# ENSC1004

Supplementary Formula and Data Sheet

| | | |
|---|---|---|
| $N_A = 6.022 \times 10^{23}\ atoms/mol$ | $k = 1.38 \times 10^{-23}\ J/atom \cdot K$<br>$k = 8.62 \times 10^{-5}\ eV/atom \cdot K$ | $R = 8.314\ J/mol \cdot K$ |
| $F = 96485\ C/mol$ | $e = 1.602 \times 10^{-19}\ C$ | |

$$\%\ ionic\ character = \{1 - \exp[-(0.25)(X_A - X_B)^2]\} \times 100$$

$$\%EL = \left(\frac{l_f - l_o}{l_o}\right) \times 100$$

$$\%RA = \left(\frac{A_o - A_f}{A_o}\right) \times 100$$

$$U_r \cong \frac{E}{2}(\varepsilon_y)^2 \cong \frac{(\sigma_y)^2}{2E}$$

$$\sigma_m = \sigma_o\left[1 + 2\left(\frac{a}{\rho}\right)^{1/2}\right]$$

$$K = Y\sigma\sqrt{\pi a}$$

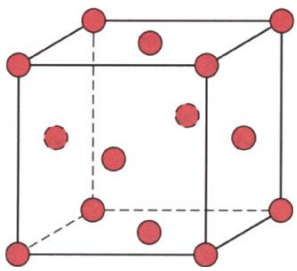
| | Three basic stress-strain states | | |
|---|---|---|---|
| | Tension/ Compression | Shear | Hydrostatic Pressure |
| Stress (MPa) Pressure (kPa) | $\sigma = \frac{F}{A_o}$ | $\tau = \frac{F}{A_o}$ | $p$ |
| Strain (%) | $\varepsilon = \frac{\Delta l}{l_o}$ | $\gamma = \frac{\Delta x}{y_o} = tan\theta$ | $\Delta = \frac{\Delta V}{V_o}$ |
| Linear **Elastic** stress-strain behaviour | | | |
| Hooke's Law | $\sigma = E\varepsilon$ | $\tau = G\gamma$ | $p = -K\Delta$ |
| **Elastic** properties: E, G, K and $\nu$ | | | |
| Poisson's Ratio | $\nu = -\frac{\varepsilon_{lateral}}{\varepsilon_{axial}}$ | | |
| Modulus (GPa) | **E** (Young's) | **G** (shear) | ***K*** (bulk) |
| | $G = \frac{E}{2(1+\nu)} \approx \frac{3}{8}E$ | | |

$$\rho = \frac{nA}{V_{uc}N_A}$$

$$APF = \frac{n\left(\frac{4}{3}\pi R^3\right)}{a^3}$$

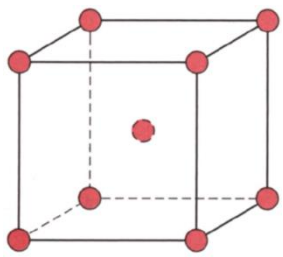
FCC structure: Al, Ni, Cu, Ag, Au, Pb

APF=0.74



BCC structure: Li, Cr, Mn, Fe, Nb, Mo, W

APF=0.68



$$\rho = \frac{1}{\sigma} = \frac{RA}{l} = \frac{UA}{Il}$$

$$\rho_t = \rho_{rt}\left[1 + \alpha(T - T_{rt})\right]$$

$$\rho = \rho_o(1 + \beta c_i)$$

$$\sigma = n|e|\mu_e$$

$$\sigma = n|e|\mu_e + p|e|\mu_h$$

$$\sigma = n_i|e|(\mu_e + \mu_h)$$

$$\sigma = \sigma_0 \cdot exp\left(-\frac{E_g}{2kT}\right)$$

$$f(E) = \frac{1}{e^{(E-E_F)/kT} + 1}$$

$$C = \frac{Q}{\Delta T \times n}$$

$$c = \frac{Q}{\Delta T \times m}$$

$$q = -k\frac{dT}{dx}$$

$$Q = -kAt\frac{\Delta T}{l}$$

$$\varepsilon_{th} = \frac{\Delta l}{l_0} = \alpha_l \Delta T$$

$$\sigma_{th} = -E\varepsilon_{th} = -E\alpha_l\Delta T$$

$$TSR = \frac{\sigma_f k}{E\alpha_l}$$

$$2H^+ + 2e^- \rightarrow H_2$$
$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$
$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$
$$M^{n+} + e^- \rightarrow M^{(n-1)+}$$
$$M^{n+} + ne^- \rightarrow M$$

