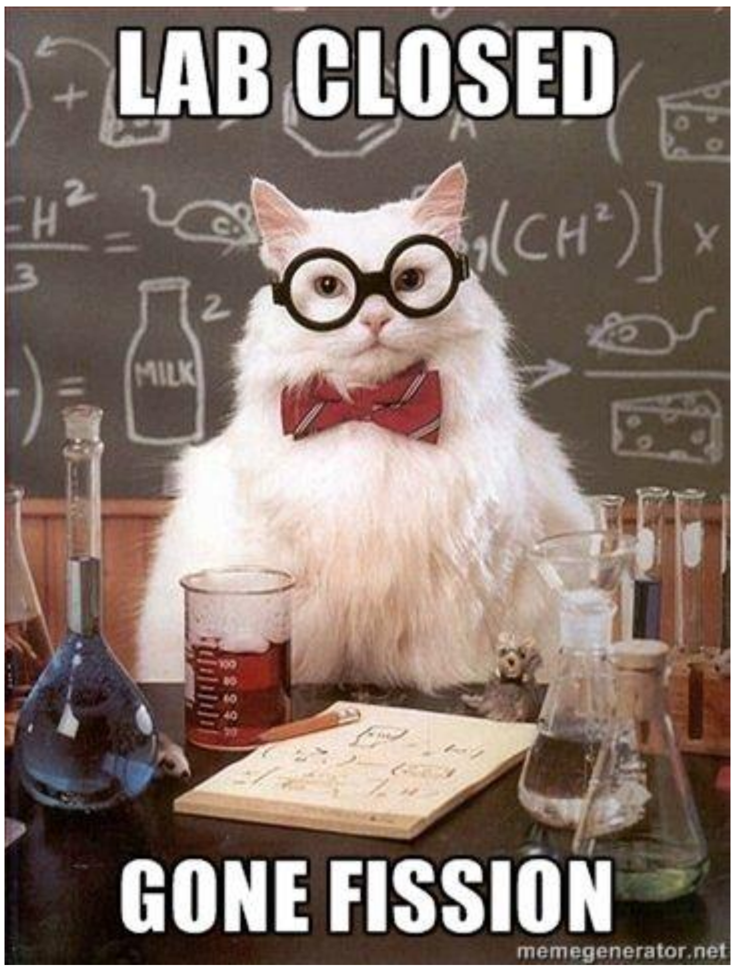
Regents Chemistry:

Practice Packet: Unit 13 Nuclear Chemistry



Lesson 1: Radioactive Decay

Objective:

- ***Construct nuclear equations for the spontaneous decay of radioactive nuclides.***

Natural Decay

Writing Nuclear Equations – Use Table N! When elements undergo radioactive decay, they change from one element to another. This happens by losing high energy alpha or beta particles, or by emitting positrons. The process of an atom becoming a different atom is called **transmutation**. Nuclear equations are written to track the changes that occur during transmutation. When writing nuclear equations, it is important to make sure that _mass and charge are conserved_. Write the complete nuclear equation for the spontaneous decay of the following nuclides: **Use Table N!!!! The first one has been done for you.**

Alpha decay:	${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}\mathbf{He}$
Beta decay:	${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\mathbf{B}$
Positron decay:	${}^{37}_{19}K \rightarrow {}^{37}_{18}Ar + {}^{0}_{+1}\mathbf{B}$

Use reference table to find the atomic number

1. ^{42}K ${}^{42}_{19}K \rightarrow {}^{0}_{-1}e + {}^{42}_{20}Ca$

2. ^{37}Ca ____________________

3. neon-19 ____________________

4. iodine-131 ____________________

5. radon-222 ____________________

6. iron-53 ____________________

7. ^{42}K ____________________

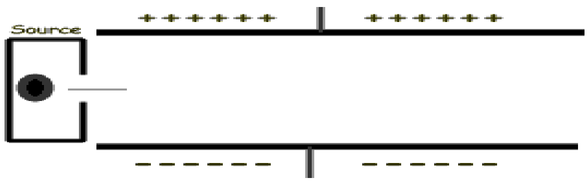
8. strontium-90 ____________________

9. ^{220}Fr ____________________

10. thorium-232 ____________________

11. ^{198}Au ____________________

12. Draw how alpha, beta, and positron particles are affected by positive and negative plates.



13. The gamma particle has no mass and no charge and can be listed as a product in most nuclear reactions. Why is it often omitted? How would it be affected by the charged plates above?

