CONTENTS

1.1 $C_p = C_v + R$ (given)

$3.42 \overset{?}{=} 2.43 + \frac{766}{778}$ for Hydrogen → from table in Appendix

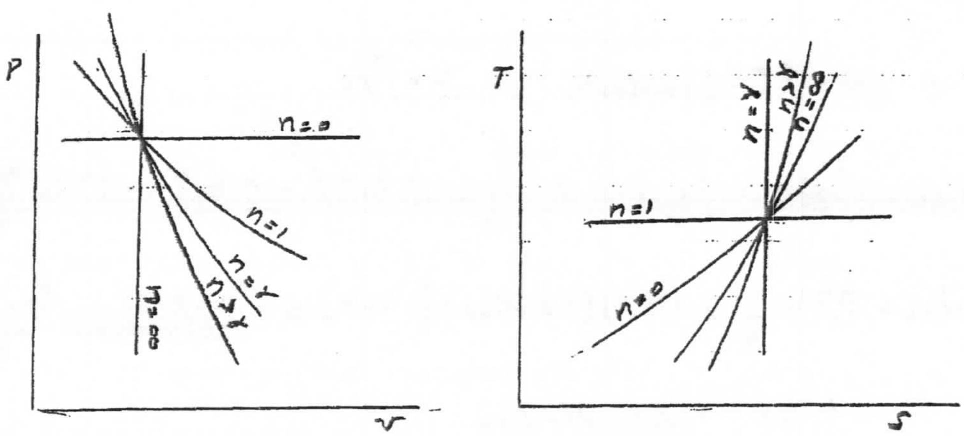
$3.42 \overset{?}{=} 2.43 + .985$

$3.42 \overset{?}{=} 3.415$ pretty close

1.2 perfect gas → $C_p = 0.532$ Btu/lb$_m$-°R, $C_v = 0.403$ Btu/lb$_m$-°R

Undergoes a reversible polytropic process, $n = 1.4$

$\gamma = C_p/C_v = .532/.403 = 1.32$ thus process $n > \gamma$

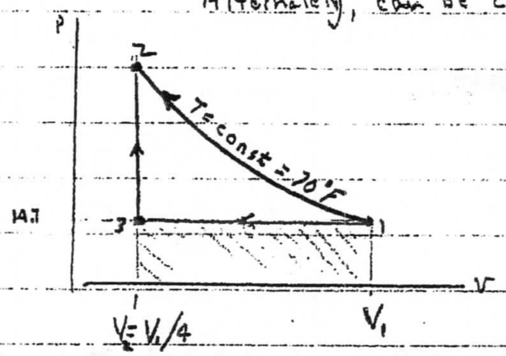


(a) Yes, there will be heat transfer in this process

(b) The process would be nearest a vertical line (vice a horizontal line) in either the P-v diagram or the T-s diagram.

1.3 (a) Nitrogen compressed from 70°F & 14.7psia by rev. T=C to 1/4 original volume.

Alternately, can be comp. to 1/4 original volume by p=C and then to same end point as above.



(a) since no work from 3→2

W_{1-3} is less than W_{1-2}

(b) $\Delta U_{1-2} = C_v \Delta T_{1-2} = 0$ for either process

from 1st Law → $Q = W + \cancel{\Delta U}^{0} = W$

$W = \int p\,dv$ → find W and we also know Q

for 1-2 by T=C → $pv = RT = C$ (constant) → $p = C/v$

$$W_{1-2} = \int_1^2 p\,dv = \int_1^2 \frac{C}{v}\,dv = C\int_1^2 \frac{dv}{v} = C \ln v \Big|_1^2 = C \ln \frac{v_2}{v_1} = RT \ln \frac{v_1/4}{v_1}$$

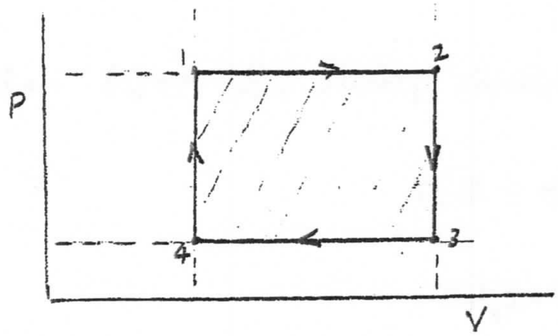
$$W_{1-2} = RT \ln \frac{1}{4} = (55.1)(70+460)(-\ln 4) = \underline{\underline{-40834}}\ \frac{\text{ft-lb}_f}{\text{lb}_m}$$

