Glasses

Silica (oxide) Glasses:

Sodic-calcium (finestre etc..), Thermal glasses (high temperature), Lead Glasses (TV and raggi x tube), Tempered Glasses (automobile) etc..

Chalcogenide glasses:

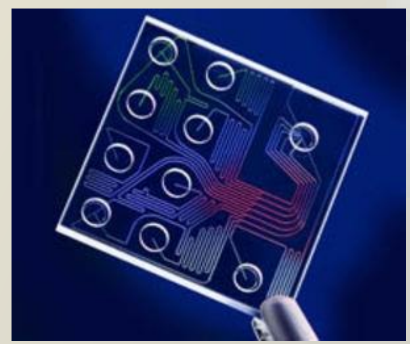
GeAsSe, GeS, GeSI, GeSbTe

Organic glasses:

Methanol, Glycerol, Sucrose

Polymer glasses:

Polyethylene, Polystyrene, PVC, Plexiglass



Metallic glasses:

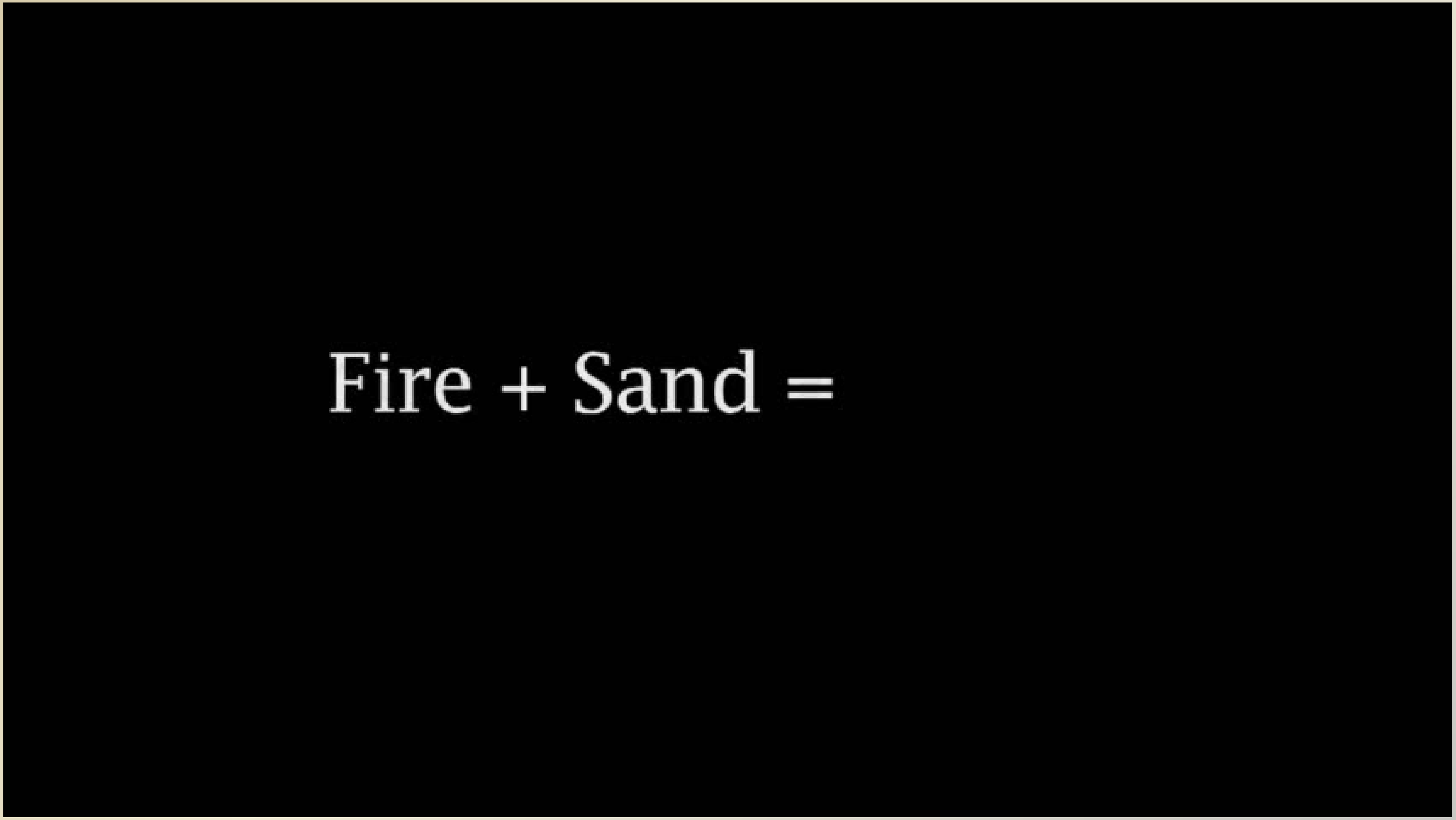
Metallic alloy obtained by extremely rapid cooling.

Glasses

Toughened glass can be made from annealed glass via a thermal tempering process. The glass is placed onto a roller table, taking it through a furnace that heats it above its annealing point of about 720 °C. The glass is then rapidly cooled with forced air drafts while the inner portion remains free to flow for a short time.

An alternative chemical toughening process involves forcing a surface layer of glass at least 0.1 mm thick into compression by ion exchange of the sodium ions in the glass surface with potassium ions (which are 30% larger), by immersion of the glass into a bath of molten potassium nitrate. Chemical toughening results in increased toughness compared with thermal toughening and can be applied to glass objects of complex shapes.

