

Chapter 33: The Atomic Nucleus and Radioactivity; 11th edition

Review questions pg. 594

Extra: How do the electric charges of alpha, beta and gamma rays differ?

Ans. The alpha 'ray' consists of alpha particles. Each alpha particle has a + 2 charge.
The beta 'ray' consists of electrons. Each electron has a -1 charge. A magnetic field will push the oppositely charged particles in opposite directions.
The gamma ray consists of photons of light. They are not charged at all.

5. Why are gamma rays not deflected by a magnetic field?

Ans. Gamma rays are photons of light and therefore do not have a charge. A magnetic field will only deflect objects that have a charge and are moving or are magnetic.

6 How does the source differ for a beam of gamma rays and a beam of X rays.

Ans. Gamma rays come from the nuclei of some atoms. X rays come from the reconfiguration of electrons surrounding the nucleus of an atom. They may also be produced when an electron undergoes a large acceleration.

Extra: Why is the mass of an atom practically equal to the mass of its nucleus?

Ans. Each nucleon is approximately 1800 times more massive than an electron.

12. Name the two different nucleons.

Ans. Protons and neutrons are found in the nuclei of atoms and are therefore called nucleons.

Extra: Give the atomic number for deuterium and for tritium.

Ans. Deuterium and tritium are both isotopes of hydrogen. Deuterium has one proton and one neutron while tritium has one proton and two neutrons. The both have atomic number 1.

Extra: When beta emission occurs, what change takes place in an atomic nucleus?

Ans. Beta emission occurs when a neutron emits an electron. The neutron changes into a proton in the process. The atomic nucleus now has one more proton than before the emission and thus is now an atom of a different element.

Extra: Distinguish between an isotope and an ion.

Ans. An isotope of an element has a different number of neutrons than a different isotope of the same element. An ion is a charged atom. It is charged because it does not have the same number of protons as electrons.

Extra: What is meant by radioactive half-life?

Ans. Radioactive half-life is the time required for one half the remaining radioactive nuclei to undergo radioactive decay.

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23. When thorium, atomic number 90, decays by emitting an alpha particle, what is the atomic number of the resulting nucleus. What happens to its atomic mass?

Ans. An alpha particle consists of two protons and two neutrons. When thorium undergoes alpha decay, the remaining nucleus will have 88 protons instead of 90. The new atom will be atomic number 88, which is radium—a different element than before. The alpha particle consists of two protons and two neutrons. Alpha decay reduces the atomic mass by four.

24. When thorium decays by emitting a beta particle (an electron), what is the atomic number of the resulting nucleus? What happens to its atomic mass?

Ans. When a nucleus undergoes beta decay, one of its neutrons changes into a proton as it emits an electron. Therefore, the atomic number increases by one. The new atomic number will be 91. Although the fleeing electron carries a tiny bit of mass away with it, the atomic mass of the atom does not change.

25. How does the atomic mass change for questions 23 and 24?

Ans. I included this answer in the answers to # 23 and #24.

26. What is the effect on the makeup of a nucleus when it emits an alpha particle? A beta particle? A gamma ray?

Ans. When the nucleus of an atom emits an alpha particle, it loses two protons and two neutrons. When the nucleus of an atom emits a beta particle a neutron changes to a proton. When the nucleus of an atom emits a gamma ray the nucleus reconfigures itself to a less energetic state.

Extra: Which isotope of carbon is radioactive? Carbon-12 or Carbon -14

Ans. Carbon-14 is a radioactive isotope of carbon.

Extra: Why is there more C-14 in new bones than there is in old bones of the same mass?

Ans. Carbon-14 changes to Nitrogen-14 with a half-life of 5,730 years. So the amount of Carbon-14 present in a substance is reduced over time

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2. X rays are most similar to which of the following: alpha, beta, or gamma?

Ans. X rays and gamma rays are most similar because they are both photons of light. The others are not.

5. Some people say that all things are possible. Is it at all possible for a hydrogen nucleus to emit an alpha particle? Explain your answer.

Ans. A hydrogen nucleus contains only one proton and zero, one or two neutrons. An alpha particle consists of two protons and two neutrons. Therefore a hydrogen atom cannot emit an alpha particle. It cannot emit what it doesn't have.

6. Why are alpha and beta rays deflected in opposite directions in a magnetic field? Why aren't gamma rays deflected?

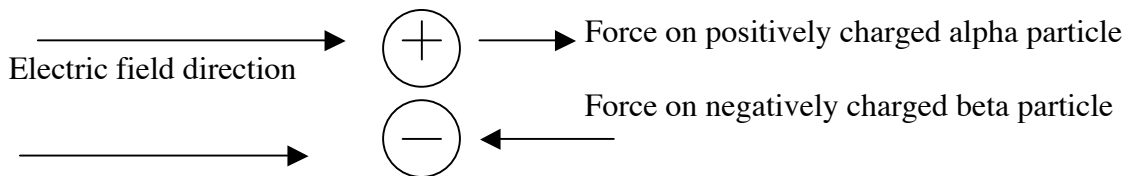
Ans. Alpha rays consist of positively charged helium nuclei. Beta rays consist of negatively charged electrons. Gamma rays are uncharged photons of light. A magnetic field will apply a force to a moving charged particle. Positively charged particles are accelerated in one direction and negative charged particles are accelerated in the opposite direction. Because gamma rays are not charged, they are unaffected by the magnetic field.

