

# Molecule & Gas Atom

## Ionization - Raising $H^+$ 13.6 electronVolts

If you're looking to orient water molecules in an electric field, a relatively modest electric field can achieve this because water is a polar molecule. To align a water molecule, an electric field on the order of 1 kV/cm is often more than enough. Given a 1/8" gap (approximately 0.318 cm), this would equate to a voltage of approximately 318 volts.

In its neutral state, a hydrogen atom is not electropositive. The hydrogen atom consists of one proton and one electron, and it is electrically neutral because the positive charge of the proton balances the negative charge of the electron. However, hydrogen can become a positive ion (a proton) if it loses its electron, such as through ionization.

If you're dealing with ionized hydrogen (protons), these would indeed be repelled by a positive electric field and attracted to a negative one. If the hydrogen atoms are not ionized, they would not be significantly affected by an electric field because they are overall electrically neutral.

If you're trying to manipulate neutral hydrogen atoms with an electric field, you may need to ionize them first. Ionization typically requires a significant amount of energy and can be achieved in various ways, such as with a high voltage, intense light, or high temperatures.

The process of converting a neutral hydrogen atom into a positively charged ion (a proton,  $H^+$ ) is called ionization. For hydrogen, this involves removing the single electron from the atom. There are several methods that can be used to achieve this:

1. **Electrical Discharge:** Passing a high-voltage electric current through the gas can strip electrons from their parent atoms, creating ions. This is the principle behind techniques like glow discharge and arc discharge.
2. **Electron Impact:** High-energy electrons can knock electrons off atoms to create ions. This often happens in devices like mass spectrometers.
3. **Photoionization:** High-energy photons (such as ultraviolet light or X-rays) can also ionize atoms by knocking off electrons.
4. **Thermal Ionization:** At very high temperatures, the kinetic energy of the atoms can be high enough to cause ionization. This is what happens in the sun and other stars.
5. **Chemical Ionization:** Certain chemical reactions can result in ionization. For example, some strong acids can ionize hydrogen.

Sure, let's delve deeper into these three methods:

1. **Electrical Discharge Ionization:** This is the process of ionizing a gas by applying a high voltage between two electrodes. When the voltage is sufficiently high, it can accelerate free electrons, which then collide with neutral gas atoms. If the kinetic energy of the electron is high enough, it can knock an electron off the atom, creating an ion. This process can create a plasma, a gas of ions and free electrons.

Glow discharge and arc discharge are two forms of electrical discharge. Glow discharge operates at lower pressures and voltages, while arc discharge operates at higher pressures and voltages.

In your context, you could potentially use an electrical discharge to ionize your hydrogen gas. You would need to carefully contain and control the discharge to ensure safety, as the process can produce heat and UV light.

2. **Electron Impact Ionization (also known as Collision Ionization):** This method is similar to electrical discharge but is usually discussed in the context of a beam of high-energy electrons colliding with a gas. When a high-energy electron collides with a neutral atom, it can knock off one of the atom's electrons, creating an ion.

This method is often used in instruments like mass spectrometers to ionize samples. It's typically used in vacuum conditions, as the mean free path of the electrons needs to be long enough for them to gain sufficient energy before they collide with the atoms.

3. **Photoionization:** This is the process of ionizing an atom using photons, which are particles of light. When a photon with enough energy collides with an atom, it can knock an electron off the atom, creating an ion. The minimum energy required to ionize the atom is called the ionization energy.

For hydrogen, the ionization energy is 13.6 electron volts (eV), which corresponds to ultraviolet light with a wavelength of about 91.2 nm. So you would need light of this energy or higher to photoionize hydrogen.

Photoionization can be a very clean method of ionization, as it doesn't introduce any new particles into the system. However, producing light of the required energy can be challenging. UV lasers can do this, but they tend to be expensive and require careful handling due to the hazards of UV light.

## ChatGP

The electronvolt (eV) is a unit of energy that is often used in the context of atoms and subatomic particles, like electrons. One electronvolt is defined as the amount of kinetic energy gained (or lost) by a single electron accelerating from rest through an electric potential difference of one volt.

So, when we say that the ionization energy of hydrogen is about 13.6 eV, it means that it takes 13.6 eV of energy to remove an electron from a hydrogen atom (in its ground state).

This energy isn't directly related to the input voltage of a circuit or device. The input voltage can create an electric field, and this field can accelerate charged particles. If a charged particle (like an electron) accelerates through a voltage difference of one volt, it will gain (or lose) an energy of one electronvolt.

But to use voltage to ionize an atom, you need a situation where free electrons can be accelerated by the electric field to gain enough kinetic energy. This can happen in an electrical discharge, for example, where a high voltage can ionize a gas. The voltage needed to achieve this can be much higher than the ionization energy of the atoms (in eV), due to inefficiencies and losses in the process. The specific voltage needed can depend on many factors, such as the pressure and composition of the gas, the distance between the electrodes, and the design of the device.

