Nuclear Chemistry Review

Proton: neutron Ratio causes ↙

1. Unstable nuclei emit radiation. Radioactive elements have unstable nuclei. Elements 84 and higher are all radioactive.
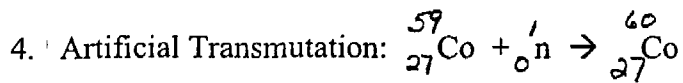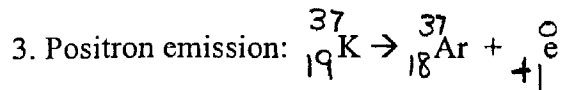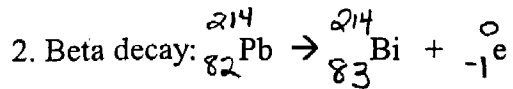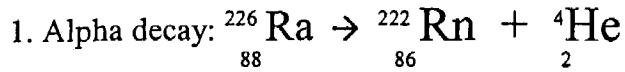2. Radioisotopes are radioactive isotopes of atoms that also have stable isotopes. Ex. C-14 (carbon with a mass of 14) is a radioisotope of carbon.
3. Transmutation is when a radioisotope changes into a new element because radiation was released. Two types natural and artificial.
4. Natural transmutation occurs **without** the help of another particle (reactant).
5. Artificial transmutation occurs **with** the help of another particle.
6. Three types of radiation. **Table O**
     A. Alpha particles = He nucleus with a mass of 4 and a +2 charge
     B. Beta particles = electron with a mass of zero and a −1 charge
     C. Gamma rays are pure energy with no mass and no charge
7. Alpha particles are attracted to the negative poles
8. Beta particles are attracted to the positive poles
9. Gamma rays pass straight through.
10. During alpha decay the mass number will decrease by 4 and the atomic number decreases by 2
11. During beta decay the mass number will not change and the atomic number increases by 1
12. During gamma decay mass and atomic number don't change.
13. During positron emission the mass doesn't change and the atomic number decreases by 1.
14. Nuclear equations must balance by mass and charge (atomic #)
15. Fusion is the fusing of two light (He or H) nuclei to form a heavier nucleus. A tremendous amount of NRG is released. A fission reaction is necessary to provide enough nrg for fusion to take place because there is tremendous repulsion of two positive nuclei that must be overcome.
16. Fission is the splitting of a heavy nucleus using 3 neutrons. U-235 and Pu-239 are fissionable materials. Not as much nrg as fusion is released. Waste products are hazardous because they emit radiation.
17. Fission creates energy from mass. $E = mc^2$
18. Half-life is the time it takes for half of a sample to decay. Half-life never changes. **Table N** gives half-life information.
19. You should be able to calculate fraction remaining, mass of original sample, and age using half-life.
20. Uses of radioisotopes:
     a. C-14 dating of organic material and to trace pathways of organic chemical reactions.
     b. U-238 dating of rocks
     c. I-131 is used to detect thyroid problems
     d. Co-60 is used to kill cancer cells
     e. Tc-99 is used as a tracer to detect cancer
21. Radioisotopes used for medicine have short half-lives and are eliminated quickly from the body.

22. Radiation is harmful to humans (especially gamma rays) because they can cause genetic mutations in sex cells (sperm and eggs). Radiation can also cause normal cells to become cancerous.

Examples of Nuclear reactions:

1. Alpha decay: $^{226}_{88}Ra \rightarrow \,^{222}_{86}Rn \; + \; ^{4}_{2}He$

2. Beta decay: $^{214}_{82}Pb \rightarrow \,^{214}_{83}Bi \; + \; ^{0}_{-1}e$

3. Positron emission: $^{37}_{19}K \rightarrow \,^{37}_{18}Ar \; + \; ^{0}_{+1}e$

4. Artificial Transmutation: $^{59}_{27}Co + \,^{1}_{0}n \rightarrow \,^{60}_{27}Co$

5. Nuclear Fission: $^{1}_{0}n + \,^{235}_{92}U \rightarrow \,^{142}_{56}Ba + \,^{91}_{36}Kr \; + \; 3^{1}_{0}n \; + energy$

6. Nuclear Fusion: $^{1}_{1}H + \,^{2}_{1}H \rightarrow \,^{3}_{2}He$
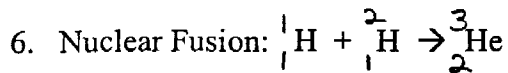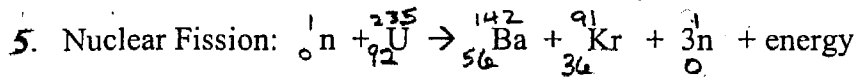
Half Life Chart   Always w/ zero start

| # of H.L.	Fraction	Time	Amount of Stuff
0	1	0	ALL of it
1	$\frac{1}{2}$	(Table N)1	(ALL of it).5
2	$\frac{1}{4}$	(Table N)2	(ALL of it).25
3	$\frac{1}{8}$	(Table N)3	(ALL of it)$\frac{1}{8}$
4	$\frac{1}{16}$	(Table N)4	(All of it)$\frac{1}{16}$

