *neither* mass nor charge?
    (1) gamma   (3) alpha
    (2) neutron   (4) beta

12. As a radioactive element emits gamma radiation only, the atomic number of the element
    (1) decreases   (3) remains the same
    (2) increases

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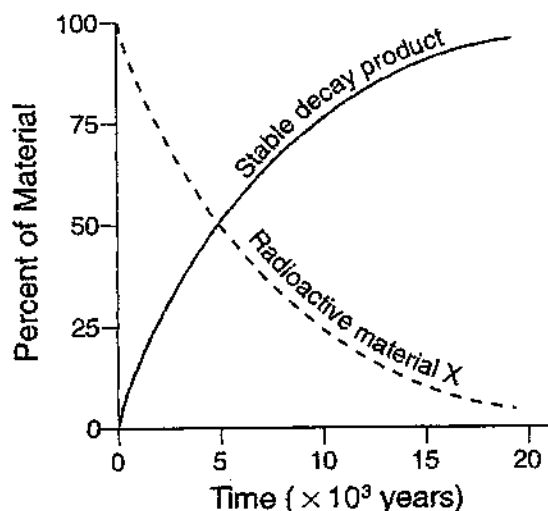   (1) 8 × 12.4 hours   (3) 3 × 12.4 hours
    (2) 2 × 12.4 hours   (4) 4 × 12.4 hours

14. The half-life of a radioactive substance is 2.5 minutes. What fraction of the original radioactive substance remains after 10 minutes?
    (1) $\dfrac{1}{2}$ (3) $\dfrac{1}{8}$
    (2) $\dfrac{1}{4}$ (4) $\dfrac{1}{16}$

Base your answers to questions **27** and **28** on on the graph below. The graph represents the decay of radioactive material X into a stable decay product.

Time ($\times 10^3$ years)

27. If radioactive material X were heated, the length of its half-life period would
    (1) decrease
    (2) increase
    (3) remain the same

28. Each of the objects below has different amounts remaining of the original radioactive material X. Which object is most likely the oldest?

(1)

Rock
10% of the radioactive material remains

(3)

Shell
41% of the radioactive material remains

(2)

Wood
33% of the radioactive material remains

(4)

Bone
52% of the radioactive material remains

29. Base your answer to the following question on the information below and on your knowledge of chemistry.

Nuclear Waste Storage Plan for Yucca Mountain

In 1978, the U.S. Department of Energy began a study of Yucca Mountain which is located 90 miles from Las Vegas, Nevada. The study was to determine if Yucca Mountain would be suitable for a long-term burial site for high-level radioactive waste. A threedimensional (3-D) computer scale model of the site was used to simulate the Yucca Mountain area. The computer model study for Yucca Mountain included such variables as: the possibility of earthquakes, predicted water flow through the mountain, increased rainfall due to climate changes, radioactive leakage from the waste containers, and increased temperatures from the buried waste within the containers.

The containers that will be used to store the radioactive waste are designed to last 10,000 years. Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed. Other isotopes found in the waste would decay more slowly, but are not powerful radioactive emitters.

In 1998, scientists discovered that the compressed volcanic ash making up Yucca Mountain was full of cracks. Because of the arid climate, scientists assumed that rainwater would move through the cracks at a slow rate. However, when radioactive chlorine-36 was found in rock samples at levels halfway through the mountain, it was clear that rainwater had moved quickly down through Yucca Mountain. It was only 50 years earlier when this chlorine-36 isotope had contaminated rainwater during atmospheric testing of the atom bomb.

Some opponents of the Yucca Mountain plan believe that the uncertainties related to the many variables of the computer model result in limited reliability of its predictions. However, advocates of the plan believe it is safer to replace the numerous existing radioactive burial sites around the United States with the one site at Yucca Mountain. Other opponents of the plan believe that transporting the radioactive waste to Yucca Mountain from the existing 131 burial sites creates too much danger to the United States. In 2002, after years of political debate, a final legislative vote approved the development of Yucca Mountain to replace the existing 131 burial sites.

Why is water flow a crucial factor in deciding whether Yucca Mountain is a suitable burial site?