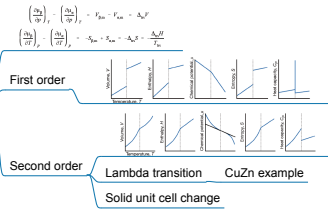


59-240
Lecture 15
Phase Transitions & Interfaces

Ehrenfest Classification of Phase Transitions



Liquid Surfaces & Surface Tension

minimize surface area
 minimize interface between different phases
 $dA = \gamma d\sigma$
 γ is a proportionality constant known as **surface tension**, having dimensions $J m^{-2}$ or $N m^{-1}$
 if $dA < 0$, surface has tendency to **contract**
 examples: water/wire example, insects on surfaces, small objects on water: mass vs. surface area
 surface tension of water: hydrogen bonding interactions, stretchy skin at surface, water has a high γ compared to most substances

Curved surfaces

Types: Bubble, Cavity, Droplet
 $p_{in} = p_{out} + \frac{2\gamma}{r}$
 Laplace equation: $p_{in} = p_{out}$
 very small bubbles/cavities/droplets have huge pressure differentials
PROOF: make sure you can do this!
 $p = p^* e^{V_m \Delta P / RT}$
 Kelvin equation: Applied pressure: $\Delta P = 2\gamma/r$
 $p = p^* e^{2\gamma V_m^L / rRT}$
 Other stuff: Shapes of bubbles, Bubble meets bubble, Soap bubbles: amphiphilic molecules, surfactant molecules, bilayer formation, Gas bubbles: cavities, gases trapped in solution, nucleation sites, areas: champagne, soda, beers, blood

Capillary action

results from surface tension
 solvent creeps up tube
 meniscus has variability in pressure
 hydrostatic equilibrium obtained when external pressure balanced by $p - 2\gamma/r + \rho gh$
 $h = \frac{2\gamma}{\rho g r}$ Capillary rise
 Capillary depression
 $h = \frac{2\gamma}{\rho g r} \cos \theta_c$
 $\cos \theta_c = \frac{\gamma_{sg} - \gamma_{sl}}{\gamma_{lg}}$
 $\gamma_{sd} = \gamma_{sg} + \gamma_{lg} - \gamma_{sl}$
 Contact angle
 contact lenses: high wettability
 car paints: low wettability
 lotus leaves: low wettability

Nucleation

nucleation centres needed to catalyze a variety of phase transitions
 examples: nucleation sites from dust particles (rain clouds), nucleation sites provided by porous carbon (superheated liquids), lack of nucleation sites (supercooled liquids, supercooled H₂O)