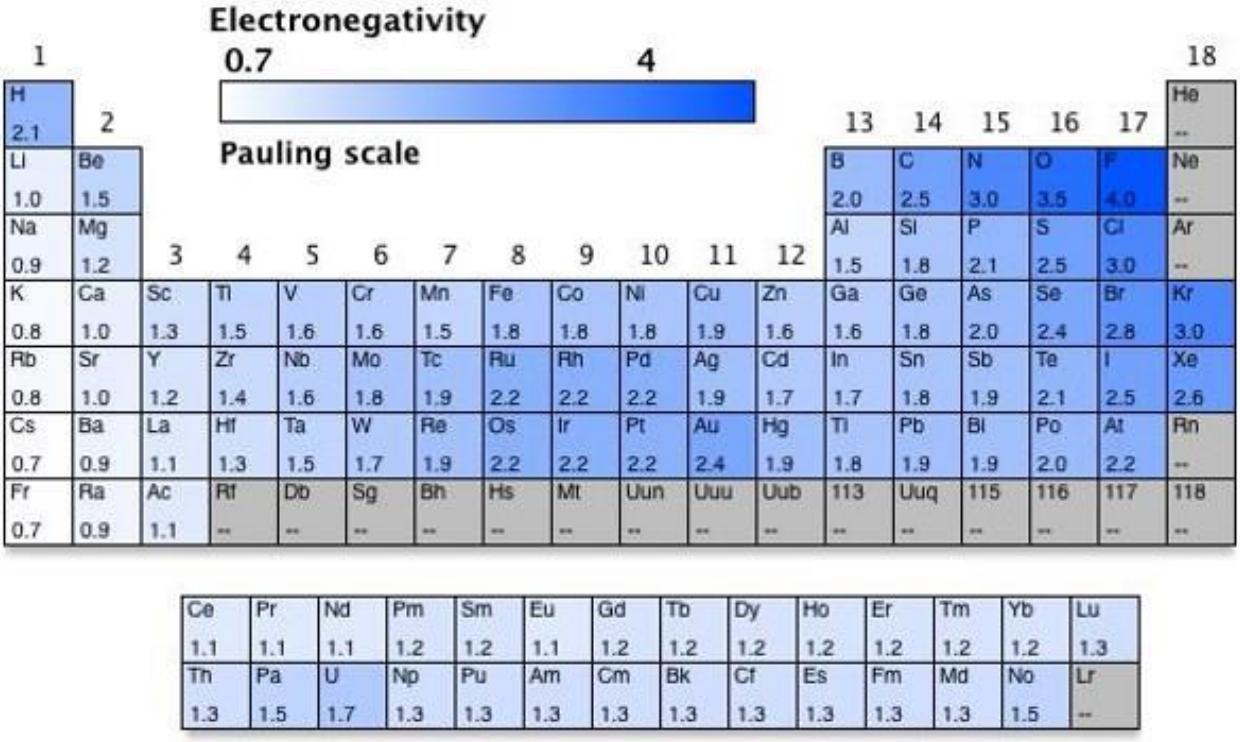
$$aA + bB \leftrightarrow cC + dD$$
$$K = \frac{(activity\ of\ C)^c (activity\ of\ D)^d}{(activity\ of\ A)^a (activity\ of\ B)^b}$$
$$\mathrm{V} = V^O - \frac{2.303RT}{nF}\log(K)$$

