Name ____________________ Date ______________ Class ______________

25 NUCLEAR CHEMISTRY

SECTION 25.1 NUCLEAR RADIATION (pages 799–802)

This section describes the nature of radioactivity and the process of radioactive decay. It characterizes alpha, beta, and gamma radiation in terms of composition and penetrating power.

▶ Radioactivity (pages 799–800)

1. Which French chemist noticed that uranium salts could fog photographic plates, even without being exposed to sunlight?

   ____

2. What name did Marie Curie give to the process by which materials give off rays capable of fogging photographic plates? ________________

3. An isotope that has an unstable nucleus is called a(n) ________________ .

4. Complete the table below to show basic differences between chemical and nuclear reactions.

Type of Reaction	Is Nucleus of Atom Changed?	Is Reaction Affected by Temperature, Pressure, or Catalysts?
Chemical		
Nuclear		

5. Complete the flowchart below, which describes the radioactive decay process.

The presence of too many or too few ________________ relative to protons leads to an unstable nucleus.

↓

At some point in time, an unstable nucleus will undergo a reaction and lose energy by emitting ________________ .

↓

During the process of radioactive decay, an ________________ radioisotope of one element is transformed eventually into a ________________ isotope of a different element.

▶ Types of Radiation (pages 800–802)

6. Complete the following table showing some characteristics of the main types of radiation commonly emitted during radioactive decay.

Type			
Consists of	2 protons and 2 neutrons	electron (or positron)	high-energy electromagnetic radiation
Mass (amu)			
Penetrating power (low, moderate, or high)			
Minimum shielding			

7. Look at Figure 25.2a on page 801. It shows the alpha decay of uranium-238 to thorium-234.

a. What is the change in atomic number after the alpha decay?

____

b. What is the change in mass number after the alpha decay?

____

8. When are radioisotopes that emit alpha particles dangerous to soft tissues?

____

9. Look at Figure 25.2b on page 801. This diagram shows the beta decay of carbon-14 to nitrogen-14.

a. What is the change in atomic number after the beta decay?

____

b. Which quantity changes in beta decay, the mass number or the charge of the nucleus? ______________________

10. Explain how gamma radiation is similar to visible light, and how it is different.

Similar: ____

Different: ____

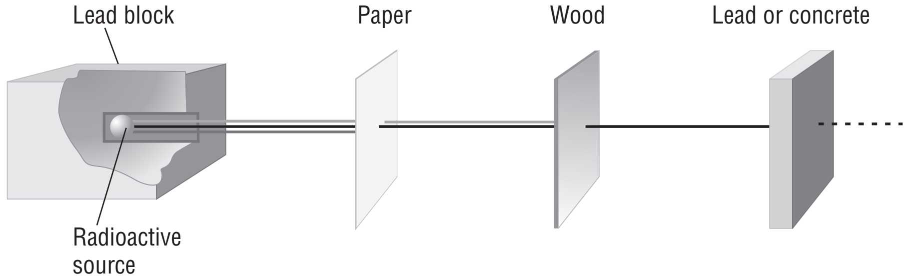
11. When are gamma rays emitted? ______________________________

____

Name ____________________________ Date ____________________ Class ____________________

12. Is the following sentence true or false? Gamma rays have no mass and no electrical charge. ______________________

13. Look at the diagram below. Below each material indicate with a checkmark which type of radiation—alpha, beta, or gamma—can be stopped by each material.



Paper	Wood	Lead or concrete
☐ alpha	☐ alpha	☐ alpha
☐ beta	☐ beta	☐ beta
☐ gamma	☐ gamma	☐ gamma

14. Is the following sentence true or false? X-rays are emitted during radioactive decay. ______________________

SECTION 25.2 NUCLEAR TRANSFORMATIONS (pages 803–808)

This section relates nuclear stability and decay to the ratio of neutrons to protons. It explains the use of half-life to measure the lifetime of unstable nuclei and gives examples of transmutations.

