Name _____ Date _____ Period _____

Nuclear Chemistry Review

Multiple Choice: *Identify the choice that best completes the statement or answers the question.*

A 1. In nuclear chemistry, an atom is referred to as a(n)
   a. nuclide. c. nucleus.
   b. nucleon. d. alpha particle.

A 2. Between protons in a nucleus,
   a. attraction due to nuclear force is greater than repulsion due to electrostatic force.
   b. repulsion due to electrostatic force is greater than attraction due to nuclear force.
   c. nuclear and electrostatic forces are balanced.
   d. electrostatic forces are negligible.

D 3. Reactions that affect the nucleus of an atom are called
   a. fusions. c. radioactive decays.
   b. fissions. d. nuclear reactions.

D 4. The process that changes the identity and number of protons in a nucleus is
   a. fusion. c. fission.
   b. transmutation. d. All of the above

D 5. The energy released in a nuclear reaction comes from
   a. electrons. c. positrons.
   b. bonds. d. the binding energy of the nucleus.

A 6. During radioactive decay, the nucleus disintegrates into
   a. a lighter and more stable nucleus. c. a lighter and less stable nucleus.
   b. a heavier and more stable nucleus. d. a heavier and less stable nucleus.

C 7. Which of the following processes always decreases the number of protons by an even number?
   a. fusion c. alpha decay
   b. beta decay d. fission

A 8. Beta particles are
   a. electrons. c. electromagnetic waves.
   b. helium nuclei. d. neutrons.

C 9. Gamma rays are
   a. electrons. c. electromagnetic waves.
   b. helium nuclei. d. neutrons.

A 10. The half-life of an isotope is the time required for half the nuclei in a sample to
   a. undergo radioactive decay. c. undergo nuclear fusion.
   b. undergo nuclear fission. d. react chemically.

B 11. Which is *not* a parent nuclide?
   a. uranium-238 c. uranium-235
   b. lead-206 d. thorium-232

C 12. Artificial radioactive nuclides are
   a. found naturally in space. c. not found naturally on Earth.
   b. found naturally on Earth. d. nonexistent.

C 13. How are elements artificially transmuted?
   a. Stable nuclei are bombarded with charged particles.
   b. Stable nuclei are bombarded with uncharged particles.
   c. Stable nuclei are bombarded with charged and uncharged particles.
   d. Unstable nuclei are bombarded with charged and uncharged particles.

D 14. In an artificial transmutation, what is required to bombard nuclei with positively charged alpha particles, protons, and other ions?
   a. great quantities of energy c. a particle accelerator
   b. small quantities of energy d. Both (a) and (c)

D 15. Some artificial radioactive isotopes can be prepared by bombarding stable nuclei with
   a. alpha particles. c. protons.
   b. beta particles. d. All of the above

C 16. Which of the following travels fastest?
   a. alpha particles c. gamma rays
   b. beta particles d. All travel at the same speed.

B 17. What unit measures radiation damage to human tissue?
   a. roentgen c. rad
   b. rem d. half-life

A 18. One rem is the quantity of ionizing radiation that does as much damage to human tissue as is done by
   a. 1 roentgen of high-voltage X rays.
   b. 100 roentgens of high-voltage X rays.
   c. 1 roentgen of low-voltage X rays.
   d. the radioactive decay of 1 kg of uranium-235.

34. ANS:

mass defect = 4(mass of proton) + 5(mass of neutron) − mass of nuclide
= 4(1.007 276 47 amu) + 5(1.008 664 90 amu) − 9.012 182 24 amu
= 4.029 105 88 amu + 5.043 324 50 amu − 9.012 182 24 amu
= 9.072 130 38 amu − 9.012 182 24 amu

mass defect = 0.059 948 14 amu

binding energy/nucleon = (0.059 948 14 amu)(1.6605 × 10^{-27} kg/amu) = 9.9594 × 10^{-29} kg

(9.9594 × 10^{-29} kg)(3 × 10^{8} m/s)^2 / 9 nucleons = 8.96 × 10^{-13} J/nucleon

binding energy/nucleon = 8.96 × 10^{-13} J/nucleon

35. ANS:

a. $^{226}_{88}\text{Ra} \rightarrow {}^{4}_{2}\text{He} + {}^{222}_{86}\text{Rn}$

b. $^{39}_{17}\text{Cl} \rightarrow {}^{0}_{-1}e + {}^{39}_{18}\text{Ar}$

c. $^{38}_{15}\text{P} \rightarrow {}^{0}_{+1}e + {}^{38}_{14}\text{Si}$

36. ANS:
0.125 mg
Solution:

$$7.15 \text{ days} \times \frac{1 \text{ half-life}}{14.3 \text{ days}} = 5 \text{ half-lives}$$

$$4.00 \text{ mg} \times \left(\frac{1}{2}\right)^5 = 0.125 \text{ mg}$$

37. ANS: half-life = 4.67 days
Solution:

$$\text{fraction of original} = \frac{31.25 \text{ g}}{250.0 \text{ g}}$$

$$= 0.125 \text{ or } \frac{1}{8}$$

x = the number of half-lives

$$\left(\frac{1}{2}\right)^x = \frac{1}{8},\ x = 3$$

2.00 weeks = 3 half-lives

$$\frac{2.00 \text{ weeks}}{3 \text{ half-lives}} = \frac{0.667 \text{ weeks}}{\text{half-life}} \times \frac{7 \text{ days}}{\text{week}} = 4.67 \text{ days}$$

B 19. How are the definitions of rem and roentgen related?
   a. The definition of roentgen depends on the rem.
   b. The definition of rem depends on the roentgen.
   c. Both are based on damage to human tissue.
   d. They are not related.

