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وزارة الــتعليم الــعالــي والــبحث الــعلمي
جـــــامعـــــــــة الـــمثنــــــــى
كليــــة الـعلـــــــــــــــــــوم
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Physical Chemistry

المحـــاضـرة 12

المرحلـة الثانـــية

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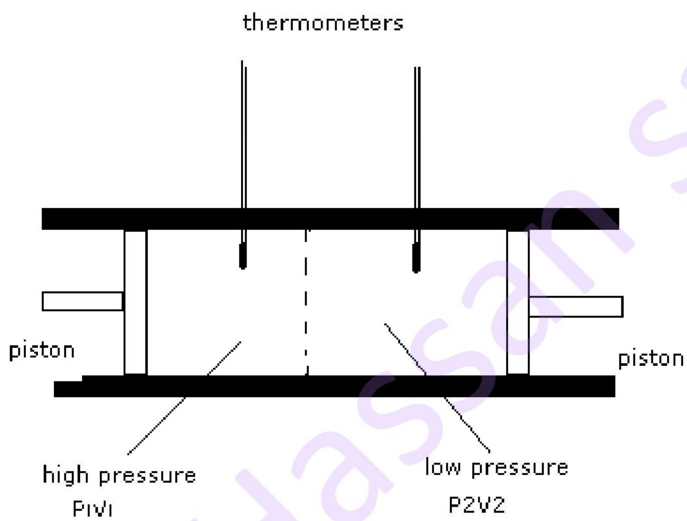
Joule-Thomson Effect

The Joule-Thomson (JT) effect is a thermodynamic process that occurs when a fluid expands from high pressure to low pressure at constant enthalpy (an isenthalpic process). Such a process can be approximated in the real world by expanding a fluid from high pressure to low pressure across a valve. Under the right conditions, this can cause cooling of the fluid.



This effect was first observed in an experiment conducted by James Joule and Thomson in 1852 in which they flowed high pressure air through a small porous plug causing the pressure to drop. Joule and Thomson noted that the air was cooled by this procedure (which is a good approximation of an isenthalpic process (process done at constant enthalpy)).

$$H_f=H_i$$

H.W) provide that $H_f = H_i$ in The Joule–Thomson experiment

An important property of a given gas is its Joule-Thomson coefficient. These coefficients are important from two standpoints;

(i) Intermolecular interaction, and (ii) liquefaction of gases.

The Joule-Thomson coefficient for gas, μ is defined by the following equation:

$$\mu_T = \left(\frac{\partial T}{\partial P}\right)_H$$

For all gases (except helium and hydrogen) at 298 K and moderate pressures $\mu_T > 0$. At room temperature and ambient pressure, μ is 0.002 K Pa^{-1} for nitrogen and 0.025 K Pa^{-1} for 2,2-dimethylpropane.

EX) A vapor at 22 atm and 5°C was allowed to expand adiabatically to a final pressure of 1.00 atm; the temperature fell by 10 K. Calculate the Joule–Thomson coefficient, μ, at 5°C, assuming it remains constant over this temperature range.

$$\mu_T = \left(\frac{\partial T}{\partial P}\right)_H = \frac{\Delta T}{\Delta P} = \frac{-10K}{(1.00-22)atm} = 0.48K\,.atm^{-1}$$

H.W) when a certain freon used in refrigeration was expanded adiabatically from an initial pressure of 32 atm and 0°C to a final pressure of 1.00 atm, the temperature fell by 22 K. Calculate the Joule–Thomson coefficient, μ_T, at 0°C, assuming it remains constant over this temperature range.

Work in the expansion process aladebetekih reverse

$W = pdv$

$dE = dq - dw$

$\because\ dq = 0$

$\therefore\ dE = -\ w$

$\because\ w = cvdT$

$\therefore\ dE = -\ cvdT$

Can be derive the maximum work Law

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$P_1V_1^{\gamma} = constant$

$\gamma P.\ V^{\gamma-1}dv + V^{\gamma}.dp = 0$

وبالقسمة على $V^{\gamma-1}$

$\gamma pdv + vdp = 0$

$Vdp = -\ \gamma pdv$ نفاضل المعادلة

$PV = RT$

$Pdv + vdp = RdT$

وبالتعويض

$$Pdv - \gamma pdv = RdT$$

$$Pdv (1-\gamma) = RdT$$

$$\because\ w= pdv$$

$$\therefore\ w= (1-\gamma) = RT$$

$$\therefore\ w= RdT$$

$$= \frac{R(T_2 - T_1)}{(1-\gamma)} \qquad T_2 > T_1 = +w\ ,\ T_1 > T_2 = -\ w$$