# Formula Sheet for LSU Physics 2112, EXAM I, Spring 2019

**Units:**

$1\,\text{m} = 39.4\,\text{in} = 3.28\,\text{ft}$ $1\,\text{mi} = 5280\,\text{ft}$ $1\,\text{min} = 60\,\text{s}$, $1\,\text{day} = 24\,\text{h}$ $1\,\text{rev} = 360° = 2\pi\,\text{rad}$

$1\,\text{atm} = 1.013{\times}10^5\,\text{Pa} = 760\ \text{torr} = 14.7\ \text{psi}$ $T = \left(\frac{1\,K}{1°\text{C}}\right)T_\text{C} + 273.15\,\text{K}$ $T_\text{F} = \left(\frac{9\,°\text{F}}{5°\text{C}}\right)T_\text{C} + 32°\text{F}$

**Constants:**

$k = 1.38\times10^{-23}\,\text{J/K}$ $R = 8.31\,\text{J/(mol·K)}$ Avogadro's # $= 6.02\times10^{23}$ particles/mol

**Properties of $H_2O$:**

| | | |
|---|---|---|
| Density: | $\rho_\text{water} = 1000\ \text{kg/m}^3$ | |
| Specific heat: | $c_\text{water} = 4187\ \text{J/(kg K)}$ | $c_\text{ice} = 2220\ \text{J/(kg K)}$ |
| Heats of transformation: | $L_\text{vaporization} = 2.256\times10^6\ \text{J/kg}$ | $L_\text{fusion} = 3.33\times10^5\ \text{J/kg}$ |

**Static Fluids:**

Density: $\boldsymbol{\rho = \frac{\Delta m}{\Delta V}}$ Pressure: $\boldsymbol{p = \frac{\Delta F}{\Delta A}}$

**Thermodynamics:**

Linear Expansion: $\Delta L = L\alpha\Delta T$ Volume Expansion: $\Delta V = V\beta\Delta T = 3\alpha V\Delta T$

Heat of Warming/Cooling: $Q = mc\Delta T$ Heat of Transformation: $Q = mL$

Work Done **by** the System: $W = \int_i^f p\ dV$

First Law: $\Delta E_{int} = Q - W$ $\Delta E_{int} = E_{int,f} - E_{int,i}$ $dE_{int} = dQ - dW$

**Ideal Gas Law:** $pV = nRT = NkT$ $\frac{pV}{T} = \text{const}$ for n=const

Kinetic Theory: $p = \frac{nMv_\text{rms}^2}{3V} = \frac{\rho v_\text{rms}^2}{3}$ $v_\text{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3kT}{m}}$

**Change in Entropy**: $\Delta S = \int_i^f \frac{dQ}{T}$ ...(reversible path) $\Delta S = S_f - S_i$

**Second Law:** $\Delta S \geq 0$ ...(closed system)

**Solids/Liquids:** $\Delta S = \frac{mL}{T}$ (transformation) $\Delta S = mc\ \ln\frac{T_f}{T_i}$ (warming/cooling)

**Ideal Gases:** $\Delta S = nR\ln\frac{V_f}{V_i} + nC_V\ln\frac{T_f}{T_i}$

| Molecule | Monoatomic | Diatomic | Polyatomic |
|---|---|---|---|
| $C_V$ | $(3/2)R$ | $(5/2)R$ | $3R$ |
| $C_p$ | $(5/2)R$ | $(7/2)R$ | $4R$ |

$\boldsymbol{\gamma = C_p/C_V}$, $\boldsymbol{E_\text{int} = nC_VT}$

| **Process Type** | **Const. Quant.** | **Useful Relations (reversible processes)** |
|---|---|---|
| **Any** path | | $W = \int p\ dV$, $\Delta E_\text{int} = Q - W = nC_V\Delta T$, $\Delta S = \int dQ/T$ |
| Isochoric | $V$ | $W = 0$, $Q = nC_V\Delta T$ |
| Isobaric | $p$ | $W = p\Delta V$, $Q = nC_P\Delta T$ |
| Isothermal | $T$ | $W = nRT\ln(V_f/V_i)$, $\Delta E_\text{int} = 0, \Delta S = Q/T$ |
| Cyclic | | $Q = W$, $\Delta E_\text{int} = 0$, $\Delta S = 0$ |
| Adiabatic | $pV^\gamma$, $TV^{\gamma-1}$ | $Q = 0$, $W = -\Delta E_\text{int}$, $\Delta S = 0$ |

**Engines:**

1st Law for Eng. and Refrig.: $0 = |Q_H| - |Q_L| - |W|$

Efficiency: $\epsilon = \frac{|W|}{|Q_H|}$ Carnot (ideal) efficiency: $\epsilon_C = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$

**Refrigerator:**

Coeff. of performance: $K = \frac{|Q_L|}{|W|}$ Carnot coeff. of performance: $K_C = \frac{|Q_L|}{|Q_H| - |Q_L|} = \frac{T_L}{T_H - T_L}$