State and explain faraday's second law of electrolysis

Lost your password? Please enter your email address. You will receive a link and will create a new password via email. Verification of Faraday's Second law of electrolysisFaraday's second law of electrolysis states that, when the same quantity of electricity is passed through several electrolytes, the mass of the substances deposited are proportional to their respective chemical equivalent or equivalent weight. So, here clearly state that "the mass of an essence deposited or enlightened at any electrode on passing a definite amount of charge is straight comparative to its chemical equal weight".The mass of the chemical, deposited due to electrolysis is not only proportional to the amount of electricity passes from end to end the electrolyte, but it also depends upon some other aspect. Every essence will have its own atomic weight. So for the similar number of atoms, dissimilar substances will have dissimilar masses. The masses of the diverse resources formed or consumed by a similar amount of electricity that passes in dissimilar electrolytes associated in series are comparative to their equal masses, Mass ∝ Equivalent weight.Two electrolytic cells containing different electrolytes, CuSO4 solution, and AgNO3 solution are connected in series with a battery, a rheostat and an ammeter (Figure). Copper electrodes are inserted in CuSO4 and silver electrodes are inserted in AgNO3.The cathodes are cleaned, dried, weighed and then inserted in the respective cells. The current is passed for some time. Then the cathodes are taken out, washed, dried and weighed. Hence the masses of copper and silver deposited are found as m1 and m2.It is found thatm1/m2 = E1/E2where E1 and E2 are the chemical equivalents of copper and silver respectively.m α EThus, the second law is verified.The gram comparable mass of the material is the mass of the essence that has the aptitude to lose or gain one mole of the electrons throughout the chemical reaction.The gram equivalent mass = the gram atomic mass/number of charges on the aspect.So, for the similar measure of electricity or accusation passes from end to end dissimilar electrolytes, the mass of deposited chemical is straight comparative to its atomic weight and inversely comparative to its valency.(The mass of the first aspect / the mass of the second element) = (The equivalent mass of the first element / the equivalent mass of the second element)"When a similar quantity of electricity is passed from end to end dissimilar electrolytes, the masses of dissimilar ions liberated at the electrodes are straight comparative to their chemical equivalents (Equivalent weights)." i.e., orThus the electrochemical equivalent (Z) of an element is straight comparative to its equal weight (E), i.e.,where, Faraday constant (F)So, 1 Faraday = 1F =Electrical charge carried out by one mole of electrons.1F = Charge on an electron × Avogadro's number.1F = Number of Faraday. In order to continue enjoying our site, we ask that you confirm your identity as a human. Thank you very much for your cooperation. (IIT JEE 1983) a) atomic number of the cation b) atomic number of the anion c) equivalent mass of the electrolyte d) speed of the cation Logic: Faraday's laws are based on the fact that addition or removal of one mole of electrons during reduction or oxidation will liberate or dissolve or deposit one equivalent weight of substance and to achieve this the amount of charge required is equal to charge on one mole of electrons (also know as 1 Faraday and is equal to 96,500 Coulombs). Conclusion: The correct option is: 'c'. FARADAY'S LAWS OF ELECTROLYSIS Faraday's I Law of Electrolysis: When an electrolyte, either in molten state