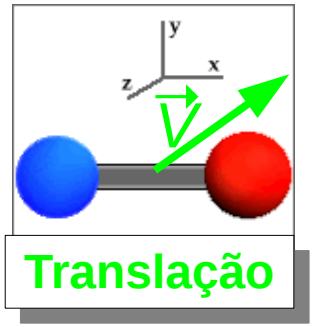
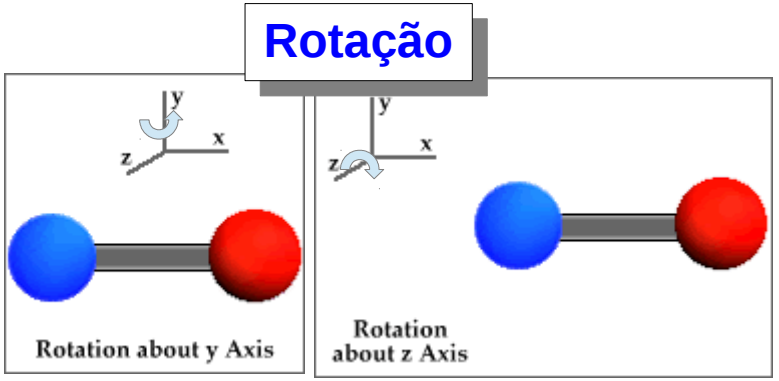
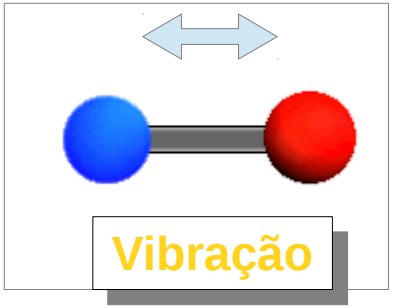
Molécula diatômica

Graus de liberdade:





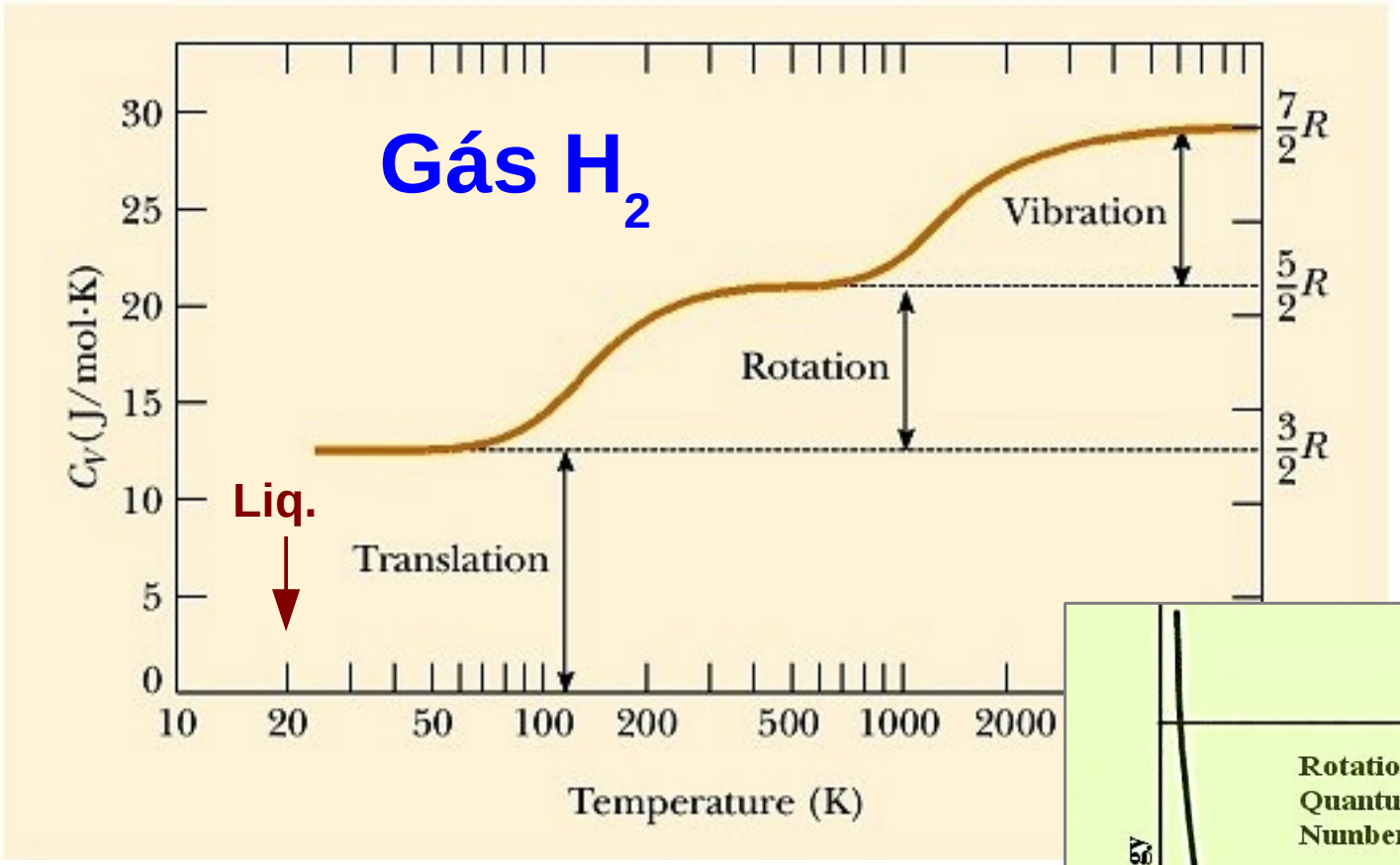


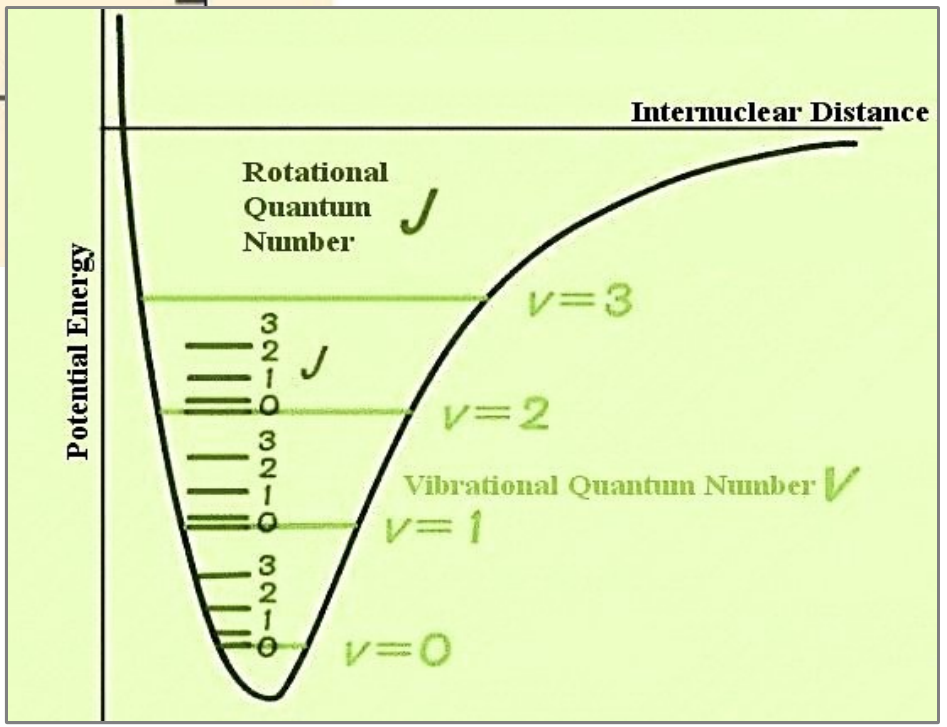
$$3\times\left(\frac{1}{2}kT\right) \qquad +2\times\left(\frac{1}{2}kT\right) \qquad +2\times\left(\frac{1}{2}kT\right)$$

$$\langle e_{mec}\rangle=\frac{3}{2}kT \qquad \langle e_{mec}\rangle=\frac{5}{2}kT \qquad \langle e_{mec}\rangle=\frac{7}{2}kT$$

