Name: _____

1) The stability of an isotope is based on its
A) ratio of electrons to protons
B) ratio of neutrons to protons
C) number of protons, only
D) number of neutrons, only

2) For most atoms with an atomic number less than 20, nuclear stability occurs when the ratio of neutrons to protons is 1:1. Which of the following atoms would be most likely to have an unstable nucleus?
A) $^{4}_{2}He$
B) $^{16}_{7}N$
C) $^{24}_{12}Mg$
D) $^{12}_{6}C$

3) Which nuclear emission has the *greatest* mass?
A) β^{+}
B) β^{-}
C) α
D) γ

4) Which of the following particles has the *greatest* mass?
A) positron
B) beta
C) alpha
D) neutron

5) Which type of radioactive emission has a positive charge and weak penetrating power?
A) neutron
B) beta particle
C) gamma ray
D) alpha particle

6) Which product of nuclear decay has mass but *no* charge?
A) alpha particles
B) beta positrons
C) neutrons
D) gamma rays

7) Alpha particles and beta particles differ in
A) both mass and charge
B) neither mass nor charge
C) mass, only
D) charge, only

8) Which of the following types of radiation has the *greatest* penetrating power?
A) positron
B) gamma
C) beta
D) alpha

9) Which radioisotope is a beta emitter?
A) ^{238}U
B) ^{220}Fr
C) ^{90}Sr
D) ^{37}K

10) Alpha particles are emitted during the radioactive decay of
A) neon-19
B) radon-222
C) calcium-37
D) carbon-14

11) What is the name of the process in which the nucleus of an atom of one element is changed into the nucleus of an atom of a different element?
A) decomposition
B) reduction
C) transmutation
D) substitution

12) Given the nuclear reaction:

$$^{60}_{27}Co \rightarrow ^{0}_{-1}e + ^{60}_{28}Ni$$

This reaction is an example of
A) artificial transmutation
B) fusion
C) fission
D) natural transmutation

13) What does *X* represent in the following reaction?

$$^{239}_{93}Np \rightarrow ^{239}_{94}Pu + X$$

A) a proton
B) an alpha particle
C) a beta particle
D) a neutron

14) Which reaction represents natural nuclear decay?
A) $H^{+} + OH^{-} \rightarrow H_2O$
B) $^{235}_{92}U \rightarrow ^{4}_{2}He + ^{231}_{90}Th$
C) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$
D) $KClO_3 \rightarrow K^{+} + ClO_3^{-}$

15) Which equation represents a spontaneous nuclear decay?
A) $C + O_2 \rightarrow CO_2$
B) $^{90}_{38}Sr \rightarrow ^{0}_{-1}e + ^{90}_{39}Y$
C) $^{27}_{13}Al + ^{4}_{2}He \rightarrow ^{30}_{15}P + ^{1}_{0}n$
D) $H_2CO_3 \rightarrow CO_2 + H_2O$

16) The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called
A) radioactive decay
B) natural decay
C) artificial transmutation
D) natural transmutation

17) Which equation is an example of artificial transmutation?
A) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
B) $^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$
C) $Mg(OH)_2 + 2HCl \rightarrow 2H_2O + MgCl_2$
D) $U + 3F_2 \rightarrow UF_6$

18) Nuclear fusion differs from nuclear fission because nuclear fusion reactions
A) form lighter isotopes from heavier isotopes
B) form heavier isotopes from lighter isotopes
C) convert energy to mass
D) convert mass to energy

19) In a nuclear fusion reaction, the mass of the products is
A) less than the mass of the reactants because some of the mass has been converted to energy
B) more than the mass of the reactants because some of the energy has been converted to mass
C) less than the mass of the reactants because some of the energy has been converted to mass
D) more than the mass of the reactants because some of the mass has been converted to energy

20) Which equation represents nuclear fusion?
A) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\,{}^{1}_{0}n$
B) $^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$
C) $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$
D) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

21) Given the fusion reaction:

$$^{2}_{1}H + {}^{2}_{1}H \rightarrow X + \text{energy}$$

Which particle is represented by X?
A) $^{3}_{1}H$
B) $^{3}_{2}He$
C) $^{4}_{2}He$
D) $^{1}_{1}H$

22) As a sample of the radioactive isotope ^{131}I decays, its half-life
A) increases
B) decreases
C) remains the same

23) Approximately what fraction of an original Co-60 sample remains after 21 years?
A) $\frac{1}{2}$
B) $\frac{1}{8}$
C) $\frac{1}{16}$
D) $\frac{1}{4}$

24) Based on the *Selected Radioisotopes* chemistry reference table, what fraction of a sample of gold-198 remains radioactive after 2.69 days?
A) $\frac{7}{8}$ B) $\frac{3}{4}$ C) $\frac{1}{4}$ D) $\frac{1}{2}$

25) After 32 days, 5 milligrams of an 80-milligram sample of a radioactive isotope remains unchanged. What is the half-life of this element?
A) 16 days
B) 4 days
C) 8 days
D) 2 days

26) Exactly how much time must elapse before 16 grams of potassium-42 decays, leaving 2 grams of the original isotope?
A) 4 × 12.4 hours
B) 2 × 12.4 hours
C) 3 × 12.4 hours
D) 8 × 12.4 hours

27) According to the *Selected Radioisotopes* chemistry reference table, which radioactive isotope will retain only one-eighth ($\frac{1}{8}$) its original radioactive atoms after approximately 43 days?
A) phosphorus-32
B) radon-222
C) gold-198
D) iodine-131

28) According to the *Selected Radioisotopes* chemistry reference table, which radioactive isotope is *best* for determining the actual age of Earth?
A) ^{238}U
B) ^{14}C
C) ^{60}Co
D) ^{90}Sr

29) Which isotope is most commonly used in the radioactive dating of the remains of organic materials?
A) ^{32}P
B) ^{14}C
C) ^{37}K
D) ^{16}N

30) Which statement explains why nuclear waste materials may pose a problem?
A) They frequently have long half-lives and remain radioactive for extended periods of time.
B) They frequently have long half-lives and remain radioactive for brief periods of time.
C) They frequently have short half-lives and remain radioactive for brief periods of time.
D) They frequently have short half-lives and remain radioactive for extended periods of time.