or solution state is electrolyzed, the amount of substance (m) deposited or dissolved at electrodes is directly proportional to the quantity of electricity (Q) passed through the electrolyte. Mathematically, m ∝ Q or m = eQ where, e = electrochemical equivalent Since e = E/F & Q = I.t We can also rewrite the equation as: m = E.I.t/F Faraday's II Law of Electrolysis: If the same quantity of electricity is passed through different electrolytic cells, connected in series containing different electrolytic solutions or melts, the amounts of substances deposited or liberated or dissolved are directly proportional to their equivalent weights. Mathematically, m1/m2 = E1/E2 2) The electric charge for electrode deposition of one equivalent of the substance is: (IIT JEE 1984) a) one ampere per second b) 96,500 Coulombs per second c) one ampere per hour d) charge on 1 mole of electrons Logic: As already explained in the previous problem, deposition one equivalent of substance requires charge on one mole of electrons. Conclusion: The correct option is 'd'. 3) Electrolysis of dilute aqueous NaCl solution was carried out by passing 10 milliampere current. The time required to liberate 0.01 mol of H2 gas at the cathode is : (IIT JEE 2008) a) 9.65 x 104 s b) 28.95 x 104 s c) 19.3 x 104 s d) 38.6 x 104 s Logic: According to Faraday's first law of electrolysis: Where: m = mass of substance E = equivalent weight of substance I = current in amperes t = time required F = 96,500 Coulombs Note: mass of H2 = m = 0.01 mol x 2 g mol-1 equivalent weight of H2 = E = Atomic weight / valence = 1 g mol-1 / 1 = 1 g mol-1 Current in ampere = I = 10 milliamperes = 10 x 10-3 amperes. Conclusion: The correct option is 'c'. 4) LINKED COMPREHENSION TYPE QUESTION: Read the following passage and give answers to the questions following it. A 4.0 molar aqueous solution of NaCl is prepared and 500 mL of this solution is electrolyzed. This leads to the evolution of chlorine gas at one of electrodes (relative atomic mass of Na = 23, Hg = 200; 1 Faraday constant = 96500 Coulombs mol-1) : (IIT JEE 2007) i) The total number of moles of chlorine gas evolved is: a) 3.0 b) 2.0 c) 0.5 d) 1.0 Logic & solution: * First we have to calculate the amount of NaCl present in 4.0 molar solution. The number of moles of NaCl in 500 mL of 4.0 molar solution = Molarity x Volume (in L) = 4.0 x 500 x 10-3 = 2.0 moles. * The following reaction occurs during electrolysis of aqueous solution of NaCl. Dissociation of NaCl: 2 NaCl(aq) ------> 2Na+(aq) + 2Cl-(aq) At cathode: 2H2O + 2e- -------> H2 + 2OH- At anode: 2Cl-(aq) ---------> Cl2(g) + 2e- Complete reaction: 2NaCl(aq) + 2H2O ------>H2 + Cl2(g) + 2Na+(aq) + 2OH-(aq) That means, two moles of NaCl gives one mole of Cl2 gas. Since there are 2.0 moles of NaCl present in the solution, one mole of Cl2 gas will be evolved at anode upon complete electrolysis. Conclusion: The correct option is 'd'. ii) If the cathode is Hg electrode, the maximum mass of Amalgam formed from this solution is: a) 200 g b) 446 g c) 225 g d) 400 g Logic & solution: * When Hg is used as cathode, Na+ will be reduced to Na instead of H2O. Thus formed Na will form sodium amalgam, Na-Hg. At cathode: Na+ + 1e- + Hg -------> Na-Hg 2.0 moles of NaCl present in the solution contain 2 moles of Na+. Hence two moles of Na-Hg is formed. The mass of 2 moles of Na-Hg = 2 (23 + 200) = 446 g. Conclusion: The correct option is 'b'. iii) The total charge required for complete electrolysis is: a) 48250 C b) 96500 C c) 193000 C d) 24125 C Logic & solution: * Since two moles of electrons are transferred during electrolysis, the total charge required for complete electrolysis is equal to 2 Faraday. i.e. 2 x 96500 = 193000 C Conclusion: The correct option is 'c'. 