

Name _____

Topic 10 - Nuclear Chemistry

_____ 1. Radioactive elements include all those elements whose nuclei contain more than

- 1) 83 amu
- 2) 83 protons
- 3) 83 neutrons
- 4) 83 nucleons

_____ 2. Samples of elements that are radioactive must contain atoms

- 1) with stable nuclei
- 2) in the excited state
- 3) in the ground state
- 4) with unstable nuclei

_____ 3. What is the neutron to proton ratio in a stable atom of carbon-12?

- 1) 1:1
- 2) 2:1
- 3) 12:1
- 4) 1:2

_____ 4. Radioactivity can be detected by the use of

- 1) volumetric titration
- 2) neutral litmus paper
- 3) photographic film
- 4) phenolphthalein dye solution

_____ 5. Which species has a positive charge?

- 1) a beta particle
- 2) an alpha particle
- 3) a sulfate ion
- 4) a bromide ion

_____ 6. The structure of an alpha particle is the same as a

- 1) lithium atom
- 2) neon atom
- 3) hydrogen nucleus
- 4) helium nucleus

_____ 7. When an alpha particle is emitted by an atom, in atomic number of the atom will

- 1) increase by 2
- 2) decrease by 2
- 3) increase by 4
- 4) decrease by 4

_____ 8 Which particle is given off when a phosphorus-32 undergoes a transmutation reaction?

- 1) a neutron
- 2) an alpha particle
- 3) a positron
- 4) a beta particle

_____ 9. A gamma ray is *best* described as having

- 1) a positive charge and a mass number of 2
- 2) a positive charge and a mass number of 4
- 3) no electric charge and no mass
- 4) a negative charge and no mass

_____ 10. Which type of radiation is *most* similar to high-energy x-rays?

- 1) neutron
- 2) alpha
- 3) beta
- 4) gamma

_____ 11. A positron has the same

- 1) mass as an electron and the same charge as a proton
- 2) mass as a proton, but a different charge
- 3) charge as an electron, but a different mass
- 4) charge as an electron, and the same mass as a proton

_____ 12. According to Table N in the Chemistry Reference Tables, a product of the radioactive decay of Ra-226 is

- 1) a beta particle
- 2) a U-226 nucleus
- 3) a U-230 nucleus
- 4) an alpha particle

_____ 13. Which nuclear emission has no charge and no mass?

- 1) alpha particle
- 2) gamma ray
- 3) beta particle
- 4) positron

_____ 14. Which radioisotope is matched with its decay mode?

- 1) H-3 and γ
- 2) N-16 and α
- 3) K-42 and β^+
- 4) P-32 and β^-

_____ 15. Which reaction is accompanied by the release of the greatest amount of energy?

- 1) combustion of 10. g of propane
- 2) electrolysis of 10. g of water
- 3) nuclear fission of 10. g of uranium
- 4) oxidation of 10. g of iron

_____ 16. Which nuclides are used to date the remains of a once-living organism?

- 1) C-14 and C-12
- 2) I-131 and Xe-131
- 3) Co-60 and Co-59
- 4) U-238 and Pb-206

_____ 17. Energy is released during the fission of Pu-239 atoms as a result of the

- 1) formation of covalent bonds
- 2) formation of ionic bonds
- 3) conversion of matter to energy
- 4) conversion of energy to matter

_____ 18. Atoms of I-131 spontaneously decay when the

- 1) stable nuclei emit alpha particles
- 2) stable nuclei emit beta particles
- 3) unstable nuclei emit alpha particles
- 4) unstable nuclei emit beta particles

_____ 19. Which type of reaction releases the greatest amount of energy per mole of reactant?

- 1) combustion
- 2) decomposition
- 3) nuclear fusion
- 4) oxidation-reduction

_____ 20. Which balanced equation represents transmutation?

- (1) ${}^9_4\text{Be} + {}^1_1\text{H} \rightarrow {}^6_3\text{Li} + {}^4_2\text{He}$
- (2) ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$
- (3) ${}^{239}_{94}\text{Pu} + {}^1_0\text{n} \rightarrow {}^{144}_{58}\text{Ce} + {}^{94}_{36}\text{Kr} + 2{}^1_0\text{n}$
- (4) ${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^4_2\text{He}$

_____ 21. During a nuclear reaction, mass is converted into

- 1) charge
- 2) isomers
- 3) energy
- 4) volume

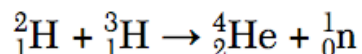
_____ 22. Compared to the mass and penetrating power of an alpha particle, the beta particle has

- 1) less mass and greater penetrating power
- 2) less mass and less penetrating power
- 3) more mass and greater penetrating power
- 4) more mass and less penetrating power

_____ 23. Which equation represents natural transmutation?

- (1) ${}^{10}_5\text{B} + {}^4_2\text{He} \rightarrow {}^{13}_7\text{N} + {}^1_0\text{n}$
- (2) ${}^{14}_6\text{C} \rightarrow {}^{14}_7\text{N} + {}^0_{-1}\text{e}$
- (3) $\text{S} + 2\text{e}^- \rightarrow \text{S}^{2-}$
- (4) $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$

_____ 24. Given the balanced equation representing a nuclear reaction:



Which phrase identifies and describes this reaction?

