**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_**

**Nuclear Chemistry Review**

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

\_\_\_\_ 1. In nuclear chemistry, an atom is referred to as a(n)

|  |  |  |  |
| --- | --- | --- | --- |
| a. | nuclide. | c. | nucleus. |
| b. | nucleon. | d. | alpha particle. |

\_\_\_\_ 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. |

\_\_\_\_ 3. Reactions that affect the nucleus of an atom are called

|  |  |  |  |
| --- | --- | --- | --- |
| a. | fusions. | c. | radioactive decays. |
| b. | fissions. | d. | nuclear reactions. |

\_\_\_\_ 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 |

\_\_\_\_ 5. The energy released in a nuclear reaction comes from

|  |  |  |  |
| --- | --- | --- | --- |
| a. | electrons. | c. | positrons. |
| b. | bonds. | d. | the binding energy of the nucleus. |

\_\_\_\_ 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. |

\_\_\_\_ 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 |

\_\_\_\_ 8. Beta particles are

|  |  |  |  |
| --- | --- | --- | --- |
| a. | electrons. | c. | electromagnetic waves. |
| b. | helium nuclei. | d. | neutrons. |

\_\_\_\_ 9. Gamma rays are

|  |  |  |  |
| --- | --- | --- | --- |
| a. | electrons. | c. | electromagnetic waves. |
| b. | helium nuclei. | d. | neutrons. |

\_\_\_\_ 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. |

\_\_\_\_ 11. Which is *not* a parent nuclide?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | uranium-238 | c. | uranium-235 |
| b. | lead-206 | d. | thorium-232 |

\_\_\_\_ 12. Artificial radioactive nuclides are

|  |  |  |  |
| --- | --- | --- | --- |
| a. | found naturally in space. | c. | not found naturally on Earth. |
| b. | found naturally on Earth. | d. | nonexistent. |

\_\_\_\_ 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. |

\_\_\_\_ 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) |

\_\_\_\_ 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 |

\_\_\_\_ 16. Which of the following travels fastest?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | alpha particles | c. | gamma rays |
| b. | beta particles | d. | All travel at the same speed. |

\_\_\_\_ 17. What unit measures radiation damage to human tissue?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | roentgen | c. | rad |
| b. | rem | d. | half-life |

\_\_\_\_ 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. |

\_\_\_\_ 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. |

\_\_\_\_ 20. Which of the following does *not* detect radiation?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | film badges | c. | scintillation counters |
| b. | Geiger-Müller counters | d. | radioactive tracers |

\_\_\_\_ 21. To use radioactive dating for a substance, you must know the substance's

|  |  |  |  |
| --- | --- | --- | --- |
| a. | melting point. | c. | rate of weathering or erosion. |
| b. | half-life. | d. | enthalpy of reaction. |

\_\_\_\_ 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. |

\_\_\_\_ 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 |

\_\_\_\_ 24. The energy as heat produced by a reactor is used to

|  |  |  |  |
| --- | --- | --- | --- |
| a. | boil water for steam turbines. | c. | produce graphite. |
| b. | melt metal. | d. | produce coal. |

\_\_\_\_ 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.

Completion: *Complete each statement.*

 29. A nucleus of an atom with a specific number of protons and neutrons is called a(n) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

 30. The nuclide  contains \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 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 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

 32. The critical mass is the minimum mass of a fissionable isotope that provides the number of neutrons needed to sustain a(n) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

 33. The splitting of the nucleus of a large atom into two or more fragments is called nuclear \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**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 , 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  108 m/s.

 35. Write the nuclear equation for each of the following reactions. Refer to a periodic table.

a. the alpha decay of 

b. the beta decay of 

c. the positron emission of 

 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?

**Nuclear Chemistry Review🡪 Answer Section**

**MULTIPLE CHOICE**

 1. ANS: A

 2. ANS: A

 3. ANS: D

 4. ANS: D

 5. ANS: D

 6. ANS: A

 7. ANS: C

 8. ANS: A

 9. ANS: C

 10. ANS: A

 11. ANS: B

 12. ANS: C

 13. ANS: C

 14. ANS: D

 15. ANS: D

 16. ANS: C

 17. ANS: B

 18. ANS: A

 19. ANS: B

 20. ANS: D

 21. ANS: B

 22. ANS: B

 23. ANS: D

 24. ANS: A

 25. ANS: A

**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. PTS: 1 DIF: II REF: 4 OBJ: 1 STA: 2.9

 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.

PTS: 1 DIF: II REF: 2 OBJ: 2 STA: 2.8

 28. ANS:

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

PTS: 1 DIF: II REF: 4 OBJ: 1 STA: 2.9

**COMPLETION**

 29. ANS: nuclide PTS: 1 DIF: I REF: 1 OBJ: 1

 30. ANS: 53 PTS: 1 DIF: I REF: 1 OBJ: 1

 31. ANS: mass defect PTS: 1 DIF: II REF: 1 OBJ: 1

 32. ANS: chain reaction

PTS: 1 DIF: I REF: 2 OBJ: 2 STA: 2.8

 33. ANS: fission

PTS: 1 DIF: I REF: 2 OBJ: 2 STA: 2.8

**PROBLEM**

 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 = (0.59 984 14 amu)(1.6605  10-27 kg/amu) = 9.9604 x 10-28 kg

(9.9604 x 10-28 kg) (3  108) ( m/s)2/9 nucleons = 8.96  1011 J/nucleon

binding energy/nucleon = 9.66  1012 J/nucleon

PTS: 1 DIF: III REF: 1 OBJ: 1

 35. ANS:

a. 

 b. 

 c. 

PTS: 1 DIF: II REF: 1 OBJ: 4 STA: 2.8 | 2.1

 36. ANS:

0.125 mg

Solution:

 PTS: 1 DIF: III REF: 2 OBJ: 3 STA: 2.11

 37. ANS: half-life = 4.67 days

Solution:

PTS:1 DIF: III REF: 2 OBJ: 3 STA: 2.11

**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.

PTS: 1 DIF: II REF: 3 OBJ: 4

 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.

PTS: 1 DIF: II REF: 4 OBJ: 2

STA: 2.9

 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.

PTS: 1 DIF: II REF: 4 OBJ: 2

STA: 2.6