

State Examination Commission – Physics Higher Level, 2006

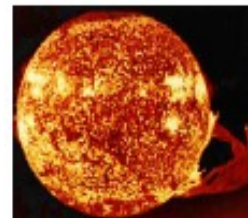
Question 8

Distinguish between fission and fusion. (12)

The core of our sun is extremely hot and acts as a fusion reactor. Why are large temperatures required for fusion to occur? (5)

In the sun a series of different fusion reactions take place. In one of the reactions, 2 isotopes of helium, each with a mass number of 3, combine to form another isotope of helium with the release of 2 protons.

Write an equation for this nuclear reaction. (12)



picture of sun from skylab

Controlled nuclear fusion has been achieved on earth using the following reaction.



What condition is necessary for this reaction to take place on earth?

Calculate the energy released during this reaction. (18)

Give one benefit of a terrestrial fusion reactor under each of the following headings:

(i) fuel;

(ii) energy;

(iii) pollution. (9)

(speed of light = $2.998 \times 10^8 \text{ m s}^{-1}$; mass of hydrogen-2 nucleus = $3.342 \times 10^{-27} \text{ kg}$; mass of hydrogen-3 nucleus = $5.004 \times 10^{-27} \text{ kg}$; mass of helium nucleus = $6.644 \times 10^{-27} \text{ kg}$; mass of neutron = $1.674 \times 10^{-27} \text{ kg}$)

Distinguish between fission and fusion. (12)

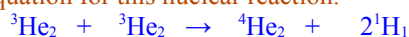
Fission and fusion are different types of nuclear reactions in which energy is released from the high-powered bonds between particles in the atomic nucleus. Fission is the splitting of a nucleus to form two smaller ones of comparable size while fusion is the fusing of two smaller nuclei to form a larger one. In each of these the binding energy of the final product or products is higher than that of the prerequisites.

The core of our sun is extremely hot and acts as a fusion reactor. Why are large temperatures required for fusion to occur? (5)

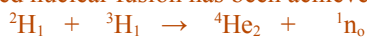
For two positive nuclei to fuse together they must have extremely high energies to overcome the electric repulsive force between them.

In the sun a series of different fusion reactions take place. In one of the reactions, 2 isotopes of helium, each with a mass number of 3, combine to form another isotope of helium with the release of 2 protons.

Write an equation for this nuclear reaction. (12)



Controlled nuclear fusion has been achieved on earth using the following reaction.



What condition is necessary for this reaction to take place on earth?

Very high temperature required.

Calculate the energy released during this reaction. (18)

$$\text{Mass of reactants} = 3.342 \times 10^{-27} + 5.004 \times 10^{-27} = 8.346 \times 10^{-27} \text{ kg}$$

$$\text{Mass of products} = 6.644 \times 10^{-27} + 1.674 \times 10^{-27} = 8.318 \times 10^{-27} \text{ kg}$$

$$\text{mass defect} = 2.8 \times 10^{-29} \text{ kg}$$

$$\begin{aligned} E &= mc^2 \\ &= (2.8 \times 10^{-29})(2.998 \times 10^8)^2 \\ &= 2.52 \times 10^{-12} \text{ J} \end{aligned}$$

Give one benefit of a terrestrial fusion reactor under each of the following headings:

(i) fuel; the fuel, deuterium and tritium, is abundant in the worlds oceans.

(ii) energy; vast amounts of energy could be produced per unit mass of fuel.

(iii) pollution; the by-products are not radioactive and do not contribute to global warming.