CHEMISTRY EQUATIONS CHEAT SHEET

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Gibbs Free Energy

Formula: $\Delta G = \Delta H - T\Delta S$

Question: *Determine whether the chemical reaction is spontaneous*

Procedure:

1. Write equation
2. Calculate change in enthalpy (ΔH) for reaction
3. Calculate change in entropy (ΔS) for reaction
4. Calculate Gibbs Free Energy (G) for equation
5. If G is positive, the reaction is not spontaneous. If G is zero or negative, the reaction is spontaneous

Equilibrium Constant

Formula: $K_{eq} = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b}$

Question: *Calculate the equilibrium constant.*

Procedure:

1. Write a balanced chemical equation
2. Convert moles of gas to concentration if necessary ($c = \frac{n}{v}$)
3. Draw ICE (Initial, Change, Equilibrium) Table(^1) if necessary
4. Calculate K_{eq} using equation

Question: *Determine if the system is at equilibrium and, if not, which way it will shift.*

Procedure:

1. The question will give you a value for K_{eq} (or you might calculate it in a previous section)
2. Use the same procedure as above, but with Q instead of K_{eq}
3. Compare Q and K_{eq}:

a. If $Q = K_{eq}$, then the system is at equilibrium

b. If $Q < K_{eq}$, then the system will proceed in the FORWARD direction

c. If $Q > K_{eq}$, then the system will proceed in the REVERSE direction

Question: *Calculate K_p*

Procedure:

1. Calculate mole fraction (no of moles/total moles of gas)
2. Multiply mole fraction by total pressure
3. Use equilibrium equation, substituting partial pressures for concentration

Question: *Given the initial concentration and pH of a compound, find K_{eq} of the dissociation/hydrolysis of the ions.*

Procedure:

1. Write the dissociation equation of the compounds (if not already given)
2. Calculate the number of H^+ ions from the pH ($H^+ = -log_{10}(pH)$)
3. Draw ICE Table (^1) with initial concentration as the initial of the compound
4. Substitute the H^+ values of each ion (from part 2) in the table as the final equilibrium concentration
5. Write K_{eq} and substitute values
6. Assume the x in number x is negligible (from equilibrium concentration of compound) and remove
7. Solve.

Acid/Base Dissociation Constant

Formula: $K_a = \frac{[\mathrm{H_3O^+}][\mathrm{A^-}]}{HA}$

Question: *What is the acid/base dissociation constant of {compound}?*

Procedure:

1. Write the equation for dissociation (reacting with water)
2. Write dissociation expression of the compound
3. Draw ICE table using the initial concentration given, and substitute the other values with x
4. Using pH/pOH, calcullate the number of H^+ or OH^- ions, and replace x with this value
5. Substitute numbers into dissociation expression

Question: *Given the concentration and Ka find the pH of the solution.*

Procedure:

1. Write the equation for the dissociation of compound (react with water)
2. Write dissociation expression of compound(^2)

3. Draw ICE table using the initial concentration given and substituting other values with 'x'
4. Substitute into dissociation expression
5. Assume x is negligible and delete the x
6. Simplify and solve to find x (concentration of H^+ ions)
7. Substitute value of x into formula to find pH ($-log[H^+]$)

Strength of Acid/Base

Formula: $pK_a = -log_{10}[K_a]$

Solubility Equilibrium

Formula: $K_{sp} = [A][B]$

Question: *Compare solubility of salt in water and another solute with shared ion (common ion effect).*

Procedure:

1. Write balanced solubility equation for dissociation of salt
2. Draw MICE table, with initial ratio of shared ion as concentration of solution
3. Substitute change with 'x'
4. Substitute into solubility expression using the values from table
5. Assume that the x in (number +x) is negligible compared to original concentration and remove it
6. Solve equation using the Ksp

Question: *Calculate solubility of compound/concentration of ions from Ksp.*

Procedure:

1. Write balanced solubility equation for dissociation of salt
2. Write Ksp equation
3. Substitute 'x' into concentrations
4. Solve using Ksp.