▶ Nuclear Stability and Decay (pages 803–804)

1. Of the more than 1500 different nuclei that are known to exist, about what portion are stable?

a. 1 of 10 **b.** 1 of 6 **c.** 1 of 3 **d.** 1 of 2

2. For small atomic numbers, stable nuclei have roughly ______________________ numbers of neutrons and protons.

3. Look at Figure 25.4 on page 803. How does the ratio of neutrons to protons for the stable nuclei change as atomic number increases from 1 to 82?

____

4. A positron has the mass of a(n) ______________________ but its charge is ______________________ .

Name ____________________ Date ______________ Class ______________

5. Complete the table below showing changes in charge and number of neutrons and protons for different types of nuclear decay.

Reason Nucleus Is Unstable	Type of Decay	Change in Nuclear Charge	Change in Number of Protons and Neutrons
Too many neutrons	Beta particle		
Too many protons	Electron capture		
Too many protons	Positron (Beta particle)		
Too many protons and neutrons	Alpha particle		

▶ Half-Life (pages 804–806)

6. What is half-life? ____

____

7. Look at Table 25.3 on page 805 to help you answer the following questions.

a. What is the half-life in years of carbon-14? ________________________

b. How many years old is an artifact that contains 50% of its original carbon-14? An artifact that contains 25% of its original carbon-14?

____

c. What radiation is emitted when potassium-40 decays?

____

d. What is the half-life of potassium-40? ____________________________

e. Which isotopes listed in Table 25.3 have a half-life similar to that of potassium-40? ____

Name ____________________ Date ______________ Class ______________

8. The decay reaction below shows how a radioactive form of potassium found in many minerals decays into argon (gas). Fill in the missing mass number and atomic number for the argon isotope that results from the decay of potassium-40.

$$^{40}_{19}\mathrm{K} + \, ^{0}_{-1}\mathrm{e} \longrightarrow \, ^{\square}_{\square}\mathrm{Ar}$$

▶ Transmutation Reactions (pages 807–808)

9. The conversion of an atom of one element to an atom of another element is called ______________ .

10. What are two ways transmutation can occur? ______________________________

____

11. Uranium-238 undergoes 14 transmutations before it reaches the stable isotope ______________ .

12. Is the following sentence true or false? All transuranium elements were synthesized in nuclear reactors and accelerators. ______________

Reading Skill Practice

By looking carefully at photographs and graphs in your textbook, you help yourself understand what you have read. Look carefully at Figure 25.5 on page 804. What important idea does this graph communicate? If you were to extend the curve indefinitely, would the percent of radioisotope remaining ever cross 0%? Why or why not? Do your work on a separate sheet of paper.

Name ____________________ Date ______________ Class ______________

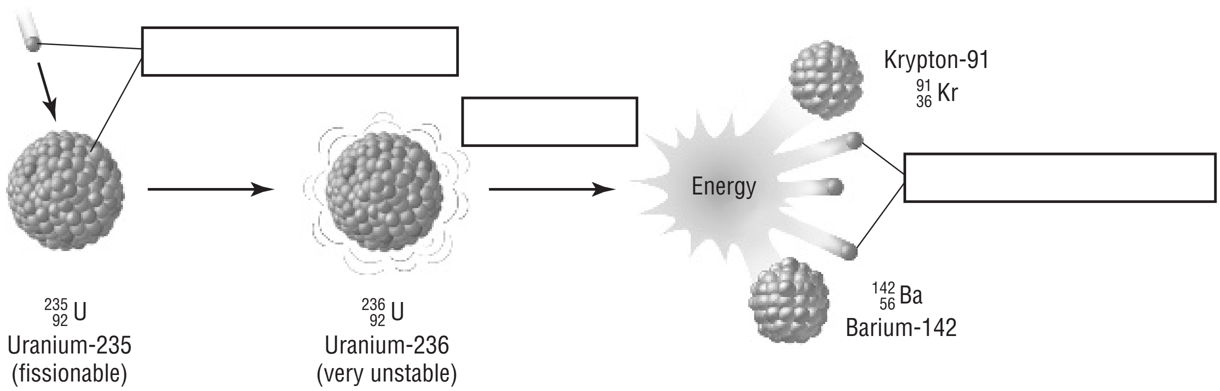
SECTION 25.3 FISSION AND FUSION OF ATOMIC NUCLEI (pages 810–813)

This section describes nuclear fission and nuclear fusion. It discusses their potential as sources of energy, methods used to control them, and issues involved in containment of nuclear waste.