5) The amount of electricity that can deposit 108 g of silver from AgNO3 solution is [AFMC 1993; MP PMT 2004] A) 1 ampere B) 1 coulomb C) 1 faraday D) None of the above Logic: For silver, the gram equivalent weight is 108 g. We know that 1 Faraday of electricity is required for deposition of 1 gram equivalent weight of an element. Conclusion: Answer: C 6) Faraday's laws of electrolysis will fail when [NCERT 1971] A) Temperature is increased B) Inert electrodes are used C) A mixture of electrolytes is used D) In none of these cases Conclusion: Answer: D 7) Which of the following aqueous solution will result in maximum number of moles of metal deposited on passing same charge? a) KI b) ZnSO4 c) AuCl3 d) CaCl2 Conclusion: Answer: a 8) The quantity of electricity required to liberate 0.01 g equivalent of an element at the electrode is: A) 9650 coulomb B) 96500 coulomb C) 965 coulomb D) 96.5 coulomb Hint: 1 g equivalent of element requires 1 Faraday (96500 C). Therefore, 0.01 g equivalent requires 0.01 Faraday or 965 C. Conclusion: Answer: C 9) During the electrolysis of molten sodium chloride, the time required to produce 0.10 mol of chlorine gas using a current of 3 amperes is: (NEET 2016) A) 55 minutes B) 110 minutes C) 330 minutes D) 220 minutes Solution: mass of chlorine gas = m = no. of moles x molecular weight = 0.10 mol x 71 g Equivalent weight of Cl2 gas = E = 35.5 g Therefore, Conclusion: Answer: B 10) The weight of silver (atomic weight =108) displaced by a quantity of electricity which displaces 5600 mL of O2 at STP will be: (NEET 2014) A) 5.4 g B) 10.8 g C) 54.0 g D) 108.0 g Solution: From Faraday's second law of electrolysis, the no. of equivalents of silver displaced is equal to no. of equivalents of dioxygen gas that is displaced, since same amount of electricity is passed through the solution(s). i.e. # equivalents of Ag = # equivalents of O2 Now Equivalent weight of O2 = 8 g Since, at STP, 32 g of O2 occupy 22400 mL 8 g of O2 occupy 5600 mL at STP i.e, # equivalents of O2 displaced = 1 Therefore, # equivalents of Ag displaced = 1 And we know the equivalent weight of Ag = 108 g (1 gram equivalent) Conclusion: Answer: D PRACTICE QUESTIONS - FARADAYS LAWS OF ELECTROLYSIS - IIT JEE NEET IIT JAM CSIR UGC NET GATE Chemistry 1) State Faraday's laws of electrolysis? 2) What are inert electrodes? < Previous question IIT JEE NEET Question bank Next question > Author: Aditya vardhan Vutturi Faraday's Laws of Electrolysis: On passing electricity through water (electrolysis), Hydrogen and Oxygen gases are liberated. The amount of gas liberated depends on different factors like the type of electrode and electrolyte used, the amount of electricity passed through the solution, etc. The effect of electric current on electrolysis was studied by the great scientist, Michael Faraday. In this article, you will explore Faraday's first and second law of Electrolysis. Learn About Faraday's Laws of Electrolysis Concept Faraday's Laws of Electrolysis: Table of Contents Need for Faraday's Laws of Electrolysis Michael Faraday \(\left({1832} \right)\) studied the phenomenon of electrolysis extensively and established a relationship between the amount of product liberated at the electrode and the quantity of electricity passed in the solution to carry out the electrolysis. He formulated important quantitative laws which govern electrolysis. The laws are commonly known as Faraday's laws of electrolysis. What is Electrolysis? The process of chemical deposition of the electrolyte by the passage of electricity through its molten or dissolved state is called electrolysis. The device in which the process of electrolysis is carried out is called an electrolytic cell. It consists of an electrolytic