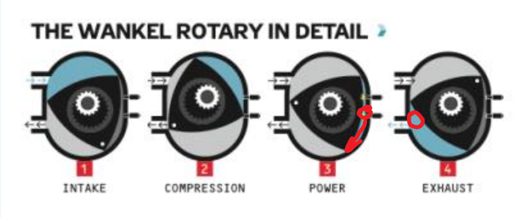
Phy 4C 1/30

Monday, January 30, 2017 9:22 AM



Advantages:
- Very compact (a lot of power in a small, light package)
- Can get to high RPM (because the mass is always moving in same direction, a piston goes back and forth)
- Very smooth (low vibration)
- High power delivery (for every rotation of crank shaft there is combustion, in piston 1 combustion for every two rotations)

Disadvantages:
- Low thermal efficiency / not all fuel combusts (shape of combustion chamber and low compression ratio)
  lower fuel efficiency and higher emissions
- Hard to keep sealed (big temp gradient since combustion is always on one side)
- Burns oil (by design, keeps engine lubed and helps make the seal between chambers)
- Poor mileage / Emissions are bad (due to above items)

Entropy: 2nd Law: $\Delta S_{\text{universe}} \geq 0$

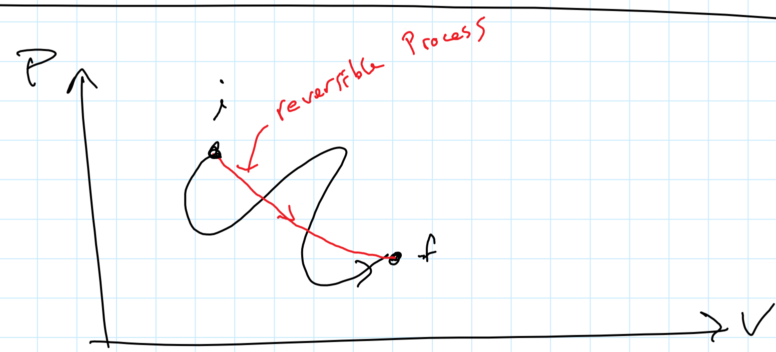
[for a complete cycle of reversible processes
$\Delta S = 0$]

Change in Entropy: $\Delta S = \frac{Q}{T}$ Reversible process at constant temp

$\Delta S > 0$ when heat flows into system

$\Delta S < 0$ when heat flows out of system

if T is Not constant: $\Delta S = \int \frac{dQ}{T}$



Entropy example

1) Constant temp

Ice cube melts in a large room at 20°C

0.1 kg ice at 0°C
becomes 0.1 kg of water at 0°C

find ΔS for the ice

find ΔS for the room

find ΔS for the universe (room + ice)

For ice:

$$\Delta S = \frac{Q}{T}$$

$$Q = m L_f = (0.1)(3.35\times10^5)$$
$$= 3.35\times10^4 \text{ J}$$
$$T = 0°C \rightarrow 273 \text{ K}$$

$$\Delta S_{ice} = + \frac{3.35\times10^4 \text{ J}}{273 \text{ K}} = 122.7 \frac{\text{J}}{\text{K}}$$

$$\Delta S_{room} = \frac{-3.35\times10^4 \text{ J}}{293 \text{ K}} = -114.3 \frac{\text{J}}{\text{K}}$$

$$\Delta S_{universe} = \Delta S_{ice} + \Delta S_{room} = 122.7 - 114.3$$

$$= +8.4 \ \frac{J}{K}$$

2) heat water

heat 1 kg of water from $0°C \rightarrow 100°C$

Find ΔS for the water

$$\Delta S = \int \frac{dQ}{T}$$

$$Q = c\, m\, \Delta T$$

$$dQ = c\, m\, dT$$

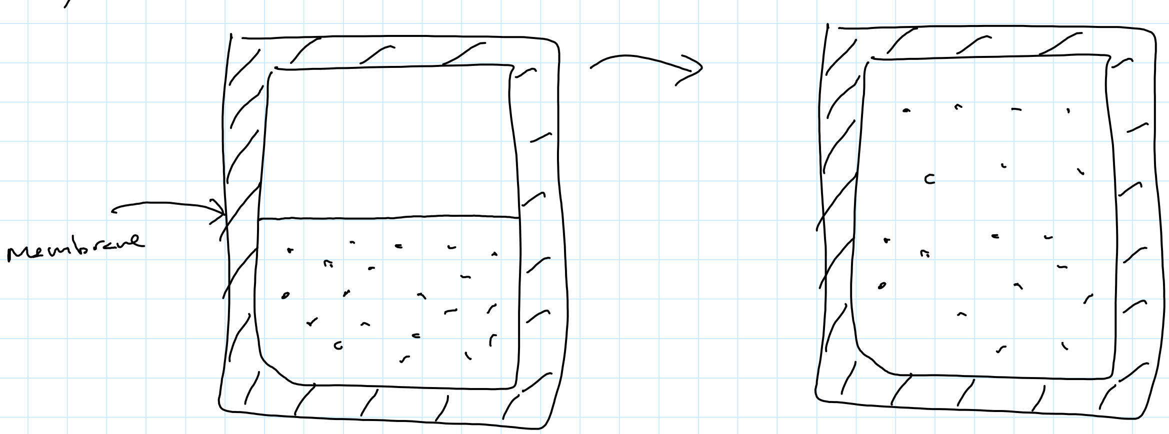
$$= c\, m \int_{T_i}^{T_f} \frac{dT}{T}$$

$$= c\, m \ln\left(\frac{T_f}{T_i}\right)$$

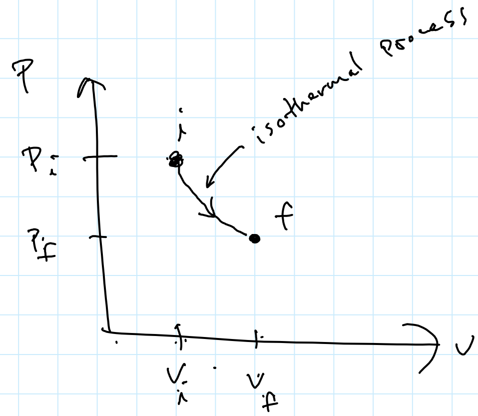
$$= (4186)(1\ kg) \ln\left(\frac{373\ K}{273\ K}\right)$$

