Summary of chapter 19

Prepared by Dr. A. Mekki

1. The number of moles, n, in a substance is

$$n = \frac{N}{N_A} = \frac{m}{M}$$

where N is the number of molecules, m is the mass of the substance, M is the molar mass of the substance and N_A is Avogadro's number.

N_A = 6.02 x 10^{-23} molecules/mole (is the number of molecules in ONE mole of the substance).

2. All real gases behave as ideal gases at low pressure. The relationship between the temperature T, the volume V, and the pressure P in this case is

$$PV = nRT$$ The ideal gas law

R = 8.31 J/mole K, is the gas constant and n is the number of moles of the gas.

We have three situations

(i) Temperature constant (**isothermal** process) $\frac{P_i}{P_f} = \frac{V_f}{V_i}$

(ii) Volume constant (**isochoric** process) $\frac{P_i}{P_f} = \frac{T_i}{T_f}$

(iii) Pressure constant (**isobaric** process) $\frac{V_i}{T_i} = \frac{V_f}{T_f}$

In the above equations *T* in Kelvin.

3. For an **isothermal process**, the **work** done ***on*** or ***by*** the gas is

$$W = nRT \ln(\frac{V_f}{V_i})$$ *T* in Kelvin

For an **isobaric process**, the **work** done ***on*** or ***by*** the gas is

$$W = P\,\Delta V$$

If $V_f > V_i$ (expansion), then $W > 0$, the gas do work

If $V_f < V_i$ (compression), then $W < 0$, external work is done on the gas.

4. The pressure of N molecules of an ideal gas is given by;

$$P = \frac{n}{3}\frac{M\, v_{rms}^{\;2}}{V}$$

where v_{rms} is the root-mean-square speed of the gas molecules = $\sqrt{v^2}$

This speed is related to the molar mass and the temperature of the gas as follows:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$ *T* in Kelvin

5. The average translational kinetic energy of an ideal gas containing N molecules is related to the temperature of the gas by

$$\overline{K} = \frac{3}{2} N\, k\, T$$ *T* in Kelvin

$k = 1.38 \times 10^{-23}$ J/K is Boltzman constant.

6. The internal energy of a monoatomic ideal gas is

$$E_{\text{int}} = \frac{3}{2} N\, k\, T = \frac{3}{2} n R T$$ *T* in Kelvin

Therefore the change in internal energy is

$$\Delta E_{\text{int}} = \frac{3}{2} n R \Delta T$$

So: ***for an isothermal process the change in internal energy of the gas is ZERO because DT = 0.***

7. ***The heat absorbed or expelled by a gas depends on the process.***

(i) for a constant volume process (isochoric) the heat is given by

$$Q = nC_v \Delta T$$

(ii) for a constant pressure process (isobaric) the heat is given by

$$Q = nC_p \Delta T$$

8. For an adiabatic process (Q = 0), the macroscopic thermodynamic variables (P, V, T) are related by

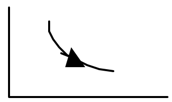
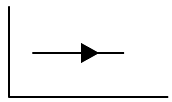
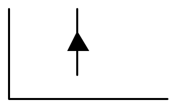
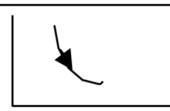
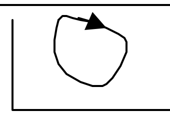
$$P_i V_i^g = P_f V_f^g$$

$$T_i V_i^{g-1} = T_f V_f^{g-1}$$

T in Kelvin

where $g = \frac{C_p}{C_v}$ is the ***specific heat ratio*** (constant).

Summary

Process	P-V diagram	W	Q	ΔE_{int}
Isothermal		$nRT\ \ln(\frac{V_f}{V_i})$	$nRT\ \ln(\frac{V_f}{V_i})$	**0**
Isobaric		$P\,\Delta V$	$n\,C_p\,\Delta T$	$n\,C_v\,\Delta T$
Isochoric		**0**	$n\,C_v\,\Delta T$	$n\,C_v\,\Delta T$
Adiabatic		$-\,n\,C_v\,\Delta T$	**0**	$n\,C_v\,\Delta T$
Cyclic		**Area enclosed**	**Area enclosed**	**0**

Note: $\Delta E_{\mathrm{int}} = nC_v\Delta T$ This is **ALWAYS** true, for all processes!

Gas	C_v	C_p	$\gamma = C_p/C_v$
Monoatomic	***3/2 R***	***5/2 R***	***1.67***
Diatomic	***5/2 R***	***7/2 R***	***1.4***

$C_p = C_v + R$