tank which is made up of some non-conducting materials like glass, wood or bakelite. The solution to be electrolysed is filled in this tank. The electrolyte can also be taken in the fused state. The cell consists of \(2\) metallic graphite rods in the solution of electrolyte and connected to a battery. The rods act as electrodes. The rod connected to the positive terminal of the battery acts as an anode, while that connected to the negative terminal of the battery acts as a cathode. What is the Mechanism of Electrolysis? Electrolysis is the process that involves the conversion of electrical energy into chemical energy. The process of electrolysis can be explained based on the theory of ionisation. When an electrolyte is passed in water, it splits up into charged particles called ions. The positively charged ion is called cations while the negatively charged ions are called anions. The ions are free to move about in an aqueous solution. When an electric current is passed through the solution, the ions respond to the applied potential difference, and their movement is directed towards the oppositely charged electrodes. The cations move towards the negatively charged electrode (cathode) while anion moves towards the positively charged electrode (anode). The formation of products at the respective electrode is due to oxidation loss of electron at anode and reduction gain of an electron at the cathode. Example: Electrolysis of an aqueous solution of sodium chloride \(\left({{\rm{NaCl}}} \right)\) \({{\rm{NaCl}}}\) in aqueous solution ionizes as \({\rm{NaCl}}\left({{\rm{aq}}} \right) \to {\rm{N}}{{\rm{a}}^{\rm{ + }}}\left({{\rm{aq}}} \right){\rm{ + C}}{{\rm{l}}^{\rm{ – }}}\left({{\rm{aq}}} \right)\)Reaction at anode, oxidation:\({\rm{C}}{{\rm{l}}^{\rm{ – }}}\left({{\rm{aq}}} \right) \to \frac{{\rm{1}}}{{\rm{2}}}{\rm{C}}{{\rm{l}}_{\rm{2}}}\left({\rm{g}} \right){\rm{ + }}{{\rm{e}}^{\rm{ – }}}\)Reaction at cathode, reduction:\({{\rm{H}}_2}{\rm{O}}\left({\rm{l}} \right) + {{\rm{e}}^ – } \to \frac{1}{2}{{\rm{H}}_2}\left({\rm{g}} \right) + {\rm{O}}{{\rm{H}}^ – }\left({{\rm{aq}}} \right)\) Thus, \({\rm{C}}{{\rm{l}}_2}\) gas is liberated at the anode, whereas \({{\rm{H}}_2}\) gas is liberated at the cathode. What is Faraday's First Law of Electrolysis? Faraday's first law of electrolysis states that the mass of any substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution or melt).Thus, if \({\rm{W}}\) gram of the substance is deposited on passing \({\rm{Q}}\) coulombs of electricity, then\({\rm{W}} \propto {\rm{Q}}\)\({\rm{W}} = {\rm{ZQ}} ……\left(1 \right)\)Where \({\rm{Z}}\) is a constant of proportionality and is called the electrochemical equivalent of the substance deposited.If a current of \({\rm{I}}\) ampere is passed for \({\rm{t}}\) seconds, then,\({\rm{Charge}} = {\rm{Current}}\; \times {\rm{time}}\)\({\rm{Q}} = {\rm{I}} \times {\rm{t}} ….\left(2 \right)\)On substituting eq \(\left(2 \right)\) in eq \(\left(1 \right)\) \({\rm{W}} = {\rm{Z}} \times {\rm{I}} \times {\rm{t}}\)Thus, if \({\rm{Q}} = 1\) coulomb or \({\rm{I}} = 1\) ampere and \({\rm{t}} = 1\) second,\({\rm{W}} = {\rm{Z}} \times 1 \times 1\)\({\rm{W}} = {\rm{Z}}\)Hence, the electrochemical equivalent of a substance may be defined as the mass of the substance deposited when a current of one ampere is passed for one second, i.e., a quantity of electricity equal to one coulomb is passed. What is Faraday's Second Law of Electrolysis? Faraday's Second Law of electrolysis states that when the same quantity of electricity is passed through different electrolytes connected in series, then the masses of the substance liberated at the electrode in the ratio of their chemical equivalent masses or the ratio of their electrochemical