09/03/15

Chapter 19 Lecture

Review

$PV = \frac{2}{3} N E_{kin}$

$E_{kin} = \frac{3}{2} k_B T$ (Kelvin)

Fixed gas law:

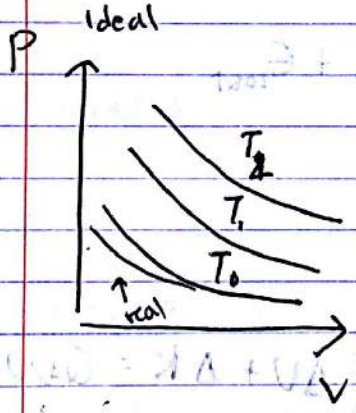
$\left(P + \frac{a}{\left(\frac{V}{n}\right)^2}\right)\left(\frac{V}{n} - b\right) = RT$

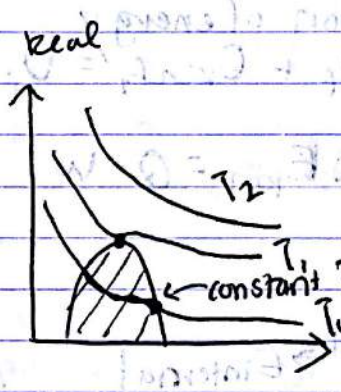
$P_{real} = P - \left(\frac{n}{V}\right)^2 a$

$\downarrow$

$\frac{nRT}{V - nb}$

$P \propto \frac{1}{V}$, $\therefore$ fixed temp = separate curve





Liquid Vapor

Heat $\rightarrow \Delta T$

caloric fluid

$\downarrow$

hot

1798 - Thompson

$\downarrow$

heat is energy

1842 von Mayer

heats mechanical energy

1843 Joule ← good @ marketing

heat $\equiv$ mechanical energy

mechanical work → ΔT

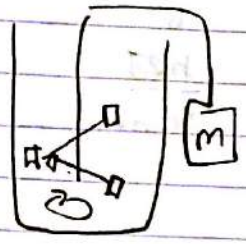
pulley

$W = \frac{1}{2} I \omega^2$

↓

ΔT

heat = Q



$mgh - \Delta E_{kin}$ $\Rightarrow \Delta T$

$E_{missing}$

conservation of energy

$W + U_f + E_{kinf} = U_i + E_{kini} + E_{lost}$

$\Delta U + \Delta E_{kin} = Q - W$

gas

→ $E_{internal}$

$\Delta E_{int} + \Delta U + \Delta K = Q + W$

extended 1st law

for a gas, ΔU and ΔK are negligible

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

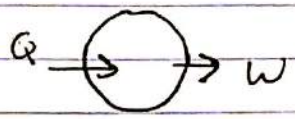
convention for $\Delta E_{int} = Q - W$

$Q \rightarrow$ heat added to system

$W \rightarrow$ work done on the system

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

$w \rightarrow$ work done by system

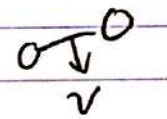


E_{int} is avg kinetic energy $\frac{1}{2} m \langle v^2 \rangle$

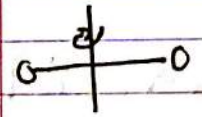
$\langle E_{kin} \rangle = \frac{3}{2} k_B T$

$E_{int} = N \langle E_{kin} \rangle = \frac{3}{2} N k_B T = \underbrace{3}_{\text{monoatomic}} \underbrace{\left(\frac{1}{2} N k_B T\right)}_{\text{equipartition of energy}}$