1. Base your answer to the following question on Given the nuclear equation:

$$^1_1H + X \rightarrow {}^6_3Li + {}^4_2He$$
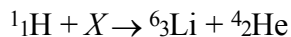
The particle represented by X is

A) ^9_4Li **B) ^9_4Be**   C) $^{10}_5Be$ D) $^{10}_6C$

2. Which isotope will spontaneously decay and emit particles with a charge of +2?

A) ^{53}Fe B) ^{137}Cs C) ^{198}Au **D) ^{220}Fr**

3. Which of these particles has the greatest mass?

A) alpha   B) beta
C) neutron   D) positron

4. Base your answer to the following question on Given the nuclear equation:

$$^{19}_{10}Ne \rightarrow X + {}^{19}_9F$$
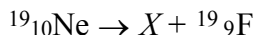
What particle is represented by X?

A) alpha   B) beta
C) neutron   **D) positron**

5. Alpha particles and beta particles differ in

A) mass, only
B) charge, only
C) both mass and charge
D) neither mass nor charge

6. Which statement best describes gamma radiation?

A) It has a mass of 1 and a charge of 1.
B) It has a mass of 0 and a charge of –1.
C) It has a mass of 0 and a charge of 0.
D) It has a mass of 4 and a charge of +2.

7. Which type of radiation is most similar to high-energy x-rays?

A) alpha   B) beta
C) neutron   **D) gamma**

8. 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?

A) 2865 y   B) 5730 y
C) 11 460 y   D) 17 190 y

9. Which isotope is most commonly used in the radioactive dating of the remains of organic materials?

A) ^{14}C   B) ^{16}N C) ^{32}P D) ^{37}K

10 Based on Reference Table N, what fraction of a radioactive ^{90}Sr sample would remain unchanged after 56.2 years?

A) $\frac{1}{2}$ **B) $\frac{1}{4}$**   C) $\frac{1}{8}$ D) $\frac{1}{16}$

11. What is the half-life and decay mode of Rn-222?

A) 1.91 days and alpha decay
B) 1.91 days and beta decay
C) 3.82 days and alpha decay
D) 3.82 days and beta decay

12. 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) 8 days   B) 2 days
C) 16 days   D) 4 days

13. Which reaction converts an atom of one element to an atom of another element?

A) combustion   B) polymerization
C) saponification   **D) transmutation**

14. Radioactive cobalt-60 is used in radiation therapy treatment. Cobalt-60 undergoes beta decay. This type of nuclear reaction is called

A) natural transmutation
B) artificial transmutation
C) nuclear fusion
D) nuclear fission

15. In which reaction is mass converted to energy by the process of fission?

A) $^{14}_7N + {}^1_0n \rightarrow {}^{14}_6C + {}^1_1H$
B) $^{235}_{92}U + {}^1_0n \rightarrow {}^{87}_{35}Br + {}^{146}_{57}La + 3{}^1_0n$
C) $^{226}_{88}Ra \rightarrow {}^{222}_{86}Ra + {}^4_2He$
D) $^2_1H + {}^2_1H \rightarrow {}^4_2He$

16. Which statement best describes what happens in a fission reaction?

A) Heavy nuclei split into lighter nuclei.
B) Light nuclei form into heavier nuclei.
C) Energy is released and less stable elements are formed.
D) Energy is absorbed and more stable elements are formed.

17. Nuclear fusion *differs* from nuclear fission because nuclear fusion reactions

   A) form heavier isotopes from lighter isotopes
   B) form lighter isotopes from heavier isotopes
   C) convert mass to energy
   D) convert energy to mass

18. 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) less than the mass of the reactants because some of the energy has been converted to mass
   C) more than the mass of the reactants because some of the mass has been converted to energy
   D) more than the mass of the reactants because some of the energy has been converted to mass

19. A fission reaction is similar to a fusion reaction in that both reactions involve

   A) collisions between nuclei of high atomic number
   B) collisions between nuclei of low atomic number
   C) the conversion of mass to energy
   D) the conversion of energy to mass

20. Which radioisotope is used for diagnosing thyroid disorders?

   A) U-238   B) Pb-206
   C) I-131   D) Co-60

21. Which radioactive isotope is used in treating cancer?

   A) carbon-14   **B) cobalt-60**
   C) lead-206   D) uranium-238

22. Radioisotopes used for medical diagnosis must have

   A) long half-lives and be quickly eliminated by the body
   B) long half-lives and be slowly eliminated by the body
   C) short half-lives and be quickly eliminated by the body
   D) short half-lives and be slowly eliminated by the body

23. A serious risk factor associated with the operation of a nuclear power plant is the production of

   A) acid rain
   B) helium gas
   C) greenhouse gases, such as CO_2
   D) radioisotopes with long half-lives

24. Refering to Table N, which substance is a radioactive waste product that is safest to release into the atmosphere after it has decayed to a safe radiation level?