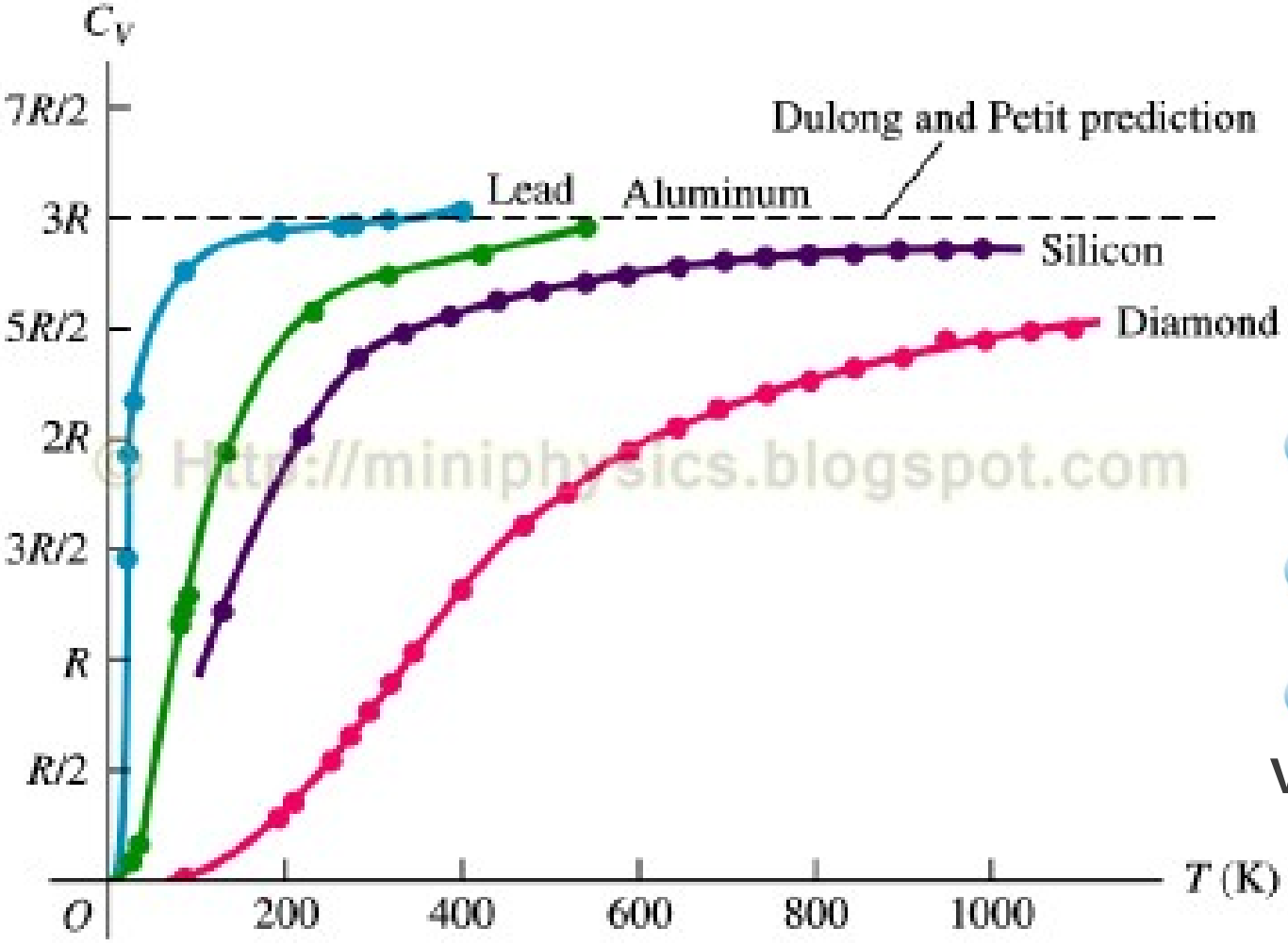
Rot. + vib.+ trans.

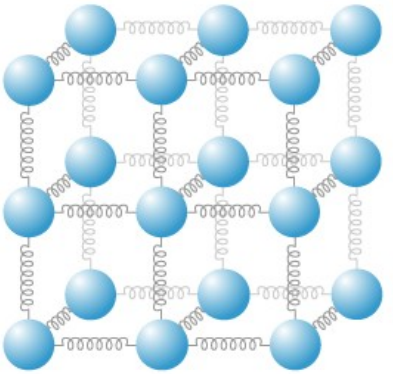
Capacidade térmica molar a volume constante C_v





Calor específico molar de sólido





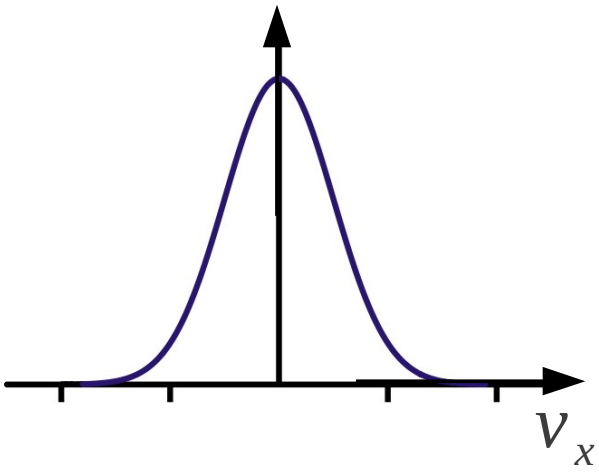
Vibração em 3 D

$$6\times\left(\frac{1}{2}kT\right)$$

Distribuição de Maxwell

1D

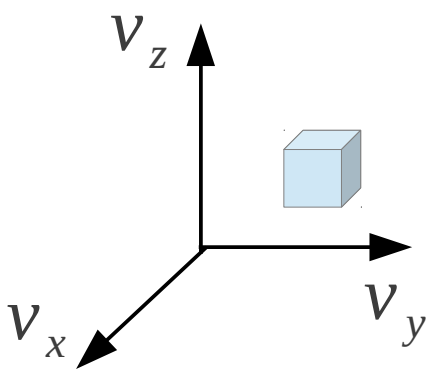
$$f(v_x) = \left(\frac{m}{2\pi k T}\right)^{1/2} e^{-\frac{m(v_x^2)}{2kT}}$$



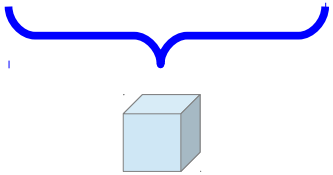
3D

$$f(v_x, v_y, v_z) = \left(\frac{m}{2\pi k T}\right)^{3/2} e^{-\frac{m(v_x^2+v_y^2+v_z^2)}{2kT}}$$

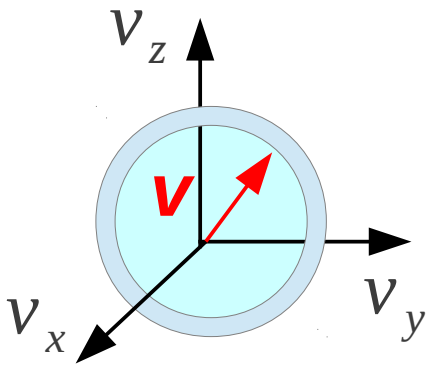
Espaço de velocidades



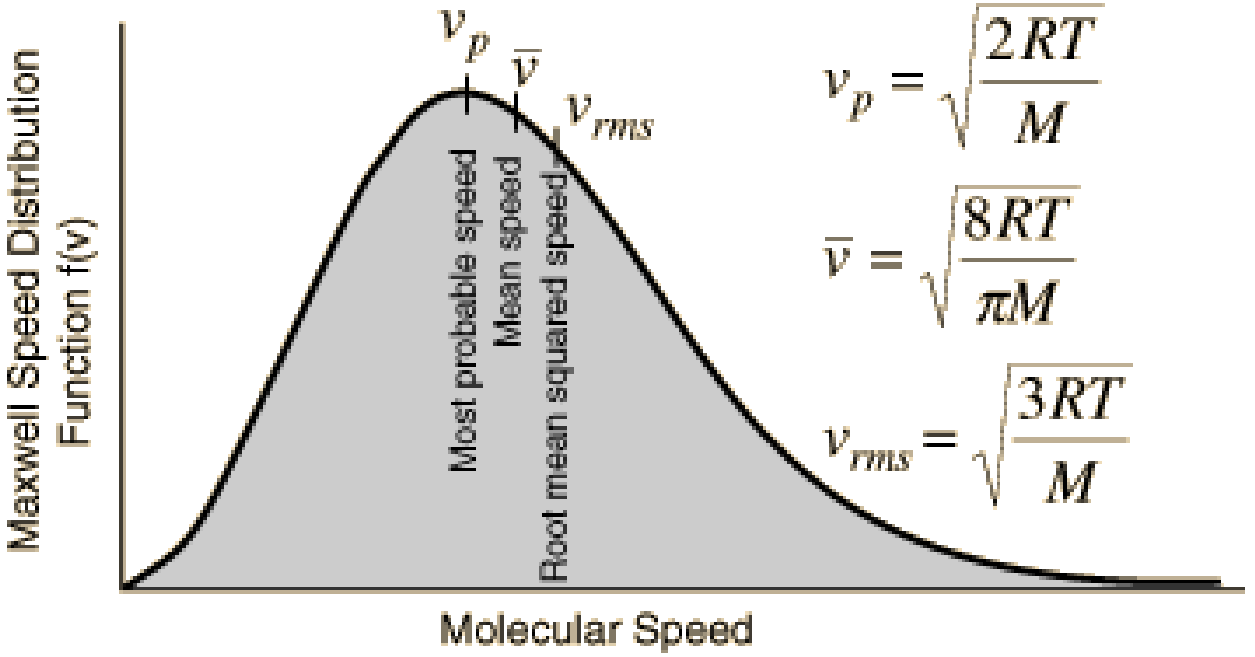
$$dP = \frac{dN}{N} = f(v_x, v_y, v_z)\, dv_x\, dv_y\, dv_z$$