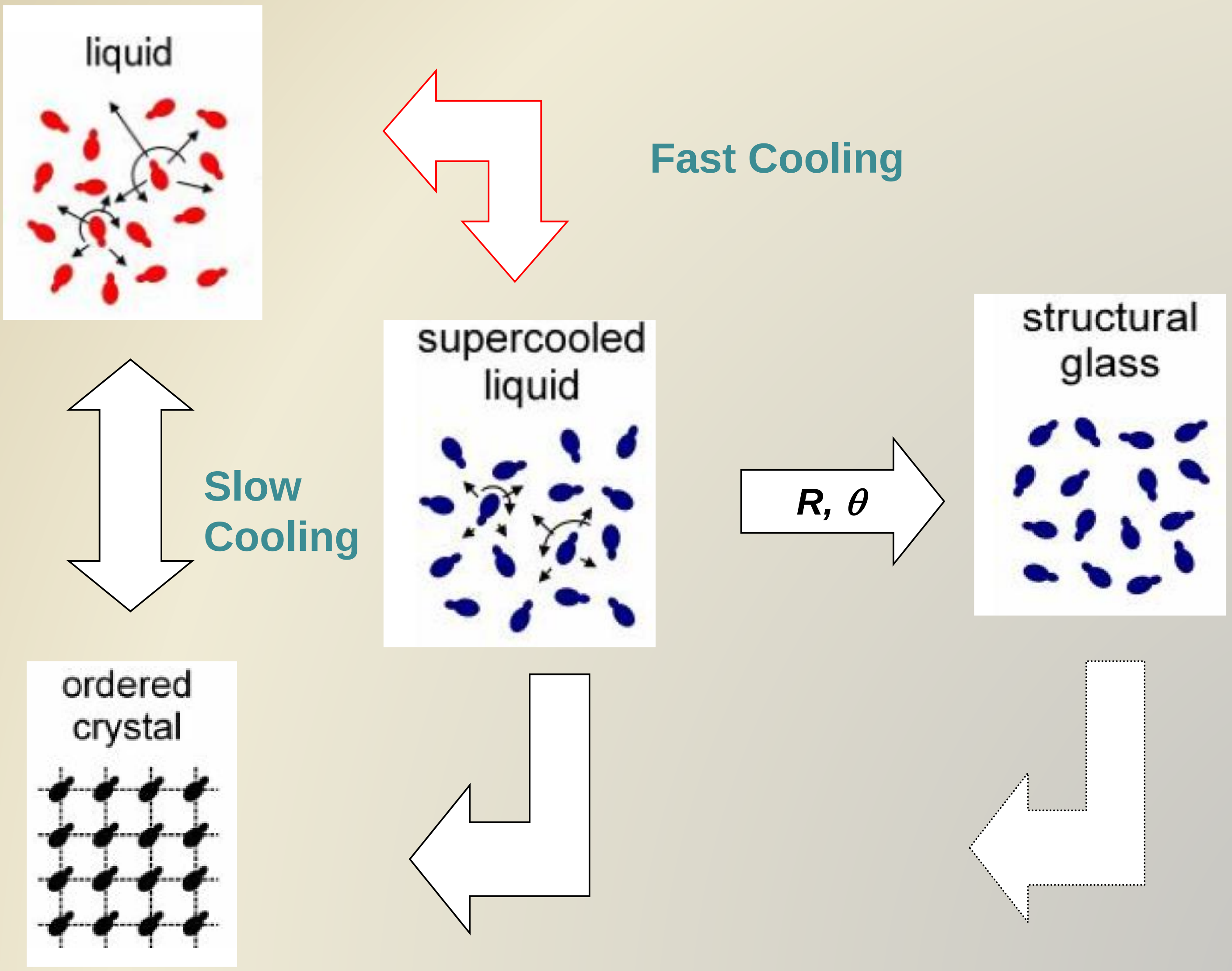
Glasses



https://www.youtube.com/watch?v=1VrdUYbHvyo

https://www.youtube.com/watch?v=wT8xI4PEU8c

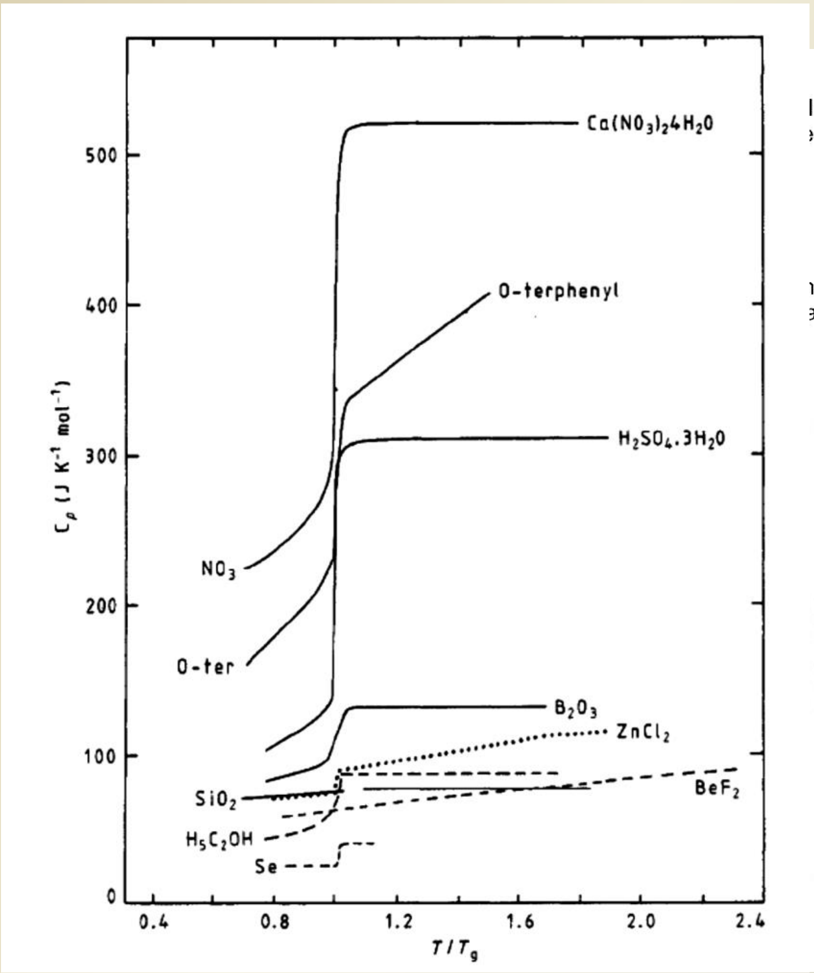
Supercooling and Glass

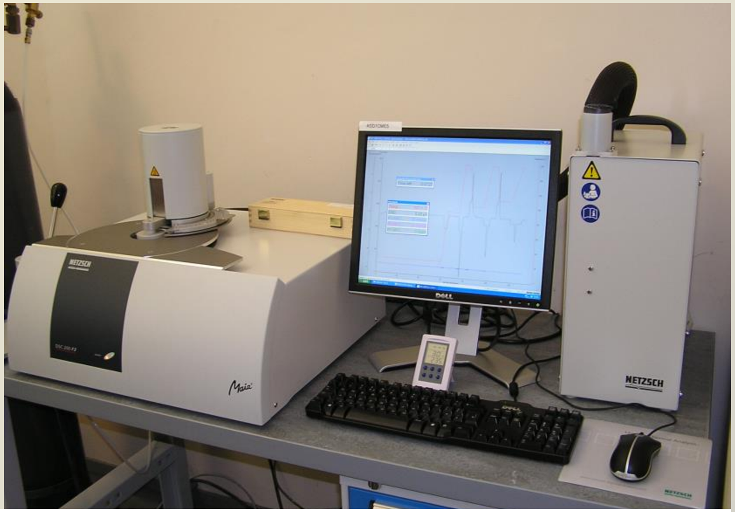


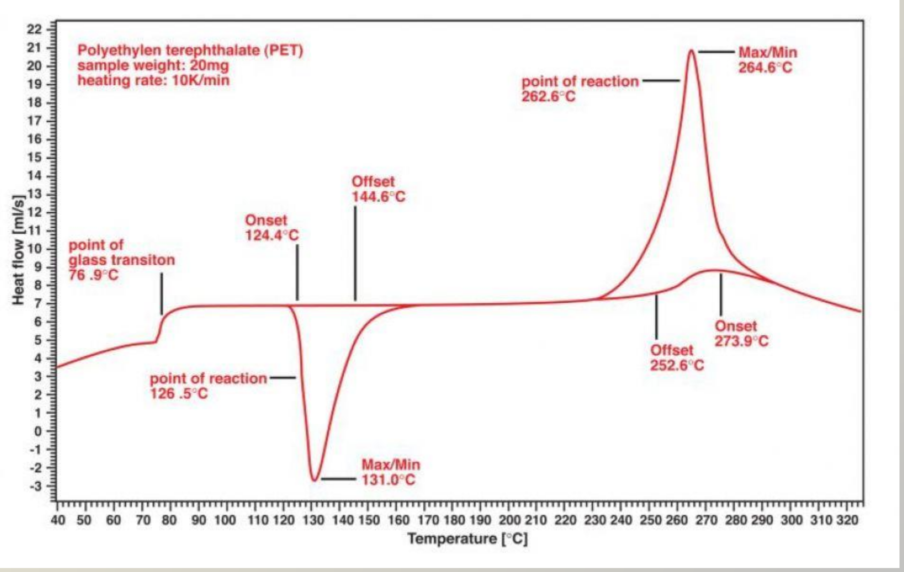