As always, dealing with high voltages and ionization processes can involve significant hazards, and it's important to follow all relevant safety procedures and guidelines.

**The water capacitor is 2 - 3" tubes, 1/2" inner and 3/4" outer SS304L. the gap is approx 1/8". what do the electric field voltage requirements look like for this?**

The electric field strength (E) in a capacitor is given by the formula  $E = V/d$ , where V is the voltage across the capacitor and d is the distance between the plates (or in this case, tubes). The electric field is usually measured in volts per meter (V/m).

The 1/8" gap between your tubes is about 0.003175 meters. If you were to apply a voltage of 1 volt across the tubes, the electric field strength would be  $E = 1V / 0.003175m = 315 \text{ V/m}$ .

If you're looking to ionize hydrogen, as discussed earlier, you'd need an electric field that's strong enough to give electrons enough energy to escape their atoms. This would likely require a field on the order of kilovolts per millimeter or higher. For a 1/8" (about 3.175mm) gap, this could mean a voltage of several kilovolts.

However, creating such a strong electric field in a gas at atmospheric pressure would likely lead to electrical breakdown and a spark or arc, rather than ionization of individual atoms. To achieve controlled ionization, you would typically need a vacuum or very low pressure, so the mean free path of the electrons is long enough for them to gain sufficient energy before they collide with another atom.

If you're simply looking to align water molecules with an electric field, you would not need such a high field strength. A field of a few kV/m (equivalent to a few volts across the tubes) could be sufficient.

## ChatGP

In order to understand how much field strength is required to apply the 13.6 electronvolt (eV) needed to ionize a hydrogen atom, we need to take into account the concept of work done.

The work done (W) on a particle by an electric field as it moves through a distance (d) is given by  $W = qEd$ , where q is the charge of the particle and E is the electric field strength. If we want to give an electron an energy of 13.6 eV, we can set W equal to this value.

The charge of an electron (q) is about  $1.6 \times 10^{-19}$  Coulombs. So, if we want to give an electron an energy of 13.6 eV (which is about  $2.18 \times 10^{-18}$  Joules), we can rearrange the equation to solve for E:

$$E = W / (q \cdot d) = (2.18 \times 10^{-18} \text{ J}) / [(1.6 \times 10^{-19} \text{ C}) \cdot d]$$

For a 1/8" (about 0.003175 m) gap, this gives:

$$E = (2.18 \times 10^{-18} \text{ J}) / [(1.6 \times 10^{-19} \text{ C}) \cdot 0.003175 \text{ m}] \approx 4.3 \times 10^7 \text{ V/m}$$

This means that you would need an electric field of about 43 million volts per meter to give an electron an energy of 13.6 eV over a distance of 1/8". That corresponds to a voltage of approximately **136.5 kV** across the 1/8" gap.

However, these calculations are a simplification, and they assume that the electron is free to move across the entire gap without any collisions. In reality, the mean free path of an electron (the average distance it can travel before colliding with an atom) in air at atmospheric pressure is much less than 1/8", and so the electron would not be able to gain this much energy before it collided with an atom.

Therefore, to achieve ionization in a controlled manner, you would typically need a vacuum or very low pressure, and the voltage required would depend on the specific conditions.

As always, working with high voltages can be dangerous, and it's important to follow all necessary safety precautions. Consult with an expert or professional if you're unsure.

ChatG

With a reduced gap distance of 1/16" or approximately 0.0015875 meters, we use the same formula for the electric field:

$$E = W / (q \cdot d)$$

To calculate the required voltage (V), we remember that electric field strength (E) is voltage (V) divided by distance (d). So we can rearrange the formula to find  $V = E \cdot d$ :

$$V = E \cdot d = W / q$$

Using the numbers we established before ( $W = 2.18 \times 10^{-18} \text{ J}$  and  $q = 1.6 \times 10^{-19} \text{ C}$ ), we find:

$$V = (2.18 \times 10^{-18} \text{ J}) / (1.6 \times 10^{-19} \text{ C}) \approx \mathbf{13.625 \text{ kV}}$$

So the voltage required across the 1/16" gap to provide an electron with 13.6 eV of energy would be approximately 13.625 kV.

Again, in reality, achieving ionization under atmospheric pressure conditions would likely require higher voltages due to factors like electron collision and energy loss. Always take proper precautions when dealing with high voltage systems.

The result is a magnitude of 10

$1/16'' = 13.6\text{kV} = 13.6\text{eV}$

$1/8'' = 136.5\text{kV} = 13.6\text{eV}$

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