Distribuição de Maxwell-Boltzmann



$$f(v) = 4\pi\left[\frac{M}{2\pi RT}\right]^{\frac{3}{2}} v^2 \exp\left[\frac{-Mv^2}{2RT}\right]$$

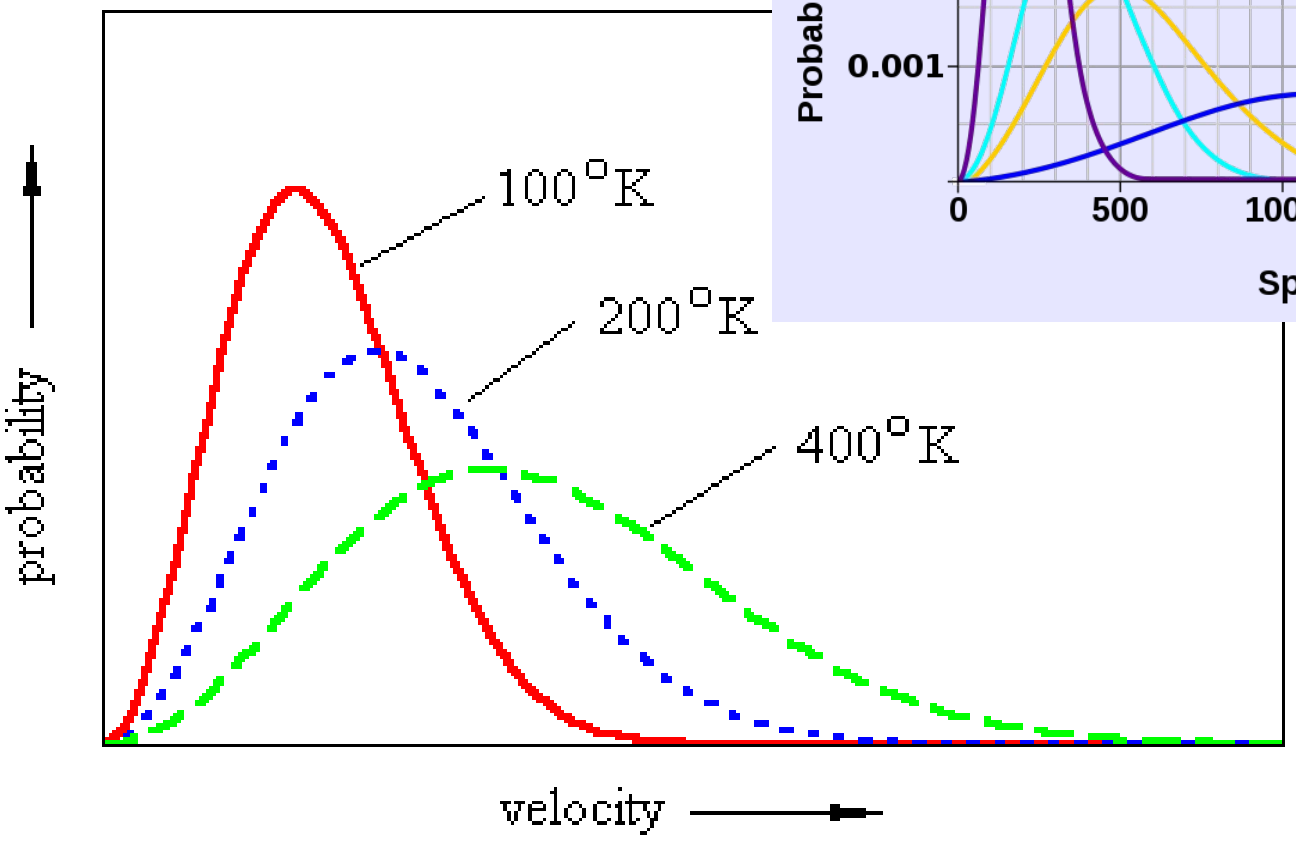


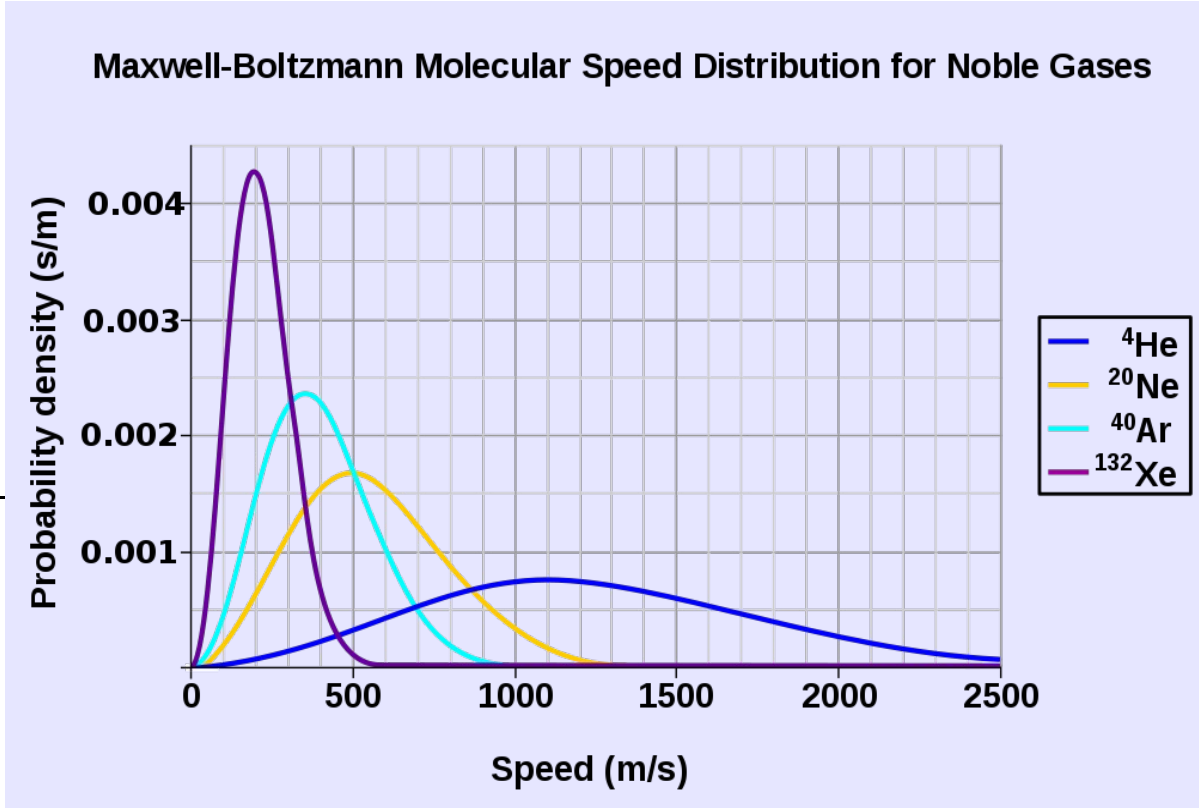
$$v_p = \sqrt{\frac{2RT}{M}}$$

$$\overline{v} = \sqrt{\frac{8RT}{\pi M}}$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Distribuição de Maxwell-Boltzmann