Supercooling and Glass

Differential Scanning Calorimetry

$C = Q/\Delta T$ Specific Heat



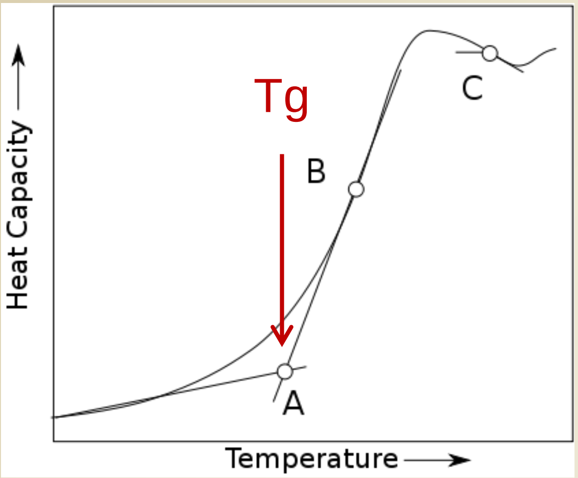


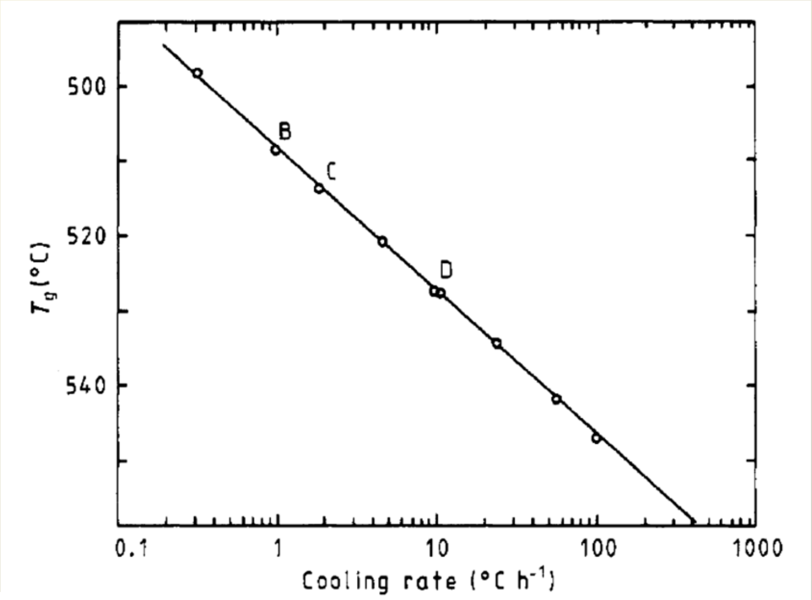


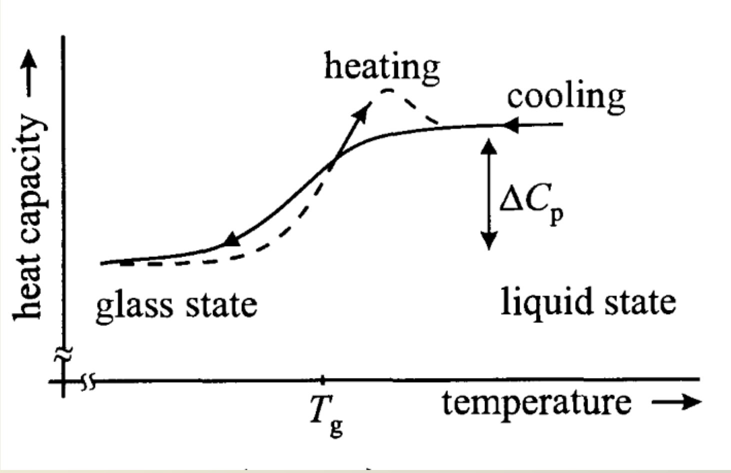
Supercooling and Glass

Specific heat

C = Q/ΔT





