Chapter 19

What is the frist law of Thermodynamics?

To sum it up the frist law of Thermodynamic is energy transfering into/out of the system as work/heat

$$\Delta E_{\text{th}} = W + Q \tag{1}$$

where:

- ΔE_{th} = Change in thermal energy (J)
- W = Work done on the system (J)
- Q = Heat added to the system (J)

19.2 Work in Ideal-Gas Processes

$$W = -\int_{V_i}^{V_f} P\,dV \tag{2}$$

Isochoric Process

$$W = 0 \tag{3}$$

Isochoric process is a process in which the volume of the system is constant and the work done is zero.

Isobaric Process

$$W = -P\Delta V \tag{4}$$

Isobaric process is a process in which the pressure of the system is constant and the work done is $-P\Delta V$. where:

- W = Work done on the system (J)
- P = Pressure of the gas (Pa)
- ΔV = Change in volume of the gas (m^3)

isothermal Process

$$W = -nRT\ln\left(\frac{V_f}{V_i}\right) = -p_iV_i\ln\left(\frac{V_f}{V_i}\right) = -p_fV_f\ln\left(\frac{V_f}{V_i}\right) \tag{5}$$

where:

- n = Number of moles of the gas (mol)
- R = Ideal gas constant (8.31 J/mol · K)
- T = Temperature of the gas (K)
- V_i = Initial volume of the gas (m^3)
- V_f = Final volume of the gas (m^3)
- p_i = Initial pressure of the gas (Pa)
- p_f = Final pressure of the gas (Pa)

$$\Delta E_{\text{th}} = 0 \tag{6}$$

Adiabatic Process

Def: An adiabatic process is a process in which no heat is added to or removed from the system.

Heat

to be continue

19.3.2 Units of Heat

$$1\ \text{cal} = 4.186\ \text{J} \tag{7}$$

19.5.1 Specific Heat and molar specifc heats of solids and liquids

Substance	c **(J/kg K)**	C **(J/mol K)**
Solids		
Aluminum	900	24.3
Copper	385	24.4
Iron	449	25.1
Gold	129	25.4
Lead	128	26.5
Ice	2090	37.6
Liquids		
Ethyl alcohol	2400	110.4
Mercury	140	28.1
Water	4190	75.4

$$Q = mc\Delta T \tag{8}$$

where:

- Q = Heat added to the system (J)
- m = Mass of the substance (kg)
- c = Specific heat of the substance (J/kg K)
- ΔT = Change in temperature of the substance (K)

$$Q = nC\Delta T \tag{9}$$

where:

- Q = Heat added to the system (J)
- n = Number of moles of the substance (mol)
- C = Molar specific heat of the substance (J/mol K)
- ΔT = Change in temperature of the substance (K)

19.5.2 Phase Changes and Heat of Transformation

Phase changes are changes in the state of a substance, such as from solid to liquid or from liquid to gas.

$$Q = mL \quad \text{(phase change)} \tag{10}$$

$$Q = \begin{cases} \pm ML_f & \text{melt/freeze} \\ \pm ML_v & \text{boil/condense} \end{cases} \tag{11}$$

Table 1: Melting/boiling temperatures and heats of transformation

Substance	T_m (°C)	L_f (J/kg)	T_b (°C)	L_v (J/kg)
Nitrogen (N_2)	-210	0.26×10^5	-196	1.99×10^5
Ethyl alcohol	-114	1.09×10^5	78	8.79×10^5
Mercury	-39	0.11×10^5	357	2.96×10^5
Water	0	3.33×10^5	100	22.6×10^5
Lead	328	0.25×10^5	1750	8.58×10^5

19.6 Caloriemtery

calorimetery:

19.7 The Specific Heats of Gases

$$Q = nC_V\Delta T \quad \text{(temperature change at constand Volume)} \tag{12}$$

$$Q = nC_P\Delta T \quad \text{(temperature change at constant Pressure)} \tag{13}$$

where:

- Q = Heat added to the system (J)
- n = Number of moles of the gas (mol)
- C_V = Molar specific heat of the gas at constant volume (J/mol K)

- C_P = Molar specific heat of the gas at constant pressure (J/mol K)
- ΔT = Change in temperature of the gas (K)

Gas	C_P	C_V	$C_P - C_V$
Monatomic Gases			
He	20.8	12.5	8.3
Ne	20.8	12.5	8.3
Ar	20.8	12.5	8.3
Diatomic Gases			
H_2	28.7	20.4	8.3
N_2	29.1	20.8	8.3
O_2	29.2	20.9	8.3

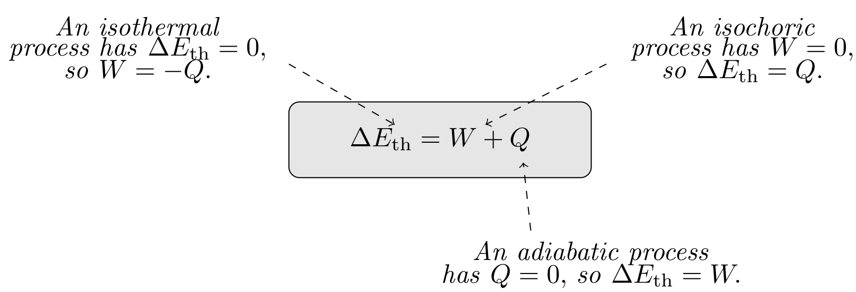
Table 2: Molar specific heats of gases (J/mol K) at $T = 0°C$

$$\boxed{C_P - C_V = R \quad \text{or} \quad C_P = C_V + R \qquad (14)}$$

$$\Delta E_{\text{th}} = nC_V\Delta T \quad \text{(any ideal-gas process)} \qquad (15)$$

19.7.3 Adiabatic Processes

FIGURE 19.19 The relationship of three important processes to the first law of thermodynamics.



$$W = nC_V\Delta T \quad \text{(adiabatic process)} \tag{16}$$

0.1 Specific Hear Ratio γ

$$\gamma = \frac{C_P}{C_V} \tag{17}$$

An adiabatic process is one in which

$$pV^\gamma = \text{constant} \quad \textit{or} \quad p_iV_i^\gamma = p_fV_f^\gamma \tag{18}$$

Addtional Notes

when you want to find M (molar mass) you can use the following formula:

$$M = \frac{m}{n} \tag{19}$$

Find the number from the periodic table and divide it by the number of moles of the gas to find the molar mass of the gas.

where:

- M = Molar mass (kg/mol)
- m = Mass of the gas (kg) usally given in grams
- n = Number of moles of the gas (mol)

Finding the number of moles of the gas

$$n = \frac{\text{mass of the gas}}{\text{molar mass of the gas}} \tag{20}$$

Celsius scale to Kelvin scale conversion

$$T_K = T_C + 273 \tag{21}$$

Find mass with given Volume

Usally these probelms give you Volume and wonder how do we get mass.

We have to take a look at the period table and find density.

After that we can now use the following formula to find mass:

$$m = \rho V \tag{22}$$