Heat Capacity

$Q \rightarrow$ [T rises (usually)] $\qquad \Delta T \sim Q$

$$Q = C\,\Delta T$$

heat capacity of object

[large C] $\xleftarrow{Q}$ $\qquad$ $\xrightarrow{Q}$ [Small C] gets hotter

heat capacity is prop. to mass

"extensive" $\rightarrow$ $C = cm$ $\leftarrow$ specific heat of material "intensive"

specific heat is a property of material, temperature, pressure, etc

$$c_{H_2O} = 4200 \frac{J}{kg\,K} = 4.2 \frac{kJ}{kg\,K} = 4.2 \frac{J}{g\,K}$$

$$= 1 \frac{cal}{g\,K} \qquad \begin{pmatrix} 1\,cal = 4.19\,J \\ 1\,Cal = 1000\,cal \end{pmatrix}$$

$$c_{Fe} = 450 \frac{J}{kg\,K} \quad \ll c_{H_2O}$$

$$c_{Pyrex} = 750 \frac{J}{kg\,K}$$

Analogy with electricity

heat $\rightarrow$ charge
Q $\quad$ Q

heat capacity $\rightarrow$ capacitance
C $\quad$ C

temperature $\rightarrow$ voltage
ΔT $\quad$ ΔV

$Q = C\Delta T \qquad Q = C\Delta V$

$$C \equiv \frac{Q}{\Delta T}$$

$$\Delta U = Q + W$$

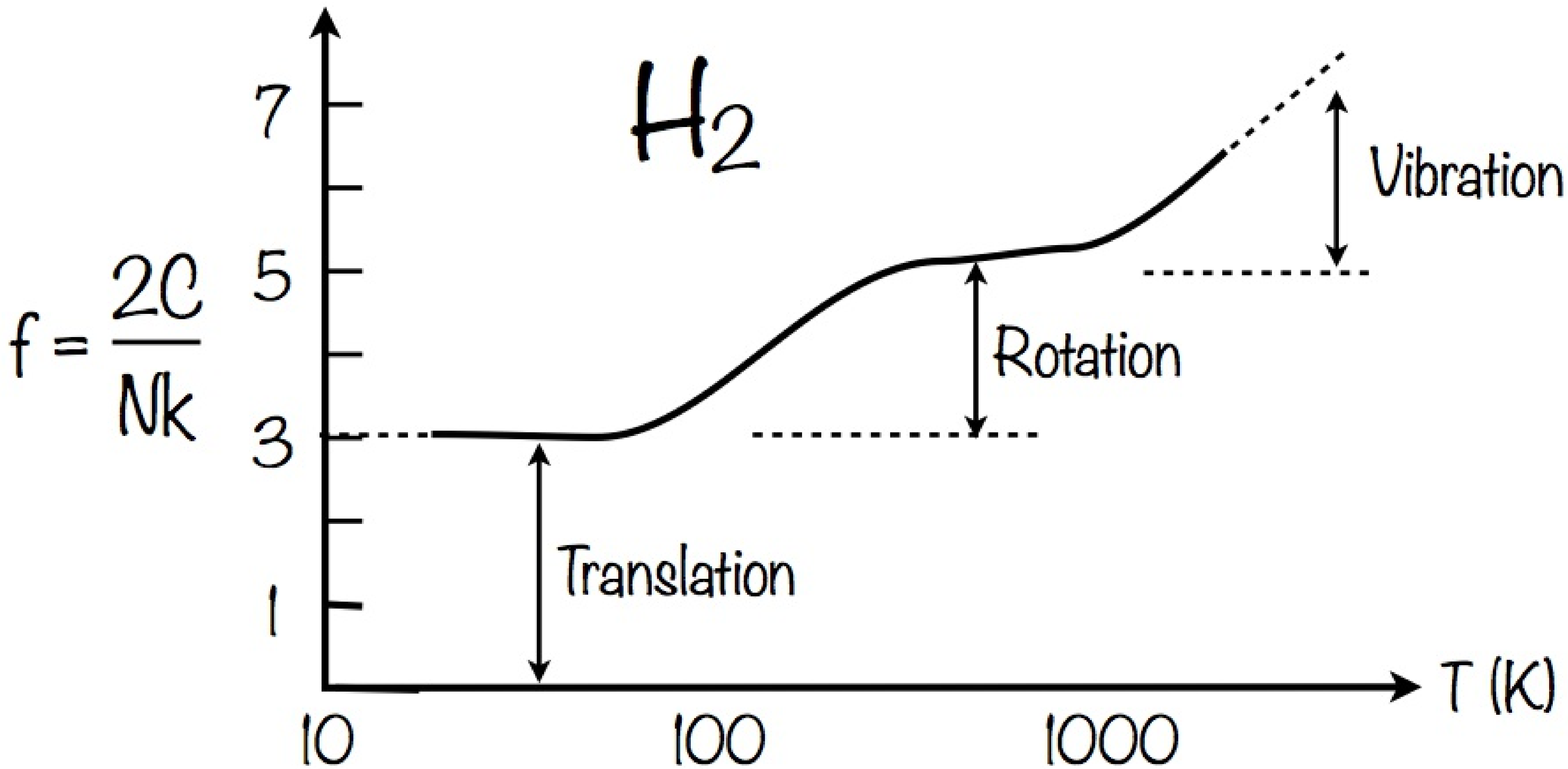
$$\rightarrow C = \frac{\Delta U - W}{\Delta T} = \frac{\Delta U}{\Delta T} - \frac{W}{\Delta T}$$