equivalence. The chemical equivalent mass of metal can be obtained by dividing its atomic mass by the number of electrons required to reduce its cation. For example, if the two electrolytic cells A containing silver nitrate \(\left({{\rm{AgN}}{{\rm{O}}_3}} \right)\) solution and \({\rm{B}}\) be containing copper sulphate \(\left({{\rm{CuS}}{{\rm{O}}_4}} \right)\) solutions are connected in series, and the same quantity of electricity is passed through the cells. Then the ratio of the mass of copper deposited at the cathode in electrolytic cell \({\rm{B}}\) is \({\rm{x}}\,{\rm{g}}\) to that of silver deposited in a cell \({\rm{A}}\) is \({\rm{y}}\,{\rm{g}}\) is equal to the ratio of their chemical equivalent masses. \(\frac{{{\rm{Mass\;of\;Cu}}\;\left({\rm{x}} \right)}}{{{\rm{Mass\;of\;Ag}}\;\left({\rm{y}} \right)}} = \frac{{{\rm{Chemical\;Equivalent\;Mass\;of\;Cu}}}}{{{\rm{Chemical\;Equivalent\;Mass\;of\;Ag}}}} = \frac{{{{\rm{Z}}_{{\rm{cu}}}}}}{{{{\rm{Z}}_{{\rm{Ag}}}}}}\)Each copper \({\rm{C}}{{\rm{u}}^{2 + }}\) ion requires \(2\) electrons to form \({\rm{Cu,}}\) and each \({\rm{A}}{{\rm{g}}^{\rm{ + }}}\) needs \(1\) electron to form \({\rm{Ag}}{\rm{.}}\)Thus, the chemical equivalent mass of \({\rm{Cu}} = \;\frac{{63.5}}{2}.\)Chemical equivalent mass of \({\rm{Ag}} = \;\frac{{108}}{1}\)Thus, the ratio \(\frac{{{\rm{x}}}}{{\rm{y}}}{\rm{ = }}\frac{{{\rm{63}}{\rm{.5}}}}{{{\rm{2 \times 108}}}}\) Relation Between Faraday, Avogadro's Constant, and Charge on an Electron The charge carried by one mole of an electron can be obtained by multiplying the charge present on one electron with Avogadro's number.\({\rm{Charge\;carried\;by\;one\;mole\;of\;electron}} = {\rm{Charge\;carried\;by\;an\;electr}}on\; \times {\rm{Avogadro's\;number}}\)\({\rm{Charge\;carried\;by\;one\;mole\;of\;electron}} = 1.6021 \times {10^{ – 19}}{\rm{C}} \times 6.022 \times {10^{23}}\)\({\rm{Charge\;carried\;by\;one\;mole\;of\;electron}} = 96487.84\;{\rm{C}} \cong 96500{\rm{C}}\) The quantity of electricity, \(96487.84\;{\rm{C}} \cong 96500{\rm{C\;}}\) is called one Faraday. As it is a constant quantity, it is known as Faraday's constant and is represented by \({\rm{F}}.\) Hence, Faraday's constant, \({\rm{F}} = 96487.84\;{\rm{Cmo}}{{\rm{l}}^{ – 1}} \cong 96500{\rm{Cmo}}{{\rm{l}}^{ – 1}}\) If n electrons are involved in the electrode reaction, the passage of \('{\rm{n}}'\) faradays (i.e., \({\rm{n}} \times 96500\;{\rm{C}}\)) of electricity will liberate one mole of the substance. In terms of gram equivalents, one faraday (i.e., \(96500\) coulombs) of electricity deposits one gram equivalent of the substance.Equivalent weight of any element =\(\frac{{{\rm{Atomic\;weight\;of\;the\;element}}}}{{{\rm{No}}{\rm{.of\;electrons\;gained\;or\;lost\;by\;one\;atom\;or\;ion\;of\;the\;element}}}}\) Conclusions of Faraday's Laws of Electrolysis As one Faraday (\(96,500\) coulombs) deposits one gram equivalent of the substance, hence electrochemical equivalent can be calculated from the equivalent weight, i.e.,\({\rm{Z}} = \frac{{{\rm{Equivalent\;\;weight\;of\;the\;substance}}}}{{96500}}\) 2. Knowing the weight of the substance deposited (\({\rm{W}}\) gram) on passing a definite quantity of electricity (\({\rm{Q}}\) coulombs), the equivalent weight of the substance can be calculated, i.e.,\({\rm{Equivalent\;\;weight}} = \;\frac{{\rm{W}}}{{\rm{Q}}} \times 96500\) Can We Combine Faraday's First and Second Law? Faraday's first law and second law can be combined to give a mathematical relation as follows:\({\rm{W}} = {\rm{ZQ}}\)\({\rm{W}} = \frac{{\rm{E}}}{{\rm{F}}} \times {\rm{Q}}\)\({\rm{W}} = \frac{{\rm{Q}}}{{\rm{F}}} \times {\rm{E}}\)\({\rm{W}} = \frac{{\rm{Q}}}{{\rm{F}}} \times {\rm{E}}\)\({\rm{W}} = \frac{{\rm{Q}}}{{\rm{F}}} \times \frac{{\rm{M}}}{{\rm{Z}}}\)\({\rm{W}} = \frac{{{\rm{C}} \times {\rm{t}}}}{{\rm{F}}} \times \frac{{\rm{M}}}{{\rm{Z}}}\)Where, \({{\rm{Z}}\,{\rm{ = }}}\) Electrochemical equivalent\({{\rm{Q}}\,{\rm{ = }}}\) Quantity of electricity passed\({{\rm{E}}\,{\rm{ = }}}\) Equivalent weight of the metal\({\rm{F}} = 1\) Faraday\({{\rm{M}}\,{\rm{ = }}}\) Atomic mass of the metal\({{\rm{C}}\,{\rm{ = }}}\) Current past\({{\rm{t}}\,{\rm{ = }}}\) Time for which current is passed\({{\rm{Z}}\,{\rm{ = }}}\) Valency of the metal Summary This is all about the concept of Faraday's first and second laws of electrolysis in detail with chemical equations and application in calculating the amount of substance deposited or liberated on passing electricity. Frequently Asked Questions (FAQs) on Faraday's Laws of Electrolysis Q.1. What is Faraday's first law of electrolysis?Ans: Faraday's first law of electrolysis states that the amount of chemical reaction and hence the mass of any substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution is in the molten state). Q.2. What is Faraday's first and second law?Ans: Faraday's first law of electrolysis states that the amount of chemical reaction and hence the mass of any substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution is in the molten state).Faraday's Second Law of electrolysis states that when the same quantity of electricity is passed through different electrolytes connected in series then the masses of the substance liberated at the electrode in the ratio of their chemical equivalent masses or the ratio of their electrochemical equivalence. Q.3. Where Faraday's law of electrolysis is used?Ans: Faraday's laws of electrolysis are used to calculate the amount of substance produced or liberated during electrolysis based on the amount of current passed through the electrolyte. Q.4. What is the value of Faraday's constant? Ans: Faraday's constant \(\left({\rm{F}} \right) = \;96487.84\;{\rm{C}} \cong 96500{\rm{C}}\) { "@context": " ", "@type": "FAQPage", "mainEntity": [{ "@type": "Question", "name": "1. What is Faraday's first law of electrolysis?", "acceptedAnswer": { "@type": "Answer", "text": "Faraday's first law of electrolysis states that the amount of chemical reaction and hence the mass of any substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution is in the molten state)." } },{ "@type": "Question", "name": "2. What is Faraday's first and second law?", "acceptedAnswer": { "@type": "Answer", "text": "Faraday's first law of electrolysis states that the amount of chemical reaction and hence the mass of any substance deposited or liberated at an electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution is in the molten state). Faraday's Second Law of electrolysis states that when the same quantity of electricity is passed through different electrolytes connected in series then the masses of the substance liberated at the electrode in the ratio of their chemical equivalent masses or the ratio of their electrochemical equivalence." } },{ "@type": "Question", "name": "3. Where Faraday's law of electrolysis is used?", "acceptedAnswer": { "@type": "Answer", "text": "Faraday's laws of electrolysis are used to calculate the amount of substance produced or liberated during electrolysis based on the amount of current passed through the electrolyte." } },{ "@type": "Question", "name": "4. What is the value of Faraday's constant?", "acceptedAnswer": { "@type": "Answer", "text": "Faraday's constant \(\left({\rm{F}} \right) = \;96487.84\;{\rm{C}} \cong 96500{\rm{C}}\)" } }] } Learn About Faraday's Second Law of Electrolysis Concept We hope this article on Faraday's Laws of Electrolysis has helped you. 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