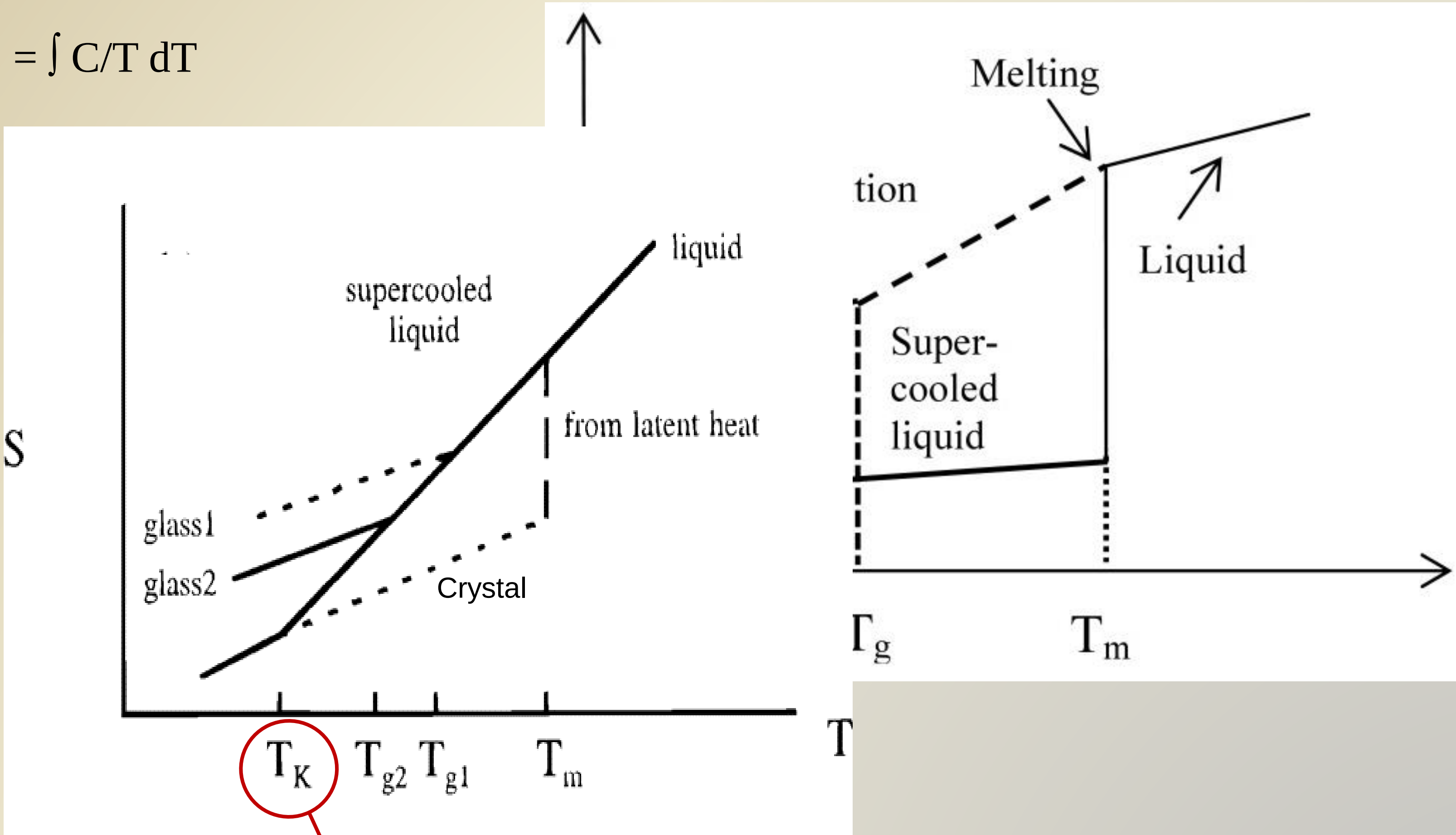


Tg is dependent:
- strongly by the cooling rate
- weakly by heating vs cooling

Supercooling and Glass

Entropy

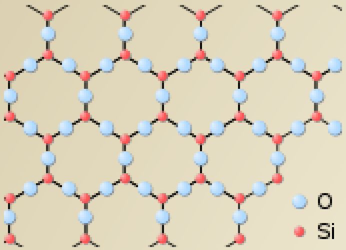
$\Delta S = \int C/T \, dT$



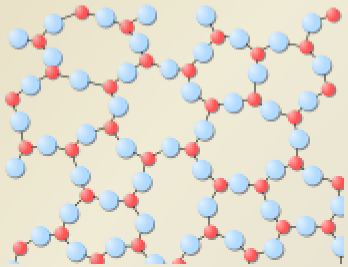
Kauzmann Temp.

Supercooling and Glass

