1. Why does a chain reaction not occur in uranium mines?
   There is not enough U-235 present in the ore. It is just 0.7% of the total uranium and it needs to be around 4% to allow chain reactions to occur.

2. What was the function of carbon rods in the atomic reactors?
   The carbon rods are the "control rods". They can capture some of the neutrons that are released in the fission process, thus slowing down the reaction if so desired. Removing the rods allow the fission process to run more quickly.

3. What are two possible fates of neutrons in uranium metal?
   Neutrons may be captured by the control rods (or the circulating water or other non-fissile material) or they may cause a U-235 nucleus to undergo fission.

4. What celebrated equation shows the equivalence of mass and energy?
   \( E = mc^2 \) This tells about the amount of energy released in nuclear processes and how it relates to the observed mass change of the nuclei.

5. In what form is energy initially released in nuclear fusion?
   We could call it thermal energy – it’s the kinetic energy of the fast moving nuclei.

6. Why does a neutron make a better nuclear “bullet” than a proton or an electron?
   It has no charge, so it is not feeling electric forces from surrounding charges. It can penetrate further before colliding with other particles.

7. A 56-kg sphere of U-235 constitutes a critical mass. If the sphere were flattened into a pancake shape, do you think it would still be critical? Explain.
   NO – if it were flat, it would be easier for neutrons to escape out of it. That is, its center would be much closer to its surface, making the path of the neutrons much more likely to take them OUT of the uranium.

8. U-235 has a half-life of about 700 million years. What does this say about the likelihood of fission power on the Earth 1 billion years from now?
   Fission will be much more difficult 1 billion years from now since there will be much less U-235 and it will be much harder to refine.

9. Why will the escape of neutrons be proportionally less in a large piece of fissionable material than in a smaller piece?
   Yes – it’s further to go to get out.

10. In what ways are fission and fusion reactions similar? What are the main differences in these reactions?
    They both release energy by converting mass to energy. The differences include that fusion combines small nuclei together and fission splits apart large one. Also the radioactive waste from the fission process is more dangerous and difficult to deal with.

11. How is chemical burning similar to nuclear fusion?
Energy is released – in one case from chemical potential energy stored in the electrical bonds, and in the other from the nuclear potential energy stored by the nucleons in the nucleus and seen as a reduction in mass.

12. Heavy nuclei can be made to fuse – for instance, by firing one gold nucleus at another one. Does such a process yield energy or cost energy? Explain.

Fusion processes only release energy when the components being fused are lighter than iron, otherwise more energy is used to make them collide than you get out from the process.

13. Which process would release energy from gold, fission or fusion? FISSION Which would release energy from carbon? FUSION From iron? NEITHER

14. If uranium were to split into three segments of equal size instead of two, would more energy or less energy be released?

More mass would probably be converted to energy since you’re breaking it into smaller nuclei closer to the size of iron

15. Mixing copper (element #29) and zinc (#30) atoms produces the alloy brass. What would be produced with the fusion of copper and zinc nuclei?

A different element – praseodymium (element 59 = 29 + 30)

16. Oxygen and hydrogen atoms combine to form water. If the nuclei in a water molecule were fused, what element would be produced?

Oxygen has 8 protons, and each hydrogen has 1 proton – so the total protons is 10, so you have element 10 (neon).

17. If a pair of carbon atoms were fused, and the product were to emit a beta particle, what element would be produced?

Two carbons => Magnesium (#12), then beta increases the number of protons by one to 13: you’d get aluminium.

18. In a nuclear fission reaction, which has more mass, the initial uranium or its products?

Energy is released, so the products have less mass – initial uranium has more mass

19. Why is there, unlike fission fuel, no limit to the amount of fusion fuel that can be safely stored in one locality?

High temperatures are needed to make the hydrogen fuse into helium, but in fission, more than a critical mass in one place is unsafe.