Formula Sheet

Class XII | Physical Chemistry

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The emboldened names are the most basic/important equations from that chapter.

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1. Solutions

1. Basic equations

- Henry's law $p = \chi K_H$, where K_H is Henry's constant
- Raoult's law $p = \chi p_1^0$, where p_1^0 is the pressure exerted by the vapours of a component 1, when component 1 is present in pure.
- Dalton's law $p_T = \sum (\text{partial pressures})$
- Colligative property $\propto \frac{1}{m_{\text{solute}}}$, where m is molecular mass.
- van't Hoff factor $i = \frac{\text{normal molar mass}}{\text{abnormal molar mass}} = \frac{\text{obs. colligative ppty.}}{\text{calc. colligative ppty.}} = \frac{\text{mol of particles after assoc./dissoc.}}{\text{mol of particles before assoc./dissoc.}}$
- Relative lowering/increase in bp/fp $\Delta T_b = iK_b m$, $\Delta T_f = iK_f m$, where m is mola**lity**, i is van't Hoff factor, subscripted K represents constants (water: $K_b = 0.52\,\text{K kg mol}^{-1}$, $K_f = 0.86\,\text{K kg mol}^{-1}$).
- Relation between van't Hoff factor and degree of dissociation (α) For a reaction A$\rightarrow n$B:
  $\alpha = \frac{i-1}{n-1}$
- Osmotic pressure $\Pi = icRT$, where c is concentration of the solution, R is the gas constant (SI: $R = 8.314\,\text{J K}^{-1}\,\text{mol}^{-1}$, Common units: $R = 0.0821\,\text{L atm}\,K^{-1}\,\text{mol}^{-1}$).
- Relative pressure lowering; to find the mole fraction of the solute/component 2
  $\chi_2 = \frac{\Delta p_1}{p_1^0} = \frac{p_1^0 - p_1}{p_1^0}$
- Law of dilution $M_1V_1 = M_2V_2$, where M is molarity, V is volume. Takes the form
  $(\sum MV)_{\text{before}} = (\sum MV)_{\text{after}}$
- In reactions, equivalence $N_1V_1 = N_2V_2$, where N is normality, and $N = M/n$, n being the number of moles.
- Mixing of solutions; resulting molarity $M = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$, weighted average over volume.

2. Determination of constants and values

- Molar mass of solute using relative pressure drop of solvent $M_2 = \frac{W_2}{W_1} \times M_1 \times \frac{p_1}{p_1^0 - p_1}$
- Molar mass of solute using elevation in bp/depression in fp $M_2 = K\frac{1000W_2}{\Delta T_b \times W_1}$

- Molar mass of solute using osmotic pressure method (for protiens and such)

  $M_2 = \frac{W_2}{V} \times \frac{RT}{\pi}$, where W_2 / V is density of solution.

- Molal elevation/depression constants $K = \frac{M_1 R (T^0)^2}{1000 \Delta H}$, where T^0 is the bp/fp of pure solvent, K, T and H have the same subscripts, be it boiling or freezing (b or f).

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2. Electrochemistry

1. Basic equations

- Cell potential $E_{\text{cell}} = E_{\text{right}} - E_{\text{left}} = E_{\text{cathode}} - E_{\text{anode}}$, where E represents **reduction** potential.
- **Nernst equations**
  - For a reaction $\text{M}^{n+}\,(\text{aq.}) + ne^- \rightarrow \text{M}\,(\text{s})$, $E_{\text{M}^{n+}/\text{M}} = E^0_{\text{M}^{n+}/\text{M}} - \frac{RT}{nF}\ln(Q_c)$
  - For a cell $E_{\text{cell}} = E^0_{\text{cell}} - \frac{RT}{nF}\ln(Q_c)$
- **Equilibrium constant from Nernst equation** $E^0_{\text{cell}} = \frac{RT}{nF}\ln(K_c)$
- **Relation b/w Gibbs Energy and cell potential** $\Delta_r G = -nFE_{\text{cell}}$, where $\Delta_r G$ is the Gibbs Energy of the reaction.
- Conductance $G = \frac{1}{R} = \sigma\frac{A}{l} = \frac{\sigma}{K}$, where R is resistance, A is cross-section of the cell, l is length of the cell, $K = l/A$ being the cell constant, $\sigma = 1/\rho$, σ being the conductivity and ρ being the resistivity.
- Conductivity $\sigma = \frac{K}{R}$, where R is the resistance of the cell, found using a Wheatstone bridge.
- Molar conductivity $\Lambda_m = \frac{\sigma}{c}$, where c is concentration. SIMPLE MISTAKES: not checking the unit of the given quantities, since the SI units and the commercial units are used interchangably here (1 L = 1 dm^3)
- **Debye-Huckel-Oansager law equation** $\Lambda_m = \Lambda^0_m - b\sqrt{c}$, where Λ^0_m is the molar conductivity at infinite dilution, b is a constant that is the same for electrlytes with the same ratio of number of cations and anions in their molecular formula, and c is the concentration of the electrolyte. This is valid ONLY for **strong electrolytes**.
- **Kohlrausch law of independent migration of ions** $\Lambda^0_{m(\text{MX})} = \Lambda^0_{m(\text{M})} + \Lambda^0_{m(\text{X})}$
- Degree of dissociation $\alpha = \frac{\Lambda_m}{\Lambda^0_m}$
- Acid dissociation constant for weak acids $K_a = \frac{c\alpha^2}{1-\alpha} = \frac{c\Lambda_m^2}{\Lambda^0_m(\Lambda^0_m - \Lambda_m)}$
- Faraday's laws (electrolysis)
  - Faraday's first law ($w \propto Q_{\text{passed}}$) $w = ZIt$, where w is mass deposited, Z is a constant called the **electrochemical equivalent**, I is current passed, and t is the time for which that current I has been passed through solution. This also defines the unit farad (1 F = 96487 C, charge on 1 mol of electrons).

- Faraday's second law $\frac{w_1}{w_2} = \frac{E_1}{E_2}$, where E stands for equivalent mass (molar mass / no. of moles of electrons required to oxidise or reduce the substance).

2. Chemical reactions

- Daniel Cell (sum of half reactions) $Cu^{2+} + Zn \rightarrow Zn^{2+} + Cu$, in aqueous solution.
- Products of electrolysis of certain solutions
  - Electrolysis of aqueous NaCl with overpotential

    At cathode $H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$, $E^0(0.00\,V) > E^0(-2.71\,V)$
    At anode $Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$, $E^0(1.36\,V) > E^0(1.23\,V)$

    Cl^- is oxidised because of overpotential, else the preferred reaction should have been $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$. Sum the reactions to get the overall reaction.
  - Electrolysis of sulphuric acid (high and low concentrations)

    At cathode $H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$, $E^0(0.00\,V) > E^0(-2.71\,V)$
    At anode $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$, $E^0 = 1.23\,V$ (1)

    OR

    $2SO_4^{2-}(aq) \rightarrow S_2O_8^{2-}(aq) + 2e^-$, $E^0 = 1.96\,V$ (2)

    At lower concentrations, reaction (1) is preffered, while at higher concentrations, (2) is preferred.

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3. Chemical Kinetics

Check the shit i made already.