

Starting equations from this class *Equations with an asterisk were not prominently featured in homework, and are key formulas for understanding course content, but will not required for the exam.

$\Delta U = Q + W$	First Law (energy flow diagrams)	(1)
$\Delta S_{\text{system}} + \Delta S_{\text{surroundings}} \geq 0$	Second Law	(2)
$W = - \int p dV$	work from a pV diagram	(3)
$\Delta S = \frac{Q}{T}$	if temperature is held constant	(4)
$\frac{1}{T} = \frac{dS}{dU}$	definition of temperature*	(5)
$S = k_B \ln \Omega$	entropy from number of microstates*	(6)
$pV = Nk_B T$	ideal gas only!	(7)
$\frac{W_{\text{net}}}{Q_{\text{in}}} \leq 1 - \frac{T_C}{T_H}$	efficiency of heat engines	(8)
$C_V = \frac{dU}{dT}$	heat capacity	(9)
energy per degree of freedom = $\frac{1}{2}k_B T$	equipartition	(10)
if $\frac{1}{2}k_B T \ll \Delta E$	can ignore that degree of freedom	(11)
if $\frac{1}{2}k_B T \gg \Delta E$	can use equipartition	(12)
$E_{\text{photon}} = \hbar\omega = \Delta E_{\text{system}}$	quantum spectra	(13)
$p = \frac{h}{\lambda} = \frac{2\pi\hbar}{\lambda}$	momentum and wavelength	(14)
$E_{\text{light}} = p_{\text{light}}c$	momentum of light	(15)
energy/time/area	intensity of light	(16)
$I = \sigma T^4$	Stefan-Boltzmann Law	(17)
spectral intensity S_λ	the intensity per wavelength	(18)
$\lambda_{\text{peak}} = \frac{b}{T}$	Wien's displacement law*	(19)

Course content that will be provided if required

- Boundary conditions for pipes etc.
- Energy level formulas for quantum systems
- An equation for spectral intensity

Course content that will not be on the exam These topics were discussed in class, but did not appear on homework, and therefore will not appear on the exam.

- Differential equations for waves
- Optical depth and cross section

Starting equations from previous classes

$$K.E. = \frac{1}{2}mv^2 \quad (20)$$

$$U = mgh \quad \text{for gravity near the surface of Earth} \quad (21)$$

$$U = k_C \frac{q_1 q_2}{r_{12}} \quad \text{for two point charges} \quad (22)$$

$$p = mv \quad \text{nonrelativistic particle} \quad (23)$$

$$v = \lambda f \quad \text{for a wave} \quad (24)$$

$$\omega = 2\pi f \quad \text{angular versus normal frequency} \quad (25)$$

$$\text{density} = \frac{m}{V} \quad (26)$$

$$\text{number density} = \frac{N}{V} \quad (27)$$

$$Q = mc\Delta T \quad \text{specific heat capacity} \quad (28)$$

Useful constants

$$k_B \approx 1.4 \times 10^{-23} \quad \text{Boltzmann's constant} \quad (29)$$

$$k_C \approx 9 \times 10^9 \text{ J m/C}^2 \quad \text{Coulomb constant} \quad (30)$$

$$e \approx 1.6 \times 10^{-19} \text{ C} \quad \text{charge of electron} \quad (31)$$

$$\text{eV} \approx 1.6 \times 10^{-19} \text{ J} \quad \text{an electron volt} \quad (32)$$

$$\hbar \approx 10^{-34} \text{ J s} \quad \text{Plank's constant} \quad (33)$$

$$c \approx 3 \times 10^8 \text{ m/s} \quad \text{speed of light} \quad (34)$$

$$m_e \approx 10^{-30} \text{ kg} \quad \text{mass of electron} \quad (35)$$

$$m_e c^2 \approx 0.5 \text{ MeV} \quad \text{mass of electron (relativistic version)} \quad (36)$$

$$u \approx 1.7 \times 10^{-27} \text{ kg} \quad \text{atomic mass unit} \quad (37)$$

$$hc \approx 1240 \text{ nm eV} \quad \text{a convenient combination} \quad (38)$$

$$N_A \approx 6 \times 10^{23} \text{ things/mol} \quad \text{Avogadro's number} \quad (39)$$

$$\sigma \approx 6 \times 10^{-8} \frac{\text{J}}{\text{s} \cdot \text{m}^2 \cdot \text{K}^4} \quad \text{Stefan-Boltzmann constant} \quad (40)$$