Student 2: High Merit

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The process of nuclear fusion is important in the future of power production in New Zealand. The fact that we need alternatives to fossil fuels and the possibilities for hydroelectricity and wind power are limited by the possible locations means another source of power will be needed. The physics behind the production of nuclear power is the fusion reaction. The most common fuel sources used are the isotopes of Hydrogen called deuterium and tritium. We can find deuterium in common sea water and tritium can be made from Lithium in the soil.

1 When the two reactants fuse it gives Helium and a neutron and releases a large amount of energy. To get the two reactants to fuse the two nuclei must join however they are both positively charged. The positive charges repel each other and so the nuclei have to overcome what is called coulombic repulsion. To do this the reaction must happen at very high temperatures and high pressures. The temperatures must be millions of degrees which make some of the electrons leave the atoms, the atoms are now ionised and the electrically charged particles are called plasma. The plasma must be very dense to give the fusion reactions. *As* the particles are subjected to high temperatures the nuclei are given a lot of kinetic energy which allows the nuclei to move much faster and have more collisions which are more forceful. So they get very close to each other which allows them to overcome the coulombic repulsion and fuse together. When they are very close together the strong nuclear force is able to overcome the coulombic repulsion. The strong nuclear force then holds the new Helium nucleus together.

When the fusion reaction has occurred the mass of the product is less than the mass of the reactants. This is because some of the mass has been converted into energy.

2 The equation $E= mc^2$ shows how much energy is created from a given amount of mass. The difference in the masses is called the mass deficit. Although the mass is a very small amount, the size of the value of c, the speed of light squared is very large so a small amount of mass gives a large amount of energy. Binding energy is the amount of energy required to break apart the nucleus. The binding energy is equal to the mass deficit. The more mass that is lost the greater the binding energy the nucleus has.

Each fusion event releases 17.6 MeV, compared with 200 MeV for a Uranium fission event. *A* pellet of nuclear fuel weighs approximately 6 grams but can give the energy equivalent to that generated by a metric tonne of coal, which makes it much more efficient. Nuclear energy is cleaner while generating electricity. Nuclear fission provides energy without releasing greenhouse gases such as carbon dioxide 90% of the carbon emissions from electricity generation in the United States come from coal-fired power plants. They emit pollutants such as sulfur dioxide, toxic metals, arsenic, cadmium and mercury. However, nuclear power plants generate significant amounts of radioactive waste. However the Tritium that needs to be produced only has a half-life of 12 years which is much less than Uranium and so it causes less long term dangerous waste.