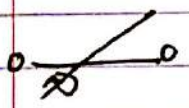
diatomic



Translational E_{kin}
+ Rotational E_{kin}
5 deg freedom

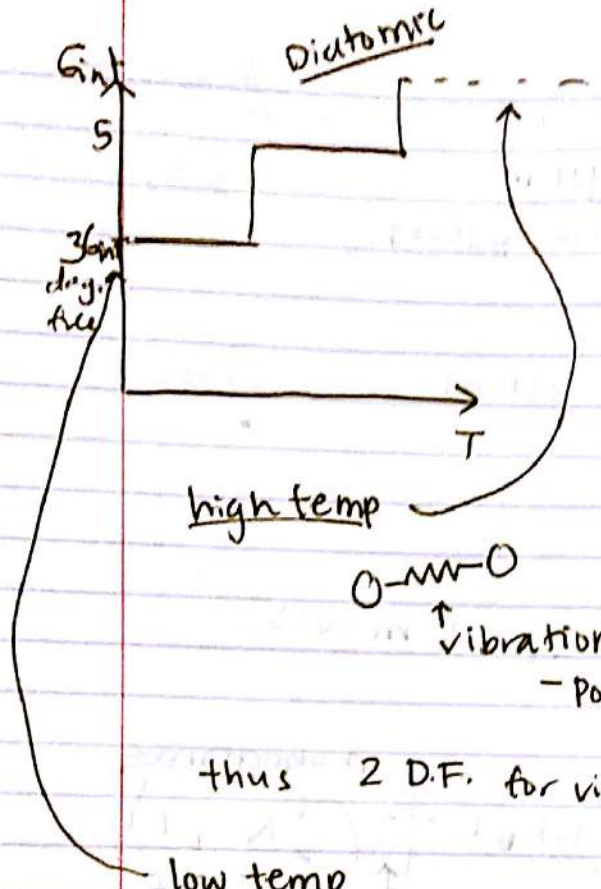


$= 5\left(\frac{1}{2} N k_B T\right)$



$E_{int} = (\#\text{ deg. freedom})(E_{kin} \text{ per D.F.})$

Degree of Freedom
Translational: D.F. = 3
v_x, v_y, v_z



O–ww–O

↑ vibrational E_{kin}

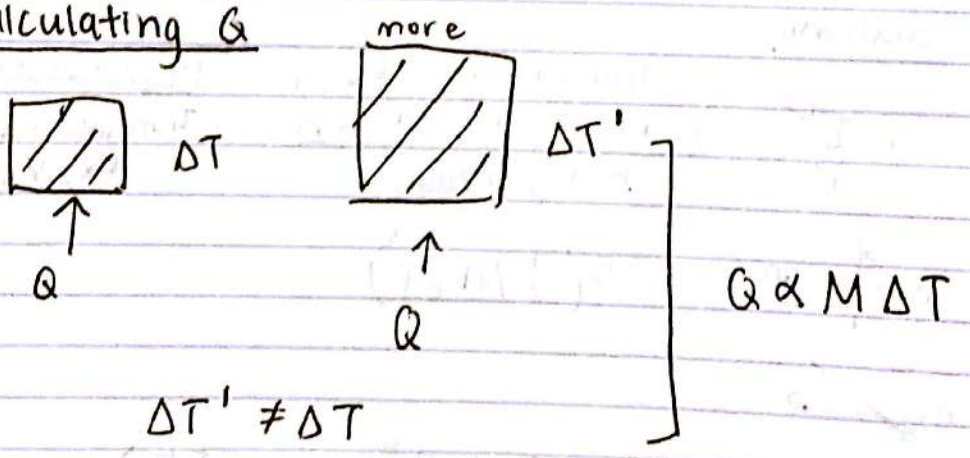
– Potential & kinetic spring

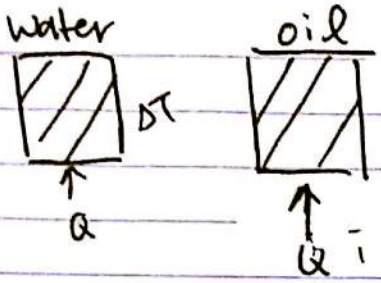
thus 2 D.F. for vibrational E_{kin}

low temp

rotation died. 3 D.F.

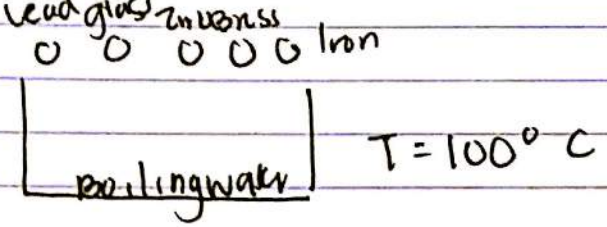
Calculating Q

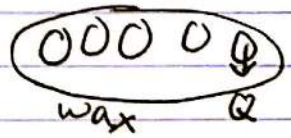




$Q = cM\Delta T$

↑ specific heat





- Brass + iron melted through wax
- glass barely made a dent

$c_{iron} > c_{glass}$

Iron has more heat, transfer more heat

★ c is how well a ~~the~~ substance transfers heat

calorie = 4.186 J ← work needed

1 g water → raise T by 1°

we assume c is constant, but