if $W = 0$, $\quad C = \dfrac{\Delta U}{\Delta T} = \dfrac{dU}{dT}$

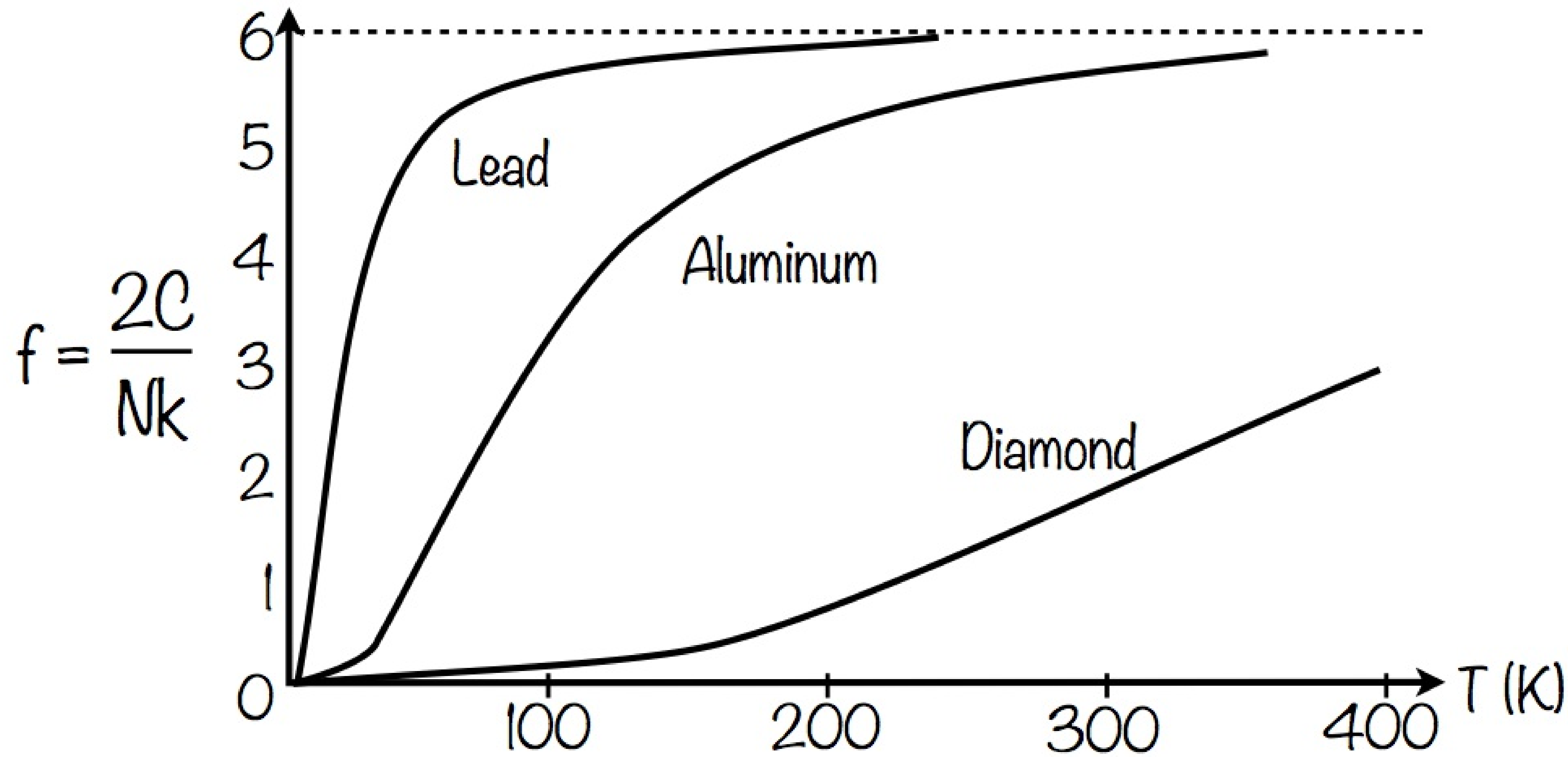
if eqp. theorem holds,

$$U = \tfrac{1}{2} N f k T$$

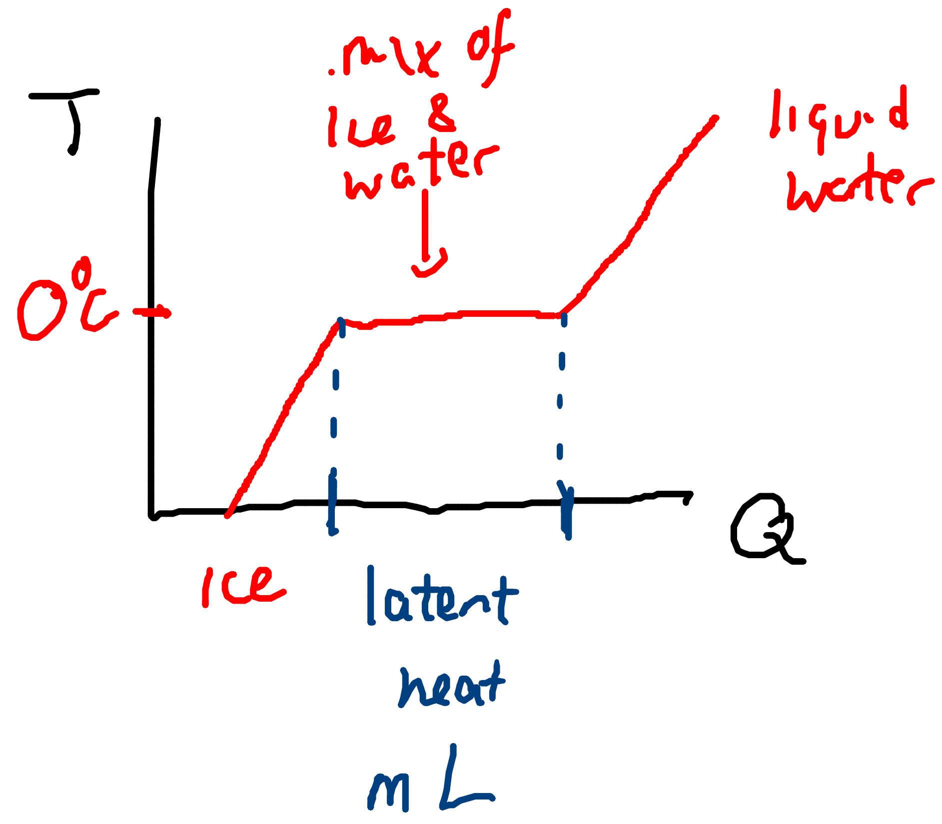
$C = \frac{1}{2} N f k$ $\quad$ if f is not dependent on T.
(freezing out process does muddle this a bit)


H2
f = 2C / Nk
7
5
3
1
Vibration
Rotation
Translation
T (K)
10
100
1000

For Solid, $f = 6$ $\quad \underbrace{C = \frac{1}{2} N f k = 3Nk.}_{\text{Law of DuLong-Petit}}$



Sometimes, adding heat does <u>not</u> increase T



$$L_{\text{ice} \to \text{water}} = 333 \frac{kJ}{kg} \qquad L_{\text{water} \to \text{steam}} = 2260 \frac{kJ}{kg}$$

$$c_{H_2O} = 4.2 \frac{kJ}{kg\,K}$$

Heat liquid water from 0°C to 100°C requires $420\ kJ/kg$

phase changes take a lot of heat to accomplish

which is why e.g. ice is great at cooling things