Crystal

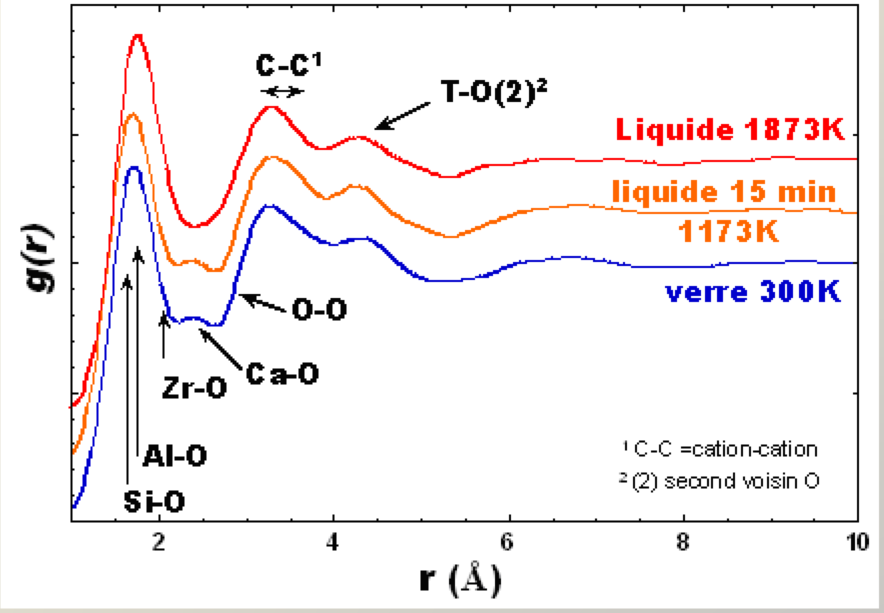


Glass vs Liquid



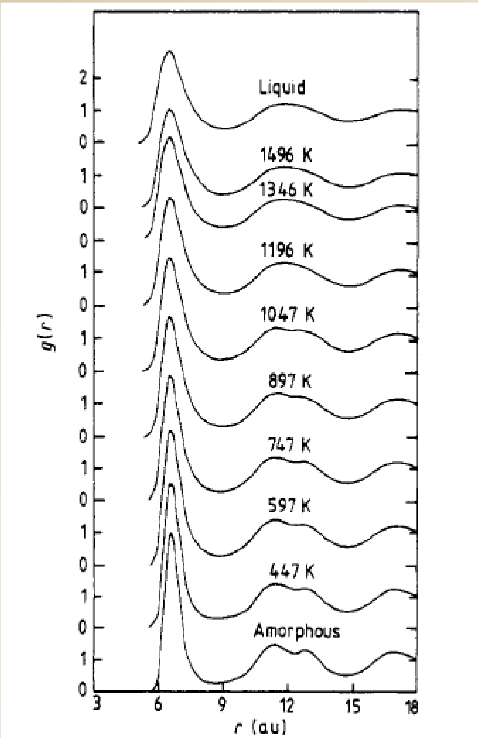
$$S(r) =< \rho(r_0,0)\rho(r_0 + r, 0) >$$

The static structure factor, as well as the two body correlation functions, does not show variation at the glass transition.

