Electroloysis of water: determination of the fundamental electronic charge

Science, Physics

ELECTROLOYSIS OF WATER: DETERMINATION OF THE FUNDAMENTAL ELECTRONIC CHARGE PURPOSE: The fundamental electronic charge of water will be determined. A system of collecting the formation of H_2 and O_2 using two inverted glass collections tubes and a 1-L beaker filled with water will be setup. An electrolyte (H_2SO_4) will be added to water to make it an electrical conductor. A small amount of electricity will be applied to the water (roughly 400 mA) to oxidize the oxygen and reduce the hydrogen at the same time. The molecular hydrogen and oxygen gases produced will be trapped in the separated, inverted tubes so that their volumes can be measured. In comparing the volume of gases produced, applying Dalton's Law and the Ideal Gas Equation along with the application of the stoichiometric ratio between the electron and the gases, the fundamental electronic charge will be determined. THEORY H^+ ions will join together at the cathode (the negative electrode) to produce H Atoms, and the H atoms will join to form molecules of H_2 gas. At the positive electrode (the anode), H20 molecules will decompose to replace the H^+ ions lost and release O_2 gas. The reactions appear below. $2H^+(aq) + 2e^- \rightarrow H_2(g)$ Reduction (at the cathode) $2H_20(l) \rightarrow 4H^+(aq) + O_2(g) + 4e^-$ Oxidation (at the anode) The volume of H_2 and O_2 will be directly proportional to the time and current applied to the system. This will provide the number of electrons consumed on a stoichiometric ratio as follows: 1 $H_2(g)$ to 2 e^- Reduction (at the cathode) (1) 1 $O_2(g)$ to 4 e^- Oxidation (at the anode) (2) The moles of electrons can be expressed as a rearrangement of the Ideal Gas Equation: $Ne = PV/RT$ (3) Where P = pressure in atm, V = volume in L, R = Gas Constant of 0. 08206 atm mol^{-1} K^{-1} and T = temperature in Kelvin The actual electronic charge of water will be calculated as follows: e- = it/NeN x the stoichiometric ratio (1) or (2) above Where i = current in amps, t = time in seconds, Ne = moles of electrons passing through the circuit from equation (3) and N = Avogadro's number. The actual electronic charge will be compared to the theoretical charge of 1. 603x10-19 Coulombs. 1. Convert height of the solution into mm Hg to get the hydrostatic pressure (pressure due to the liquid left in the gas collection tube): height of solution x density of solution density of mercury 2. atmospheric pressure in the room — hydrostatic pressure = Ptotal (total pressure exerted by the gas trapped in the gas collection tubes) 3. a)Ptotal (total pressure) = PH2 + PH20 or Ptotal = PO2 + PH20 b) PH2 = Ptotal - PH20 c)PH2 / 760 = Patm (Pressure) 4. Ne = PV/RT 5. e- = it/NeN x the stoichiometric ratio | | Run 1 | Run1 | | Run 2 | Run 2 | | | - (cathode) | + (anode) | | - (cathode) | + (anode) | | | Tube 2 | Tube 1 | | Tube 2 | Tube 1 | | | H2 | O2 | | H2 | O2 | Run Time in seconds | | 987. 13 | 987. 13 | | 1102. 82 | 1102. 82 | Average Current | | 0. 303 | 0. 303 | | 0. 277 | A | Height of Solution | Hsol mm | 400. 0 | 325. 0 | | 81. 5 | 314. 2 | Volume of gas produced | Vgas (mL) | 40. 10 | 19. 72 | | 40. 10 | 19. 80 | | Vgas (L) | 0. 04010 | 0. 01972 | | 0. 04010 | 0. 01980 | Temperature of solution | C | 24. 0 | 24. 0 | | 25. 6 | 25. 6 | | Kelvin | 297. 15 | 297. 15 | | 298. 75 | 298. 75 | Vapour pressure of water | mm Hg | 22. 377 | 22. 377 | | 24. 617 | 24. 617 | Atmospheric pressure | Patm mm Hg | 770. 50 | 770. 50 | | 770. 50 | 770. 50 | | Patm | 0. 94567 | 0. 95293 | | 0. 97354 | 0. 95103 | hhg hydrostatic pressure (mm Hg) | | 29. 41 | 23. 90 | | 5. 99 | 23. 10 | Ptotal (mm Hg) in the tube | | 741. 09 | 746. 60 | | 764. 51 | 747. 40 | PH2 (mm Hg) | | 718. 71 | | | 739. 89 | | PO2 (mm Hg) | | | 724. 23 | | | 722. 78 | | | | | | | | moles gas n (rearranged Ideal Gas Equation) Ne = PV/RT | 0. 001555 | 0. 0007707 | | 0. 001592 | 0. 0007681 | e- = it/NeN | | 3. 194E-19 | 6. 445E-19 | | 3. 185E-19 | 6. 604E-19 | stoichiometric ratio | Final | 1. 597E-19 | 1. 611E-19 | | 1. 593E-19 | 1. 651E-19 | | theoretical | 1. 603E-19 | 1. 603E-19 | | 1. 603E-19 | 1. 603E-19 | | Difference | -6. 193E-22 | 8. 166E-22 | | -1. 028E-21 | 4. 801E-21 | | % Error | -0. 4% | 0. 5% | | -0. 6% | 3. 0% |