Question: *Calculate molar solubility of the compound from Ksp.*

Procedure:

1. Write balanced solubility equation for the dissociation of the salt
2. Determine concentration for the ions and use mole ratios to substitute as 's'
3. Write equilibrium expression and substitute 's' into value, solve to find 's'

Question: *When two solutions are mixed, will a precipitate form, given Ksp of precipitate.*

Procedure:

1. Write separate dissociation equations for both solutions
2. Calculate the number of moles in each of the solutions for the volume given
3. Find new concentration of the precipitate forming ions (moles/new volume)
4. Substitute new concentrations into Qsp
5. Compare with Ksp to assess if precipitate forms

***Question:** Give Ksp values, which compound precipitates first?**

Procedure:

1. Write separate dissociation equations for both compounds
2. Write Ksp equation and substitute 'x' for concentrations
3. Solve for 'x' using given Ksp
4. Repeat for the other compound
5. Compare values of x, lower volume precipitates first

Question: *Given Ksp and number of moles of reactants in mixture, calculate concentration of ions at equilibrium.*

Procedure:

1. Write equation of both reactant solutions to form precipitate
2. Find limiting reagent
3. Find moles of excess reagent (total moles – moles of limiting reagent)
4. Write Ksp equation
5. Rearrange equation as (ions) = Ksp / (other ions)

6. Substitute given Ksp values and concentration of excess reagent (using number of moles from step 3)
7. Solve for concentration of ions

Heat of Neutralisation

Formula: $q = mc\Delta T$

Question: *Calculate the heat of neutralisation of a reaction.*

1. Write balanced equation for reaction
2. Calculate number of moles of each reagent to find any limiting reagent
3. If there is limiting reagent, find the new mass that is full volume of limiting reagent + volume of other reagent that reacts (calculate using c=n/v, with n as the moles of limiting reagent)
4. Substitute values into equation

- c (for water) = 4.18
- m (in L if using 4.18, in mL if using 4.18 x 10^3) q in J/mol mass is the amount that is used to react (not the full volume/mass of reagents)
- q in J/mol

Enthalpy of Neutralisation

Formula: $H_n = -\frac{q}{n}$

pH (Power of Hydrogen)

Formula: $pH = -log_{10}[H^+]$

Self-Ionisation Constant

Formula: $K_w = [\mathrm{OH}^- \times [\mathrm{H_3O}^+]$

Concentration of H^+ or OH^- ions (Strong Acids/Bases)

Formulae:

- $[\mathrm{H}^+] = 10^{-pH}$
- $[\mathrm{OH}^-] = 10^{-pOH}$
- $[\mathrm{H}^+] = \frac{10^{-14}}{[\mathrm{OH}^-]}$

Question: *Calculate the pH of a non-reacting solution (Dilution)*

Procedure:

1. Calculate number of moles of acid/base
2. Calculate total volume of final solution
3. Calculate the new concentration in moles using combined volumes of mixtures (c = n/v)
4. If acid/base is strong, (H+) = (acid)
5. Calculate pH or pOH using formula

Question: *Calculate the pH of a reacting solution (Neutralisation)*

Procedure:

1. Write balanced chemical equation for reaction
2. Calculate number of moles for both reacting solutions
3. Use mole ratios to determine the excess reagent
4. Calculate the number of moles of the excess H or OH ions
5. Find the new concentration in using the combined volume of mixtures (c = n/v)
6. Calculate pH or pOH using formula

Heat of Combustion

Formula: $H_c = \frac{q}{n}$

Question: *Calculate the mass of (substance) that must be burnt to increase the temperature of water by (amount).*

Procedure:

1. Calculate the heat of neutralisation for water (q = mcat)
2. Sub value into the heat of combustion (h = q/n) to find number of moles
3. Use mole ratios to determine number of moles of ethanol required
4. Convert moles to mass (m = n x MM)

Percentage Yield

Formula: $\% \text{ Yield} = \frac{\text{Actual Mass}}{\text{Theoretical Mass}} \times 100\%$

Percentage Purity

Formula: $\% \text{ Purity} = \frac{\text{Mass of useful product}}{\text{Total mass of sample}} \times 100$

Percentage Ionisation

Formula: $\% \text{ Ionisation} = \frac{[\text{A}^-]}{[\text{HA}]} \times 100\%$