CHAPTER 21 REVIEW

Nuclear Chemistry

SECTION 1

SHORT ANSWER Answer the following questions in the space provided.

1. _____ Based on the information about the three elementary particles in the text, which has the greatest mass?
   (a) the proton
   (b) the neutron
   (c) the electron
   (d) They all have the same mass.

2. _____ The force that keeps nucleons together is
   (a) a strong nuclear force.
   (b) a weak nuclear force.
   (c) an electromagnetic force.
   (d) a gravitational force.

3. _____ The stability of a nucleus is most affected by the
   (a) number of neutrons.
   (b) number of protons.
   (c) number of electrons.
   (d) ratio of neutrons to protons.

4. _____ If an atom should form from its constituent particles,
   (a) matter is lost and energy is taken in.
   (b) matter is lost and energy is released.
   (c) matter is gained and energy is taken in.
   (d) matter is gained and energy is released.

5. _____ For atoms of a given mass number, those with greater mass defects, have
   (a) smaller binding energies per nucleon.
   (b) greater binding energies per nucleon.
   (c) the same binding energies per nucleon as those with smaller mass defects.
   (d) variable binding energies per nucleon.

6. Based on Figure 1.1 of the text, which isotope of He, helium-3 or helium-4,
   ________________  a. has the smaller binding energy per nucleon?
   ________________  b. is more stable to nuclear changes?

7. The number of neutrons in an atom of magnesium-25 is _____.

8. Nuclides of the same element have the same ________________.
SECTION 1 continued

9. Atom X has 50 nucleons and a binding energy of $4.2 \times 10^{-11}$ J. Atom Z has 80 nucleons and a binding energy of $8.4 \times 10^{-11}$ J.

__________________ a. The mass defect of Z is twice that of X. True or False?

__________________ b. Which atom has the greater binding energy per nucleon?

__________________ c. Which atom is likely to be more stable to nuclear transmutations?

10. Identify the missing term in each of the following nuclear equations. Write the element’s symbol, its atomic number, and its mass number.

__________________ a. $^{14}_6\text{C} \rightarrow ^0_1\text{e} + ____$

__________________ b. $^{63}_{29}\text{Cu} + ^1_1\text{H} \rightarrow ____ + ^4_2\text{He}$

11. Write the equation that shows the equivalency of mass and energy.

12. Consider the two nuclides $^{56}_{26}\text{Fe}$ and $^{14}_6\text{C}$.

   a. Determine the number of protons in each nucleus.

   b. Determine the number of neutrons in each nucleus.

   c. Determine whether the $^{56}_{26}\text{Fe}$ nuclide is likely to be stable or unstable, based on its position in the band of stability shown in Figure 1.2 of the text.

PROBLEM Write the answer on the line to the left. Show all your work in the space provided.

13. _________________ Neon-20 is a stable isotope of neon. Its actual mass has been found to be 19.992 44 u. Determine the mass defect in this nuclide.
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**Nuclear Chemistry**

**SECTION 2**

**SHORT ANSWER** Answer the following questions in the space provided.

1. _____ The nuclear equation \( ^{210}_{84}\text{Po} \rightarrow ^{206}_{82}\text{Pb} + ^{4}_{2}\text{He} \) is an example of an equation that represents
   (a) alpha emission.
   (b) beta emission.
   (c) positron emission.
   (d) electron capture.

2. _____ When \( ^{8}_{6}Z \) undergoes electron capture to form a new element X, which of the following best represents the product formed?
   (a) \( ^{a-1}_{b}X \)
   (b) \( ^{a+1}_{b}X \)
   (c) \( ^{a}_{b+1}X \)
   (d) \( ^{a}_{b-1}X \)

3. _____ Which of the following best represents the fraction of a radioactive sample that remains after four half-lives have occurred?
   (a) \( \left( \frac{1}{2} \right)^{4} \)
   (b) \( \left( \frac{1}{2} \right)^{4} \times 4 \)
   (c) \( \frac{1}{4} \)
   (d) \( \left( \frac{1}{2} \right)^{2} \times 4 \)

4. Match the nuclear symbol on the right to the name of the corresponding particle on the left.
   _____ beta particle
   _____ proton
   _____ positron
   _____ alpha particle
   (a) \( ^{1}_{0}\text{p} \)
   (b) \( ^{4}_{2}\text{He} \)
   (c) \( ^{0}_{-1}\text{B} \)
   (d) \( ^{0}_{+1}\text{B} \)

5. Label each of the following statements as True or False. Consider the U-238 decay series in Figure 2.7 of the text. For the series of decays from U-234 to Po-218, each nuclide
   a. shares the same atomic number
   b. differs in mass number from others by multiples of 4
   c. has a unique atomic number
   d. differs in atomic number from others by multiples of 4
SECTION 2 continued

6. ________________ Identify the missing term in the following nuclear equation. Write the element’s symbol, its atomic number, and its mass number.

\[ ? \rightarrow {}_{90}^{231}{\text{Th}} + {}_{2}^{4}{\text{He}} \]

7. Lead-210 undergoes beta emission. Write the nuclear equation showing this transmutation.

8. Einsteinium is a transuranium element. Einsteinium-247 can be prepared by bombarding uranium-238 with nitrogen-14 nuclei, releasing several neutrons, as shown by the following equation:

\[ {}_{92}^{238}{\text{U}} + {}_{7}^{14}{\text{N}} \rightarrow {}_{99}^{247}{\text{Es}} + {}_{0}^{1}n \]

What must be the value of x in the above equation? Explain your reasoning.

PROBLEMS Write the answer on the line to the left. Show all your work in the space provided.