14. Which particle is the most penetrating? The least?

Regents Practice:

15. What is the mass number of an alpha particle?
    (1) 1 (3) 0
    (2) 2 (4) 4

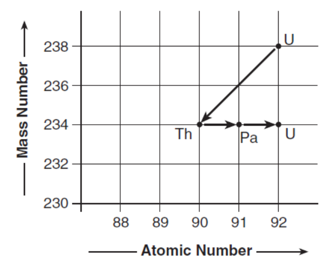
16. Which nuclear emission has the greatest mass?
    (1) alpha particle (3) gamma ray
    (2) beta particle (4) positron

17. Which nuclear decay emission consists of energy, only?
    (1) alpha particle (3) gamma radiation
    (2) beta particle (4) positron

18. Which group of nuclear emissions is listed in order of increasing charge?
    (1) alpha particle, beta particle, gamma radiation
    (2) gamma radiation, alpha particle, beta particle
    (3) positron, alpha particle, neutron
    (4) neutron, positron, alpha particle

19. Which two nuclides are isotopes of the same element?
    (1) $^{20}_{11}Na$ and $^{20}_{10}Ne$ (3) $^{39}_{19}K$ and $^{42}_{19}K$
    (2) $^{39}_{19}K$ and $^{40}_{20}Ca$ (4) $^{14}_{6}C$ and $^{14}_{7}N$

20. The chart below shows the spontaneous nuclear decay of U-238 to Th-234 to Pa-234 to U-234.



What is the correct order of nuclear decay modes for the change from U-238 to U-234?
    (1) β^- decay, γ decay, β^- decay
    (2) β^- decay, β^- decay, α decay
    (3) α decay, α decay, β^- decay
    (4) α decay, β^- decay, β^- decay

ASSESS YOURSELF ON THIS LESSON: __________/20

If you missed more than 3, do the Additional Practice. If not, go on to the next hw video!!!

Name:

ADDITIONAL PRACTICE LESSON 1

Solve for X in the reactions:

1) $^{3}_{1}H \rightarrow ^{3}_{2}He + X$ ____________
2) $^{238}_{92}U \rightarrow ^{4}_{2}He + X$ ____________
3) $X \rightarrow ^{42}_{20}Ca + ^{0}_{-1}e$ ____________
4) $^{234}_{90}Th \rightarrow ^{234}_{91}Pa + X$ ____________

Write the equations for the decay for the following:

5) Fr-220 ____________________________________
6) Au -198 ____________________________________
7) Fe-53 ____________________________________

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: __________/7

If you missed more than 1 you should see me for extra help and/or re-watch the lesson video assignment

Challenge: Nuclear Decay Fill-Ins

Directions: Observe the first few steps of the Uranium decay process. Uranium needs 14 separate decay processes in order to reach a stable nucleus. Fill in the remaining decay equations.

PARENT NUCLIDE			DAUGHTER NUCLIDE		
1)	α)	$^{238}_{92}U$	→ $^{4}_{2}He$ + $^{234}_{90}Th$		
2)	β⁻)	$^{234}_{90}Th$	→ $^{0}_{-1}e$ + $^{234}_{91}Pa$		
3)	β⁻)	$^{234}_{91}Pa$	→ $^{0}_{-1}e$ + $^{234}_{92}U$		
4)	α)	$^{234}_{92}U$	→ $^{4}_{2}He$ + $^{230}_{90}Th$		
5)	α)	$^{230}_{90}Th$	→ _______ + __________		**OK, now YOU finish them off!**
6)	α)				
7)	α)				
8)	α)				
9)	β⁻)				
10)	β⁻)				
11)	α)				
12)	β⁻)				
13)	β⁻)				
14)	α)				

Name:

Lesson 2: Half-Lives

Objective:

- ***Calculate the half-lives of selected nuclides***

Radioactive isotopes are unstable, which means that they spontaneously (readily) decay (break apart) into different isotopes or elements. Radioactive isotopes give off radiation during the process of radioactive decay. Radiation can be in the form of particles (alpha, beta, or positron) and/or pure energy (gamma rays). For radioactive isotopes, the rate (speed) of radioactive decay is constant. All radioactive isotopes have a specific **half-life**, or **time that it takes for exactly half of the sample to decay into something else and half of the sample to remain unchanged.** It is because of information about half-lives that we can know how old the Earth is and how old fossils are.