D 20. Which of the following does *not* detect radiation?
   a. film badges
   b. Geiger-Müller counters
   c. scintillation counters
   d. radioactive tracers

B 21. To use radioactive dating for a substance, you must know the substance's
   a. melting point.
   b. half-life.
   c. rate of weathering or erosion.
   d. enthalpy of reaction.

B 22. Which statement about nuclear reactions is *not* true?
   a. Nuclear power plants use fission of uranium.
   b. In fission, the total mass of the reactants equals the total mass of the products.
   c. In fission, nuclei are split, and in fusion, nuclei are combined.
   d. Heat and light in the sun are produced by hydrogen fusion reactions.

D 23. Which of the following is a fusion reaction?
   a. uranium-235 absorbing a neutron and splitting into xenon-140, strontium-94, and two neutrons
   b. hydrochloric acid combining with sodium hydroxide to form NaCl and water
   c. carbon-14 decaying into nitrogen-14 and a beta particle
   d. curium-246 combining with carbon-12 to form nobelium-254 and four neutrons

A 24. The energy as heat produced by a reactor is used to
   a. boil water for steam turbines.
   b. melt metal.
   c. produce graphite.
   d. produce coal.

A 25. At present, fusion reactions
   a. cannot be used to produce energy in reactors.
   b. produce the energy in some nuclear power plants.
   c. produce the energy in most nuclear power plants.
   d. produce the energy in all recent nuclear power plants.

Short Answer: Answer on a separate piece of paper

26. Compare fusion, fission, and transmutation?
27. Briefly describe alpha particles, beta particles, and gamma rays.
28. Explain how a chain reaction occurs.

SHORT ANSWER

26. ANS:
In a transmutation, the identity of a nucleus changes because its number of protons changes. Fission and fusion are two processes that change the number of protons. In fission, a heavy nucleus breaks up, decreasing the number of protons. In fusion, light nuclei join, increasing the number of protons.

27. ANS:
Alpha particles are helium nuclei that are emitted from heavy elements. Beta particles are high-energy electrons emitted from nuclei when neutrons become protons. Gamma rays are high-energy electromagnetic waves.

28. ANS:
Neutrons produced by a nuclear reaction can initiate the same reaction in surrounding nuclides, producing more neutrons to initiate more reactions.

Completion: *Complete each statement.*

29. A nucleus of an atom with a specific number of protons and neutrons is called a(n) nuclide.
30. The nuclide $^{125}_{53}I$ contains 53 protons.
31. The difference between the sum of the individual masses of the protons, neutrons, and electrons in an atom and the mass of the atom is called mass defect
32. The critical mass is the minimum mass of a fissionable isotope that provides the number of neutrons needed to sustain a(n) chain reaction
33. The splitting of the nucleus of a large atom into two or more fragments is called nuclear fission.

Problem: Show all work for each problem and calculation → Label all units!

34. Calculate the mass defect and the binding energy/nucleon of the nuclide $^{9}_{4}Be$, which has a mass of 9.012 182 24 amu. The mass of a proton is 1.007 276 47 amu and the mass of a neutron is 1.008 664 90. One amu = 1.6605×10^{-27} kg and the speed of light is 3.00×10^{8} m/s.
35. Write the nuclear equation for each of the following reactions. Refer to a periodic table.
   a. the alpha decay of $^{226}_{88}Ra$
   b. the beta decay of $^{39}_{17}Cl$
   c. the positron emission of $^{30}_{15}P$
36. Phosphorus-32 has a half-life of 14.3 days. How many milligrams of phosphorus-32 remain after 71.5 days if you start with 4.00 mg of the isotope?
37. What is the half-life of an isotope if after 2.00 weeks you have 31.25 g remaining from a 250.0 g starting sample size?

Essay — answer on a separate paper

38. Explain the process of radioactive dating.
39. Compare and contrast a nuclear power plant and a nuclear bomb
40. What is the half-life of a radioisotope?

ESSAY

38. ANS:
The radioactive isotopes in a material decay over time. If the half-life of an isotope and the original amount of the isotope are known, the age of the material containing the isotope can be estimated.

39. ANS:
A nuclear power plant is designed to control the nuclear reaction. A nuclear bomb is designed to cause an uncontrolled nuclear reaction. Power plants and uranium bombs both use fission.

40. ANS:
No two radioactive isotopes decay at the same rate. Half-life is the time required for half the atoms of a radioactive nuclide to decay. This is a cycle that will continue until the amount of the radioisotope is negligible. More stable nuclides decay slowly and have longer half-lives. Less-stable nuclides decay very quickly and have shorter half-lives, sometimes just a fraction of a second.