Potencial interatômico

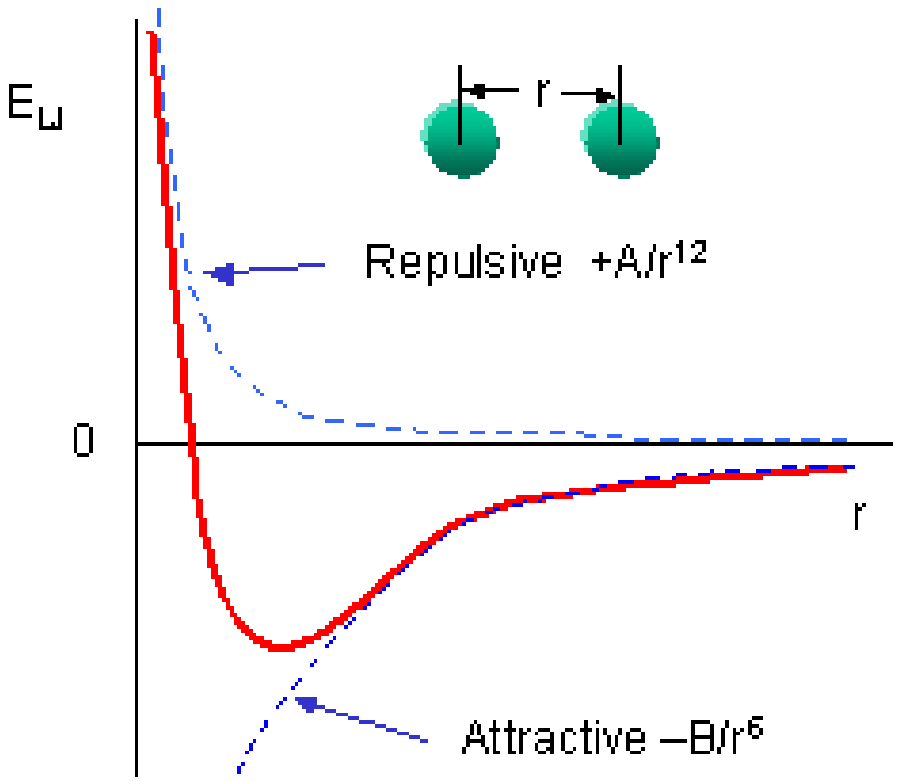
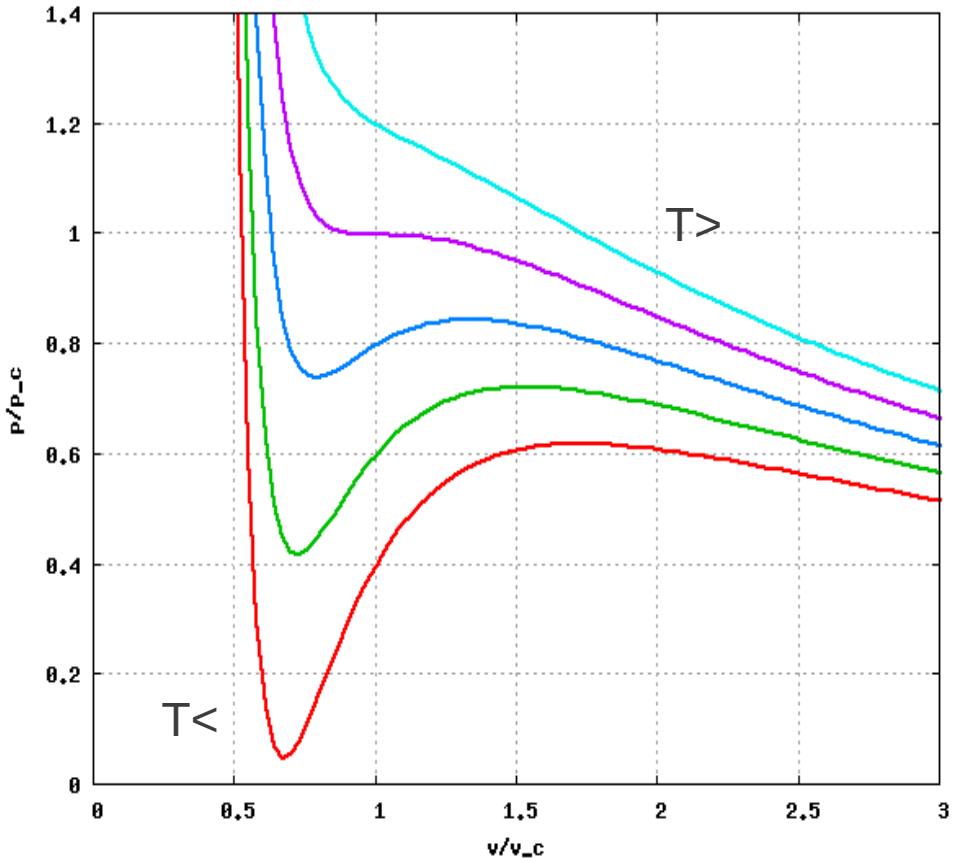


