O Level Physics Tutorial 20: Radioactivity

Syllabus :
(a) describe the composition of an atom in terms of a positive nucleus (with protons and neutrons) and negatively charged electrons

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1. (i) State the three particles that make up an atom.

(ii) The common hydrogen atom has only two particles. State the names of these particles.

(iii) Which particle is positive, and which one is negative?

(iv) One particle is nearly 2000 heavier than the other. State the name of this particle. What is the name of the other particle.

(v) Which particle is at the centre of the atom?

(b) use the terms proton (atomic) number Z, nucleon (mass) number A and isotope

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2. (i) What is an isotope?

(ii) What is the meaning of atomic number and mass number of an atom?

(iii) What is an isotope?

(iv) An iron isotope has has an atomic number 26, and mass number 54. What are its atomic number and proton number?

(c) use and interpret the term nuclide and use the nuclide notation ${}^{Z}_{A}X$

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3. (i) State the meaning of nuclide.

(ii) What is the meaning of the nuclide notation ${}^{14}_{6}C$?

(d) show an understanding that nuclear decay is a random and spontaneous process whereby an unstable nucleus loses energy by emitting radiation

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4. (i) A uranium nuclide $^{238}_{92}U$ decays by emitting a small a helium nuclide $^{4}_{2}He$ and another nuclide $^{Z}_{A}X$. Find the nucleon number Z and proton number Z of X.

(ii) That the uranium nuclide can decay spontaneously means that it is unstable. In the decay process, it becomes more stable by losing energy. In what form is the uranium nuclide's energy lost in this case?

(e) show an understanding of the nature of alpha (α), beta (β), and gamma (γ) radiation (including ionising effect and penetrating power) [β-particles are assumed to be β– particles only]

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5. For each of the following particles, describe its ionising effect and penetrating power :

(i) alpha (α) particles,

(ii) beta (β) particles,

(iii) gamma (γ) radiation.

(f) use equations involving nuclide notation to represent changes in the composition of the nucleus when radioactive emissions occur

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6. Use equations involving nuclide notation to represent each of decay below:

(a) A radium nuclide $^{226}_{88}Ra$ decays into a radon nuclide $^{222}_{86}Rn$ by emitting an alpha particle.

(b) A polonium nuclide $^{218}_{84}Po$ decays into an astatine nuclide $^{218}_{85}At$ by emitting a beta particle.

(g) show an understanding of background radiation

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7. What is background radiation?

(h) use the term half-life in simple calculations, which might involve information in tables or decay curves

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8. Carbon-14 is an isotope of carbon that is present the carbon in nature. Carbon is a part of living things. Only 1 in 10^{12} carbon atoms is carbon-14. Carbon-14 decays into a nitrogen-14 atom by emitting a beta particle.

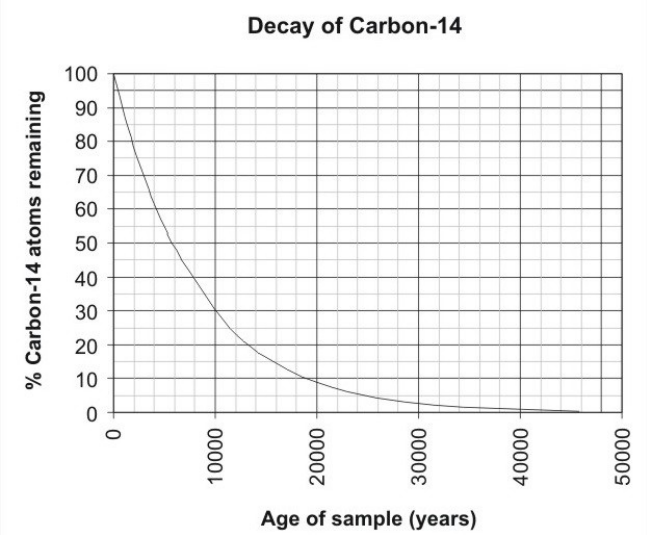

Figure 20-1

A plant or animal has a roughly constant fraction of carbon that is carbon-14 because it keeps taking in and passing out nutrients from nature. But once it dies, the carbon-14 in its body is not replaced anymore and the percentage starts decreasing..

(i) A sample of an ancient plant part is measured to have 20% the carbon-14 expected in a living plant. Using the graph above, determine the age of the sample.

(i) discuss the applications (e.g. medical and industrial uses) and hazards of radioactivity based on:
(i) half-life of radioactive materials,
(ii) penetrating abilities and ionising effects of radioactive emissions

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9. (i) Technetium-99m can be injected into the body and used for imaging organs of the body to detect disease. It has a short half-life of 6 hours. Why is it good that it has such a short half life?

(ii) Penetrating ability:

- Beta particles can be used to monitor paper thickness. Why is gamma ray not used?
- How is gamma ray is used to detect maximum liquid level when filling containers automatically?

(iii) Ionising effects:

- The thyroid gland in the throat tends to absorb needs iodine to produce hormones. It happens that the iodine-131 isotope emits β particles. How can this be used to treat thyroid cancer?
- Why is food packaged in factories passed through gamma radiation or X ray in many countries?

(j) state the meaning of nuclear fusion and nuclear fission and relate these nuclear processes with the release of energy from nuclear fuels (recall of the energy-mass equivalence and details of technologies in nuclear power plants are not required).

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10. (a) (i) State the meaning of nuclear fusion. Describe what happens in the figure below.

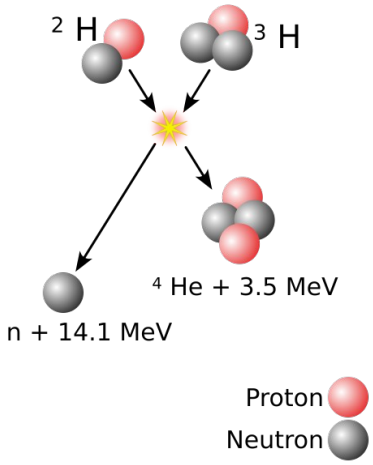

Figure 20-2(a)

(ii) State the meaning of nuclear fission. Describe what happens in the figure below.

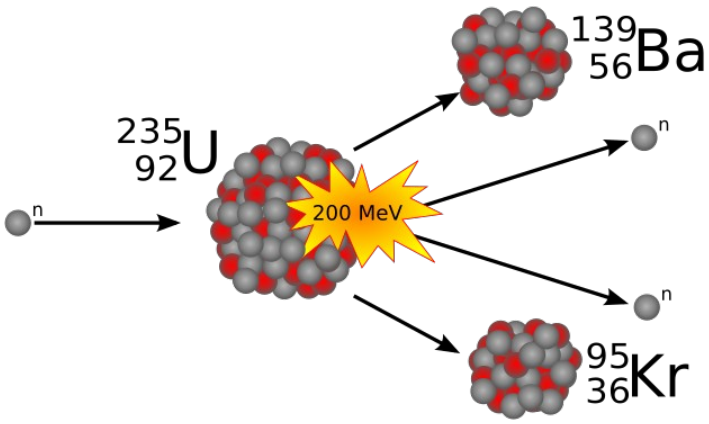

Figure 20-2(b)

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