Half-Life Problems

Time Elapsed

1. How long will it take for 30. g of ^{222}Rn to decay to 7.5 g?

# HL	Time	Mass	Fraction
0	0	30.g	1
1			1/2
2			1/4
3			1/8

2. How long will it take for a 28 g sample of ^{226}Ra to decay to 3.5 g?

Name:

Amount Remaining

3. How many grams of ^{16}N will be left from a 16.0 g sample after 21.6 s?

4. After 9.8×10^{10} years, how many grams will be left from a 256 g sample of Th-232?

Fraction Remaining:

5. What fraction of a 100 g sample of K-42 will remain after 24.8 hours?

6. What fraction of a radioactive I-131 sample would remain unchanged after 32.28 days?

Name:

Number of Half-Lives

7. How many half-life periods will it take for 50 g of ^{99}Tc to decay to 6.25 g?

8. How many half-lives have elapsed if a 100 g sample of a radioactive isotope has only 12.5 g remaining?

Original Mass:

9. If 2 grams of an original sample of gold-198 remained after 13.45 days, what was the mass of the original sample?

10. If 16.5 g of uranium-235 remain after 2.84×10^9 years, how much of the radioactive isotope was in the original sample?

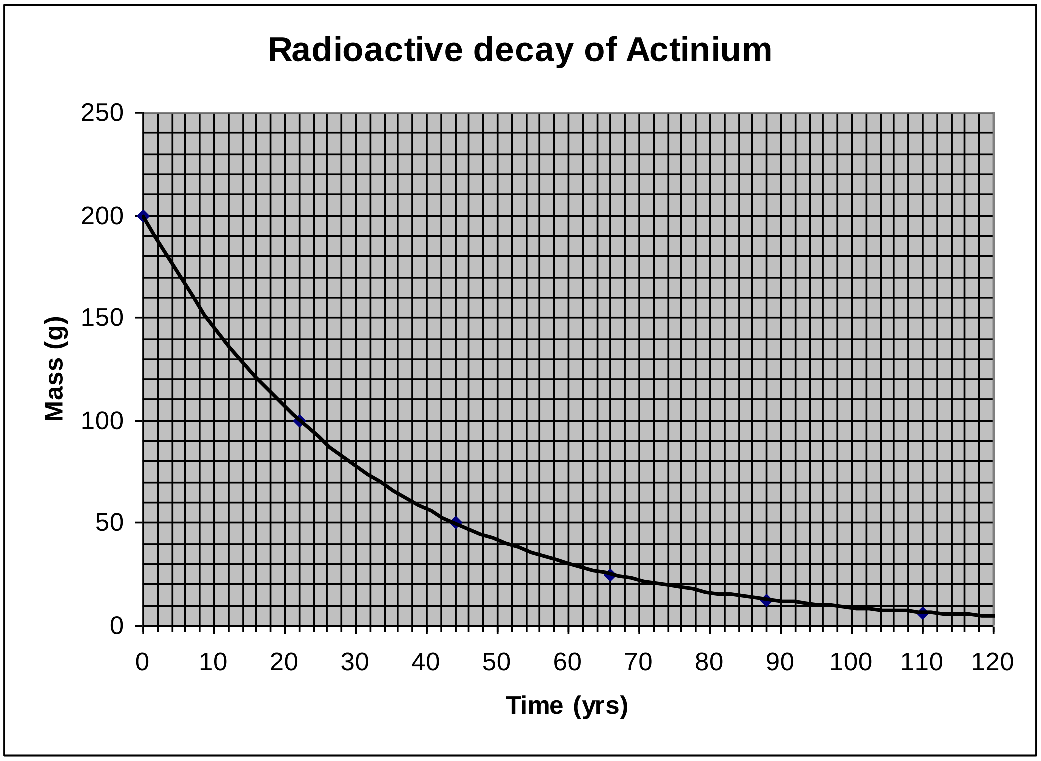
Half Life:

11. An original sample of the radioisotope fluorine-21 had a mass of 80.0 milligrams. Only 20.0 milligrams of this original sample remain unchanged after 8.32 seconds. What is the half-life of fluorine-21?

