PHYS 1200 Physics of Everyday Experience

Review questions and exercises for Lecture 35 (MP-3)

1. What are the masses and charges of the particles in the nucleus? What is the nucleus of a hydrogen atom?
2. What are the atomic number Z, neutron number N, and atomic mass (or weight) A?
3. What are isotopes? Give a few examples.
4. What holds the nucleus together?
5. Why do stable heavy nuclei have more neutrons than protons?
6. What types of particles are emitted by radioactive nuclei?
7. What are α's, β's, and γ's ?
8. How are α's, β's, and γ's affected by a magnetic field?
9. How is the "half-life" of a radioactive substance defined?
10. What is nuclear activation, and how is it used in cancer therapy?
11. What are the numbers of protons and neutrons in the following nuclei:

    (a) ${}^{215}_{84}Po$ (b) ${}^{212}_{83}Bi$ (c) ${}^{60}_{27}Co$ (d) ${}^{131}_{53}I$ (e) ${}^{226}_{88}Ra$

12. Identify the nuclei having:

    (a) N = 22, A = 40 (b) Z = 19, N = 21

    (c) Z = 27, A = 56 (d) N = 64, A = 108

    (Consult a periodic table to identify the elements.)

13. A radioactive nuclear material is produced in a medical cyclotron device. Initially the sample contains 100,000 radioactive nuclei and 80 s later it contains 250,000 radioactive nuclei. What is the half-life of this nuclei?
14. A sample of radioactive nuclei contains 80,000 atoms. If the half-life of the nuclei is 1 day, how many nuclei, on average, will be left after 4 days?
15. Uranium-238 decays by emitting an alpha particle. What is the decay product?

Answers and Solutions:

1. The nucleus contains protons which have a charge of +1 elementary charges, and neutrons which have no charge. The mass of the proton and the mass of the neutron are nearly the same. The nucleus of a hydrogen atom is a single proton.
2. Z is the number of protons, N is the number of neutrons, and A = Z + N.
3. Isotopes are nuclei of the same element (same Z) having different numbers of neutrons. For example: deuterium and tritium are isotopes of hydrogen.
4. The nuclear force holds the nucleus together.
5. Neutrons being uncharged, increase the amount of nuclear force that holds the nucleus together without increasing the repulsive electric force.
6. Alphas, betas, and gammas.
7. Alpha particles are the nucleus of a helium atom, ${}^{4}_{2}He$, betas are just electrons, and gammas are high energy photons.
8. Alphas and betas have electric charge (alpha + 2, and beta –1) so they are deflected in opposite directions by a magnetic field. Gammas have no charge, and therefore are not affected by a magnetic field.
9. The half-life is defined as the time for half of the radioactive nuclei in a sample to decay.
10. Nuclear activation is a process in which a sample of stable nuclei is exposed to neutrons which cause the nuclei to become unstable. Activated nuclei having a short half-life are injected into a cancerous tumor to kill the cancerous cells.
11. (a) ${}^{215}_{84}Po \rightarrow N = 215 - 84 = 131$

    (b) ${}^{212}_{83}Bi \rightarrow N = 212 - 83 = 129$

    (c) ${}^{60}_{27}Co \rightarrow N = 60 - 27 = 33$

    (d) ${}^{131}_{53}I \rightarrow N = 131 - 53 = 78$

    (e) ${}^{226}_{88}Ra \rightarrow N = 226 - 88 = 138$

12. (a) Z = 40 – 22 = 18 → argon → ${}^{40}_{18}Ar$

    (b) Z = 19 --> potassium, A = 19 + 21 = 40 → ${}^{40}_{19}K$

    (c) Z = 27 → cobalt, N = 56 – 27 = 29 → ${}^{56}_{27}Co$

(d) Z = 108 – 64 = 44 → xenon → $^{108}_{44}Xe$

13. In 80 s, the number of nuclei was reduced by ¼. Therefore 80 s much be twice the half-life, so the half-life must be 40 s.

14. A table of the number of nuclei present after each half-life is shown:

Time (days)	**Number**
0	80,000
1	40,000
2	20,000
3	10,000
4	5000

Thus after 4 days, 5000 nuclei would remain.

15. Uranium has Z = 92, so U-238 → $^{238}_{92}U$. If this decays by alpha $^{4}_{2}He$ emission, Z decreases by 2 and A decreases by 4. The element with Z = 90 is thorium, so the decay is $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$.