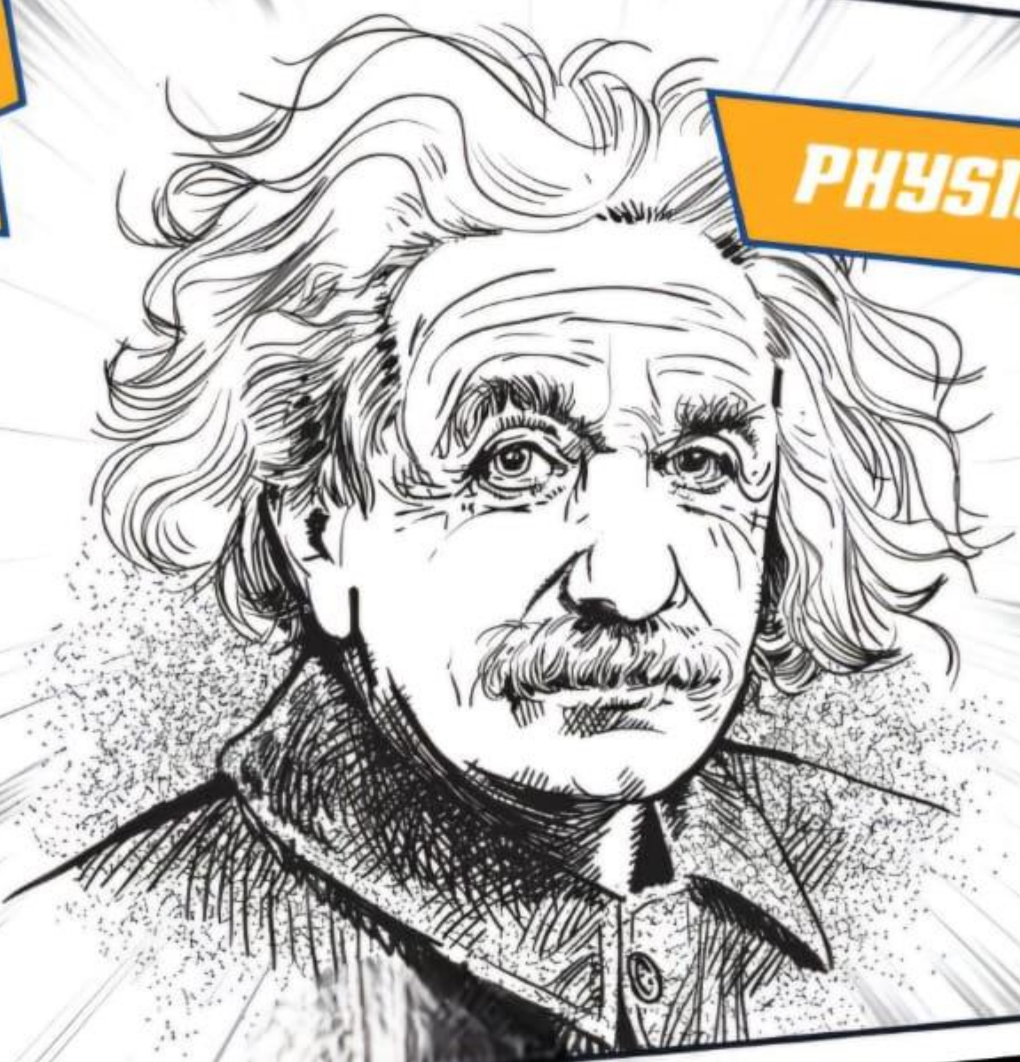
PHYSICS
(Heat)
Thermodynamics

2024

NO. 7

1ST YEAR

PHYSICS DEP.



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HI MARVEL,WE HAVE SUPER HEROS TO

Dynamics of ideal gas at constant pressure

▶ If a gas heated at const pressure, the volume of gas increased from V_1 to V_2

$$w = \int_{V_1}^{V_2} P.dv = P\int_{V_1}^{V_2} dv = P(V_2 - V_1)$$

$$W = PV_2 - PV_1$$

$$PV = mRT$$

$$W = mRT_2 - mRT_1$$

$$\boldsymbol{W = mR(T_2 - T_1)}$$

Change in internal energy at const pressure due to change in temperature from T_1 to T_2

$$dE = mC_v(T_2 - T_1)$$

From first law
$$dH = dE + dw \quad or \quad H = E + w$$

$$H = mc_v(T_2 - T_1) + \frac{w}{J}$$

If the gas is cooling at const pressure: $P = const.$

▶ The change in internal energy

$$E = -mc_v(T_2 - T_1)$$

▶ The work done on the gas.

$$w = -mR(T_2 - T_1)$$

▶ The amount of heat expelled from gas.

$$H = -mc_p(T_2 - T_1)$$

Example

contain gas occupies volume of $0.3\ m^2$ at pressure $2\ kg/cm^2$ and temperature of 77℃ is heated so that the size remains constant, the pressure reaches to $7\ kg/cm^2$ find