▶ Nuclear Fission (pages 810–811)

1. When certain heavy isotopes are bombarded with ____________________, they split into smaller fragments.

2. Use the following labels to complete the diagram below: *fission, fission fragments,* and *neutrons/chain reaction.*



3. The uncontrolled fission of 1 kg of uranium-235 can release energy equal to

____________________ tons of dynamite.

4. Look at Figure 25.11 on page 811. This figure shows the basic components of a nuclear power reactor.

   a. What part of the reactor contains the nuclear fuel?

   ____

   b. What are the two parts of the reactor that control the fission reaction, one by reducing the speed of neutrons, the other by absorbing neutrons?

   ____

   c. What is the role of the coolant? ______________________________

   ____

Name ______________________ Date ________________ Class ________________

▶ Nuclear Waste (page 812)

5. Which parts of a nuclear reactor must be removed and replaced periodically?

____

6. Look at Figure 25.12 on page 812. Where are spent fuel rods stored in a typical nuclear power plant?

____

▶ Nuclear Fusion (page 813)

7. Look at Figure 25.13 on page 813. What happens to each pair of hydrogen nuclei during nuclear fusion?

____

____

8. What problem has prevented the practical use of nuclear fusion?

____

____

SECTION 25.4 RADIATION IN YOUR LIFE (pages 816–819)

This section explains three methods of detecting radiation and describes applications of radioisotopes in medicine and research.

▶ Detecting Radiation (page 816–817)

1. Why are beta particles called ionizing radiation? ________________________

____

2. A device that detects flashes of light after ionizing radiation strikes a specially coated phosphor surface is called a ________________________ .

▶ Using Radiation (pages 818–819)

3. How is neutron activation analysis used?

____

4. Look at Figure 25.15 on page 819. How is radioactive iodine-131 being used as a diagnostic tool? ________________________________

____

Name ____________________ Date ______________ Class ______________

GUIDED PRACTICE PROBLEMS

GUIDED PRACTICE PROBLEM 7 (page 806)

7. Manganese-56 is a beta emitter with a half-life of 2.6 h. What is the mass of manganese-56 in a 1.0-mg sample of the isotope at the end of 10.4 h?

Analyze

Step 1. What are the known values?

____

Step 2. How many half-lives have passed during the elapsed time?

$$\text{Number of half-lives} = \frac{\text{elapsed time}}{t_{1/2}} = \frac{\boxed{}}{2.6\ \text{h/half-life}} = \boxed{}\ \text{half-lives}$$

Solve

Step 3. Multiply the initial mass by $\frac{1}{2}$ for each half-life.

1.0 mg × ______________ = ____________ mg Mn-56

Evaluate

Step 4. How do you know your answer is correct? ____________________

____

EXTRA PRACTICE (similar to Practice Problem 7, page 806)

7. Iodine-126 is a beta emitter with a half-life of 13 days. What is the mass of iodine-126 in a 8.0-mg sample of the isotope at the end of 39 days?

GUIDED PRACTICE PROBLEM 8 (page 806)

8. A sample of thorium-234 has a half-life of 24.1 days. Will all the thorium undergo radioactive decay in 48.2 days? Explain.

Step 1. How many half-lives have passed in 50 days?

$$\frac{48.2\ \text{days}}{\boxed{}} = \boxed{}\ \text{half-lives}$$

____

Step 2. What fraction of the thorium will remain after 50 days?

____

Step 3. Will all the thorium decay in 50 days? Explain.

____