

## Plasma Questions and Answers

### **1) Why does a fluorescent tube glow when placed next to a plasma globe?**

*Answer:* The plasma globe is a high frequency voltage supply. The globe has sufficient energy to cause any free electrons in the fluorescent bulb to oscillate in the changing electromagnetic field. The oscillating electrons collide with other atoms knocking off other electrons. This cascade of electrons causes a plasma. The tube is filled with argon gas and mercury vapor. Many of the mercury atoms will have electrons knocked to a higher energy state than ground. As each electron returns to the lower energy state, a photon of light is emitted. This photon is usually in the ultraviolet range. This photon can now hit the phosphorous coating on the inside of the bulb. Here, the photon is absorbed, which causes the electrons in the phosphorous to rise to up a higher energy level. As these electrons return to the ground state, light in the visible range is emitted.

### **2) What is fusion and what way is it considered to be superior to fission?**

*Answer:* Fusion is the combination of two elements to form another element. A popular combination involves combining two hydrogen atoms together to produce helium. Deuterium and tritium, which are isotopes of hydrogen that have one and two extra neutrons respectively, are used for the hydrogen atoms. The sum of the mass of the two hydrogen atoms before the nuclear reaction is slightly greater than the total mass after the reaction. According to Einstein's famous equation,  $E=mc^2$ , the slight difference in mass yields a large amount of energy. Fission on the other hand, starts with large atoms and splits it into smaller atoms. The mass of the large atom, which is usually uranium, before the nuclear reaction is slightly greater than total mass of the atoms after the reaction. The lost mass is converted into energy. Nuclear reactions, like chemical reactions, yield something different from what was started with. Radioactive waste is the major concern when dealing with nuclear reactions. Fusion byproducts include harmless helium while fission byproducts are usually radioactive and numerous.

### **3) How can you tell that fluorescent tubes are more efficient than incandescent bulbs?**

*Answer:* Incandescent bulbs work by heating the filament to a very high temperature. This high temperature generates electromagnetic radiation in a wide range of frequencies. The frequencies outside the visible light spectrum are lost energy. Fluorescent lamps are designed to give visible light by exciting atoms of mercury. The frequency of the light produced is in the visible spectrum so very little heat is lost.

### **4) Why can fluorescent tubes operate at a 110 volts, yet require a much higher voltage to start them?**

*Answer:* To start a fluorescent light, a voltage above the breakdown voltage is required to overcome the nearly infinite resistance of the gas in the tube. Above the breakdown voltage, a plasma is established. This plasma has a very low resistance, so it can sustain a current at a much lower voltage.

**5) Plasma is formed at high temperatures. What keeps fluorescent lights from getting extremely hot?**

*Answer:* Each of the ions in the plasma does have a high temperature, but each ion can only carry a small amount of energy. Since there are very few total ions and electrons in the tube, not much heat energy can be transferred.

**6) A particular fluorescent bulb uses 650 mA at a DC voltage of 100 V.**

**a) What is the resistance in the bulb when the light is not energized?**

*Answer:* The tube contains a neutral noble gas, which would have infinite resistance.

**b) What is the resistance of the bulb when energized?**

*Answer:* The resistance in the tube can be found using Ohm's law  $R=V/I$ .  $100V/.65A = 154 \Omega$ .

**7) How would the spectrum change if a fluorescent tube had an absolute vacuum inside?**

*Answer:* In a pure vacuum, there are no atoms, ions or electrons. Therefore there's nothing to excite or heat. The lamp would never turn on, no plasma could be established, no current would flow, so no light would be produced.

**8) It has been demonstrated that 800 volts is necessary to start a fluorescent light. Why can a fluorescent tube at 400 volts illuminate when touched with a plastic rod that has just been rubbed with a piece of cat fur?**

*Answer:* The small charge on the rod is at a relatively high voltage. This will usually be enough to ionize a few electrons from the atoms in the tube. Once liberated, the electrons and the positive ions will feel a force due to the potential difference and start to accelerate in opposite directions. The electrons pickup sufficient momentum to knock other electrons free from other atoms, creating more electrons and positive ions, which then repeat the process. This cascading effect creates a plasma which readily conducts electrical current due to the high percentage of charged particles in the superheated gas. As the electrons recombine with the ions, photons of ultraviolet light are given off. The white phosphorous powder on the inside of the bulb will absorb this light and emit visible light.

**9) Discuss the similarities and differences in the spectrum of the energized fluorescent tube which has the phosphorus coating on the inside, to the spectrum of tube which is uncoated.**

*Answer:* The spectral lines of uncoated bulb would be distinct and indicative of the element mercury. The coated tube would have spectral lines depending on what type of phosphorous is coating the tube. If several different phosphorus coatings are mixed together, it is possible to essentially make a continuous spectrum of light in the visible range.

## **Plasma - The Fourth State of Matter**

**Plasma** is defined as an ionized gas that responds to electric and magnetic fields.

### **Plasma Facts**

- ) The visible universe is made of 99% plasma. The remaining 1% of matter consists of solid, liquid and gas.
- ) The Sun is a giant ball of plasma.
- ) High temperature Plasma must be contained in magnetic bottles. If the plasma were to come into contact with a physical container, it would vaporize the container.
- ) Lightning is a stream of plasma.
- ) Fusion will most likely involve plasma due to the temperatures needed to start the fusion process  $\sim 10,000,000$  °C.

### **Plasma Balls**

Plasma spheres are large glass bulbs which contain one or more gases at a very low pressure (about 1/10 atmospheric pressure). A small round glass dome located in the center of the plasma ball contains a high voltage, high frequency power supply called a Tesla coil which can generate voltages up to 50,000 V. This high voltage ionizes the gas (rips electrons from the gas molecules leaving positive ions) in the sphere. This ionized gas is a plasma. The large glass sphere is at a much lower voltage than the center ball. The streamers that jump from the center ball to the larger glass sphere are seeking ground. When you place your finger on the glass sphere, a path to ground is established. A small current flows between the inner ball and ground. The current does not flow through your body, but rather around your body. This phenomenon is called the skin effect and occurs when high frequency electricity rides on the surface of objects. The electrical current can not be seen with the human eye. Each streamer in the globe is actually the light which is emitted as energetic electrons recombine with positive ions. The frequency of light, called the color of light when in the visible range, is determined by the type of gas contained in the globe. Most plasma balls contain Argon gas along with trace amount of other gases such as Neon and Mercury vapor.