12. What is the half-life of a 208 g sample of sodium-24 if it decays to 13.0 g of sodium-24 within 60.0 hours?

Name:

Graphing Questions



13. What was the original mass of the astatine sample?
14. How many grams of astatine remain after 44 years?
15. What is the half life of astatine?

16. What mass of astatine remains after one half-life?
17. What fraction of astatine remains after one half-life?
18. How many half-lives must astatine go through until only 25% of the original sample mass remains?

19. How many half-lives until only 6.25% remains?

20. How many half-lives will it take for all of the original sample to decay?

21. A radioisotope's half-life is 1 min. Given that the initial mass of the sample is 12g, calculate the mass of the radioisotope that has not decayed after 1 min, 2min, 3min, 4min, 5min and 6min. Draw a graph of the radioisotope mass versus time (don't forget to label your axes).

#HL	Time	Mass	Fraction
0	0	12g	1

22. Estimate the time that must elapse in order for ½ of the radioisotope to be present.

23. By interpolation of the graph, estimate the grams of the radioisotope left after 1.5min.

24. The initial mass of a sample of a radioisotope is 100g. After 1 hour, 80g remain. After 2 hours, 60g remains, after 4hours, 41g remain and after 6 hours, 26.2g remain. On the next grid, draw a graph of mass of radioisotope remaining versus time.

25. Use this graph to estimate the half-life of the radioisotope.

26. Use your answer to number 5 to calculate the amount of time required for 25g of the radioisotope to remain. Compare that to the time you would get if you used the graph.

27. By extrapolation of the graph, find the mass of the radioisotope remaining after 8 hours.

ASSESS YOURSELF ON THIS LESSON: __________/27

If you missed more than 4, do the Additional Practice. If not, go on to the next hw video!!!

ADDITIONAL PRACTICE LESSON 1

1. How long will it take for 50% of a sample of iodine-131 to decay?
2. How long will it take a sample of Fr-220 to decay to 1/4 of its original amount?
3. What is the amount of a 500. gram sample of iron-53 that will remain unchanged after 34.04 minutes?
4. What amount of a 100 g sample of K-42 will remain after 24.8 hours?

5. What fraction of a sample of ^{32}P will be left after 42.9 days?

6. What fraction of a sample of ^{3}H will be left after 36.78 years?

7. How many half-lives will pass by the time a 60.0g sample of Co-60 decays to 7.5 g?

8. After 62 hours, 1 g remains unchanged from a sample of K-42. How much K-42 was in the original amount?

9. How many half-lives of K-37 will pass after 6.15 seconds?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: __________/9

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Name:

Lesson 3: Nuclear Fusion and Fission

Objective:

- ***Determine the type of nuclear reaction***
- ***Determine benefits and risks associated with fission and fusion reactions***

Fission: (splitting) *A neutron bombards an atom causing it to split into two or more pieces and gives off a lot of energy.* This is the energy behind nuclear power plants (controlled chain reaction) and atomic bombs (uncontrolled chain reaction).

Fusion: (to fuse/join) two nuclei unite to form a heavier nucleus. High temperature and pressure are needed, which is why this occurs on the SUN. Creates more energy than fission.

1. Explain why fission is considered a chain reaction and could be dangerous.

2. Explain why fusion is not as dangerous as fission in terms of control and products made.

3. Why is it so difficult for hydrogen atoms to combine? (Why is fusion not cost effective?)

4. Where does all the energy that is produced in fission and fusion come from?

5. What type of transmutation are both fission and fusion?

6. What are the benefits of nuclear reactions vs chemical reactions?

Artificial vs Natural Decay

Natural Transmutation:

- Decay is spontaneously
- 1 Reactant

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$$

Artificial Transmutation:

- Decay is not spontaneous
- 2 reactants

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{93}_{36}Kr + ^{140}_{56}Ba + 3^{1}_{0}n$$

Name:

Complete the table below by determining the identity of X and the type of decay

Reaction	Particle X	Is this an example of natural decay or artificial transmutation?
1) $^{40}_{20}Ca + X \longrightarrow ^{40}_{19}K + ^{1}_{1}H$		
2) $^{96}_{42}Mo + ^{2}_{1}H \longrightarrow ^{1}_{0}n + X$		
3) $^{64}_{26}Fe + ^{4}_{2}He \longrightarrow 2\ ^{1}_{1}H + X$		
4) $^{246}_{96}Cm + ^{12}_{6}C \longrightarrow 4\ ^{1}_{0}n + X$		
5) $^{82}_{35}Br \longrightarrow ^{82}_{36}Kr + X$		
6) $^{19}_{10}Ne \longrightarrow ^{0}_{+1}e + X$		
7) $^{37}_{18}Ar + ^{0}_{-1}e \longrightarrow X$		
8) $^{98}_{42}Mo + ^{1}_{0}n \longrightarrow ^{99}_{43}Tc + X$		
9) $^{40}_{18}Ar + X \longrightarrow ^{43}_{19}K + ^{1}_{1}H$		
10) $X \longrightarrow ^{23}_{11}Na + ^{0}_{+1}e$		

ASSESS YOURSELF ON THIS LESSON: __________/16

If you missed more than 3, do the Additional Practice. If not, go on to the next hw video!!!

ADDITIONAL PRACTICE LESSON 3

Classify the following equations as either fission or fusion.

$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}p$	
$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\ ^{1}_{0}n$	
$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{138}_{54}Xe + ^{95}_{38}Sr + 3\ ^{1}_{0}n$	
$^{3}_{2}He + ^{3}_{2}He \rightarrow ^{4}_{2}He + 2\,^{1}_{1}H$	

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: __________/4

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Name:

Lesson 4: Benefits and Risks of Radioactive Isotopes

Objective:

- ***Determine benefits and risks associated with fission and fusion reactions***

1. Which radioactive isotope is used in treating cancer?
   (1) carbon-14 (3) lead-206
   (2) cobalt-60 (4) uranium-238

2. Which nuclide is used to investigate human thyroid gland disorders?
   (1) carbon-14 (3) cobalt-60
   (2) potassium-37 (4) iodine-131

3. Which nuclide is paired with a specific use of that nuclide?
   (1) carbon-14, treatment of cancer
   (2) cobalt-60, dating of rock formations
   (3) iodine-131, treatment of thyroid disorders
   (4) uranium-238, dating of once-living organisms

4. The decay of which radioisotope can be used to estimate the age of the fossilized remains of an insect?
   (1) Rn-222 (3) Co-60
   (2) I-131 (4) C-14

5. According to Table N, which radioactive isotope is best for determining the actual age of Earth?
   (1) ^{238}U (3) ^{60}Co
   (2) ^{90}Sr (4) ^{14}C

6. Which isotope is most commonly used in the radioactive dating of the remains of organic materials?
   (1) ^{14}C (3) ^{32}P
   (2) ^{16}N (4) ^{37}K

Name:

7. 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.

   (a) 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.

$$^{241}_{95}\text{Am} \rightarrow \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_$$

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

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

8. A substance known as heavy water can be obtained from ordinary water and could be a significant source of energy in the future. Heavy water contains deuterium, H-2. Instead of the two hydrogen atoms in a typical water molecule, a heavy water molecule has two deuterium atoms. In 3.78 kilograms of ordinary water, the percent composition by mass of heavy water is approximately 0.0156%.

   Deuterium atoms completely ionize at approximately 108 K. The result is an ionized gas consisting of electrons and deuterons (the nuclei of deuterium). A triton is the nucleus of a tritium atom, H-3. These particles react according to the equations below. In the second equation, *X* represents an unidentified product.

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \rightarrow ^{3}_{1}\text{H} + ^{1}_{1}\text{H} + \text{energy}$$

$$^{2}_{1}\text{H} + ^{3}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + X + \text{energy}$$

   (a) Calculate the mass of heavy water in a 3.78-kilogram sample of ordinary water. Your response must include *both* a correct numerical setup and the calculated result.

   (b) Identify particle *X* in the second nuclear equation. Your response must include the symbol, atomic number, and mass number of the particle.

ASSESS YOURSELF ON THIS LESSON: __________/8

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