9. ________________ Phosphorus-32 has a half-life of 14.3 days. How many days will it take for a sample of phosphorus-32 to decay to one-eighth its original amount?

10. ________________ Iodine-131 has a half-life of 8.0 days. How many grams of an original 160 mg sample will remain after 40 days?

11. ________________ Carbon-14 has a half-life of 5715 years. It is used to determine the age of ancient objects. If a sample today contains 0.060 mg of carbon-14, how much carbon-14 must have been present in the sample 11430 years ago?
CHAPTER 21 REVIEW

Nuclear Chemistry

SECTION 3

SHORT ANSWER Answer the following questions in the space provided.

1. The radioisotope cobalt-60 is used for all of the following applications except
   (a) killing food-spoiling bacteria. (c) treating heart disease.
   (b) preserving food. (d) treating certain kinds of cancers.

2. All of the following contribute to background radiation exposure except
   (a) radon in homes and buildings.
   (b) cosmic rays passing through the atmosphere.
   (c) consumption of irradiated foods.
   (d) minerals in Earth’s crust.

3. Which one of the graphs shown below best illustrates the decay of a sample of carbon-14? Assume each division on the time axis represents 5715 years.

![Graphs](image_url)
4. Match the item on the left with its description on the right.

- _____ Geiger-Müller counter
- _____ scintillation counter
- _____ film badge
- _____ radioactive tracers

  (a) device that uses film to measure the approximate radiation exposure of people working with radiation
  (b) instrument that converts scintillating light to an electric signal for detecting radiation
  (c) meter that detects radiation by counting electric pulses carried by gas ionized by radiation
  (d) radioactive atoms that are incorporated into substances so that movement of the substances can be followed by detectors

5. Which type of radiation is easiest to shield? Why?

__________________________________________________________________________

6. One technique for dating ancient rocks involves uranium-235, which has a half-life of 710 million years. Rocks originally rich in uranium-235 will contain small amounts of its decay series, including the nonradioactive lead-206. Explain the relationship between a sample’s relative age and the ratio of lead-206 to uranium-235 in the sample.

__________________________________________________________________________

PROBLEMS Write the answer on the line to the left. Show all your work in the space provided.

7. ____________________ The technetium-99 isotope has a half-life of 6.0 h. If a 100. mg sample of technetium-99 were injected into a patient, how many milligrams would still be present after 24 h?

8. ____________________ A Geiger-Müller counter, used to detect radioactivity, registers 14 units when exposed to a radioactive isotope. What would the counter read, in units, if that same isotope is detected 60 days later? The half-life of the isotope is 30 days.
SECTION 4

SHORT ANSWER Answer the following questions in the space provided.

1. Match each of the following statements with the process(es) to which they apply, using one of the choices below:

   (1) fission only       (3) both fission and fusion
   (2) fusion only        (4) neither fission nor fusion

   _____ a. A very large nucleus splits into smaller pieces.
   _____ b. The total mass before a reaction is greater than the mass after a reaction.
   _____ c. The rate of a reaction can be safely controlled for energy generation in suitable vessels.
   _____ d. Two small nuclei form a single larger one.
   _____ e. Less-stable nuclei are converted to more-stable nuclei.

2. Match the reaction type on the right to the statement(s) that applies to it on the left.

   _____ It requires very high temperatures.       (a) uncontrolled fusion
   _____ It is used in nuclear reactors to make electricity.       (b) uncontrolled fission
   _____ It occurs in the sun and other stars.       (c) controlled fusion
   _____ It is used in atomic bombs.       (d) controlled fission

3. Match the component of a nuclear power plant on the right to its use on the left.

   _____ limits the number of free neutrons       (a) moderator
   _____ is used to slow down neutrons       (b) fuel rod
   _____ drives an electric generator       (c) control rod
   _____ provides neutrons by its fission       (d) shielding
   _____ removes heat from the system safely       (e) coolant
   _____ prevents escape of radiation       (f) turbine

4. _____ A chain reaction is any reaction in which
   (a) excess reactant is present.       (c) the rate is slow.
   (b) the material that starts the reaction is also a product.       (d) many steps are involved.
SECTION 4 continued

5. As a star ages, does the ratio of He atoms to H atoms in its composition become larger, smaller, or remain constant? Explain your answer.

_______________________________________________________________
_______________________________________________________________
_______________________________________________________________
_______________________________________________________________

6. The products of nuclear fission are variable; many possible nuclides can be created. In the feature “An Unexpected Finding,” in the text, it was noted that Meitner showed radioactive barium to be one product of fission. Following is an incomplete possible nuclear equation for the production of barium-141:

\[
\frac{235}{92} U + \frac{1}{0} n \rightarrow \frac{141}{56} Ba + ? + 4 \frac{1}{0} n + \text{energy}
\]

__________________  a. Determine the missing fission product formed. Write the element’s symbol, its atomic number, and its mass number.

__________________  b. Is it likely that this isotope in part a is unstable?

7. Small nuclides can undergo fusion.

__________________  a. Complete the following nuclear equation by identifying the missing term. Write the element’s symbol, its atomic number, and its mass number.

\[ \frac{3}{1} H + \frac{7}{3} Li \rightarrow ? + \text{energy} \]

b. When measured exactly, the total mass of the reactants does not add up to that of the products in the reaction represented in part a. Why is there a difference between the mass of the products and the mass of the reactants? Which has the greater mass, the reactants or the products?

_______________________________________________________________
_______________________________________________________________
_______________________________________________________________

8. What are some current concerns regarding development of nuclear power plants?

_______________________________________________________________
_______________________________________________________________
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_______________________________________________________________

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