# August 2019 Qualifying Exam

# Part I

Calculators are allowed.  No reference material may be used.

Please clearly mark the problems you have solved and want to be graded.  Do only mark the required number of problems.

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**Physical Constants:**

**Planck constant:**  h = 6.62606896 * $10^{-34}$ Js,  ħ = 1.054571628 * $10^{-34}$ Js
**Boltzmann constant:**  $k_B$ = 1.3806504 * $10^{-23}$ J/K
**Elementary charge:**  $q_e$ = 1.602176487 * $10^{-19}$ C
**Avogadro number:**  $N_A$ = 6.02214179 * $10^{23}$ particles/mol
**Speed of light:**  c = 2.99792458 * $10^{8}$ m/s
**Electron rest mass:**  $m_e$ = 9.10938215 * $10^{-31}$ kg
**Proton rest mass:**  $m_p$ = 1.672621637 * $10^{-27}$ kg
**Neutron rest mass:**  $m_n$ = 1.674927211 * $10^{-27}$ kg
**Bohr radius:**  $a_0$ = 5.2917720859 * $10^{-11}$ m
**Compton wavelength of the electron:**  $\lambda_c$ = h/($m_e$c) = 2.42631 * $10^{-12}$ m
**Permeability of free space:**  $\mu_0$ = 4π $10^{-7}$ N/$A^2$
**Permittivity of free space**:  $\epsilon_0$ = 1/$\mu_0 c^2$
**Gravitational constant:**  G = 6.67428 * $10^{-11}$ $m^3$/(kg $s^2$)
**Stefan-Boltzmann constant:**  σ = 5.670 400 * $10^{-8}$ W $m^{-2}$ $K^{-4}$
**Wien displacement law constant:**  $\sigma_w$ = 2.897 7685 * $10^{-3}$ m K
**Plank radiation law:**  I(λ,T) = (2h$c^2$/$\lambda^5$)[exp(hc/(kT λ)) – 1]$^{-1}$