**P6.1 Why are some materials radioactive?**

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| **Before** | **Objectives** | **After** |
|  | 1. Recall that some elements emit ionising radiation all the time and are called radioactive. |  |
|  | 2. Understand that radioactive elements are naturally found in the environment, contributing to background radiation. |  |
|  | 3. Understand that an atom has a nucleus, made of protons and neutrons, which is surrounded by electrons. |  |
|  | 4. Understand that the results of the Rutherford-Geiger-Marsden alpha particle scattering experiment provided evidence that a gold atom contains a small, massive, positive region (the nucleus). |  |
|  | **5. Understand that protons and neutrons are held together in the nucleus by a strong force which balances the repulsive electrostatic force between the protons.** |  |
|  | 6. Understand that, if brought close enough together, hydrogen nuclei can fuse into helium nuclei releasing energy, and that this is called nuclear fusion. |  |
|  | **7. Understand that Einstein’s equation E = mc2 is used to calculate the energy released during nuclear fusion and fission (where E is the energy produced, m is the mass lost and c is the speed of light in a vacuum)**  **energy = mass × [speed]2** **(joules, J) (kilograms, kg) ([metres per second]2,[m/s]2)** |  |
|  | **8. Understand that every atom of any element has the same number of protons but the number of neutrons may differ, and that forms of the same element with different numbers of neutrons are called isotopes.** |  |
|  | 9. Understand that the behaviour of radioactive materials cannot be changed by chemical or physical processes. |  |
|  | 10. Recall that three types of ionising radiation (alpha, beta and gamma) are emitted by radioactive materials **and that alpha particles consist of two protons and two neutrons, and that beta particles are identical to electrons.** |  |
|  | 11. Recall the penetration properties of each type of radiation. |  |
|  | **12. Describe radioactive materials in terms of the instability of the nucleus, radiation emitted and the element left behind.** |  |
|  | **13. Complete nuclear equations for alpha and beta decay.** |  |
|  | 14. Understand that, over time, the activity of radioactive sources decreases. |  |
|  | 15. Understand the meaning of the term half-life. |  |
|  | 16. Understand that radioactive elements have a wide range of half-life values. |  |
|  | **17. Carry out simple calculations involving half-life.** |  |

**P6.2 How can radioactive materials be used and handled safely, including waste?**

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| **Before** | **Objectives** | **After** |
|  | 1. Understand that ionising radiation can damage living cells and these may be killed or may become cancerous. |  |
|  | 2. Understand that ionising radiation is able to break molecules into bits (called ions), **which can then take part in other chemical reactions.** |  |
|  | 3. Recall **and explain** how ionising radiation can be used:a. to treat cancerb. to sterilise surgical instrumentsc. to sterilise foodd. as a tracer in the body |  |
|  | 4. Recall that radiation dose (in sieverts) (based on both amount and type of radiation) is a measure of the possible harm done to your body. |  |
|  | 5. Interpret given data on risk related to radiation dose. |  |
|  | 6. Understand that radioactive materials expose people to risk by irradiation and contamination. |  |
|  | 7. Understand that we are irradiated and contaminated by radioactive materials all the time and recall the main sources of this background radiation. |  |
|  | 8. Relate ideas about half-life and background radiation to the time taken for a radioactive source to become safe. |  |
|  | 9. Recall categories of people who are regularly exposed to risk of radiation and that their exposure is carefully monitored, including radiographers and workers in nuclear power stations. |  |
|  | 10. Understand that a nuclear fuel is one in which energy is released by changes in the nucleus. |  |
|  | **11. Know that in nuclear fission, a neutron splits a large and unstable nucleus (limited to uranium and plutonium) into two smaller parts, roughly equal in size, releasing more neutrons.** |  |
|  | 12. Recall that the amount of energy released during nuclear fission is much greater than that released in a chemical reaction involving a similar mass of material. |  |
|  | **13. Understand how the nuclear fission process in nuclear power stations is controlled, and use the terms chain reaction, fuel rod, control rod and coolant.** |  |
|  | 14. Understand that nuclear power stations produce radioactive waste. |  |
|  | 15. Understand that nuclear wastes are categorised as high level, intermediate level and low level, and relate this to disposal methods. |  |