31) Given the nuclear equation:

$$^{58}_{29}Cu \rightarrow {}^{58}_{28}Ni + X$$

What nuclear particle is represented by X?

32) Given the nuclear equation:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3^{1}_{0}n + \text{energy}$$

(a) State the type of nuclear reaction represented by the equation.

(b) The sum of the masses of the products is slightly less than the sum of the masses of the reactants. Explain this loss of mass.

(c) This process releases greater energy than an ordinary chemical reaction does. Name another type of nuclear reaction that releases greater energy than an ordinary chemical reaction.

33) (a) State *one* possible advantage of using nuclear power instead of burning fossil fuels.

(b) State *one* possible risk of using nuclear power.

(c) If animals feed on plants that have taken up Sr-90, the Sr-90 can find its way into their bone structure. Explain *one* danger to the animals.

Questions 34 through 36 refer to the following:

NUCLEAR WASTE STORAGE PLAN FOR YUCCA MOUNTAIN

In 1978, the U.S. Department of Energy began a study of Yucca Mountain which is located 90 miles from Las Vegas, Nevada. The study was to determine if Yucca Mountain would be suitable for a long-term burial site for high-level radioactive waste. A three-dimensional (3-D) computer scale model of the site was used to simulate the Yucca Mountain area. The computer model study for Yucca Mountain included such variables as: the possibility of earthquakes, predicted water flow through the mountain, increased rainfall due to climate changes, radioactive leakage from the waste containers, and increased temperatures from the buried waste within the containers.

The containers that will be used to store the radioactive waste are designed to last 10,000 years. Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed. Other isotopes found in the waste would decay more slowly, but are not powerful radioactive emitters.

In 1998, scientists discovered that the compressed volcanic ash making up Yucca Mountain was full of cracks. Because of the arid climate, scientists assumed that rainwater would move through the cracks at a slow rate. However, when radioactive chlorine-36 was found in rock samples at levels halfway through the mountain, it was clear that rainwater had moved quickly down through Yucca Mountain. It was only 50 years earlier when this chlorine-36 isotope had contaminated rainwater during atmospheric testing of the atom bomb.

Some opponents of the Yucca Mountain plan believe that the uncertainties related to the many variables of the computer model result in limited reliability of its predictions. However, advocates of the plan believe it is safer to replace the numerous existing radioactive burial sites around the United States with the one site at Yucca Mountain. Other opponents of the plan believe that transporting the radioactive waste to Yucca Mountain from the existing 131 burial sites creates too much danger to the United States. In 2002, after years of political debate, a final legislative vote approved the development of Yucca Mountain to replace the existing 131 burial sites.

34) State *one* uncertainty in the computer model discussed in the reading passage that limits the reliability of the computer model.

35) According to the reading passage, scientists assume that a manufacturing defect would cause at least one of the waste containers stored in the Yucca Mountain repository to leak within the first 1,000 years. State *one* possible effect such a leak could have on the environment near Yucca Mountain.

36) If a sample of cesium-137 is stored in a waste container in Yucca Mountain, how much time must elapse until only $\frac{1}{32}$ of the original sample remains unchanged?

Questions 37 through 39 refer to the following:

RADIOACTIVITY AT HOME

You may be surprised to learn that you do not need to visit a nuclear power plant or a hospital x-ray laboratory to find sources of radioactivity. They are all around us. In fact, it is likely that you'll find a few at home. Your front porch may incorporate cinder blocks or granite blocks. Both contain uranium. Walk through the front door, look up, and you'll see a smoke detector that owes its effectiveness to the constant source of alpha particle emissions from Americium-241. As long as the gases remain ionized within the shielded container, electricity flows, and all is calm. When smoke enters the chamber, it neutralizes the charges on these ions. In the absence of these ions, the circuit breaks and the alarm goes off.

Indicator lights on your appliances may use Krypton-85; electric blankets, promethium-147; and fluorescent lights, thorium-229. Even the food we eat is radioactive. The more potassium-rich the food source, the more potassium-40 — a radioactive isotope that makes up about 0.01% of the natural supply of this mineral — is present. Thus, brazil nuts, peanuts, bananas, potatoes, and flour, all rich in potassium, are radiation sources.

—*Chem Matters*, April 2000

37) Write the equation for the alpha decay that occurs in a smoke detector containing Americium-241 (Am-241).

38) How is the radioactive decay of Krypton-85 different from the radioactive decay of Americium-241?

39) State *one* benefit or useful application of radioactivity *not* mentioned in the given article.

40) Which mass measurement contains four significant figures?

A) 3870 g
B) 0.431 g
C) 0.086 g
D) 1003 g

41) During a laboratory experiment, a sample of aluminum is found to have a mass of 12.50 grams and a volume of 4.6 milliliters. What is the density of this sample, expressed to the correct number of significant figures?

A) 3 g/mL
B) 2.72 g/mL
C) 2.717 g/mL
D) 2.7 g/mL