Level of Response Questions – P6 Radioactive Materials

General guidance

- Write some keywords / phrases that relate to the question, before you write your answer. As you write your answer try to use these keywords / phrases appropriately. To get 5 or 6 you need to include the scientific language you have learnt and use it correctly.
- Draw a diagram if you can to help to illustrate the main point(s). Add simple labels that might save you writing several whole sentences. This can help you get started.
- To get the highest marks (5 or 6), check your spelling, punctuation and grammar. It may help to write in short sentences. Remember full stops and capital letters, and spell the key terms correctly.
- In chapters where there are calculations, don't be surprised if you have to do some calculation in the long answer questions.
- Suggested key points are given at the end, for some of the questions.

1. Describe the process of nuclear fission and how it is controlled to produce steam in a nuclear power station.

2. Some people are worried about nuclear waste from power stations. Explain what problems it presents us with, and how we keep this waste from harming people.

3. Medical scans are sometimes performed using technetium-99, a radioactive isotope whose half-life is 6 hours. Explain why this isotope is suitable. Explain some precautions to minimise risk to family members and to the public.

4. Medical scans are sometimes performed using technetium-99, a radioactive isotope whose half-life is 6 hours. Explain the risks and benefits to the patient. How is risk reduced for medical staff involved in this procedure?

5. Some scientists believe nuclear fusion could soon be a viable commercial way to generate mains electricity. Describe the process of nuclear fusion and explain why it might be better than nuclear fission.

6. A power generation company wants to build a new nuclear power station. Some people who live near the proposed site protest whilst others are enthusiastic. Describe who might be exposed to increased risk and who might benefit. Explain why the government might approve the plan in spite of the protests.

7. A cancer patient is treated with gamma radiation and is worried that he may become radioactive. Explain whether the patient's family will be at risk or not from this treatment.

8. Radon gas can cause cancer, and many people in the UK live in areas of high radon concentration. Explain how radon can cause cancer and how you could minimise the risk is you live in a one of these areas.

1. Describe the process of nuclear fission and how it is controlled to produce steam in a nuclear power station.

   U-235 (stable) is hit with a neutron.
   Nucleus splits (fissions), into two roughly equal parts, PLUS (usually / about) 3 neutrons.
   Each of these neutrons could hit another U-235 nucleus.
   This process is called a chain reaction.
   The neutrons emitted are too fast to reliably split other nuclei, so a moderator is used to slow them down.
   Of the 3 neutrons emitted in each fission, 2 (on average) must be absorbed to keep the reaction going at a steady rate – if the reaction is increasing in speed, control rods are lowered more into the reaction vessel to absorb more neutrons; if the reaction is slowing down, then the control rods are lifted more out of the vessel, to allow more neutrons the chance of splitting other nuclei.
   The fission reaction releases thermal energy (and when the fast moving neutrons are absorbed, the control rods get hotter). A coolant takes this thermal energy out of the reaction vessel (stopping the vessel from overheating) and uses is to boil water to generate steam to drive the turbines.

2. Some people are worried about nuclear waste from power stations. Explain what problems it presents us with, and how we keep this waste from harming people.

   Nuclear waste is radioactive, so it gives out alpha, beta and gamma radiation.
   This radiation can damage DNA of living cells and so cause cancer.
   To protect people from the radiation, shielding is used and the public are kept at a distance from the waste.
   Some of the isotopes are highly radioactive, but have a relatively short half-life. We keep this waste in cooling ponds until its activity has decreased enough.
   Waste is kept in containers so it cannot leak into the environment causing contamination of ground water.
   Intermediate level waste is kept in a securely (protected from terrorist attack) – we don't have a long term solution for this yet.
   Low level waste is sealed in concrete in steel drums and covered with soil – as its half-life is much longer, it will remain dangerously radioactive for thousands of years.

3. Medical scans are sometimes performed using technetium-99, a radioactive isotope whose half-life is 6 hours. Explain why this isotope is suitable. Explain some precautions to minimise risk to family members and to the public.

   Tc-99 gives out gamma radiation – very penetrating, so it can easily pass through the patient's body and be detected outside; not very ionising, so doesn't deliver much dose to the patient.
   Half-life is short enough to minimise dose to patient and those near patient but is long enough to allow test to be carried out.
   Patient will be contaminated (will have radioactive material inside his/her body).
   Tc-99 has half-life of 6 hours, so after 24 hours activity of patient will decrease to ½ x ½ x ½ x ½ = 1/16, after two days it will be 1/256 (about 0.4%) of original level.
   For a couple of days after the procedure, do not travel on public transport – other passengers would be irradiated.
   For a couple of days flush toilet twice to be sure to remove traces of excreted isotope.

4. Medical scans are sometimes performed using technetium-99, a radioactive isotope whose half-life is 6 hours. Explain the risks and benefits to the patient. How is risk reduced for medical staff involved in this procedure?

Patient will find out if treatment is needed or not – improve long term health.
Patient will be contaminated (will have radioactive material inside his/her body).
This will expose patient to radiation dose (which will increase risk of cancer at some point in the future).
Tc-99 has short half-life (6 hours), so dose is kept low.
Shielding is used (around the syringe) to reduce dose to staff involved. Staff may go to another room (to reduce their dose) whilst the scan takes place, or they may wait behind a (protective / lead glass) screen. Gloves are worn whilst preparing the Tc-99, so contamination risk is reduced.

5. Some scientists believe nuclear fusion could soon be a viable commercial way to generate mains electricity. Describe the process of nuclear fusion and explain why it might be better than nuclear fission.

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