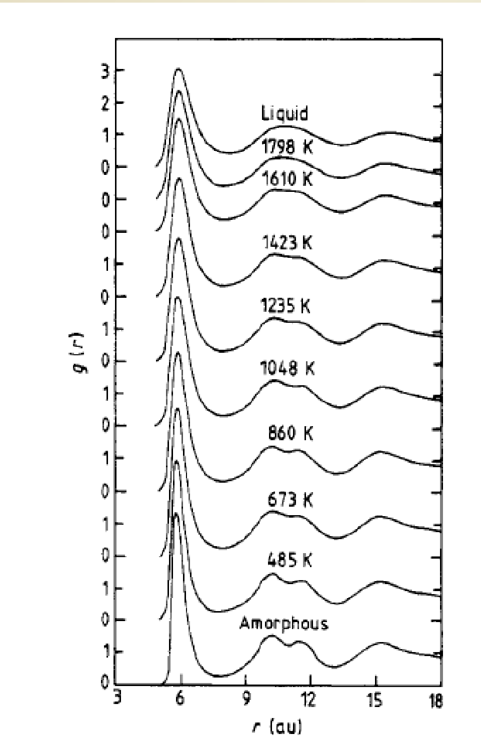


Supercooling and Glass

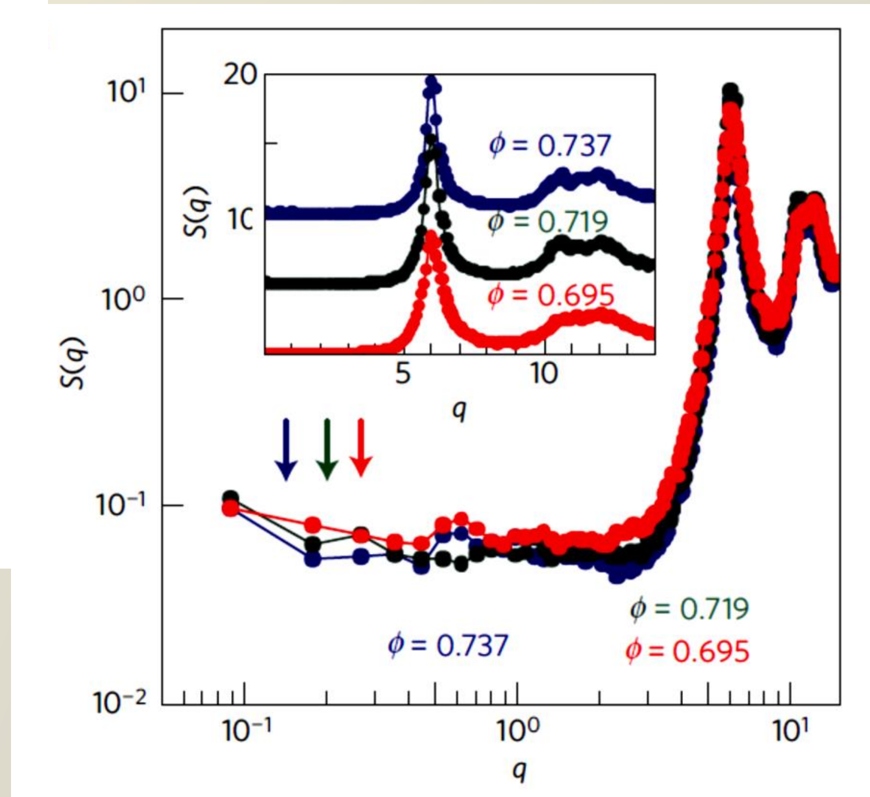
$$S(q) = < \rho(-q,0)\rho(q,0) >$$



Ittirio (Y)



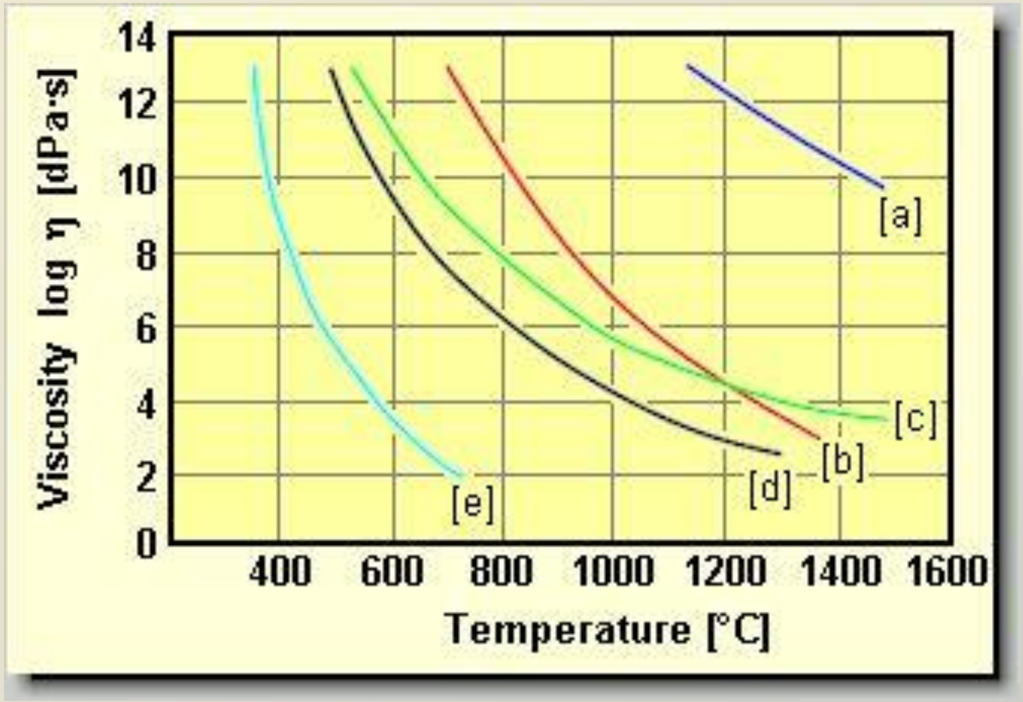
Zirconio (Zr)



Supercooling and Glass

The dynamics shows spectacular variation at the glass transition.

