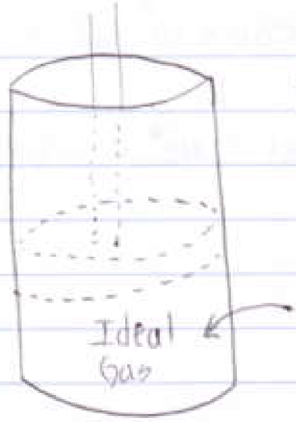
HEAT AND THE FIRST LAW OF

alexDIF

CHAPTER 19



Piston

volume V
Pressure P
temperature T

* <u>Last time:</u>

$$PV = nRT = \frac{2}{3} E_{int}$$

total energy of all molecules in the gas

~ <u>FOCUS 4 CH.19</u>:

Ignore everything except the kinetic energy from random motion of molecules.

also called thermal energy

$$\left\{ \underbrace{E_{int}}_{\text{Internal Energy}} = \frac{3}{2} PV = \frac{3}{2} nRT \right.$$

~ <u>Compare</u>:

$1m^3$ of air at 1atm pressure has $E_{int} = \frac{3}{2} PV \approx 1.5 \times 10^5 J$ energy from random molecular motion	A 1000kg rock held 15m above the ground has $mgh \approx 1.5 \times 10^5 J$ potential energy

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* Example:

Burger = 500 Cal = 500 kcal = 500×10^3 cal = about 2×10^6 J (Huge amount of energy)

1 cal = 4.19 J

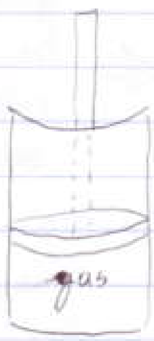
energy needed to raise 1 gram of water by 1 Celsius degree

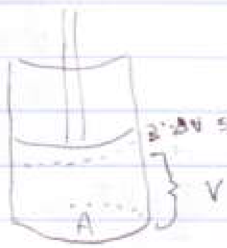
[[CONSERVATION OF ENERGY]]

$W = \int F\,dx$

$dW = F\,dx = \underbrace{\frac{F}{A}}_{P}\,\underbrace{A\,dx}_{dV}$

Work done by piston: $dW = P\,dV$





ΔV small $\Rightarrow \Delta W = P\Delta V$

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* Remember:

$\frac{3}{2}nRT = E_{int} \Rightarrow \frac{3}{2}nR\Delta T = \boxed{\Delta E_{int} = Q - W}$

↑ IDEAL GAS

(heat) a quantity of energy transferred because a temperature difference

Q means heat added to gas

(work done by the gas on the outside world)

R = gas constant

n = # of moles (no leaks)

How to give it

FIRST LAW OF THERMODYNAMICS

Heat added is +
Heat lost is −
Work on system −
Work by system is +

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Heating up stuff:

$$[Q] = [\text{energy}] = [J] = [\text{cal}] \cdot [\text{Btu}]$$

$$\left[\frac{\Delta Q}{\Delta t}\right] = [\text{power}] = [W] = [\text{cal}/s] = \ldots$$

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$$\boxed{Q = mc\Delta T}$$

(c = specific heat)

the more mass the more energy it takes to het it up

specific heat of H_2O is $\frac{1 \text{ cal}}{1 \text{ gram } 1^\circ C}$

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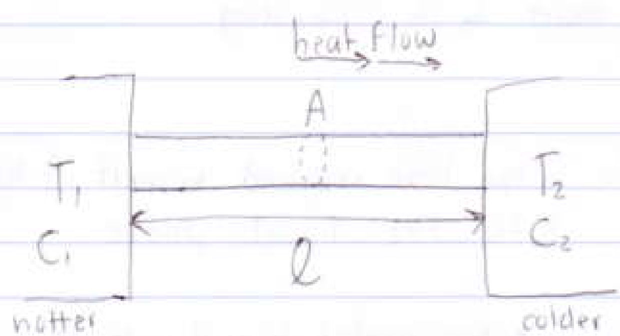
HEAT TRANSFER: CONDUCTION
CONVECTION &
RADIATION

*CONDUCTION:



