Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

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To see more of Brunning's work, go to compoundchem.com. To see all of C&EN's Periodic Graphics, visit cenm.ag/periodicgraphics.

The science of fusion reactors

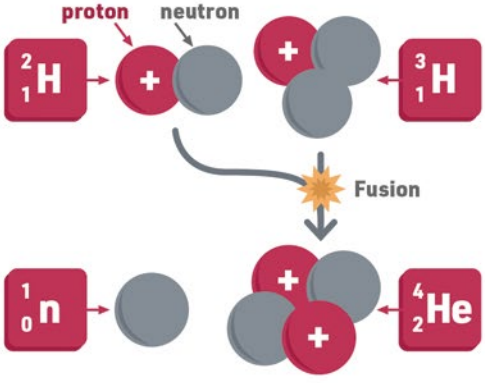
PERIODIC GRAPHICS

Fusion has been touted as a future solution to our energy problems, but getting more energy out of the process than is put in remains a challenge. Here we look at fusion reactors and their history.

What is nuclear fusion?

Nuclear fusion is a reaction in which two nuclei fuse to form one heavier one, releasing massive amounts of energy. Fusion requires very high temperatures and pressures, such as those found in stars, where fusion is the main source of energy.

Fusion of deuterium and tritium to form helium



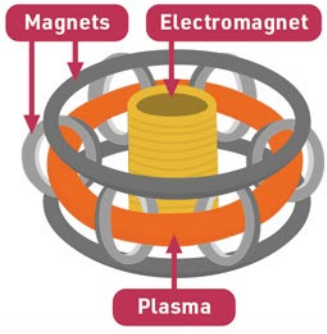
Temperature	Pressure
>100 million K	>203 kPa

Research on using fusion reactions to generate electricity on Earth has been ongoing since the 1930s. Most proposed fusion reactors use the fusion of deuterium and tritium, heavy isotopes of hydrogen. But until recently, reaching the high temperatures and pressures needed for fusion required more energy than the fusion reactions released.

Types of nuclear fusion reactors

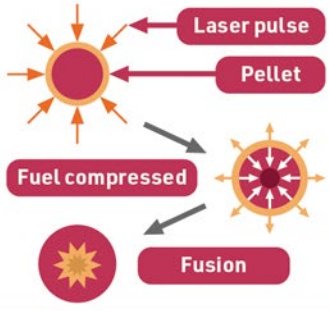
Magnetic confinement

These reactors use a magnetic field to confine the heated plasma in which fusion takes place. The most common magnetic confinement reactor is the doughnut-shaped tokamak.



Inertial confinement

These reactors fire laser pulses at a tiny pellet of deuterium and tritium. The lasers spark an explosion of the outer layer of the pellet, an action that compresses the inner layers, triggering fusion.



Fusion power milestones

1934	Ernest Rutherford's lab successfully fuses deuterium into helium.
1958	Los Alamos National Laboratory achieves controlled nuclear fusion.
1974	KMS Fusion demonstrates the first laser-induced fusion reaction.
1997	The Joint European Torus (JET) tokamak produces 22 MJ of fusion energy, settting a world record not exceeded until 2021.
2022	Lawrence Livermore National Laboratory demonstrates the first-ever net energy production from fusion.