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Answer 1:

The rate of a chemical reaction is defined as the change in concentration of reactants or products per unit time. It is usually expressed as the decrease in concentration of reactants or increase in concentration of products per unit time.

For a first-order reaction, the rate is proportional to the concentration of the reactant:

Rate = $-d[A]/dt = k[A]$

To derive the integrated rate equation:

$d[A]/[A] = -k\,dt$

Integrating both sides:

$\int d[A]/[A] = -k\int dt$

$\ln[A] = -kt + C$

At $t = 0$, $[A] = [A]_0$, so $C = \ln[A]_0$

Therefore, $\ln[A]_t = \ln[A]_0 - kt$

This can be rearranged to: $\ln[A]_0/[A]_t = kt$

For the half-life calculation:

$t_{1/2} = 0.693/k$

$t_{1/2} = 0.693/0.0693 = 10$ minutes

Answer 2:

(a) Faraday's laws of electrolysis:

First law: The mass of a substance deposited at an electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

$m \propto Q$ or $m = ZQ$ (where Z is the electrochemical equivalent)

Second law: When the same quantity of electricity is passed through different electrolytes, the masses of substances deposited are proportional to their chemical equivalent weights.

(b) To calculate the mass of copper deposited:

Current (I) = 2 amperes

Time (t) = 30 minutes = 30 × 60 = 1800 seconds

Quantity of electricity (Q) = I × t = 2 × 1800 = 3600 coulombs

1 Faraday = 96500 coulombs = 1 mole of electrons

Number of moles of electrons = 3600/96500 = 0.0373 moles

For copper deposition: $Cu^{2+} + 2e^{-} \rightarrow Cu$

So, 2 moles of electrons deposit 1 mole of copper

Number of moles of copper = 0.0373/2 = 0.01865 moles

Mass of copper = 0.01865 × 63.5 = 1.18 g

Answer 3:

(a) Hybridization in methane (CH_4):

In methane, the carbon atom undergoes sp^3 hybridization. The ground state electronic configuration of carbon is $1s^2\ 2s^2\ 2p^2$. During hybridization, one electron from the 2s orbital is promoted to the empty 2p orbital, resulting in four unpaired electrons. The 2s and three 2p orbitals then mix to form four equivalent sp^3 hybrid orbitals.

These sp^3 hybrid orbitals are oriented in a tetrahedral arrangement with bond angles of 109.5°. Each sp^3 hybrid orbital of carbon overlaps with the 1s orbital of a hydrogen atom to form four equivalent C-H sigma bonds. This tetrahedral arrangement gives methane its stable structure and explains its geometry.

(b) Lewis structure and VSEPR theory for PCl_5:

The Lewis structure of PCl_5 shows the phosphorus atom at the center with five single bonds to chlorine atoms. Phosphorus has 5 valence electrons, and each chlorine contributes 7 valence electrons. Phosphorus uses all its 5 valence electrons to form 5 bonds with chlorine atoms.

According to VSEPR theory, the five electron pairs (all bonding pairs) around the phosphorus atom adopt a trigonal bipyramidal arrangement to minimize electron-pair repulsion. Three chlorine atoms lie in the equatorial plane at 120° angles to each other, while two chlorine atoms occupy the axial positions at 180° to each other. The axial bonds are slightly longer than the equatorial bonds due to greater repulsion. The molecular geometry of PCl_5 is trigonal bipyramidal.