$$\mathrm{PB} = \frac{M_{oxide}\rho_{metal}}{nM_{metal}\rho_{oxide}}$$

**Standard EMF Series**

| Electrode Reaction | Standard Reduction Potential (V) |
|---|---|
| $Au^{3+} + 3e^- \rightarrow Au$ | +1.420 |
| $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ | +1.229 |
| $Pt^{2+} + 2e^- \rightarrow Pt$ | +1.2 |
| $Ag^+ + e^- \rightarrow Ag$ | +0.800 |
| $Fe^{3+} + e^- \rightarrow Fe^{2+}$ | +0.771 |
| $O_2 + 2H_2O + 4e^- \rightarrow 4(OH^-)$ | +0.401 |
| $Cu^{2+} + 2e^- \rightarrow Cu$ | +0.340 |
| $2H^+ + 2e^- \rightarrow H_2$ | 0.000 |
| $Pb^{2+} + 2e^- \rightarrow Pb$ | -0.126 |
| $Sn^{2+} + 2e^- \rightarrow Sn$ | -0.136 |
| $Ni^{2+} + 2e^- \rightarrow Ni$ | -0.250 |
| $Co^{2+} + 2e^- \rightarrow Co$ | -0.277 |
| $Cd^{2+} + 2e^- \rightarrow Cd$ | -0.403 |
| $Fe^{2+} + 2e^- \rightarrow Fe$ | -0.440 |
| $Cr^{3+} + 3e^- \rightarrow Cr$ | -0.744 |
| $Zn^{2+} + 2e^- \rightarrow Zn$ | -0.763 |
| $Al^{3+} + 3e^- \rightarrow Al$ | -1.662 |
| $Mg^{2+} + 2e^- \rightarrow Mg$ | -2.363 |
| $Na^{2+} + 2e^- \rightarrow Na$ | -2.714 |
| $K^+ + e^- \rightarrow K$ | -2.924 |

Platinum
Gold
Graphite
Titanium
Silver
316 Stainless steel (passive)
304 Stainless steel (passive)
Inconel (80Ni–13Cr–7Fe) (passive)
Nickel (passive)
Monel (70Ni–30Cu)
Copper–nickel alloys
Bronzes (Cu–Sn alloys)
Copper
Brasses (Cu–Zn alloys)
Inconel (active)
Nickel (active)
Tin
Lead
316 Stainless steel (active)
304 Stainless steel (active)
Cast iron
Iron and steel Carbon steels
Aluminum alloys
Cadmium
Commercially pure aluminum
Zinc
Magnesium and magnesium alloys




| 1 | | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H 2.1 | 2 | | | | | | | | | | | | | | | | He -- |
| Li 1.0 | Be 1.5 | | | | | | | | | | | B 2.0 | C 2.5 | N 3.0 | O 3.5 | F 4.0 | Ne -- |
| Na 0.9 | Mg 1.2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Al 1.5 | Si 1.8 | P 2.1 | S 2.5 | Cl 3.0 | Ar -- |
| K 0.8 | Ca 1.0 | Sc 1.3 | Ti 1.5 | V 1.6 | Cr 1.6 | Mn 1.5 | Fe 1.8 | Co 1.8 | Ni 1.8 | Cu 1.9 | Zn 1.6 | Ga 1.6 | Ge 1.8 | As 2.0 | Se 2.4 | Br 2.8 | Kr 3.0 |
| Rb 0.8 | Sr 1.0 | Y 1.2 | Zr 1.4 | Nb 1.6 | Mo 1.8 | Tc 1.9 | Ru 2.2 | Rh 2.2 | Pd 2.2 | Ag 1.9 | Cd 1.7 | In 1.7 | Sn 1.8 | Sb 1.9 | Te 2.1 | I 2.5 | Xe 2.6 |
| Cs 0.7 | Ba 0.9 | La 1.1 | Hf 1.3 | Ta 1.5 | W 1.7 | Re 1.9 | Os 2.2 | Ir 2.2 | Pt 2.2 | Au 2.4 | Hg 1.9 | Tl 1.8 | Pb 1.9 | Bi 1.9 | Po 2.0 | At 2.2 | Rn -- |
| Fr 0.7 | Ra 0.9 | Ac 1.1 | Rf -- | Db -- | Sg -- | Bh -- | Hs -- | Mt -- | Uun -- | Uuu -- | Uub -- | 113 -- | Uuq -- | 115 -- | 116 -- | 117 -- | 118 -- |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ce 1.1 | Pr 1.1 | Nd 1.1 | Pm 1.2 | Sm 1.2 | Eu 1.1 | Gd 1.2 | Tb 1.2 | Dy 1.2 | Ho 1.2 | Er 1.2 | Tm 1.2 | Yb 1.2 | Lu 1.3 |
| Th 1.3 | Pa 1.5 | U 1.7 | Np 1.3 | Pu 1.3 | Am 1.3 | Cm 1.3 | Bk 1.3 | Cf 1.3 | Es 1.3 | Fm 1.3 | Md 1.3 | No 1.5 | Lr -- |