From: Greg Kirkwood
Sent: Wednesday, February 01, 2006 11:18 AM
Subject: dielectric strength of water

All,

I had a question during my lecture regarding the absence of a value for the dielectric strength of water in Table 26.1 of Serway (p 812). The best guess I had at the time is that it is probably difficult to remove all the impurities from the water, so that any experimentally obtained values vary greatly. Can anyone enlighten me so I can provide my classes with a good answer? Thanks.

V/R
CDR Greg Kirkwood
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From: "Capt. Jessie Carman" <carman@usna.edu>
Date: Wednesday - February 1, 2006 11:55 AM
Subject: Re: dielectric strength of water

I found an interesting link regarding others who had this question:
http://www.pupman.com/listarchives/1997/november/msg00394.html

It has to do with not only removing the impurities, but maintaining sufficiently pure water to act as a dielectric. Water will react with your plates and thus have ions in solution -- and immediately become a very good conductor. Conductivity of water with ions is so sensitive to the ion concentrations that it's how we measure ocean salinities nowadays -- via conductivity.

Cheers,
JCC

From: Prof John Fontanella <jjf@usna.edu>
Date: Wednesday - February 1, 2006 2:42 PM
Subject: Re: dielectric strength of water

Hi,

Even pure water contains ions since water dissociates into protons and hydroxyl ions i.e. pure water is a weak electrolyte. The resultant conductivity is too high for water to be classified as a dielectric.

Also, what determines the breakdown voltage of most materials is the defect structure of the material. What usually happens is that trapped or defect electrons are accelerated. Those electrons eject other electrons, etc. hence the breakdown. Consequently, dielectric breakdown is only indirectly related to the nature of the atoms making up the material.

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From: "Prof James R. Huddle" <huddle@usna.edu>
Date: Wednesday - February 1, 2006 3:00 PM
Subject: Re: dielectric strength of water

I found a link (http://www.lsbu.ac.uk/water/ionis.html) that points out that water always has a small amount of H+ and OH- ions in it...the article quoted a ratio of concentrations [H+]/[H2O] = 2.8 x 10^-9 at 37 degrees C.

Here's a link that says that it takes only 5.2 eV to break the H-OH bond in H2O: http://hyperphysics.phy-astr.gsu.edu/hbase/MPII/P3402Hw10.html

Given those facts, I'm guessing that it doesn't take a very large electric field to accelerate the protons to enough energy to ionize a water molecule by impact and initiate breakdown.

Jim H.

From: Carl Mungan <mungan@usna.edu>
Date: Wednesday - February 1, 2006 3:06 PM
Subject: Re: dielectric strength of water

>I had a question during my lecture regarding the absence of a value
>for the dielectric strength of water in table 26.1 of Serway. The
>table is on page 812. The best guess I had at the time is that it
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>water, so that any experimentally obtained values vary greatly. Can
>anyone enlighten me so I can provide my classes with a good answer?
>Thanks.

In addition to the CAPT's interesting note on purity, other important factors to consider are temperature (pure water's static dielectric constant drops from 87.9 at 0 C to 55.6 at 100 C, reference: http://www.lsbu.ac.uk/water/data.html) and the frequency at which you measure the dielectric constant, the constant (some constant!) tending to fall with increasing frequency (but still below IR absorption frequencies) as the orientations of the water molecules cannot keep up. That of ice is perhaps even more interesting than water, as it is (surprisingly) even higher than that of liquid water in the static limit -- see the previous table again, in striking contrast to water vapor. The explanation has to do with proton mobility in crystalline ice.

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