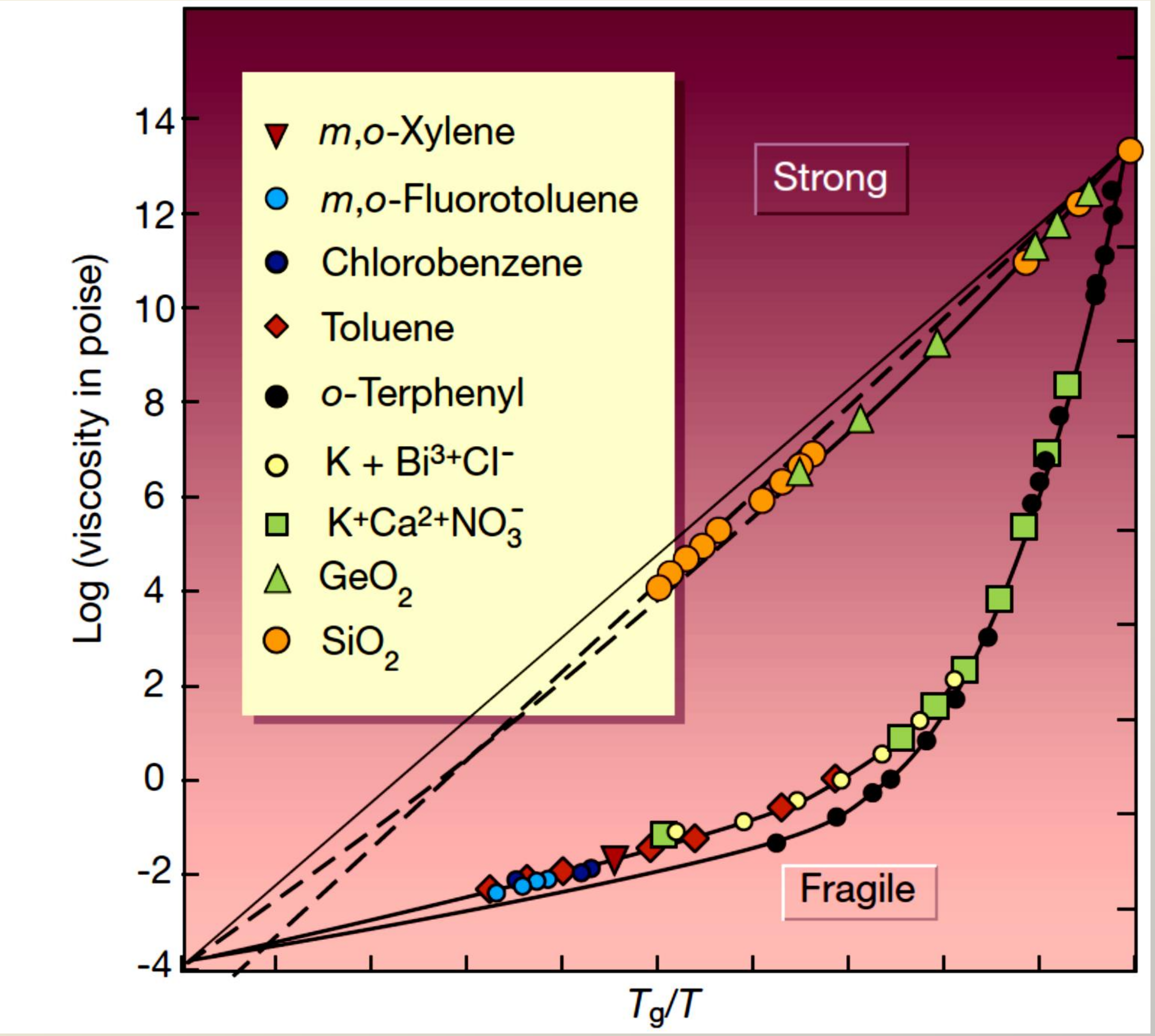
For example the viscosity or the structural relaxation time
Increase of a factor 10^{12} for about 10^{2} temperature variation.



(a) fused silica,
(b) alumosilicate,
(c) borosilicate,
(d) soda-lime-silica
(e) lead borate

