

## **“Plasma” the Fourth State of Matter**

### **Segment one**

Welcome everyone, my name is Amaal Jalal .M.AL Hammoury, at Al-Medmar high school, Al Baqaa-Jordan. I'm glad to be your guest today; I want to introduce useful information in physics, I hope it will be fun!

I have some questions to ask you, but, I will show you the following video before asking, hope you will enjoy.

*(A video about universe is showed).*

Did you like the video? I hope so.

Imagine that you were in this space, where peace and quietness all over!!!

Is there any thing in between these planets and galaxies? Or it is only the vacuum and nothing else? Discuss this issue with your colleagues; I will be back within few minutes.

### **Segment Two**

Welcome back again. I have another question to ask but I will show you the following presentation; please watch carefully.

*(Presentation is showed).*

Is there any common thing among all the pictures you have seen?

Discuss it together; I will be back in few minutes.

### **Segment Three**

Welcome back. You must have reached to exciting and interesting ideas about the images and the video you have watched by now.

You have to be patients till you realize the aim of asking these questions.

Now I want to ask: What are the states of matter?

You all must know that there are three states of matter: solid, liquid and gas.

How can we change the state of matter from solid to liquid? Certainly, we will need energy to do that. Similarly, if we want to change a liquid to the gaseous state we will also need energy. My question now is: what if we kept on rising the temperature of a gas, what do we get?

Please talk about this, and I will get back to you after few minutes.

## **Segment Four**

Welcome again. You must have concluded that if we keep on rising the temperature of gas, it will change into a new state of matter... Yes a new state of matter!!! It is the fourth state of matter which is called “Plasma”.

As we know, the gas atoms contain equal number of positive and negative charges; any neutral atom has equal number of negative charged – electrons- and positive charged –protons- . The continuous raising of the atoms’ temperature up to 100000°C, leads to releasing some or all the free electrons, so they move freely; here we say that the gas is ionized. If sufficient degree of ionization happened, then the fourth state matter is reached or “plasma” is reached.

A simple comparison between the gaseous state and plasma would result in the following points:

Considering electrical conductivity; it is known that gases do not conduct electricity, while plasma is a good conductor. In relation to interaction; it is binary in gaseous state due to the collisions occurring between each two particles, while it is cumulative in case of plasma. As for interacting type; all gas particles behave similarly, they are all affected by force of gravity, collide with one another, and obey the known gas laws. However, particles in plasma; which consist of electrons (negative charges), positive ions, and neutral particles each behave independently according to its charge.

Now, I would like to show you this video, it is about producing plasma in lab, its very interesting, let us watch it together.

*(Video is shown).*

The question now; in your opinion, in what fields can we use plasma? Please discuss this together; I will be back in few minuets.

## **Segment Five**

Welcome again. You must have come up with some uses of “plasma”; the most common uses are “Fluorescent lamps” and “Plasma rockets”. You know that in order to launch a spaceship into space, tons of fuel is burned. The greater the force the gases are released off form the rocket’s engine the less amount of fuel is needed for launching; this was achieved by using plasma. Imagine that launching one spaceship of NASA didn’t require more than 80 -100 kilograms of fuel because of the very high speed at which the gases are released of these rockets. The cost of using one kilogram of fuel would reach up 200000 \$, as you can see, using plasma reduces the amount of fuel needed to launch spaceships; therefore the cost was reduced too.

There are many other advantageous uses of plasma; I would like to introduce you to one these by watching this video. It demonstrates waste

disposal method without burning. How is that? This can be done using plasma technique, let's watch.

*(Video is shown with the following narration).*

*This is an area in Washington in which plasma technique is used for waste treatment and disposal. The continuous demand on sound fuel and safe waste disposal methods, were behind using plasma technique for waste disposal, instead of burning it can be turned into beneficial items that can be used in various fields. All kinds of waste; medical, domestic and hazardous waste can be disposed by this method. All kinds of waste are dumped into the Gasifier, where it is partially oxidized as you see, producing many products that settles down at a glassy surface. Using a plasma generator, the chamber's temperature reaches to about 10000°C, which will break the chemical bonds between the atoms of these compounds, so they can be segregated and used in industry, as you can see there is the gold, iron and copper ....etc. All the inorganic matter is collected and used in industrial and construction uses. Getting a clear gas is a by-product of this process, gases such as ethanol is collected separately.*

*Another country that uses this technique widely is Japan. They use this process in huge industrial and economical projects. In Taiwan the same technique is used to treat waste and convert it into useful substances using 20000 ton of wastes are treated daily. This use of plasma techniques changed the people prospective to waste treatment. Since about 50 billion barrel of fuel can be produced in US. This way we can get clear fuel and clean safe environment.*

I hope you enjoyed watching the video. You must have noticed the growing demand for clean environment, and sound waste disposal led to using plasma technique for waste treatment and disposal. As you have seen, hazardous, medical, and domestic waste are dumped in a gasifier where it is exposed to very high temperature about to 100000°C, resulting in partial oxidization and breaking down of waste into its basic component. Also you have noticed that inorganic components separate and flow into special tanks. These can be used in production of useful materials for various commercial and construction fields. The produced gases such as hydrogen can also be used to make ethanol which can be used as clean fuel.

My question now: You noticed that another use of plasma is "Fluorescent lamps" that are widely used. Do you have any idea about how this lamp works? It may seem difficult to you, but using you information about plasma you will help you figure out how it works. I hope you will cooperate together to achieve this. I will be back in few minutes.

