# Chemistry — HSC Reference Sheet

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## Constants & Data

**Avogadro's constant**
$N_A = 6.022 \times 10^{23}$ mol⁻¹

**Universal gas constant**
$R = 8.314$ J mol⁻¹ K⁻¹

**Molar volume of an ideal gas at STP (0 °C, 100 kPa)**
$V_m = 22.71$ L mol⁻¹

**Molar volume of an ideal gas at 25 °C, 100 kPa**
$V_m = 24.79$ L mol⁻¹

**Ionic product of water**
$K_w = 1.0 \times 10^{-14}$ mol² L⁻²

**Specific heat capacity of water**
$c = 4.18$ J g⁻¹ K⁻¹

**Faraday constant**
$F = 96\,485$ C mol⁻¹

## Mole & Stoichiometry

**Moles from mass**

$$n = \frac{m}{M}$$

**Moles from number of particles**

$$n = \frac{N}{N_A}$$

**Moles from volume (solutions)**

$$n = cV$$

## Gases

**Ideal gas law**

$$PV = nRT$$

**Molar volume (gas volume)**

$$V = nV_m$$

## Solutions & Concentration

**Molar concentration**

$$c = \frac{n}{V}$$

**Dilution formula**

$$c_1V_1 = c_2V_2$$

**Parts per million (mass/mass)**

$$\text{ppm} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^6$$

## Energetics & Calorimetry

**Heat transferred (calorimetry)**

$$q = mc\Delta T$$

**Molar enthalpy of reaction**

$$\Delta H = -\frac{q}{n}$$

**Hess's Law**

$$\Delta H_{\text{rxn}} = \sum \Delta H_{\text{products}} - \sum \Delta H_{\text{reactants}}$$

## Equilibrium & Acids/Bases

**Equilibrium constant expression**

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

**Reaction quotient**

$$Q = \frac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b}$$

**pH definition**

$$\text{pH} = -\log_{10}[\text{H}^+]$$

**pOH and the water relationship**

$$\text{pH} + \text{pOH} = 14$$

**Ionic product of water**

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

**Acid dissociation constant**

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

**pKa**

$$\text{p}K_a = -\log_{10} K_a$$

## Electrochemistry

**Charge transferred in electrolysis**

$$Q = It$$

**Moles of electrons (Faraday's law)**

$$n_e = \frac{Q}{F}$$

**Mass deposited in electrolysis**

$$m = nM$$

## Standard Electrode Potentials

### Standard reduction potentials (electrochemical series)

| Reduction half-equation | E° (V) |
|---|---|
| $F_2 + 2e^- \rightleftharpoons 2F^-$ | +2.87 |
| $Ag^+ + e^- \rightleftharpoons Ag$ | +0.80 |
| $Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ | +0.77 |
| $Cu^{2+} + 2e^- \rightleftharpoons Cu$ | +0.34 |
| $2H^+ + 2e^- \rightleftharpoons H_2$ | 0.00 |
| $Pb^{2+} + 2e^- \rightleftharpoons Pb$ | -0.13 |
| $Fe^{2+} + 2e^- \rightleftharpoons Fe$ | -0.44 |
| $Zn^{2+} + 2e^- \rightleftharpoons Zn$ | -0.76 |
| $Al^{3+} + 3e^- \rightleftharpoons Al$ | -1.66 |
| $Mg^{2+} + 2e^- \rightleftharpoons Mg$ | -2.37 |
| $Na^+ + e^- \rightleftharpoons Na$ | -2.71 |
| $Li^+ + e^- \rightleftharpoons Li$ | -3.04 |

## Spectroscopy (Module 8)

### Infrared absorption data

| Bond | Wavenumber (cm$^{-1}$) | Intensity |
|---|---|---|
| O–H | 3230–3550 | strong, broad |
| N–H | 3300–3500 | medium |
| C–H | 2850–3000 | medium |
| O–H (acid) | 2500–3000 | very broad |
| C≡N | 2220–2260 | sharp |
| C=O | 1680–1750 | strong |
| C=C | 1620–1680 | medium |
| C–O | 1000–1300 | strong |

### $^1$H NMR chemical shift data

| Type of proton | Chemical shift δ (ppm) |
|---|---|
| R–CH$_3$, R–CH$_2$–R (alkyl) | 0.9–1.8 |
| C–H next to C=O / aromatic | 2.0–3.0 |
| C–H next to O / halogen | 3.3–4.5 |
| Alkene C=C–H | 4.5–6.5 |
| Aromatic H | 6.5–8.0 |
| Aldehyde –CHO | 9.0–10.0 |
| Carboxylic acid –COOH | 10.0–12.0 |

### $^{13}$C NMR chemical shift data

| Type of carbon | Chemical shift δ (ppm) |
|---|---|
| Alkyl C (C–C) | 5–40 |
| C–N | 40–60 |
| C–O | 50–90 |
| C=C / aromatic C | 100–150 |
| C=O (ester/acid) | 160–185 |
| C=O (aldehyde/ketone) | 190–220 |

### UV-visible spectroscopy

$$A = \varepsilon c l$$