   A) radon-222   B) radium-226
   C) cesium-137   D) cobalt-60

Base your answers to questions **25** through **27** on the information below, the Reference Tables for Chemistry, and your knowledge of chemistry.

   Radioactivity and radioactive isotopes have the potential for both benefiting and harming living organisms. One use of radioactive isotopes is in radiation therapy as a treatment for cancer. Cesium-137 is sometimes used in radiation therapy.
   A sample of cesium-137 was left in an abandoned clinic in Brazil in 1987. Cesium-137gives off a blue glow because of its radioactivity. The people who discovered the sample were attracted by the blue glow and had no idea of any danger. Hundreds of people were treated for overexposure to radiation, and four people died.

25. Suppose a 40-gram sample of iodine-131 and a 40-gram sample of cesium-137 were both abandoned in the clinic in 1987. Explain why the sample of iodine-131 would not pose as great a radiation risk to people today as the sample of cesium-137 would.

26. If 12.5 grams of the original sample of cesium-137 remained after 90.69 years, what was the mass of the original sample?

27. Using Reference Table N, complete the equation provided in your answer booklet for the radioactive decay of $^{137}_{55}Cs$. Include both atomic number and mass number for each particle.

Base your answers to questions **28** through **30** on in the information below.

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.

Equation 1: $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}Kr + {}^{142}_{56}Ba + 2{}^{1}_{0}n + energy$
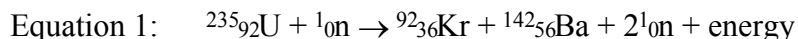
For this reaction, the sum of the masses of the products is slightly less than the sum of the masses of the reactants. Another possible reaction of U-235 is represented by the incomplete, balanced equation below.

Equation 2: $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{38}Sr + \underline{\quad} + 2{}^{1}_{0}n + energy$
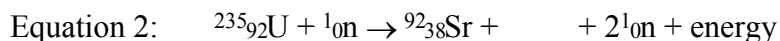
28. Determine the half-life of krypton-92 if only 6.0 milligrams of an original 96.0-milligram sample remains unchanged after 7.36 seconds.

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

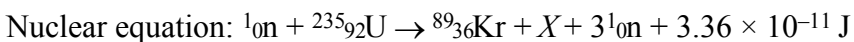30. Identify the type of nuclear reaction represented by equation 1.

31. Base your answer to the following question on the information below.

Hydrocarbons and fissionable nuclei are among the sources used for the production of energy in the United States. A chemical reaction produces much less energy than a nuclear reaction per mole of reactant.
The balanced chemical equation below represents the reaction of one molecule of a hydrocarbon with two molecules of oxygen.

Chemical equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 1.48 \times 10^{-18}$ J
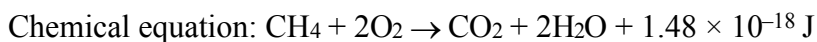
The nuclear equation below represents one of the many possible reactions for one fissionable nucleus. In this equation, X represents a missing product.

Nuclear equation: $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{89}_{36}Kr + X + 3{}^{1}_{0}n + 3.36 \times 10^{-11}$ J

Write an isotopic notation for the missing product represented by X in the nuclear equation.

32. Given the nuclear equation:

$^{58}_{29}Cu \rightarrow {}^{58}_{28}Ni + X$
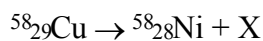
What nuclear particle is represented by X?

Base your answers to questions **33** and **34** on the information below.

Scientists are investigating the production of energy using hydrogen-2 nuclei (deuterons) and hydrogen-3 nuclei (tritons). The balanced equation below represents one nuclear reaction between two deuterons.

$$^2_1H + \, ^2_1H \rightarrow \, ^3_2He + \, ^1_0n + 5.23 \times 10^{-13}\,J$$
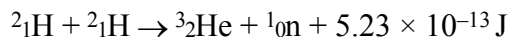
33. Identify the type of nuclear reaction represented by the equation.

34. State, in terms of subatomic particles, how a deuteron differs from a triton.

35. Base your answer to the following question on the information below.

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.