1) Final degree of the tractor

2) Gas block

3) Change in internal energy

Assuming that $C_v = 0.017\ cal/\frac{g}{c^2}$, $R = 29.3\ kg.m/kg/°k$

Solution

$$V_1 = 0.3\ m^3\ ,\ \ P_1 = 2\frac{kg}{cm^2} = 2 \times 10^4\ kg/m^2$$

$$T_1 = 77℃ = 77 + 273 = 350°k$$

$$P_2 = 7\frac{kg}{cm^2} = 7 \times 10^4\ kg/m^2$$

1) $P \propto T$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right) = 350 \ \times \frac{7 \times 10^4}{2 \times 10^4} = 1225\ K$$

2) $PV = mRT$

$$m = \frac{PV}{RT} = \frac{2 \times 10^4 \times 0.3}{29.3 \times 350} = 0.585\ kg$$

3) Change in internal energy.

$$dE = mC_v(T_2 - T_1)$$

$$dE = 0.585 \times 0.17(1225 - 350) = 102.13\ Kcal$$

Example

the amount of gas of volume $0.14\ m^3$ and pressure of $1.5\ kg/cm^2$ unitill he become so under const pressure find

1) T_F
2) $workdone$
3) dE
4) amount of heated expelled

$R = 29.3\ kg.m/kg/°k$, $C_v = 0.17\ Cal/gm/℃$, $C_p = 0.24\ Cal/gm/℃$

Solution

$$V_1 = 0.14\ m^3\ ,\ \ P = 15\frac{kg}{cm^2} = 1.5\ \times 10^4\ kg/m^2$$

$$T_1 = 100 + 273 = 373\ K$$

1) $$\frac{T_1}{T_2} = \frac{V_!}{V_2}$$

$$T_2 = T_1\left(\frac{V_2}{V_1}\right) = 373 \times \frac{0.112}{0.14} = 293.4\ K$$

2) $Work = P(V_2 - V_1) = 1.5 \times 10^4(0.112 - 0.14) = -420\ kg.m$

3) $PV = mRT$

$$m = \frac{PV_1}{RT_1} = \frac{1.5 \times 10^4 \times 0.14}{29.3 \times 373} = 0.19\ kg$$

$$E = mC_v(T_2 - T_1) = 0.19 \times 0.17(293.4 - 373) = -2.41\ Kcal$$

4) $H = mC_p(T_2 - T_1) = 0.19 \times 0.24\ (293.4 - 373) = -3.4\ K\ cal$

Second law and entropy

Second law of thermodynamics

- Heat transfer from hottest body to body least hot until they reach to thermal equilibrium

"الحرارة تنتقل دائمًا من الجسم الساخن إلى الجسم البارد بشكل طبيعي الى ان تصل للاتزان الحرارى".

❶ Klazeos formula:

- It is impossible to make heat transfer from the body at low temperature to body at higher temperature without making external work

"لا يمكن أن تعود الحرارة من البارد إلى الساخن إلا إذا قمنا ببذل شغل (طاقة)".

❷ Kelvin – Planck formula:

- It is not possible to get continuous work from body temperature fell below ambient temperature

لا يمكنك الحصول على عمل مستمر من جسم حرارته أقل من حرارة البيئة المحيطة.

الشرح:

(Work) يتم إنتاجه عادة عندما يكون هناك فرق في درجة الحرارة.

على سبيل المثال: في محركات الحرارة، مثل محركات السيارات، يتم تحويل الفرق في درجة الحرارة بين الوقود المحترق (درجة حرارة عالية) والبيئة الخارجية (درجة حرارة منخفضة) إلى عمل ميكانيكي.

Entropy (S)

- Measure the degree of random (irregular) of particle in system.

Third law of thermodynamics

"As the temperature of a system approaches absolute zero (0 Kelvin or -273.15°C), the entropy of a perfect crystalline substance approaches zero."

" عندما تقترب درجة حرارة نظام ما من الصفر المطلق (0 كلفن أو -273.15 درجة مئوية)، فإن الإنتروبيا (الفوضى) لمادة بلورية مثالية تقترب من الصفر."

Relation between entropy and amount of heat

$$dH = Tds$$

Where:

dH → change in heat

T → Absolute temperature

ds → change in entropy

Entropy of ideal gas

❶ Entropy as function in (T,V)

According to first law

$$dH = dE + dw$$

$$Tds = dE + dw$$

$$dE = C_V dT \quad , \quad dw = P.dV$$

$$Tds = C_V dT + P.dV$$

$$ds = C_V \frac{dT}{T} + \frac{P.dV}{T}$$

$$PV = nRT \quad , \quad \frac{P}{T} = \frac{R}{V} \quad from\; n = 1$$

$$ds = C_V \frac{dT}{T} + R\frac{dV}{V}$$

by integration

$$S = C_V \ln T + R \ln V + const$$

❷ Entropy as function (T, P)

$$C_P - C_V = R \quad , \quad C_V = C_P - R$$

$$ds = (C_P - R)\,\frac{dT}{T} + R\,\frac{dV}{V}$$

$$ds = C_P\frac{dT}{T} - R\left(\frac{dT}{T} - \frac{dV}{V}\right)$$

From law of gas $PV = RT$

$$PdV + VdP = RdT \qquad /PV$$

$$\frac{dV}{V} + \frac{dP}{P} = \frac{dT}{T}$$

$$ds = C_P\frac{dT}{T} - R\frac{dP}{P}$$