HEAT CONDUCTION

$T_1 > T_2$

$$\boxed{\frac{\Delta Q}{\Delta t} = kA \frac{T_1 - T_2}{l}}$$

k = constant depends on material

Rate is given by this formula

k = Thermal Conductivity

$$\Delta Q_1 = m_1 c_1 \Delta T_1$$

$$\Delta Q_2 = m_2 c_2 \Delta T_2$$

$$m_1 c_1 \frac{\Delta T_1}{\Delta t} = \frac{\Delta Q_1}{\Delta t} = -\frac{\Delta Q}{\Delta t} = kA\,\frac{T_2 - T_1}{l}$$

$$\frac{\Delta T_1}{\Delta t} = \frac{kA}{m_1 c_1} \cdot \frac{T_2 - T_1}{l}$$

$$\frac{\Delta T_2}{\Delta t} = \frac{kA}{m_2 c_2} \quad \frac{T_1 - T_2}{l}$$

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* RADIATION:

$$\boxed{\frac{\Delta Q}{\Delta t} = \varepsilon \sigma A T^4}$$

T in kelvins

emissivity

stefan-Boltzmann

(* page 517)
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~ Rate of energy being transferred from the object to its surrounding

- The Heat of Fusion = is the heat required to melt 1 kg of a solid into the liquid phase.

$$\frac{\text{energy needed to melt material}}{\text{mass of material}}$$

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• The Heat of Vaporization : $\dfrac{\text{energy needed to evaporate liquid}}{\text{mass of liquid}}$

PRACTICE

EX 1 (Heat of fusion)

1 kg of lead 0.031

$25 = \dfrac{E}{1\text{kg}}$

$25 = E$

$2.5 \times 10^4 J = 25\ kJ$ to melt 1 kg of Pb (~~lea~~ lead)

EX 2

$2.26 \times 10^6 J = 2.26\ MJ$ to evaporate 1 kg of water.

EX 3

$3.33 \times 10^5 J = 333\ kJ$ to melt 1 kg of ice

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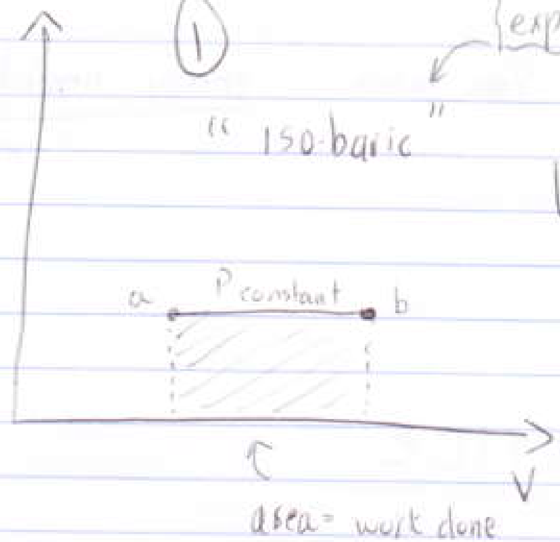
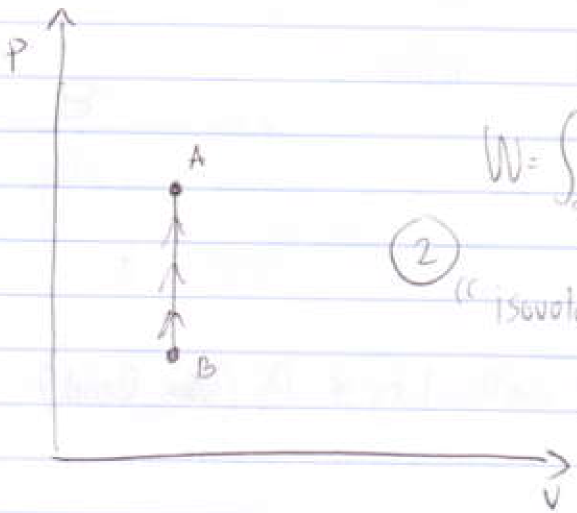
① "iso-baric"

expand slowly



$$W = P\Delta V$$



$$W = \int_a^b P\,dV = 0$$

② "isovolumeric"

* for more pressure you need to heat it up

isobaric

$$\Delta E_{int} = Q - W = Q - P\Delta V$$

$$\boxed{Q = nC_p\Delta T}$$

(* page 511)