## **Segment Six**

Welcome again. I hope you have thought of how Fluorescent lamp works. These lamps are widely used; we find them in houses, offices, shops and many other places. Basically, fluorescent lamp consists of a glass tube. This tube is vacuumed, its two ends are connected to electrodes that are attached to a filament, the inner surface of the bulb is coated with phosphorescent material that gives these lamps the distinguished light color, and also there are few mercury atoms as well as atoms of a noble gas such as Argon. Once the bulb is on and the electric current reaches the tube it heats the filament which releases electrons. These electrons collide with the Argon atoms, causing its ionization, which means that the gas changed into the plasma state. Through applying 240 volts across the tube ends, electrons are accelerating toward the positive electrode while the positive ions move toward the negative electrode; this completes a closed circuit which allows a current flow. This is simply the idea behind the Fluorescent lamp.

All what I can say now, is that 99% of our visible universe is plasma. The pictures of universe, and the photos of Aurora, lightning, plasma TV, and others, all are applications using “Plasma” or proving its existence, so “Plasma” is all around us.

You have learned now about the fourth state of matter; “Plasma” state. I would like to ask you: do you think there are other states of matter? It's a confusing question, isn't it? Why don't you look for an answer? I wish you all good luck, good bye.

## **Teacher's Guide Segment**

Hello, my name is Amaal Jalal AL Hammoury, I welcome you all my colleagues physics teachers, hope this module is a step towards making your students closer to physics and show more enthusiasm towards it. So they see how fun it is, and realize its relation and importance in their daily life.

I chose an interesting subject hoping it will be the same for you.

All through scholastic years, we teach students about the three states of matter: solid, liquid and gas, and we never introduce the fourth state of matter, so I wanted here to emphasize on the fourth state of matter “Plasma”.

I have used multimedia to attract students' attention and to raise their interest. And I tried to avoid classical teaching method as much as possible.

## **In Pause one**

After viewing the universe video, ask students to discuss it; let each of them share their ideas with each others, keep records of their ideas and participation.

### **In Pause two**

After viewing the presentation, ask student to name some common things among the images they have seen. Plasma may not be mentioned among their inputs, this is expected and it's ok. No need to reveal the concept, because it will be clarified later.

### **In Pause three,**

After asking what will happen to a substance in the gaseous state while raising its temperature above 100000°C? Please dear colleague distribute the provided worksheet including this question. The students are asked to complete it, and to predict what will happen to the matter after raising its temperature. Group discussions among students is recommended, an over all discussion will reveal the concept "plasma" either by the teacher himself or waiting until the concept will be revealed in the following video.

### **In Pause four,**

Dear teacher allow your students to share their ideas, listen to any volunteer they may give different answers about the possible applications of plasma considering videos and presentation they watched, and this is ok, but please motivate them to predict other applications through their understanding of plasma.

### **In Pause five**

Students may face difficulty of explaining how fluorescent lamp works. Students shouldn't know every detail about fluorescent lamps; it's enough for them to know the basics, although you can give them more details using this background information.

A basic element of the fluorescent lamp is vacuumed glass tube, containing Argon gas, and small amount of Mercury atoms (Hg). The inner surface of the tube is coated with phosphorescent material. The tubes ends are connected with electrodes attached to filament. This filament is heated once electricity passes through it.

Now, when the electric current flows on, the filament gets hot and release electrons. These electrons will collide with Argon atoms, so the gas atoms will lose some or all its electrons, so the gas is ionized, which means we reach the plasma state.

These negative charged electrons will move to the positive electrode, and the gas ions will move towards the negative electrode, so we will have closed electric circuit, through which the electric current flows in the fluorescent tube.

Let's dig deeper. The collision between the accelerated electrons and the Hg atoms will stimulate these atoms, so electrons will jump up to a higher level, but the soon return to their places. Meanwhile, the atoms will emit photons within the ultraviolet spectrum. The problem is that this part of the electromagnetic spectrum is indivisible by human eye, then how can we see the fluorescent light?? .

Here comes the role of phosphorescent coating of the inner surface of the tube. Once photons hit the phosphorescent coating it stimulates that atoms causing jumping of the electrons from their orbits. Once they return back they will emit low energy light which is within the visible spectrum, this will be seen as called fluorescent light.

As we all know, the light we see is a combination of the seven colors spectrum.

The absorption of ultraviolet spectrum and emission of visible light is called "Fluorescence", and this is the reason of calling these lamps "Fluorescent lamps".

You know, that for fluorescent lamp to light up an important component of lamp, called "starter" should be available. The starter is simply a small lamp similar to the camera flash, it consists of two wires. When the lamp is turned on, electrical discharge happens, giving a glow appears. This glow heats the wires, and expands them until they are connected to each other, which allows electric current flow. Without this process it is difficult for the current to flow through Argon gas, because of its high resistance to electricity. The starter helps in Argon ionization as a result of collision between electrons and Argon atoms, once it is ionized, it become a good conductor of electricity so it allows the flow of the electric current through it, consequently we can see the lamps light.

It is worth mentioning that the fluorescent lamp does not light up once it is switched on due to the time needed for the mentioned process to occur. We need to wait for filament to be heated and the wires to expand and the discharging to occur etc...so this delay is a disadvantage of the fluorescent lamps: taking a while before it operates.

That is all for today! I hope this module was interesting and useful for your students, and I have accomplished the goals I wanted ...

Thank you for using this scientific module.

Good bye.

