جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلـــوم
قــســـــــم الادلة الجنائية

Lecture (5)

Heat capacity and First Law of Thermodynamic

Second stage

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Heat capacities of Ideal gas

Known as the amount of thermal energy needed to raise the temperature of a particular body have mass (m) one degree Celsius. Heat Capacity Unit (J / Cº) .

Specific Heat

It is defined as the thermal capacity of each gram of material , that represented amount of thermal energy needed to raise the temperature one gram of material one degree Celsius. Specific heat unit (J / g Cº).

Molar Heat Capacity

Is the amount of energy needed to raise the temperature of one mole of the material one degree Celsius, and its unit (J / mole Cº) . For water: Molar thermal capacity is the thermal capacity of 18 g of Water is equal to 18 x 4.18 = 75.3 J / mole.

Heat capacity at constant volume (Cv) and at constant pressure (Cp).

Cv heat Capacity :is heat obtained at a constant volume is used only to raise the kinetic energy of molecules, while the heat obtained at the constant pressure of Cp is used for a particular work due to the expansion and contraction of the gas, in addition to raise the kinetic energy of molecules.

Mathematically It can be expressed as follows:

$Cv = dE / dT$

$Cp = dH / Dt$

For an ideal single-atomic gas, kinetic energy transitional is ((3/2) R T)

$Cv = d (3/2 RT) / dT$

$= 3/2 R\, d T / d T$

$= 3/2 R$

$Cv = 3/2 R$ -------- (1)

$Cp = dH / dT$

$= d(E + PV) / dT$

$= dE / dT + d(PV) / dT$

When the pressure is constant :

$Cp = dE / dT + P\,dV / dT$

For one mole of ideal gas where:

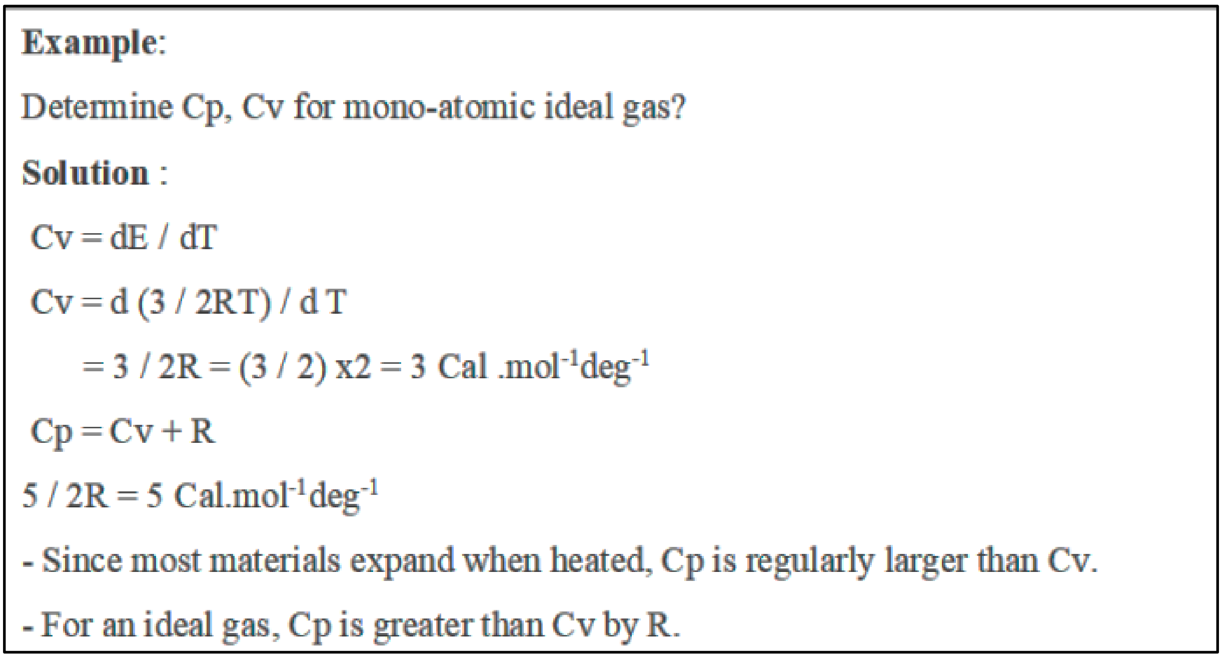
$PV = RT$

When the pressure is constant: $P\,dV = R\,dT$

$Cp = dE / dT + R\,dT / dT$

$= Cv + R$ ---------- (2)

$$\mathbf{Cp = Cv + R}$$



Example:

Determine Cp, Cv for mono-atomic ideal gas?

Solution :

$Cv = dE / dT$

$Cv = d(3/2RT) / dT$

$= 3/2R = (3/2) \times 2 = 3$ Cal $.mol^{-1}deg^{-1}$

$Cp = Cv + R$

$5/2R = 5$ Cal$.mol^{-1}deg^{-1}$

- Since most materials expand when heated, Cp is regularly larger than Cv.

- For an ideal gas, Cp is greater than Cv by R.

The First law in thermodynamics

The law that deals with energy is the same energy conservation law There are a number of different texts that all express about very important result which is the outcome of countless experiments related by the energy changes accompanying to the situation changes.

*** Helmholtz text**

"When a quantity of a particular form of energy disappears, it must produce an equivalent amount in another form".

