PHYS 317 Fall 2018

Summary for Exam 1

Ideal Gas:

$pV = NkT = \nu RT$ and microscopic picture

Equipartition Theorem:

$U_{\text{therm}} = N\frac{f}{2}kT$ (apply and determine f)

1st Law of Thermodynamics:

$\Delta U = Q + W$ $W = -\int p\mathrm{d}V$

(pV diagrams, adiabat, isotherm, straight lines)

Heat Capacities and Enthalpy:

$C = \frac{Q}{\Delta T}$ $C_V = \left(\frac{\partial U}{\partial T}\right)_V$ $C_p = \left(\frac{\partial H}{\partial T}\right)_p$

$C = m\,c$

$H = U + pV$ (apply to reactions; if on exam, then table will be provided)

~~**Heat Conduction, Diffusion:** microscopic picture~~

Multiplicities:

systems: 2-state, Einstein solid, ideal gas (& similar)

derive Ω, Ω_{tot}, apply Stirling formula and $\ln(1+x) \approx x$, ~~know EXCEL commands~~

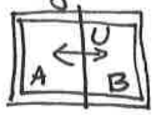
Entropy: $S = k\,\ln\Omega$

determine S, ΔS

2nd Law of Thermodynamics: major concept

SUMMARY FOR EXAM2

$dU = TdS - p\,dV + \mu\,dN$ derive each term: e.g.



S_{tot} max

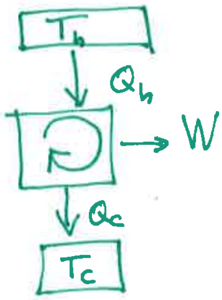
$\ldots \rightarrow \frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_{V,N}$

$\Omega \rightarrow S \rightarrow S(U) \rightarrow T \rightarrow U(T) \rightarrow C_V$

Einstein Solid, paramagnet, polymer, ideal gas

$\Delta S = \int \frac{Q}{T} = \int \frac{C_{V,p}\,dT}{T}$

heat engine:



$e = \frac{W}{Q_h} = \frac{W_{by}}{Q_h}$

thermodynamic potentials: $U, F, H, G, \ldots$

- thermodynamic identities: derive $dF = \ldots$ etc. & Maxwell relations
- derive $G = \mu N$ etc.
- $\Delta S_{tot} \geq 0 \rightarrow F_{min}$ etc. (derive)
- $dS_{tot} \geq 0 \rightarrow dG \leq 0 \rightarrow G\,min.$
- apply, using tables

phase transitions:

- main concepts
- apply G_{min} $G(p)$, $G(T)$
- van der Waals: $p(V)$, $p(T)$, $S(T)$, $G(p)$ (& derive Clausius-Clapeyron etc.) T_c, p_c, V_c
- phase transitions of mixtures $G(x)$, $T(x)$

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Summary for Exam 3

Canonical Distribution:

- Derive $P(s) = \frac{\mathrm{e}^{-E(s)/(k_\mathrm{B}T)}}{Z}$ and similar probabilities
- Apply: $\overline{X} = \sum_s X(s)P(s)$ $\overline{X} = \frac{\sum_s X(s)\mathrm{e}^{-E(s)/(kT)}}{Z}$ $Z = \sum_s \mathrm{e}^{-E(s)/(kT)}$
  - apply $\overline{X}$ to any system (below examples)
  - Three state system
  - Hydrogen
  - Show $\overline{E} = -\frac{\partial \ln Z}{\partial \beta}$ and fluctuation dissipation relations
  - $Z \longrightarrow \overline{E} \longrightarrow S$
  - rotations
  - paramagnet
  - derive equipartition theorem
  - Maxwell speed distribution and velocity averages and maximum
  - composite systems
- $F = -k_\mathrm{B}T \ln Z$
  - $Z \longrightarrow F \longrightarrow \mu, S, p$
  - ideal gas

Ising Ferromagnet:

- derive 1 dim. Z and U

Summary for after Exam 3

Ising Ferromagnet: Meanfield: derive and sketch (for solutions)

Grand Canonical Distribution:

$$P(s) = \frac{e^{-[E(s)-\mu N(s)]/(kT)}}{\mathcal{Z}} \qquad \overline{X} = \frac{\sum_s X(s) e^{-[E(s)-\mu N(s)]/(kT)}}{\mathcal{Z}} \qquad \mathcal{Z} = \sum_s e^{-[E(s)-\mu N(s)]/(kT)}$$

- Derive
- Apply to any system. (below applications in class and HW)
  - CO and O_2 with hemoglobin
  - Bosons & Fermions: microstates
  - derive $\overline{n}_{\rm FD}$ and $\overline{n}_{\rm BE}$
  - degenerate Fermi-gas: derive $\epsilon_{\rm F}$, U, N
  - **Black Body Radiation:** derive $U_{\rm tot}$,$N_{\rm tot}$, $u(\epsilon)$, $u(\lambda)$
  - **Bose-Einstein condensation:** main concepts