Diagrama P x V - isotermas

Gás real

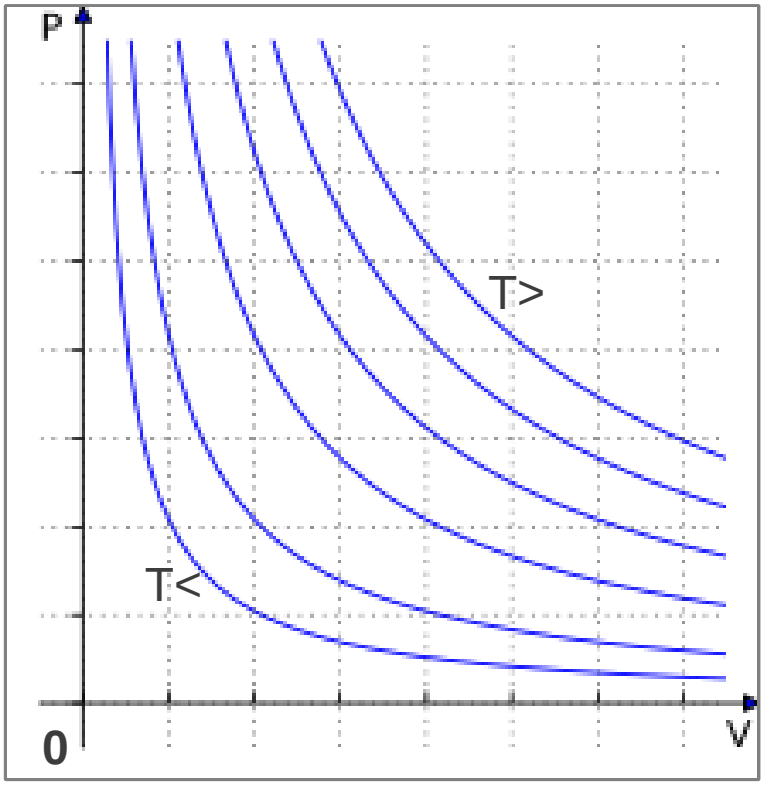
isotermas de *van der Waals*

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

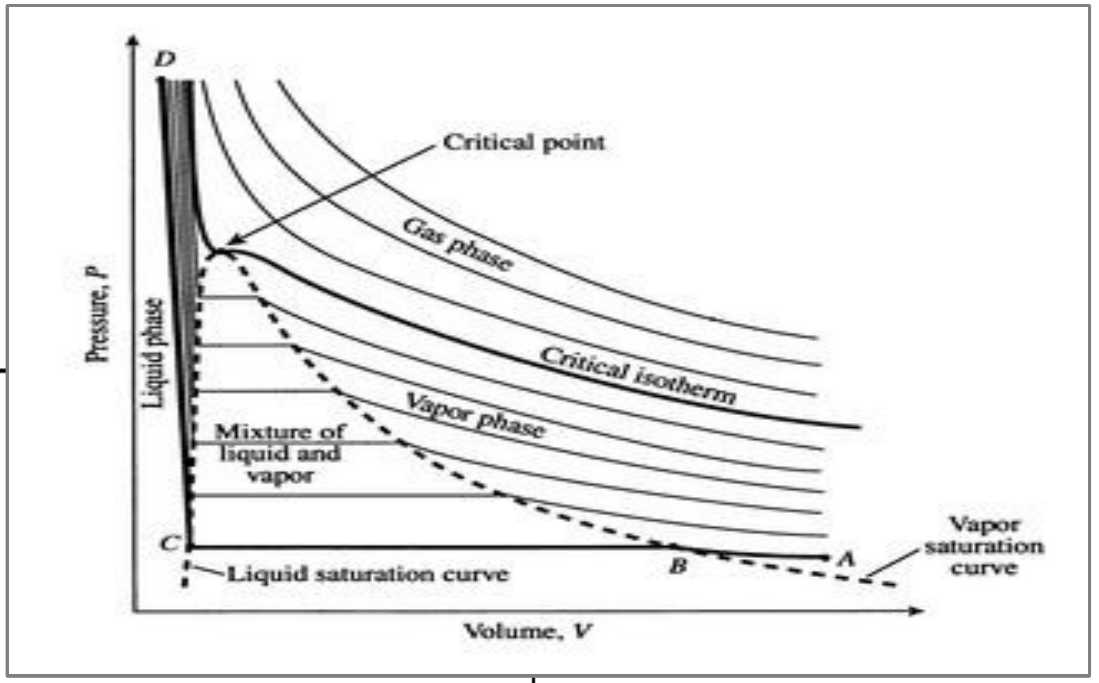


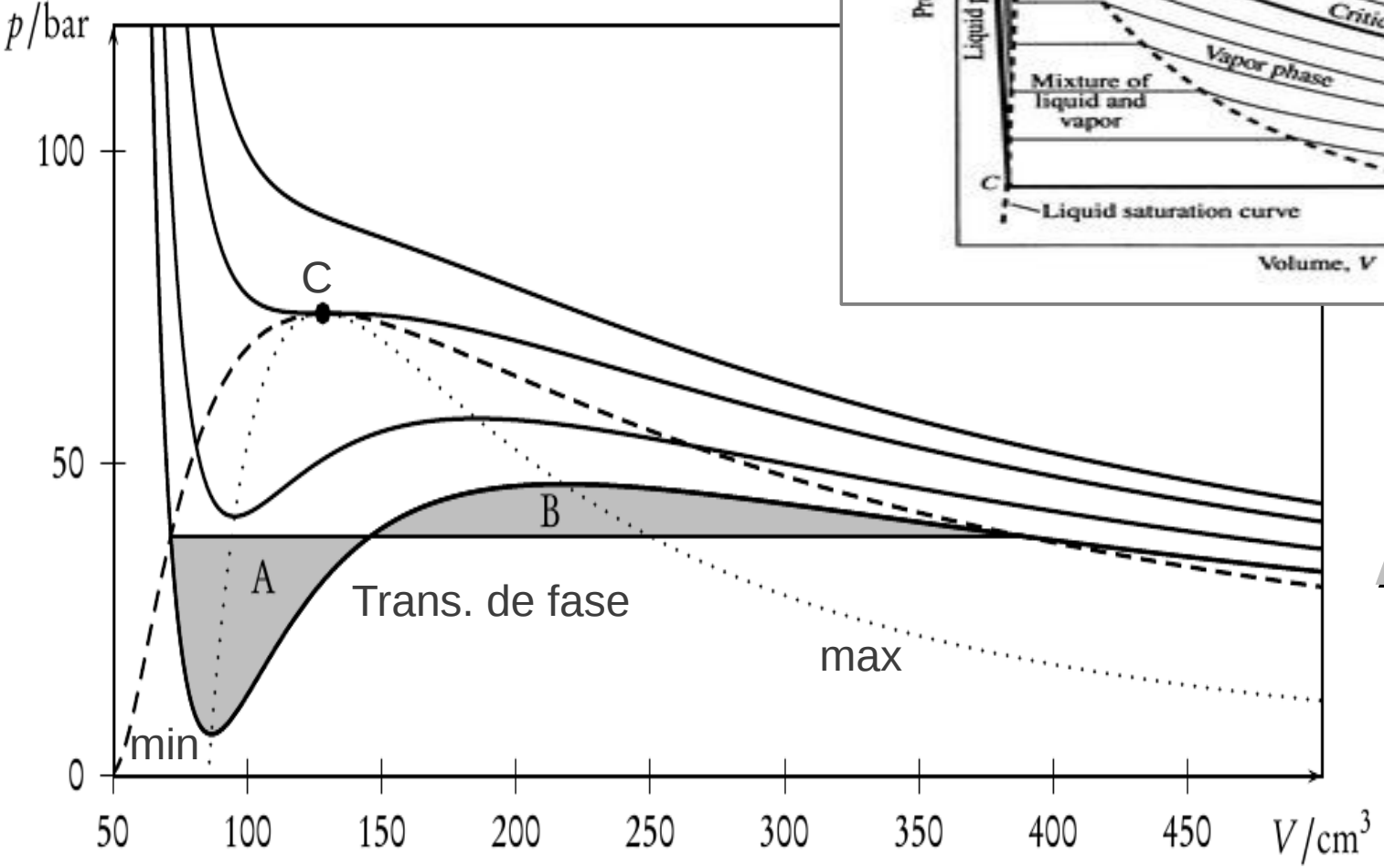
Gás Ideal

$$PV = nRT$$



Construção de Maxwell





Áreas iguais:
A = B

Diagrama de Fases (P x T)