Supercooling and Glass

Angell Plot ,
the glass can be classified in
Strong vs Fragile



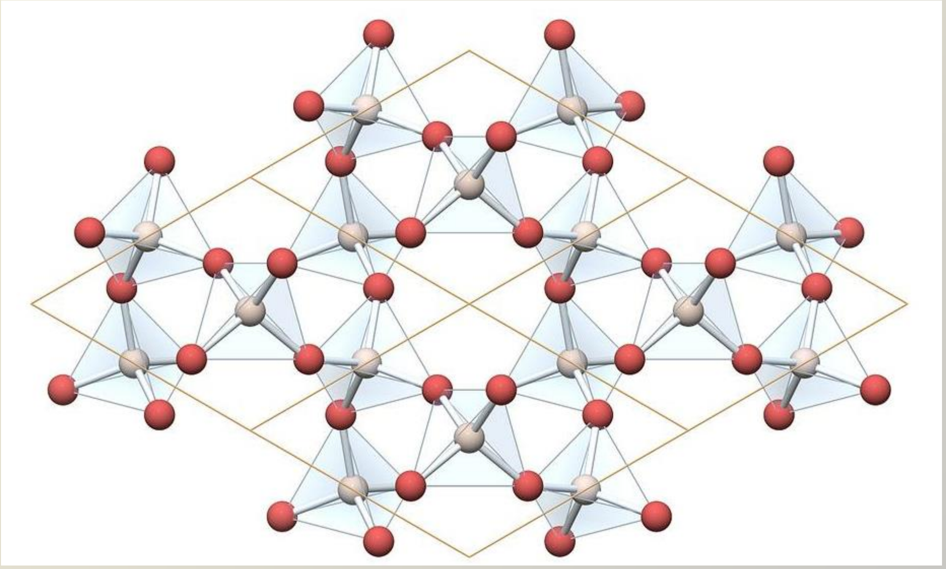
Supercooling and Glass

Strong

Arrhenius temperature dependence

$$n(T) \approx n_o e^{\frac{A}{T}}$$

Silica Glasses have not a structure based on SiO_2 molecule, but a network where each Silicon atom is bond to 4 atoms of Oxygen by covalent bonds.



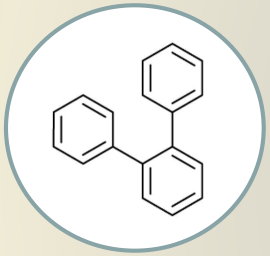
Supercooling and Glass

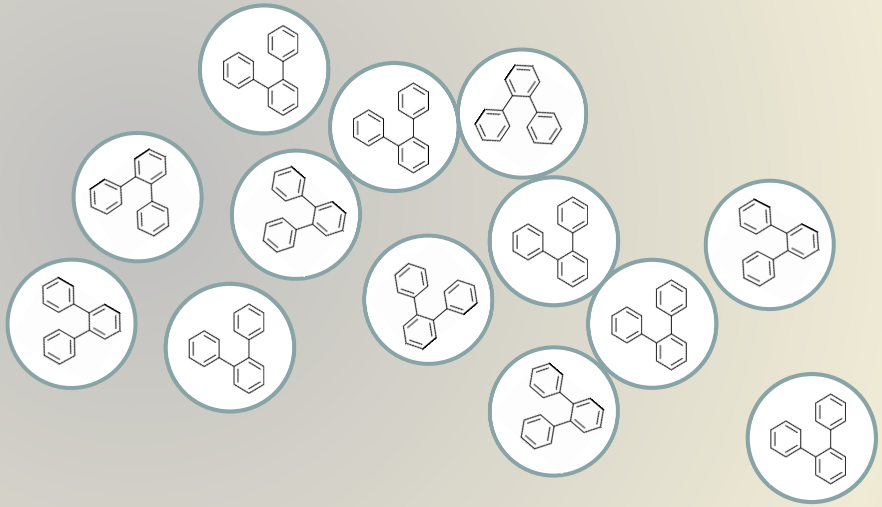
Fragile

Vogel-Fulcher (Non-Arrehnius) temperature dependence

$$n(T) \approx n_o e^{\frac{A'}{(T-To)}}$$

O-Terphenyl





o-terphenil glasses are based on molecules interacting by Van derWaals bonds

Fragility Parameter:

m

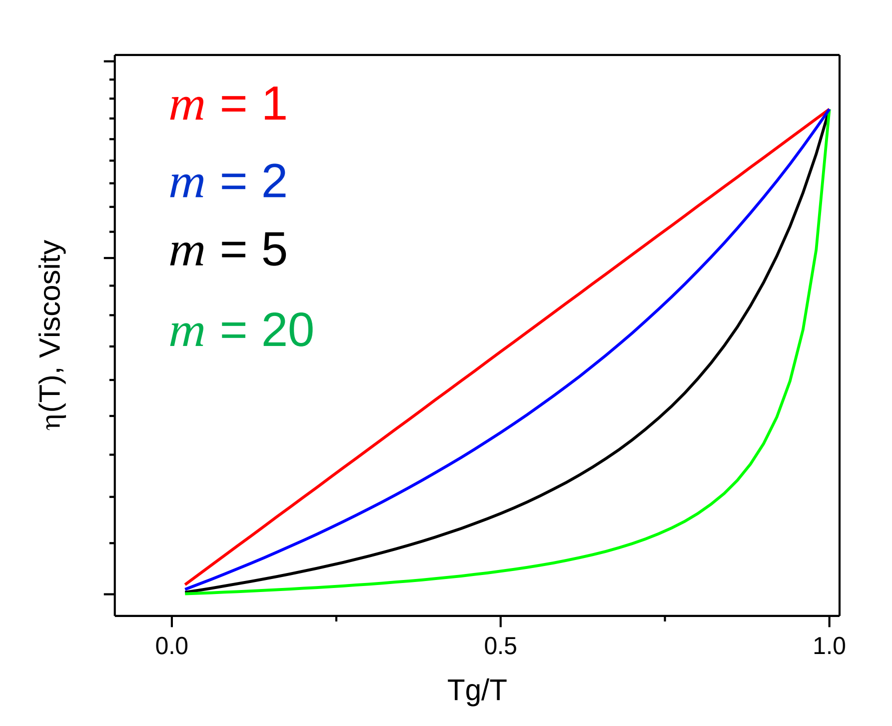
$$n(T) = n_o e^{\frac{A^2}{m\left(\frac{T}{Tg}-1\right)+A}}$$

$m << m_0$

$$n(T) \approx n_o e^{\frac{A}{T}}$$

$m >> m_0$

$$n(T) \approx n_o e^{\frac{A'}{(T-To)}}$$



$$n(T) = e^{\frac{1}{m\left(\frac{T}{Tg}-1\right)+1}}$$