Complete the nuclear equation below for the decay of Am-241. Your response must include the symbol, mass number, and atomic number for each product.

$$^{241}_{95}Am \rightarrow \underline{\hspace{3cm}} + \underline{\hspace{3cm}}$$

Base your answers to questions **36** through **39** on the reading passage below and on your knowledge of chemistry.

A Glow in the Dark, and Scientific Peril

The [Marie and Pierre] Curies set out to study radioactivity in 1898. Their first accomplishment was to show that radioactivity was a property of atoms themselves. Scientifically,that was the most important of their findings, because it helped other researchers refine their understanding of atomic structure. More famous was their discovery of polonium and radium. Radium was the most radioactive substance the Curies had encountered. Its radioactivity is due to the large size of the atom, which makes the nucleus unstable and prone to decay, usually to radon and then lead, by emitting particles and energy as it seeks a more stable configuration.Marie Curie struggled to purify radium for medical uses, including early radiation treat-ment for tumors. But radiums bluish glow caught peoples fancy, and companies in theUnited States began mining it and selling it as a novelty: for glow-in-the-dark light pulls, for instance, and bogus cure-all patent medicines that actually killed people.What makes radium so dangerous is that it forms chemical bonds in the same way as calcium, and the body can mistake it for calcium and absorb it into the bones. Then, it can bombard cells with radiation at close range, which may cause bone tumors or bone-marrow damage that can give rise to anemia or leukemia.
    – Denise Grady, The New York Times, October 6, 1998

36. If a scientist purifies 1.0 gram of radium-226, how many years must pass before only 0.50 gram of the original radium-226 sample remains unchanged?

37. Using information from the Periodic Table, explain why radium forms chemical bonds in the same way as calcium does.

38. Using Reference Table *IV,* complete the equation for the nuclear

decay of $^{226}_{88}$Ra. Include *both* atomic number and mass number for *each* particle.

39. State one risk associated with the use of Radium.

Base your answers to questions **40** through **43** on the article below, the *Reference Tables for PhysicalSetting/Chemistry*, and your knowledge of chemistry.

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

40. State one risk or danger associated with radioactivity.

41. State one benefit or useful application of radioactivity *not* mentioned in this article.

42. How is the radioactive decay of Krypton-85 different from the radioactive decay of Americium-241?

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

Answer Key
Unit 11 - Review Packet

1. **B**
2. **D**
3. **A**
4. **D**
5. **C**
6. **C**
7. **D**
8. **C**
9. **A**
10. **B**
11. **C**
12. **A**
13. **D**
14. **A**
15. **B**
16. **A**
17. **A**
18. **A**
19. **C**
20. **C**
21. **B**
22. **C**
23. **D**
24. **A**
25. Responses include, but are not limited to, these examples: Iodine-131 would decay faster • Iodine has a much shorter half-life • Most of the I-131 would be gone.
26. 100
27. Responses include, but are not limited to, these examples:
$$^{137}_{55}Cs \rightarrow \, ^{0}_{-1}e + \, ^{137}_{56}Ba$$
• $^{137}_{55}Cs \rightarrow \, ^{0}_{-1}\beta + \, ^{137}_{56}Ba$

28. 1.84 s
29. xenon-142 or $^{142}_{54}Xe$
30. fission or transmutation
31. $^{144}_{56}Ba$ or barium-144
32. $^{0}_{+1}e$ or $^{0}_{+1}ß$ or $ß^{+}$ or positron.
33. Examples: fusion; thermonuclear fusion
34. Examples: A deuteron has one neutron and a triton has two neutrons.; A deuteron has one fewer neutron than a triton.
35. $$^{4}_{2}\alpha \text{ or } ^{4}_{2}He.$$
$$^{237}_{93}Np$$
36. 1600
37. Radium and calcium are both located in Group 2 on the Periodic Table or same family or 2 valence electrons
38. $^{226}Ra \rightarrow \, ^{4}He + \, ^{222}Rn$ or $^{226}Ra \rightarrow \, ^{222}Rn + \, ^{4}\alpha$ 88   2   86   88   86   2
39. cause bone tumors or damage bone marrow or can cause leukemia or anemia or radioactive or DNA damage or death

40. Acceptable responses: Extensive exposure can make people sick, contamination of environment, introduction of radioactive materials into the ecosystem
41. Acceptable responses: Radioactivity can be used in medical diagnosis and/or treatment, food irradiation, radioactive dating.
42. Acceptable responses: ^{85}Kr undergoes beta decay and ^{241}Am undergoes alpha decay, Decay mode and half-life are different, half-lives different.
43. $^{241}_{95}Am \rightarrow \, ^{4}_{2}He + \, ^{237}_{93}Np$