$\div\ 778 = \underline{\underline{-52.04}}$ Btu/lbm

(-sign indicates work done on the gas)

from above → $Q = W = -\underline{\underline{52.04}}$ Btu/lbm (- sign indicates heat removed from gas)

1.4



$P_1 = P_2 = 1.0$ MPa $\quad M = 10^6$

$P_3 = P_4 = 0.4$ MPa

$V_1 = V_4 = 0.6\ m^3$

$V_2 = V_3 = 1.0\ m^3$

$\oint dE = \oint dH = \oint dS = 0$ cyclic integral of any property $= 0$

$\oint \delta W =$ area enclosed by diagram (if processes are reversible)

$$\oint \delta W = (V_3 - V_4)(P_2 - P_3) = (1.0 - 0.6)(1.0 - 0.4)(10^6)$$

$$= (.4)(.6)10^6 = .24 \times 10^6 \ \frac{N}{\cancel{m^2}} \cdot m^{\cancel{3}} = \underline{.24 \times 10^6 \ N\text{-}m}$$

(is positive because cycle is clockwise → Net WORK DONE BY MEDIUM)

1.5 METHANE → Rev. polytropic process with $n = 1.4$ → Perfect gas.

$$Q = W + \Delta U = \int_1^2 p\,dv + C_v \Delta T$$

from $pv^n = c$, $p = c/v^n$

$$Q_{1-2} = \int_1^2 \frac{c}{v^n}\,dv + C_v(T_2 - T_1) = \frac{c\,(v^{-n+1})}{-n+1}\Big]_1^2 + C_v(T_2 - T_1)\ , \quad \text{but } c = pv^n$$

$$Q_{1-2} = \frac{pv}{1-n}\Big]_1^2 + C_v(T_2 - T_1) = \frac{P_2V_2 - P_1V_1}{(1-n)} + C_v(T_2 - T_1), \quad \text{but } pv = RT$$

$$Q_{1-2} = \frac{R}{1-n}(T_2 - T_1) + C_v(T_2 - T_1) = \left[\frac{R}{1-n} + C_v\right](T_2 - T_1)$$

$$Q_{1-2} = \left[\frac{519}{1-1.4} + 1690\right](T_2 - T_1) = (-1297.5 + 1690)(T_2 - T_1)$$

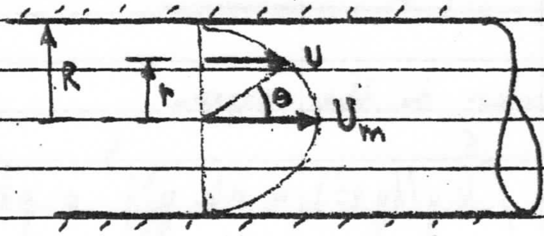
$$\frac{N\text{-}m}{kg\text{-}^\circ K} \qquad \frac{J \text{ or } N\text{-}m}{kg\text{-}^\circ K}$$

$$Q_{1-2} = \underline{\underline{392.5}}\,(T_2 - T_1) \quad \frac{N\text{-}m}{Kg} \text{ or } \frac{\text{JOULES}}{Kg}$$

$C_p - C_v = R$, $C_p = C_v + R$, $\Delta h = C_p \Delta T$

No. Q is <u>not</u> equal to Δh or Δu for same ΔT

2.1



HEMISPHERICAL VELOCITY DISTRIBUTION

$$u = U_m \cos\Theta$$

$$\dot{m} = \int \rho u \, dA = \rho \int U_m \cos\Theta \, (2\pi r \, dr)$$

$$\dot{m} = 2\pi \rho U_m \int_0^R \cos\Theta \, r \, dr$$

$r = R \sin\Theta$
$dr = R\cos\Theta \, d\Theta$

$$\dot{m} = 2\pi \rho U_m \int \cos\Theta \, (R\sin\Theta)(R\cos\Theta \, d\Theta)$$

$$= 2\pi R^2 \rho U_m \int_0^{\pi/2} \sin\Theta \cos^2\Theta \, d\Theta$$

$$= 2\pi R^2 \rho U_m \left[-\frac{1}{3}\cos^3\Theta \right]_0^{\pi/2} = -\frac{2}{3}\pi R^2 \rho U_m (0 - 1)$$

$$\dot{m} = \frac{2}{3}\pi R^2 \rho U_m$$

But $\dot{m} = \rho A V_{av} = \rho \pi R^2 V_{av}$

THUS $\rho \pi R^2 V_{av} = \frac{2}{3}\pi R^2 \rho U_m$

$$V_{av} = \frac{2}{3} U_m$$