Chapter 15 Equations

First Law of Thermodynamics (U = internal energy):

$\Delta U = Q - W$ or $\Delta KE + \Delta PE + \Delta U = Q - W$

work = W = area under $P(V)$ curve. $W = P\Delta V$ for isobaric processes.

heat = Q = heat absorbed by the system. $Q = 0$ for adiabatic processes.

Heat Engines:

$W = Q_H - Q_L$, efficiency $e = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$, $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$ for ideal Carnot cycle.

Cooling Machines, Heat Pumps:

$W = Q_H - Q_L$, refrigerators: COP $= \frac{Q_L}{W}$, heat pumps: COP $= \frac{Q_H}{W}$, $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$ for ideal Carnot.

Power:

$P_{\text{ave}} = \frac{W}{t}$, or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}$.

Chapter 14 Equations

Internal Energy:

$U = \frac{3}{2}Nk_BT = \frac{3}{2}nRT$, for ideal monatomic gases.

Mechanical Equivalent of Heat, Specific Heat, Latent Heat:

1 cal = 4.186 J, $Q = mc\Delta T$, $Q = mL_F$, $Q = mL_V$.

For water, $c = 1.00$ cal/g·C° = 4.186 kJ/kg ·C°, $c_{\text{ice}} = 0.50$ cal/g·C° = 2.1 kJ/kg ·C°.

$L_F = 79.7$ kcal/kg = 333 kJ/kg, $L_V = 539$ kcal/kg = 2260 kJ/kg.

Heat Transfer:

Conduction: $P = \frac{Q}{t} = kA\frac{\Delta T}{l}$.

Radiation: $P = \frac{\Delta Q}{\Delta t} = e\sigma AT^4$, $P = \frac{\Delta Q}{\Delta t} = e\sigma A(T_1^4 - T_2^4)$, $\sigma = 5.67 \times 10^{-8}$ W/m^2· K^4.

Solar Energy: $P = \frac{\Delta Q}{\Delta t} \approx (1000 \text{ W/m}^2)\, eA\cos\theta$

Chapter 13 Equations

Atomic Theory & Moles:

$n = \frac{N}{N_A}$, $n = \frac{m}{M_A}$, $N_A = 6.022 \times 10^{23}$/mol, 1 u $= \frac{1 \text{ gram}}{N_A} = 1.6605 \times 10^{-27}$ kg.

Temperature scales:

T(°C) = $\frac{5}{9}$[T(°F)-32], T(°F)=$\frac{9}{5}$ T(°C)+32, T(K)=T(°C)+273.15

Thermal Expansion:

$\Delta L = \alpha L_0 \Delta T$, $\Delta V = \beta V_0 \Delta T$.

Ideal Gas Law:

$PV = nRT$, or $PV = Nk_BT$, $R = 8.314$ J/mol·K, $k_B = \frac{R}{N_A} = 1.38 \times 10^{-23}$ J/K.

Kinetic Theory:

$\bar{\text{KE}} = \frac{1}{2}mv_{\text{rms}}^2 = \frac{3}{2}k_BT$, $v_{\text{rms}} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3RT}{M_A}}$, $m = M_A/N_A$.

Pressure Units:

1 Pa = 1 N/m^2, 1 bar = 10^5 Pa = 100 kPa, 1 mm-Hg = 133.3 Pa.

1.00 atm = 101.3 kPa = 1.013 bar = 760 torr = 760 mm-Hg =14.7 lb/in^2.

(over)

Some Elemental Properties

symbol	element	atomic number	mass number
H	hydrogen	1	1.00794
He	helium	2	4.00260
C	carbon	6	12.0107
N	nitrogen	7	14.0067
O	oxygen	8	15.9994
Ne	neon	10	20.180
Ar	argon	18	39.948
Fe	iron	26	55.845
Ni	nickel	28	58.693
Cu	copper	29	63.546
Au	gold	79	196.97
U	uranium	92	238.03

Mass numbers are atomic masses in units of "u" where 1 u = 1.6605×10^{-27} kg,
or, molar masses for the element (1 mole = 6.02×10^{23} atoms), measured in grams.
($N_A \times 1$ u = 1 gram)

Energy, Force, Power

Work & Kinetic & Potential Energies:

$W = Fd\cos\theta$, $\quad \mathrm{KE} = \frac{1}{2}mv^2$, $\quad \mathrm{PE}_{\mathrm{gravity}} = mgy$, $\quad F_{\mathrm{gravity}} = -mg$. $\quad \mathrm{PE}_{\mathrm{spring}} = \frac{1}{2}kx^2$, $\quad F_{\mathrm{spring}} = -kx$.

Conservation or Transformation of Energy:

"work-KE theorem" $\Delta\mathrm{KE} = W_{\mathrm{net}}$, $\quad$ **or use conservation law**: $\quad \Delta\mathrm{KE} + \Delta\mathrm{PE} = W_{\mathrm{NC}}$. $\quad E_2 = E_1 + W_{\mathrm{NC}}$.

Power:

$P_{\mathrm{ave}} = \frac{W}{t}$, $\quad$ or use $P_{\mathrm{ave}} = \frac{\mathrm{energy}}{\mathrm{time}}$.

Trig summary

$\sin\theta = \frac{(\mathrm{opp})}{(\mathrm{hyp})}$, $\quad \cos\theta = \frac{(\mathrm{adj})}{(\mathrm{hyp})}$, $\quad \tan\theta = \frac{(\mathrm{opp})}{(\mathrm{adj})}$, $\quad (\mathrm{opp})^2 + (\mathrm{adj})^2 = (\mathrm{hyp})^2$.

$\sin\theta = \sin(180^\circ - \theta)$, $\quad \cos\theta = \cos(-\theta)$, $\quad \tan\theta = \tan(180^\circ + \theta)$, $\quad \sin^2\theta + \cos^2\theta = 1$.