Ion Drives

The Variable Specific Impulse Magnetoplasma Rocket (VASIMR) is the most efficient rocket propulsion system in operation today. Argon atoms are used as a propellant and in an ionization chamber they are given a charge of +*e*. They then pass through an accelerating potential and travel out of the back of the rocket at high speeds. In a VASIMR rocket the accelerating potential is created with plates that are 0.550 m apart with a potential difference of 2.0 x 105 V.



* 1. Determine the Electric Field inside the VASIMR.
	2. How much kinetic energy does a single Argon atom gain travelling through the VASIMR?
	3. The mass of one Argon atom is 6.63 x 10-26 kg. Determine the velocity of an Argon atom after leaving VASIMR.
	4. If VASIMR is being used to propel a 1000 kg space probe determine how many Argon atoms must be injected into VASIMR to give a change in velocity of 2500 m/s. *(Hint: You will need to make use of conservation of momentum).* How many moles of Argon would be required?
1. The European Space Agency used an Ion Drive called the Hall Effect Thruster to send a space probe (SMART-1) to the moon. This Ion Drive generates an electric field of 1.73 x 104 V/m and requires a potential difference of 5.0 kV.
	1. How far apart should the plates in the capacitor be placed?
	2. SMART-1 uses a singly ionized Xenon atom. Determine the change in Kinetic Energy of a Xenon atom as it is accelerated by SMART-1. If the mass of one Xenon atom is 2.18 x 10-22 kg determine the velocity of the Xenon atom.
2. An experimental Ion Drive is using alpha particles as a propellant. The alpha particles are accelerated from rest to a velocity of 2.45 x 104 m/s as the travel 25.0 cm through a parallel plate capacitor. Determine the Potential Difference and Electric field required by the Ion Drive.
3. The first experimental Ion Drive was called NSTAR and accelerated charged particles through a potential difference of 2.3 kV. These charged particles gained 7.36 x 10-16 J of Kinetic Energy. What potential difference would be required to increase the Kinetic Energy to 1.00 x 10-15 J?

Motion Perpendicular to Electric Fields

A pair of parallel plates are connected to a 300 V power supply. The plates are separated by 0.10 m and are 0.50 m long. An electron enters a parallel plates next to the negative plate as shown in the diagram.



1. On the diagram draw the direction of the electric field
2. On the diagram, sketch the trajectory of the electron.
3. Determine the magnitude of the electric field between the plates.
4. Determine the magnitude of the electric force on the electron.
5. Determine the magnitude and direction of the acceleration of the electron.
6. If the electron strikes the left edge of the bottom plate, how long is the electron between the plates for?
7. Determine the horizontal distance the electron travels.

Millikan’s Experiment

When trying to determine the charge on an electron a physicist focused on a single drop with a mass of 9.10 x 10-17 kg as shown below:



When placed in between two parallel plates with a variable potential difference and separated by 7.0 cm she gathered the following data:

|  |  |
| --- | --- |
| **Potential Difference (V)** | **Acceleration of oil drop (m/s2)** |
| 50.0 | -2.10 |
| 75.0 | +1.59 |
| 100 | +5.38 |
| 125 | +8.95 |
| 150 | +13.04 |

* Use this data to determine the acceleration due to gravity.
* Use this data to determine the charge on an electron.
* What voltage will cause the oil drop to be suspended?