7. The alpha particle has twice the electric charge of the beta particle but, for the same velocity, accelerates less than the beta in a magnetic field. Why?

Ans. From Newton's second law of motion we know that acceleration is directly proportional to the net force applied to an object and inversely proportional to the objects mass. Although the force applied to the alpha particle is twice that applied to the beta particle, the alpha particle is approximately 3600 times more massive than the beta.

8. How do the paths of alpha, beta and gamma radiation compare in an electric field?

Ans. The positively charged alpha particle will accelerate in the direction of the magnetic field, the negatively charged beta will accelerate in the opposite direction of the field and the gamma photon will not be effected by the electric field.



9. Which type of radiation results in the greatest change in atomic mass? Atomic number?

Ans. Alpha radiation. Alpha radiation. The resulting nucleus will be missing two protons and two neutrons. The atomic mass will be four less than the original and the atomic number will be two fewer than the original.

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10. Which type of radiation results in the least change in atomic mass? The least change in atomic number?

Ans. Gamma radiation. There is no change in mass number or atomic number because a gamma ray is a photon of light.

12. In bombarding atomic nuclei with proton "bullets", why must the protons be accelerated to high energies if they are to make contact with the target nuclei?

Ans. Atomic nuclei are positively charged. The proton "bullets" are positively charged. They will be repelled away from each other by the electromagnetic force.

23. The amount of radiation from a point source is inversely proportional to the distance from the source. If a Geiger counter 1 meter from a small sample reads 360 counts per minute, what will be its counting rate 2 meters from the source? 3 meters from the source?

Ans. Doubling the distance will result in a count of $(1/2)^2 = 1/4$ the original count. $1/4$ of 360 = 90 counts per minute. Tripling the distance will result in $(1/3)^2 = 1/9$ the original count. $1/9$ of 360 = 40 counts per minute.

28. When ${}^{226}_{88}\text{Ra}$ decays by emitting an alpha particle, what is the atomic number of the resulting nucleus? What is the name of the element?

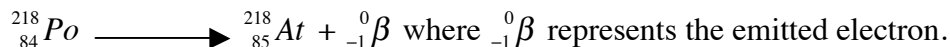
Ans. When the nucleus of an atom emits an alpha particle, it loses two protons and two neutrons. The remaining nucleus will be atomic number 86 and its mass number will be 222. The reaction can be written as follows:



29. When ${}^{218}_{84}\text{Po}$ emits a beta particle, it transforms into a new element. A) What are the atomic number and atomic mass of this new element? B) What are atomic number and atomic mass if the polonium instead emits an alpha particle?

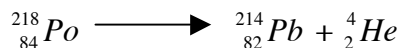
Ans. A) Beta emission occurs when a neutron emits an electron as it changes into a proton.

When ${}^{218}_{84}\text{Po}$ emits a beta particle, its atomic number increases by one and its atomic mass remains unchanged. The resulting atom will be atomic number 85 and its atomic mass is 218. The reaction can be written as follows:



B) When the nucleus of an atom emits an alpha particle, it loses two protons and two neutrons. If

${}^{218}_{84}\text{Po}$ emits an alpha particle its new atomic number will be 82 and its new atomic mass will be 214. The reaction can be written as follows:



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32. State the number of protons and neutrons in each of the following nuclei:

${}^2_1\text{H}$, ${}^{12}_6\text{C}$, ${}^{56}_{26}\text{Fe}$, ${}^{197}_{79}\text{Au}$, ${}^{90}_{38}\text{Sr}$, and ${}^{238}_{92}\text{U}$.

Ans. Hydrogen 2 has 1 proton and 1 neutron.
Carbon 12 has 6 protons and 6 neutrons.
Iron 56 has 26 protons and 30 neutrons.
Gold 197 has 79 protons and 118 neutrons.
Strontium 90 has 38 protons and 52 neutrons.
Uranium 238 has 92 protons and 146 neutrons.

33. How is it possible for an element to decay forward in the periodic table—that is, to decay to an element of higher atomic number?

Ans. When the nucleus of an atom of an element undergoes beta decay, one of its neutrons changes to a proton as it emits an electron. This will increase the number of protons and therefore the atomic number, by one.

45. When food is irradiated with gamma rays from a cobalt-60 source, does the food become radioactive?

Ans. No. The cobalt-60 is radioactive and never touches the food. The gamma rays are energetic photons of light that kill bacteria.

49. The age of the Dead Sea Scrolls was found by carbon dating. Could this technique apply if they were carved in stone tablets? Explain.

Ans. Carbon dating requires that the object have some carbon in it. Unless the stone tablets had some carbon in them, their age could not be determined using carbon dating.

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Prob.1 If a sample of a radioactive isotope has a half-life of 1 year, how much of the original sample will be left:

At the end of one year?

Ans. 1/2

At the end of two years?

Ans. 1/4

At the end of three years?

Ans. 1/8

Prob. 2 A sample of a particular radioisotope is placed near a Geiger counter, which is observed to register 160 counts per minute. Eight hours later the detector counts at a rate of 10 counts per minute. What is the half-life of the material?

Ans. The half-life is 2 hours. Here is my reasoning. If you cut 160 in half you will have 80. 1/2 of 80 = 40. 1/2 of 40 = 20. 1/2 of 20 = 10. We repeated this process 4 times. Four half-lives have elapsed. Eight hours divided by 4, equals 2 hour