#moles

molar specific heat for constant pressure

Pressure Constant

isovolumeric

$$\Delta E_{int} = Q - W = Q$$

$$\boxed{Q = nC_v\Delta T}$$

Volume Constant

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(3) "isothermal"

T = constant

$PV = nRT$

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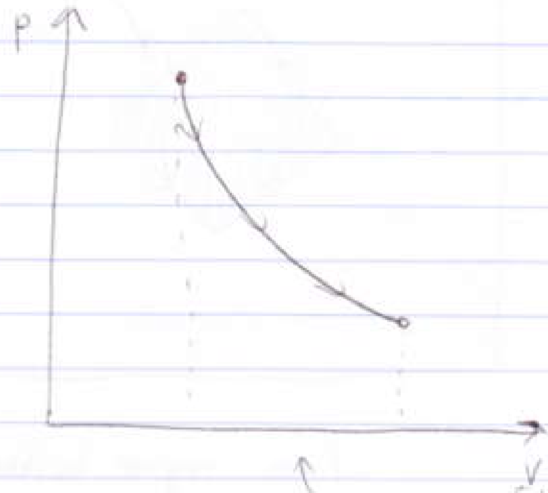


area $= W = \int_a^b P\,dV$

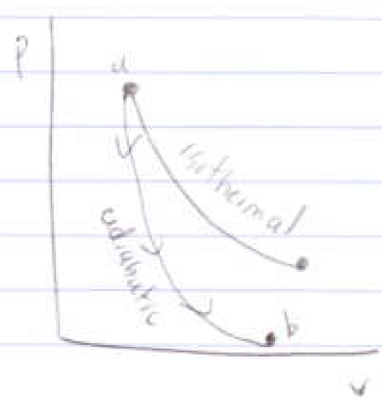
ideal Gas $\Delta E_{int} = \frac{3}{2} nR\Delta T$

$= 0 = \Delta E_{int} = Q - W \Rightarrow Q = W$ ← (*page 510) nice chart look it up

(4) "adiabatic" ← expand quickly.

$Q = 0$

$\Delta E_{int} = -W = -\int_a^b P\,dV$



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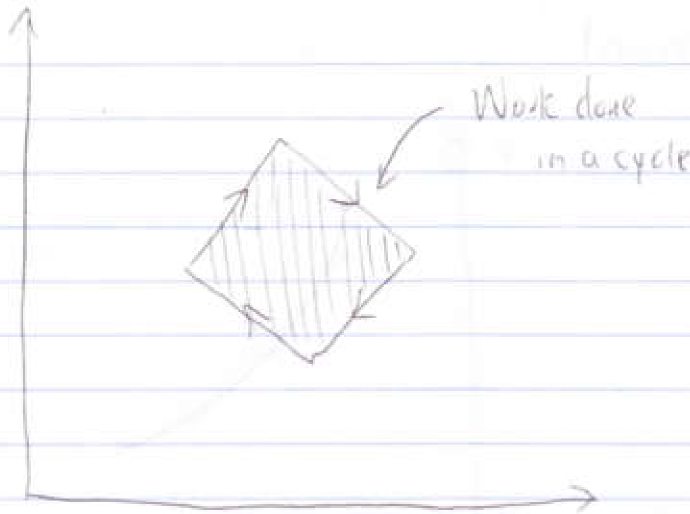
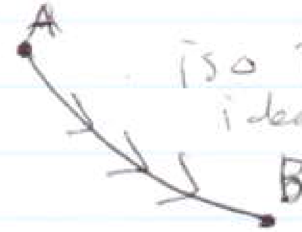


if run engine backwards
it does negative work.

Added by prof:

More formulas:



iso thermal ideal gas $\Rightarrow W = nRT \ln\left(\frac{V_B}{V_A}\right)$

because $\int_A^B P\,dV = \int_A^B nRT \frac{dV}{V}$

Adiabatic ideal gas $\Rightarrow PV^\gamma = \text{constant}$

where $\gamma = \frac{C_p}{C_V}$

$\hookrightarrow$ See Example 19-12 for more!

$C_p - C_V = R$ (= gas constant)

(monoatomic) ideal gas: $C_V = \frac{3}{2} R$