



PART 2

Read the text below and answer questions 14–26.

NUCLEAR FUSION: CHASING THE SUN ON EARTH

A

For decades, nuclear fusion has been portrayed as the “holy grail” of energy research: a way to recreate, on Earth, the process that powers the sun and stars. In the most commonly discussed reaction for early power plants, deuterium and tritium—two isotopes of hydrogen—fuse to form helium and release energy. The attraction is not merely the size of that energy release, but the character of the technology if it can be made practical: there is no runaway chain reaction as in fission, the fuel inputs are not tied to a single scarce resource, and the carbon emissions profile could be extremely low. Yet the same features that make fusion attractive also make it difficult to deliver: it demands extraordinary conditions and extremely precise control, turning the engineering problem into a long-running scientific and industrial chase.

B

The central obstacle is achieving a plasma that is hot, dense, and confined long enough for fusion reactions to occur at useful rates. Fuel must be heated to temperatures commonly described as hotter than the sun’s core—often cited as over 150 million degrees Celsius—so that positively charged nuclei can overcome their electrical repulsion. At such temperatures, matter exists as plasma: a soup of ions and electrons that does not behave like an ordinary gas and is highly sensitive to electromagnetic forces. Creating a plasma is challenging; keeping it stable, away from material surfaces, and sustained over time is harder. Even small losses of heat or confinement can collapse performance, because the reaction rate depends strongly on temperature and density.

C

A practical fusion plant must therefore accomplish three tasks simultaneously: heat the fuel, confine it so it does not touch the vessel walls, and extract the released energy in a controllable way. Preventing contact with walls is essential because it would cool the plasma almost instantly and can also damage internal components. Most mainstream designs seek a “burning plasma” regime, where heat from fusion reactions contributes significantly to keeping the plasma hot, reducing the burden on external heating systems. The best-known approach is magnetic confinement, particularly the tokamak: a doughnut-shaped device in which powerful superconducting magnets guide charged particles along magnetic field lines, holding the plasma away from the wall. The international ITER project under construction in France aims to demonstrate the physics at a scale relevant to power



generation, with a headline target of an energy gain factor Q greater than 10—meaning roughly ten times more fusion power than the power used to heat the plasma.

D

However, tokamaks face severe operating constraints, especially plasma stability. A magnetically confined plasma is not a quiet substance; it can develop instabilities in which small fluctuations grow into large disruptions. When a disruption occurs, energy and particles can strike the inner wall in brief, intense bursts that risk eroding protective layers and shortening component lifetime. This is why tokamak operation is inseparable from control: sensors must diagnose the plasma state in real time, while feedback systems adjust magnetic configuration, density, and temperature to keep behaviour within safe bounds. In addition, a demonstration that works for a short pulse is not the same as a power-plant mode. Long-duration confinement, consistent performance, and predictable shutdown behaviour are essential if fusion is to move beyond experimental milestones into routine generation.

E

Even if stability is mastered, the reactor environment remains punishing. In deuterium-tritium fusion, high-energy neutrons carry much of the reaction energy and stream outward, colliding with the vessel structure. Over time, this bombardment can degrade materials, alter microstructure, and contribute to neutron embrittlement—weakening components in ways that are difficult to predict from conventional industrial experience. Engineering a plant therefore requires materials that can tolerate prolonged neutron exposure while still being manufacturable, inspectable, and replaceable at acceptable cost. This is not a marginal detail: it shapes the economics of maintenance, the feasible design of blankets and shielding, and the long-term reliability of a commercial reactor. The path from a successful plasma experiment to a power station is, to a significant extent, a materials and maintenance problem.

F

Another constraint is that “success” must be counted at the level of the whole system, not just inside the plasma. Even if a plasma produces substantial fusion energy, a plant must pay the energetic costs of magnets, heating, cryogenic systems, pumps, cooling loops, and electricity generation equipment. No experiment has yet demonstrated a complete, power-plant-style chain producing more electricity than it consumes overall once all losses are included. This is especially clear in the alternative approach of inertial confinement fusion (ICF), which compresses a tiny fuel pellet with intense lasers to achieve fusion conditions for a fraction of a second. In 2022, the National Ignition Facility reported “ignition,” where the fusion energy released exceeded the laser energy delivered



to the target. The key caveat is that this accounting does not include the much larger energy required to power the laser system and associated infrastructure, and scaling ICF to a repeatedly firing power plant would require major advances in laser efficiency, repetition rate, and target manufacture.

G

These realities shape the development landscape and the likely timeline. Tokamaks aim for steady or long-duration operation but must solve stability control, component lifetime, and complex remote maintenance. ICF can reach extreme conditions briefly, but faces steep hurdles in efficiency and repetition. In parallel, private companies are exploring smaller devices and alternative magnetic geometries, sometimes arguing that advances in superconductors, materials science, and computational modelling could shorten iteration cycles. Even so, commercial fusion remains uncertain enough that many analysts argue it will not materially contribute to meeting 2050 climate goals, which require large emissions reductions within a few decades. Fusion's more plausible role, if the remaining constraints are overcome later, is as a carbon-free baseload source that complements intermittency from wind and solar. In that scenario, fusion would not replace near-term decarbonisation tools; it would add a powerful option for grid stability and industrial-scale energy in the longer run.

Questions 14–18

Which paragraph contains the following information?

14 an outline of the basic requirements a working fusion power station must meet.

15 an explanation of why a tokamak must be carefully controlled to avoid damaging disruptions.

16 a reference to neutron damage and the difficulty of developing long-lasting reactor materials.

17 a 2022 achievement described as “ignition”, together with a key caveat about the energy accounting.

18 the view that fusion will not make a significant contribution to meeting 2050 climate goals.

Questions 19–23

Choose **YES** if the statement agrees with the claims of the writer, choose **NO** if the statement contradicts the claims of the writer, or choose **NOT GIVEN** if it is impossible to say what the writer thinks about this.



19 The passage states that preventing the plasma from touching the reactor walls is essential to avoid cooling and physical damage.

20 The writer indicates that ITER has already achieved an energy gain factor (Q) above 10 during normal operation.

21 The passage gives the exact amount of government funding committed to ITER in euros.

22 The passage suggests that inertial confinement fusion can currently operate at a repetition rate appropriate for a commercial plant.

23 The writer is certain that private-sector initiatives will overcome the remaining barriers to commercial fusion.

Questions 24–26

Complete the notes below. Choose **NO MORE THAN TWO WORDS AND/OR A NUMBER** from the text for each answer.

Key targets and remaining obstacles

- One major international project aims for an energy gain factor Q greater than **24**
- However, commercial viability still depends on engineering solutions, including materials that can tolerate prolonged **25**
- In the long term, fusion is presented as a potential carbon-free **26** that could work alongside intermittent renewables.

Answer Key

14. C

15. D

16. E

17. F

18. G

19. YES

20. NO

21. NOT GIVEN



22. NO

23. NO

24. 10

25. neutron exposure

26. baseload source