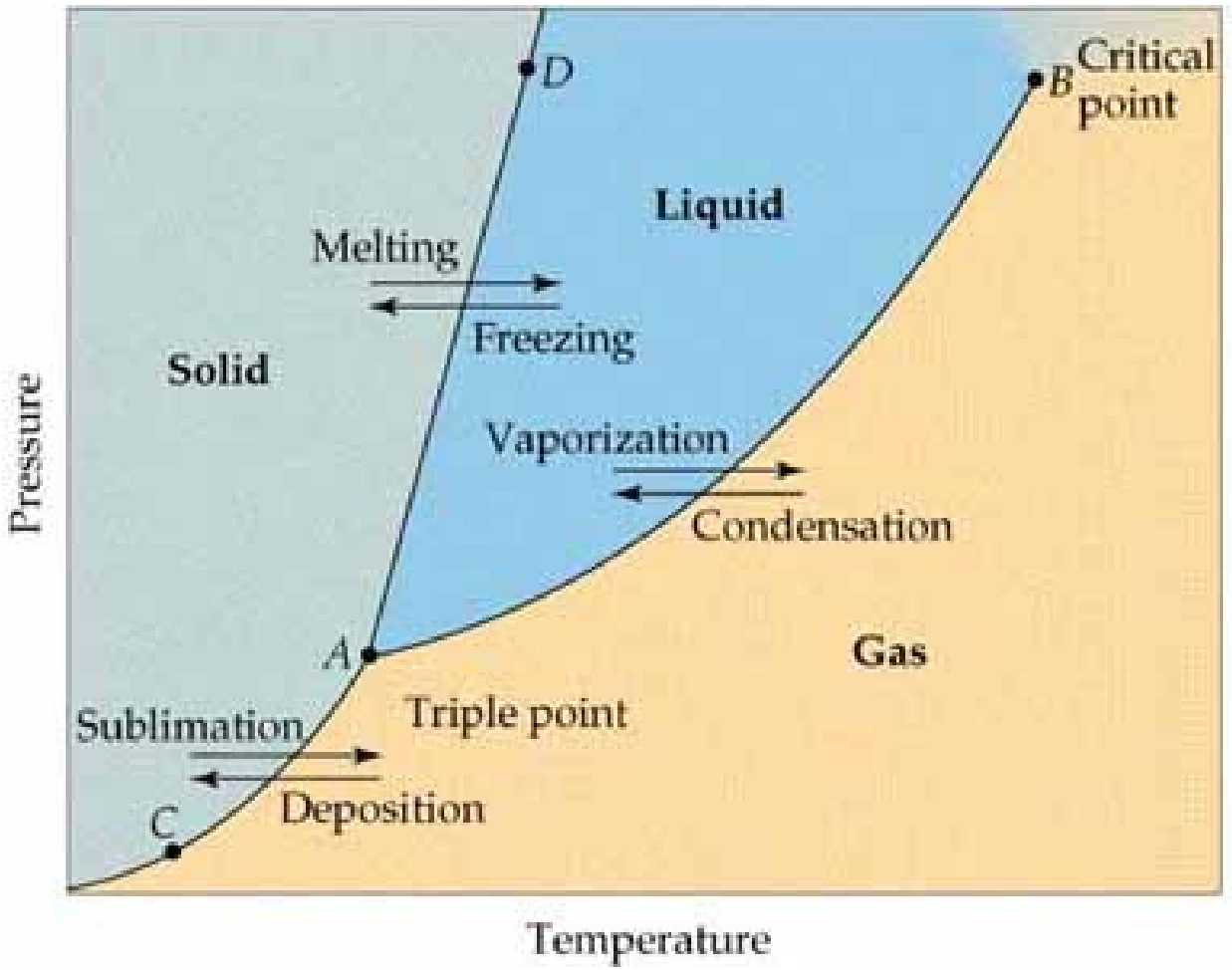
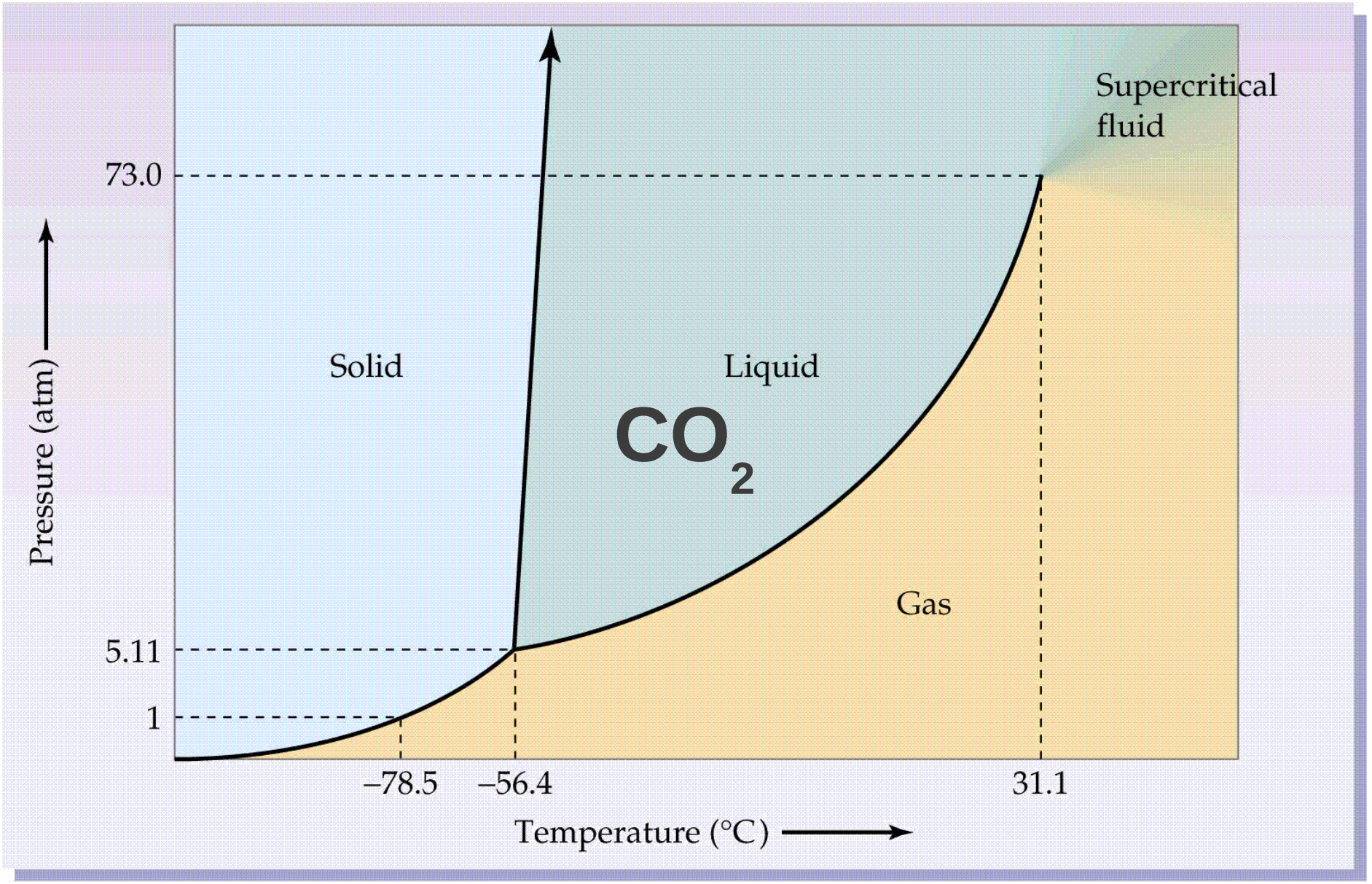
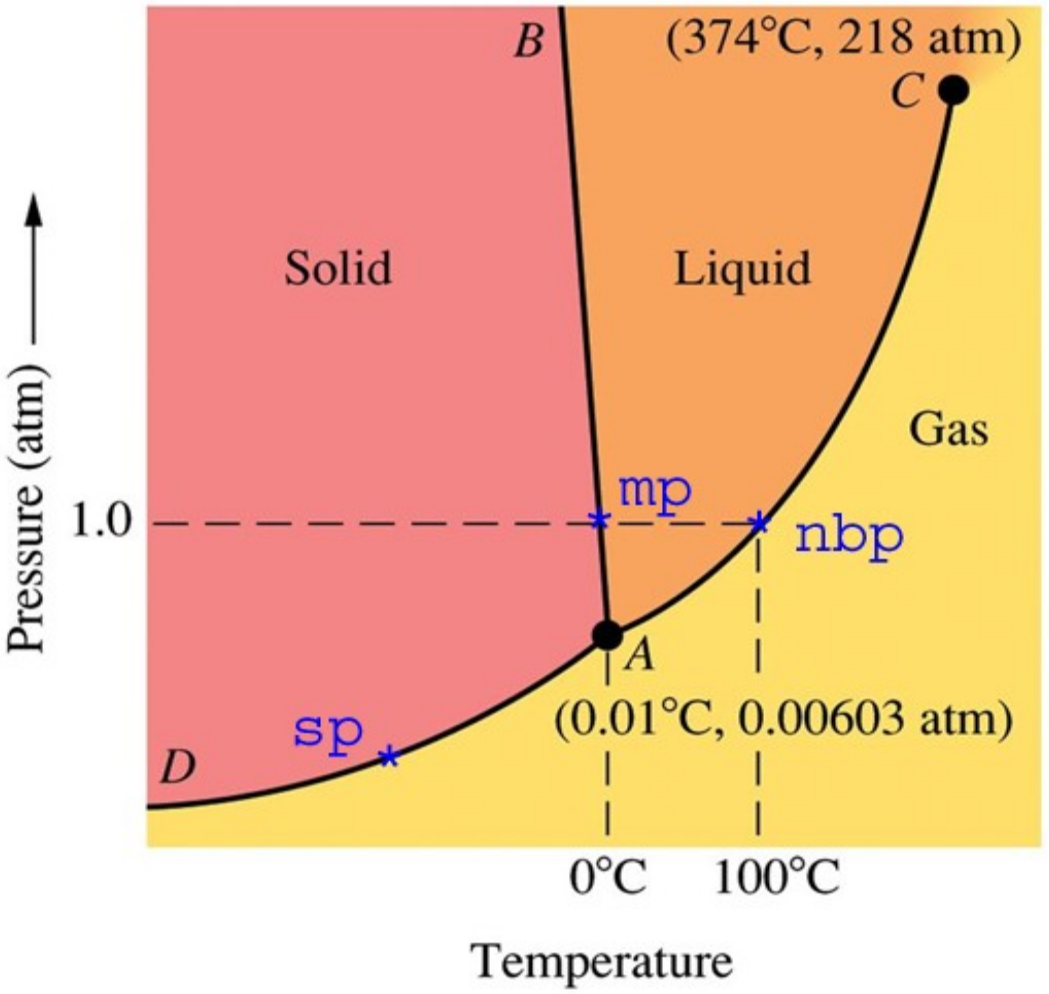


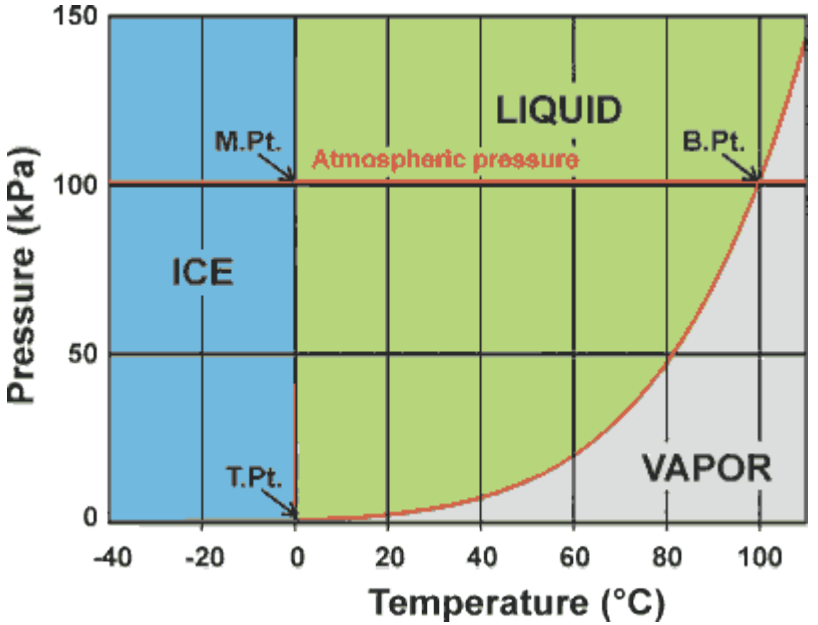
Diagrama de fases do gelo seco



P x T da água



Em escala linear:



Fases cristalinas do gelo etc.
P x T em escala logarítmica

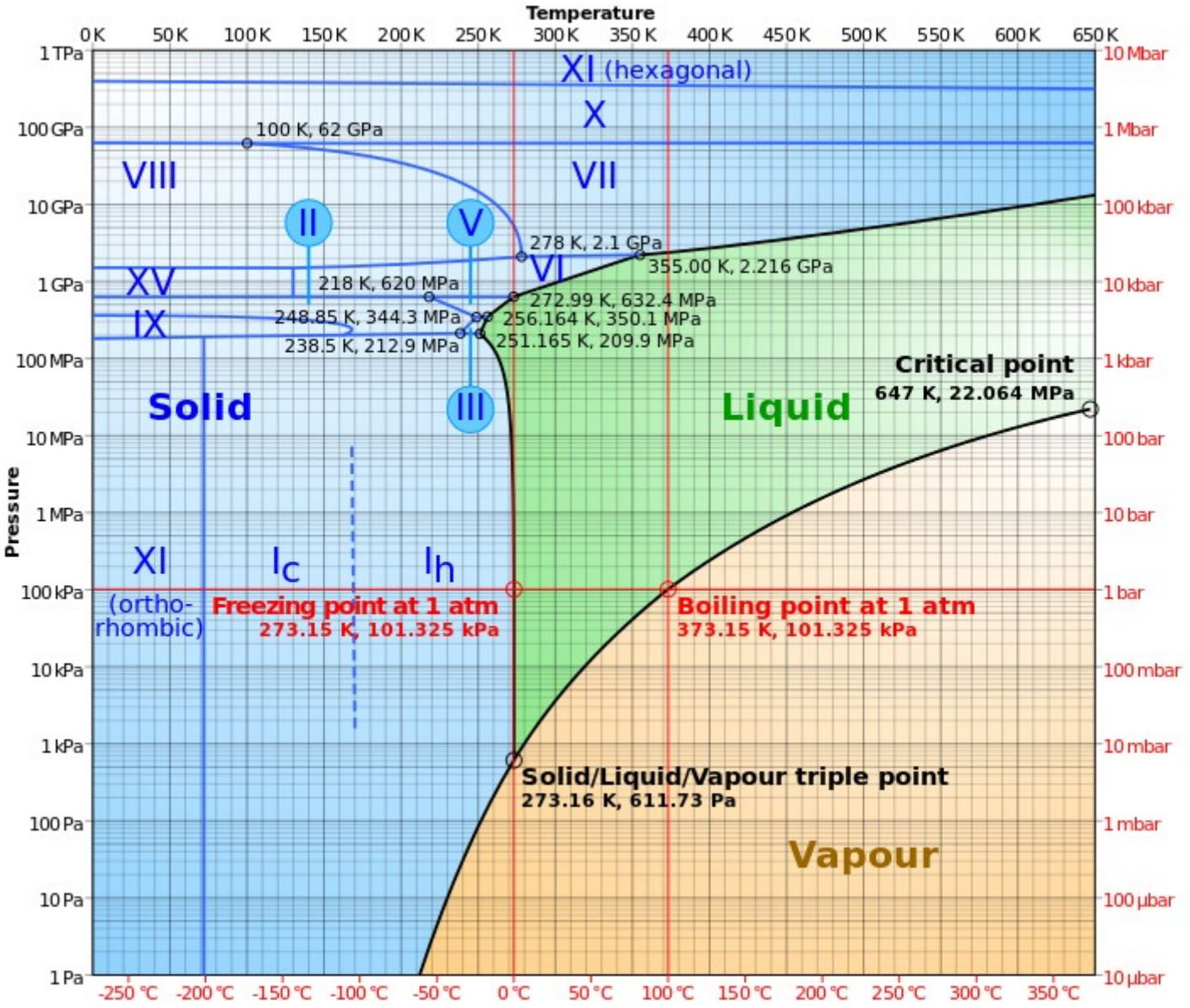
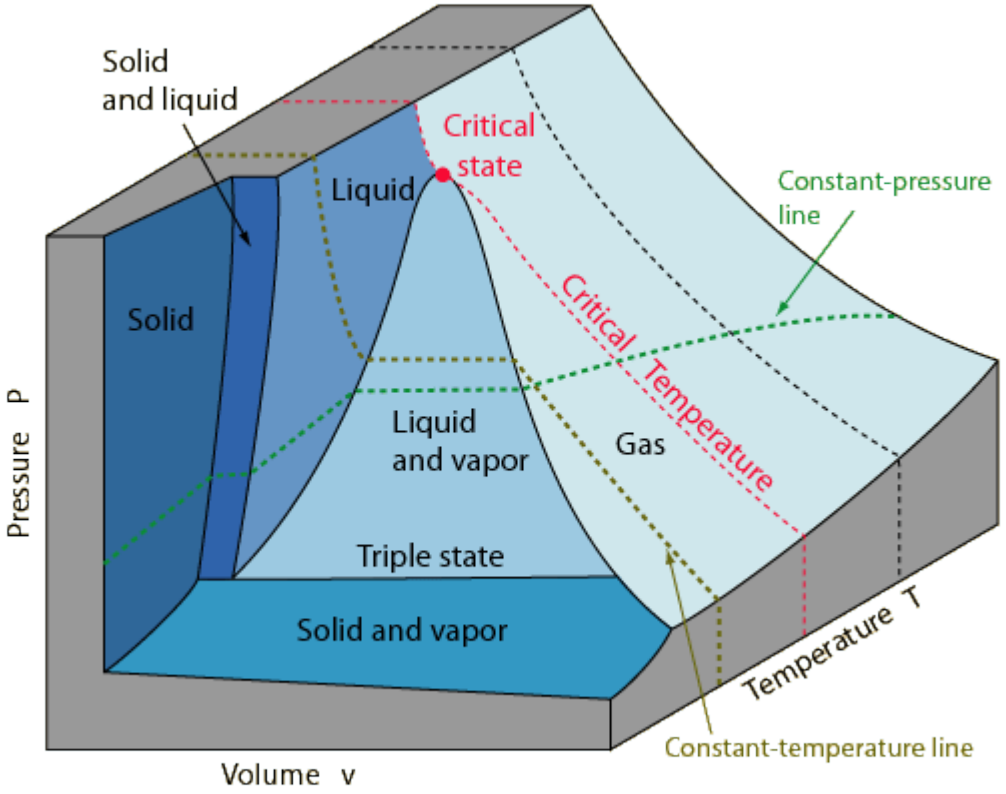
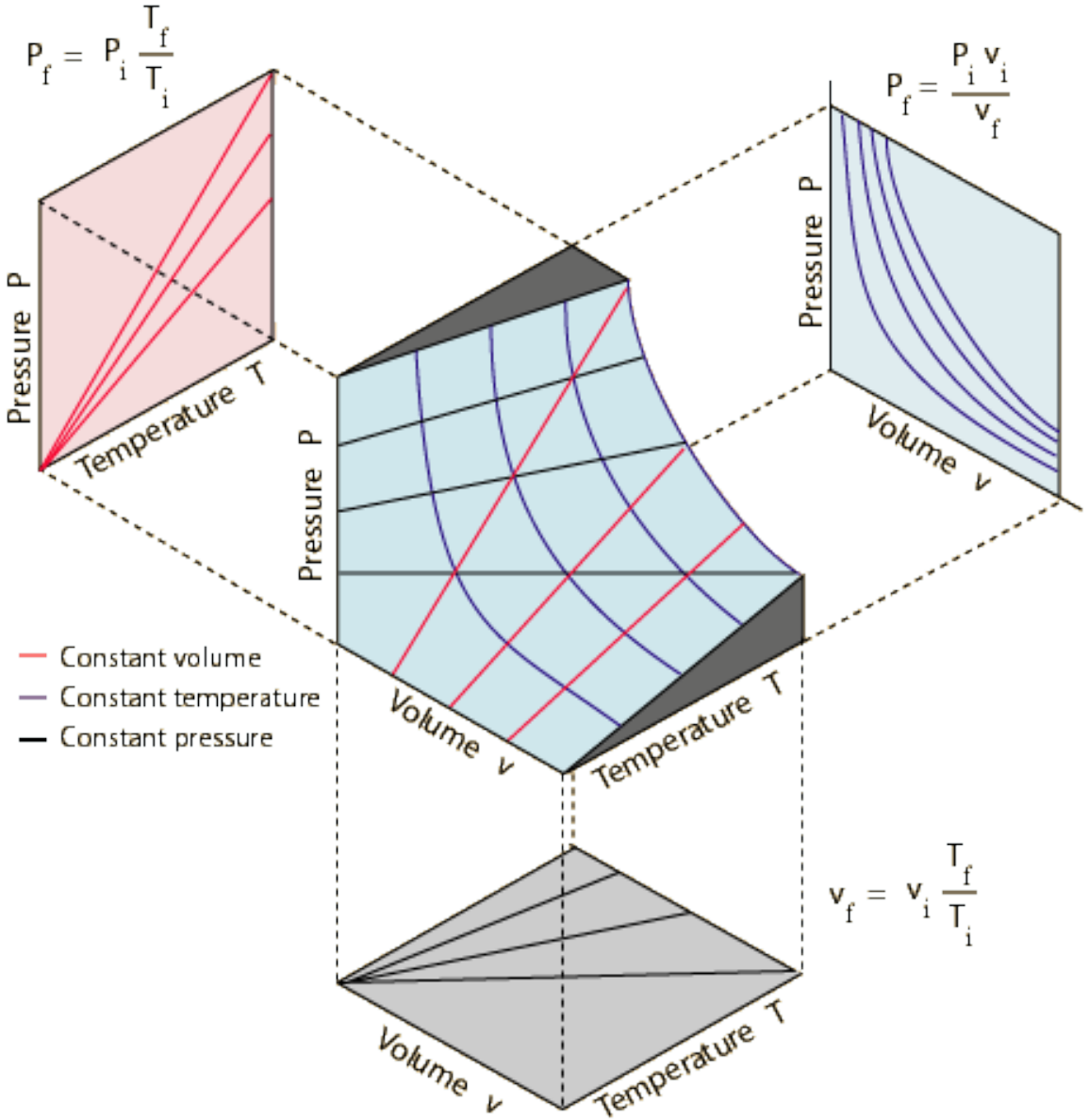