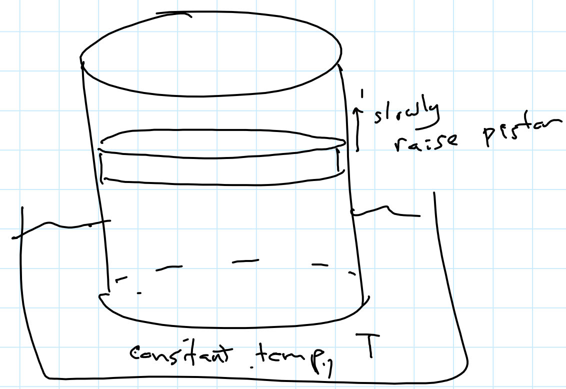
$$= 1.31 \times 10^{3} \ \frac{J}{K}$$

3) irreversible process



$T_i = T_f = T$





$V_f = 2 V_i$

$P_f = \frac{1}{2} P_i$

	For the Free expansion	For our isothermal Process
Q	0	Not zero
W	0	Not zero
ΔE_{int}	0	0

use $\Delta S = \frac{Q}{T}$ constant T

Need to figure out Q:

$\Delta E_{int} = Q + W_{on}$

$Q = -W_{ON}$ or $Q = W_{By}$

$W_{by} = nRT \ln \frac{V_f}{V_i}$ (isothermal Process)

$= nRT \ln 2$

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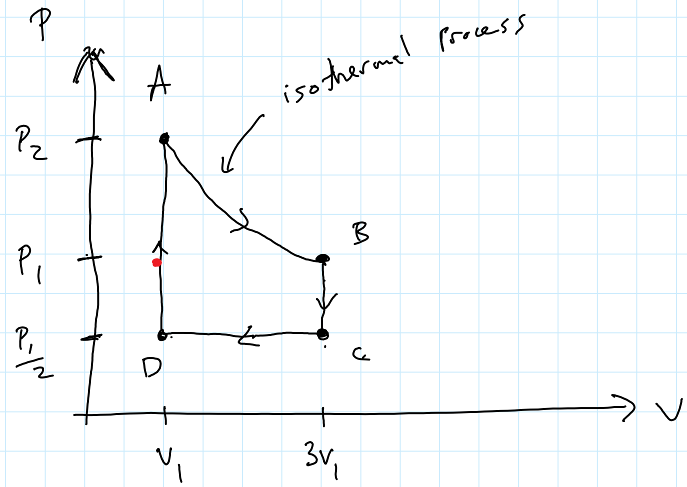
$$\Delta S = \frac{Q}{T} = \frac{nR\cancel{T} \ln 2}{\cancel{T}} = nR \ln 2$$

PV Diagram Problem: Heat Engine

given:
- monatomic ideal gas
- $T_A = 400°C$
- $P_2 = 500\ kPa$
- 2 moles



1) Find the efficiency of this engine.

2) compare to a Carnot engine operating between the max and min temperatures.

	A	B	C	D
P	$5 \times 10^5\ Pa$	$1.67 \times 10^5\ Pa$	$8.34 \times 10^4\ Pa$	$8.34 \times 10^4\ Pa$
V	$0.0224\ m^3$	$0.0671\ m^3$	$0.0671\ m^3$	$0.0224\ m^3$
T	$400°C \to 673\ K$	$673\ K$	$336.5\ K$	$112.2\ K$
E_{int}	$16{,}786\ J$	$16{,}786\ J$	$8393\ J$	$2798\ J$

Green = given info

$PV = nRT \Rightarrow V = \frac{nRT}{P}$

$E_{int} = \frac{3}{2} nRT$ (monatomic ideal gas)

1st) Find all info for A

2nd) $V_A = \frac{1}{3} V_B$

$V_B = V_C$

$V_A = V_D$

$T_A = T_B$

3rd) Find P_B

$P_c = \frac{1}{2} P_B$

$P_c = P_D$

4th) Find T_c and T_D

Path	Q	W_{ON}	ΔE_{int}
$A \to B$	$+12{,}294$ J	$-12{,}294$ J	0
$B \to C$	-8393 J	0	-8393 J
$C \to D$	-9323 J	$W = -P\Delta V$ $+3728$ J	-5595 J
$D \to A$	$+13{,}988$ J	0	$+13{,}988$ J
Net			0

$$\Delta E_{int} = Q + W_{ON}$$

$A \to B$ isotherm: $W_{ON} = nRT \ln \frac{V_i}{V_f}$

5th) Find ΔE_{int}

6th) Find W for each

7th) use $\Delta E = Q + W$ to get Q

$$e = \frac{\text{Net work done by the gas}}{Q_{in}}$$

$$= \frac{(12{,}294\ J - 3728\ J)}{(12{,}294 + 13{,}988)} = 0.33$$

← Positive Q's only

Find e for a Carnot engine between these temp extremes:

$$e = 1 - \frac{T_c}{T_H} = 1 - \frac{112.2}{673} = 0.83$$