- 1) fission, mass converted into energy
- 2) fission, energy converted into mass
- 3) fusion, mass converted into energy
- 4) fusion, energy converted into mass

_____ 25. Which radioisotope emits alpha particles?

- 1) Fe-53
- 2) Au-198
- 3) Sr-90
- 4) Pu-239

_____ 26. Which balanced reaction represents a fusion reaction?

- (1) ${}^{235}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{93}_{36}\text{Kr} + {}^{140}_{56}\text{Ba} + 3{}^1_0\text{n}$
- (2) ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0\text{n}$
- (3) ${}^{14}_7\text{N} + {}^4_2\text{He} \rightarrow {}^{17}_8\text{O} + {}^1_1\text{H}$
- (4) ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$

_____ 27. What is the total number of years that must pass before only 25.00 grams of an original 100.0 gram sample of C-14 remains unchanged?

- 1) 2865 y
- 2) 11 460 y
- 3) 5730 y
- 4) 17 190 y

_____ 28. Which radioisotope is used for diagnosing thyroid disorders?

- 1) U-238
- 2) I-131
- 3) Pb-206
- 4) Co-60

_____ 29. In which type of reaction is an atom of one element converted to an atom of a different element?

- 1) saponification
- 2) transmutation
- 3) decomposition
- 4) neutralization

_____ 30. Which nuclide is listed with its half-life and decay mode?

- (1) K-37, 1.24 h, α
- (2) N-16, 7.2 s, β^-
- (3) Rn-222, 1.6×10^3 y, α
- (4) U-235, 7.1×10^8 y, β^-

- _____ 31. Which isotope is used to treat cancer?
 1) C-14 2) Co-60
 3) U-238 4) Pb-206
- _____ 32. In which type of reaction do two lighter nuclei combine to form one heavier nucleus?
 1) combustion 2) nuclear fission
 3) decomposition 4) nuclear fusion
- _____ 33. Which radioisotope has an atom that emits a particle with a mass number of 0 and a charge of +1?
 (1) ${}^3\text{H}$ (3) ${}^{19}\text{Ne}$
 (2) ${}^{16}\text{N}$ (4) ${}^{239}\text{Pu}$
- _____ 34. Which nuclear emission has the greatest mass and the least penetrating power?
 1) an alpha particle 2) a neutron
 3) a beta particle 4) a positron
- _____ 35. A beta particle may be spontaneously emitted from
 1) a ground-state electron
 2) a stable nucleus
 3) an excited electron
 4) an unstable nucleus
- _____ 36. Which particle has the greatest mass?
 1) an alpha particle 2) a neutron
 3) a beta particle 4) a positron
- _____ 37. Which nuclide is used to investigate human thyroid gland disorders?
 1) carbon-14 2) cobalt-60
 3) potassium-37 4) iodine-131
- _____ 38. What is a problem commonly associated with nuclear power facilities?
 1) a small quantity of energy is produced.
 2) reaction products contribute to acid rain
 3) it is impossible to control nuclear fission
 4) it is difficult to dispose of wastes
- _____ 39. Which particle is emitted when an atom of ${}^{85}\text{Kr}$ spontaneously decays?
 1) an alpha particle 2) a neutron
 3) a beta particle 4) a proton
- _____ 40. Which type of reaction occurs when a high- energy particle collides with the nucleus of an atom, converting that atom to an atom of a different element?
 1) neutralization
 2) addition
 3) transmutation
 4) substitution
- _____ 41. An original sample of K-40 has a mass of 25.00 grams. After 3.9×10^9 years, 3.125 grams of the original sample remains unchanged. What is the half-life of K-40?
 1) 1.3×10^9 years 2) 3.9×10^9 years
 3) 2.6×10^9 years 4) 1.2×10^{10} years
- _____ 42. Which list of radioisotopes contains an alpha emitter, a beta emitter, and a positron emitter?
 1) C-14, N-16, P-32
 2) Cs-137, Fr-220, Tc-99
 3) Kr-85, Ne-19, Rn-222
 4) Pu-239, Th-232, U-238
- _____ 43. Which nuclear decay emission consists of energy, only?
 1) alpha particle 2) beta particle
 3) gamma radiation 4) positron
- _____ 44. The energy released by a nuclear reaction results primarily from the
 1) breaking of bonds between atoms
 2) formation of bonds between atoms
 3) conversion of mass into energy
 4) conversion of energy into mass
- _____ 45. Which balanced equation represents nuclear fusion?
 (1) ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow {}_{56}^{142}\text{Ba} + {}_{36}^{91}\text{Kr} + 3{}_0^1\text{n}$
 (2) ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_2^4\text{He}$
 (3) ${}_3^6\text{Li} + {}_0^1\text{n} \rightarrow {}_1^3\text{H} + {}_2^4\text{He}$
 (4) ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + {}_0^1\text{n}$
- _____ 46. According to Reference Table N, which pair of isotopes spontaneously decays?
 1) C-12 and N-14
 2) C-14 and N-14
 3) C-12 and N-16
 4) C-14 and N-16