* Clausius text

"The total amount of system energy and its surroundings remains constant, although it can be transformed from one form to another "

*** Energy conservation law text**

"Energy is not destroyed and is not created from scratch, but it can be from one image to another equivalent to it"

The first law can be formulated in thermodynamics as follows:

* The total energy of the insulated system remains constant and the energy can be transformed from one image to another.

* The total energy of an insulated system is always constant, ie the change in the internal energy of the system = the amount of heat absorbed Of the system, less the workload of the system. $\Delta E = E2 - E1 = q - w$

This is the mathematical expression of the first law in thermodynamics as it is the formula of energy conservation law It is correct for all changes in the situation that include heat and work as the signals should be taken care when dealing with this relationship.

If there is a tiny change of system, the differential of the first law is: $dE = \partial q - \partial w$

Working at the expansion and contraction of gas:

When the gas expansion is balanced or reflective that includes the external pressure is less than the internal pressure in a very small value throughout the expansion process , and in this case **P = Pext.**

$$w = -\int_{v1}^{v2} P_{ext}\, dV$$

By integrating the previous equation with considered the gas being ideal and consisting of a number of moles, then a law can be used ideal gas law

$$PV = nRT$$

If the process is isothermal

$$w = -\int_{v1}^{v2} n\,RT/V\,.\,dV$$

$$w = -n\,RT \int_{v1}^{v2} d\ln V$$

$$W = -n\,RT\ln V_2 / V_1$$

from Boyle Law: $P1V1 = P2V2$

Therefore: $W = -n\,RT\ln P1 / P2$

Example :

Calculate the maximum amount of work that can be obtained from the reflective isothermal expansion 2 mole of the nitrogen gas and the volume change from 10 liters to 20 liters at 25 ° C ?

Solution:

$T_k = T_C + 273$

$T_k = 25 + 273 = 298$

Therefore:

$w = -\,n\,RT\,\ln V_2 / V_1$

$= -\,(2)\,(2)\,(298)\,\ln 20 / 10$

$= -\,822$ cal.

Example :

One of the acids was added to a metal , then reaction happened between them , resulting to formation a quantity of hydrogen gas (30 liters).

Calculate the work performed by the gas to overcome the atmospheric pressure which have value (1 atom) (assume constant temperature) ?

Solution:

Since atmospheric pressure is constant, gas expansion will be against this constant pressure, so the wok Performed calculated from

$W = -P (V_2-V_1)$

Where $V_1=0$

because the gas did not form the furthest reaction occurred .

$V_2= 30$ L

$W = -1 (30-0) = -30$ L. atom

$= - 30 \times 101.39J = - 3041.7J$

Special cases of equation ΔE= q - PΔV

A) At a fixed volume – (Isochoric Process)

At the fixed volume, ($\Delta V= 0$) and since the process occurs without volume change, therefore the work ($w = 0$) . Thus, the equation

$$\Delta E = q - P\Delta V$$

deviate to

$$\Delta E = q_v$$

Where: qv heat reaction when volume fixed. This means that the change in internal energy ΔE is equal to the amount of heat absorbed (q).

B) At a fixed temperature – (Isothermal Process)

In which the system temperature is constant as the system changes from one state to another, ie ($\Delta T = 0$) , therefore the change in the internal energy is equal to zero ($\Delta E = 0$) and the equation is eliminated

$$\Delta E = q - P\Delta V$$

When the temperature is set to

$$q = - w = P\Delta V$$

This means that the work done is equal to the amount of heat.

(C) At Insulated system - (Adiabatic process)

In this case, no heat exchange occurs between the system and the surrounding , so that it is not added to the system and no energy is taken from it , ($q = 0$) therefore

$$\Delta E = q - P\Delta V$$

is equal to

$$\Delta E = w = - P\Delta V$$

In this case, the change in internal energy equals the work done.

Questions

1-In an isochoric process, what is the relationship between heat added to the system (q) and the change in internal energy (ΔE)? a) $\Delta E = q + P\Delta V$ b) $\Delta E = q - P\Delta V$ c) $\Delta E = q$ d) $\Delta E = 0$ e) $\Delta E = P\Delta V$

2-During an isothermal process, what happens to the internal energy (ΔE) of an ideal gas?

a) $\Delta E = 0$ b) $\Delta E = q$ c) $\Delta E = -q$ d) $\Delta E = P\Delta V$ e) $\Delta E = q – P\Delta V$

3-In an adiabatic process, what is the heat exchange (q) between the system and its surroundings?

a) $q = 0$ b) $q = P\Delta V$ c) $q = \Delta E$ d) $q = -P\Delta V$ e) $q = \Delta E + P\Delta V$

4-In an isothermal process, the heat added to the system is used to: a) Increase internal energy. b) Do external work. c) Increase temperature. d) Decrease internal energy. e) Decrease temperature.

5-Which of the following processes involves no heat exchange between the system and its surroundings?

a) Isobaric b) Isochoric c) Adiabatic d) Isothermal e) Isentropic

6-In an adiabatic process, the change in internal energy (ΔE) is equal to: a) q b) $-P\Delta V$ c) $P\Delta V$ d) $q – P\Delta V$ e) w

7-During an isothermal expansion of an ideal gas, the temperature: a) Increases. b) Decreases. c) Remains constant. d) Fluctuates. e) Cannot be determined.