Constructed Response Questions

Use the following information to answer questions 1 and 2:

A battery-operated smoke detector produces an alarming sound when its electrical sensor detects smoke particles. Some ionizing smoke detectors contain the radioisotope americium-241, which undergoes alpha decay and has a half-life of 433 years. The emitted alpha particles ionize gas molecules in the air. As a result, an electric current flows through the detector. When smoke particles enter the detector, the flow of ions is interrupted, causing the alarm to sound.

1. State one scientific reason why Am-241 is a more appropriate radioactive source than Fr-220 in an ionizing smoke detector.

2. Explain, in terms of particle behavior, why smoke particles cause the detector alarm to sound.

Use the following information to answer questions 3 through 5

In living organisms, the ratio of the naturally occurring isotopes of carbon, C-12 to C-13 to C-14, is fairly consistent. When an organism such as a woolly mammoth died, it stopped taking in carbon, and the amount of C-14 present in the mammoth began to decrease. For example, one fossil of a woolly mammoth is found to have 1/32 of the amount of C-14 found in a living organism.

3. Identify the type of nuclear reaction that caused the amount of C-14 in the woolly mammoth to decrease after the organism died.

4. Determine the total time that has elapsed since this woolly mammoth died.

5. State, in terms of subatomic particles, how an atom of C-13 is different from an atom of C-12.

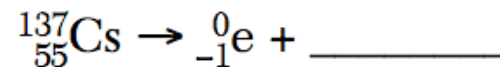
Use the following information to answer questions 6-8

Cobalt-60 is commonly used as a source of radiation for the prevention of food spoilage. Bombarding cobalt-59 nuclei with neutrons produces the nuclide cobalt-60. A food irradiation facility replaces cobalt-60, a source of gamma rays, when the radioactivity level falls to 1/8 (one-eighth) of its original level. The nuclide cesium-137 is also a source of radiation for the prevention of food spoilage.

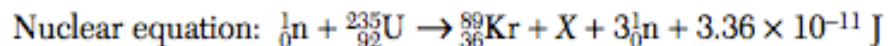
6. Identify *one* emission spontaneously released by a cobalt-60 nucleus.

7. Determine the total number of years that elapse before an original cobalt-60 source in an irradiation facility must be replaced.

8. Complete the nuclear equation below for the decay of cesium 137. Your response must include the symbol, atomic number, and mass number of _____ the missing particle.

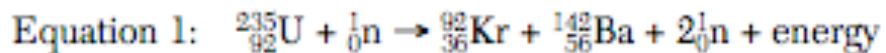


9. Given the nuclear equation below, give the symbol for product X including element symbol, atomic number and atomic mass.

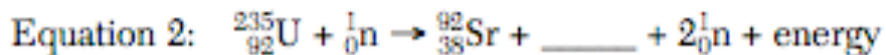


Using the information below, answer questions 10-12.

When a uranium-235 nucleus absorbs a slow-moving neutron, different nuclear reactions may occur. One of these possible reactions is represented by the complete, balanced equation below.



For this reaction, the sum of the masses of the products is slightly less than the sum of the masses of the reactants. Another possible reaction of U-235 is represented by the incomplete, balanced equation below.



10. Identify the type of nuclear reaction represented by equation 1.

11. Write a notation for the missing product in equation 2.

12. Determine the half-life of krypton-92 if only 6.0 milligrams of an original 96.0-milligram sample remains unchanged after 7.36 seconds.

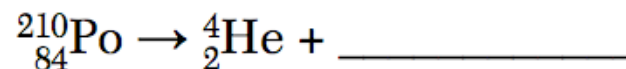
Base your answers to questions 13-15 on the information below.

Polonium-210 occurs naturally, but is scarce. Polonium-210 is primarily used in devices designed to eliminate static electricity in machinery. It is also used in brushes to remove dust from camera lenses.

Polonium-210 can be created in the laboratory by bombarding bismuth-209 with neutrons to create bismuth-210. The bismuth-210 undergoes beta decay to produce polonium-210. Polonium-210 has a half-life of 138 days and undergoes alpha decay.

13. State one beneficial use of Po-210.

14. Complete the nuclear equation below for the decay of Po-210, by writing a notation for the missing product.



15. Determine the total mass of an original 28.0-milligram sample of Po-210 that remains unchanged after 414 days.