Diagrama PVT



PVT gás ideal



Ideal x vdW

Comparison of ideal and van der Waals gas

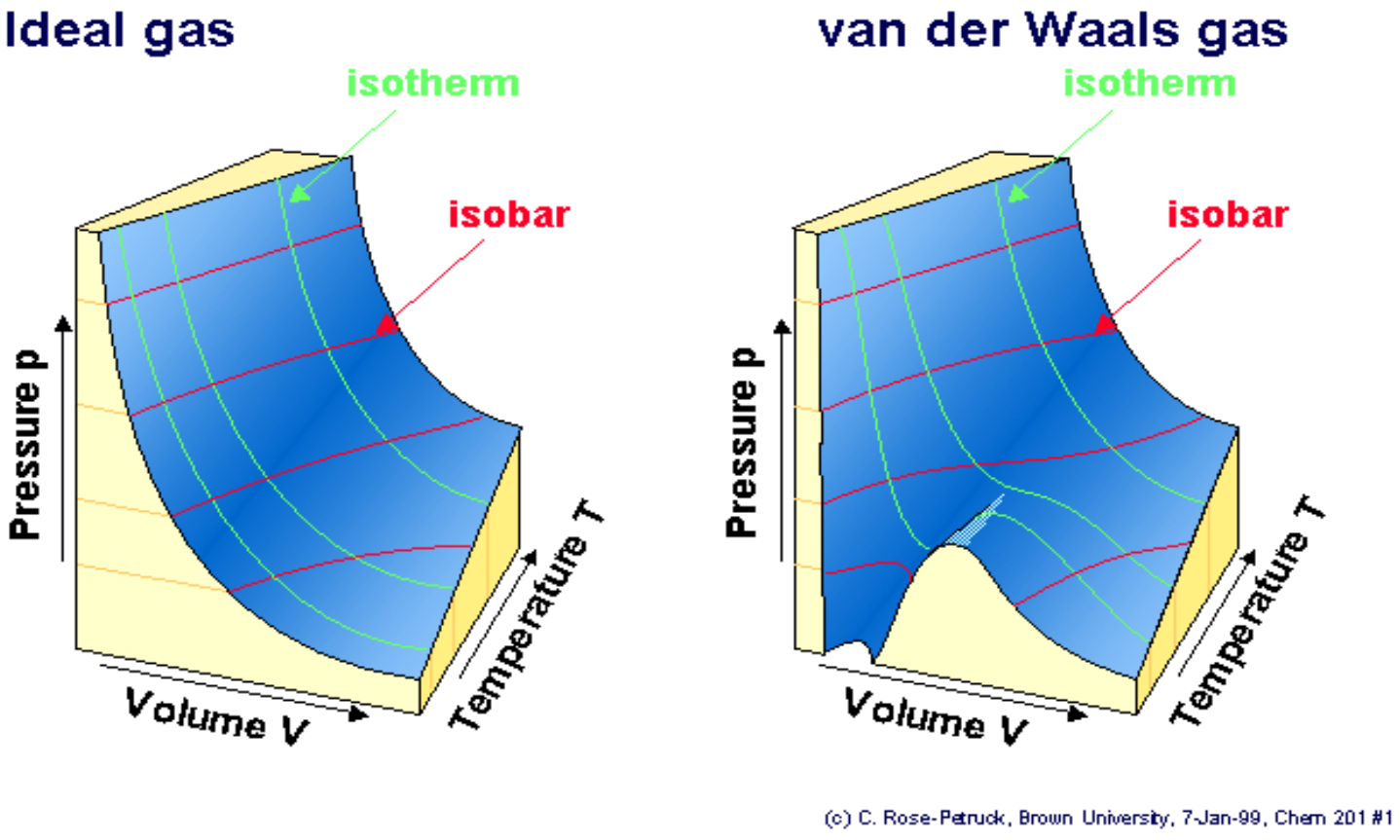
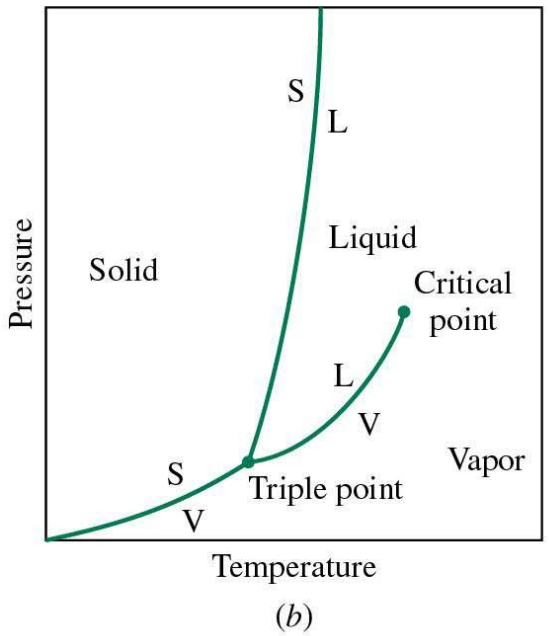
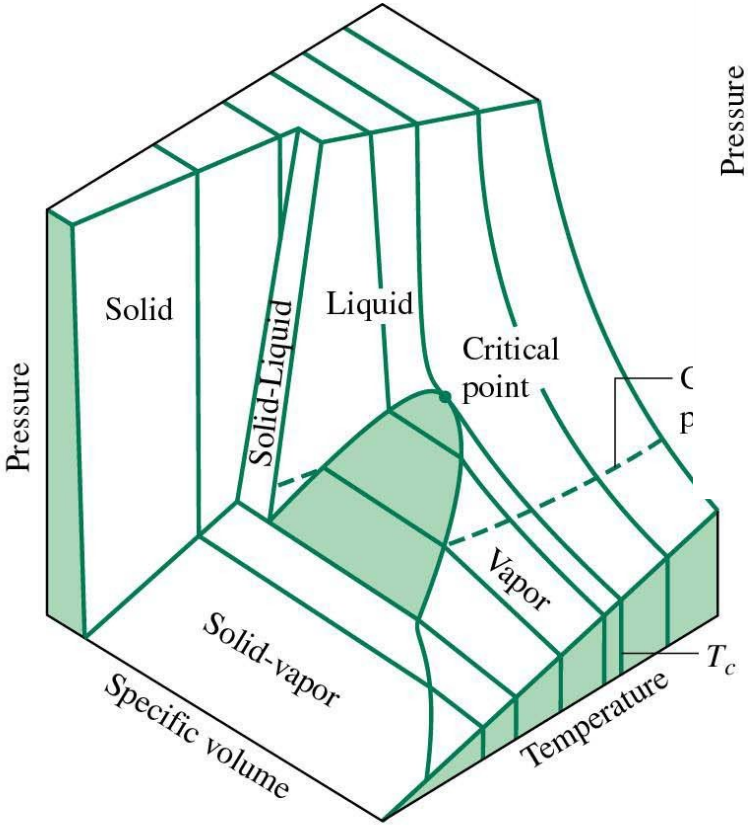
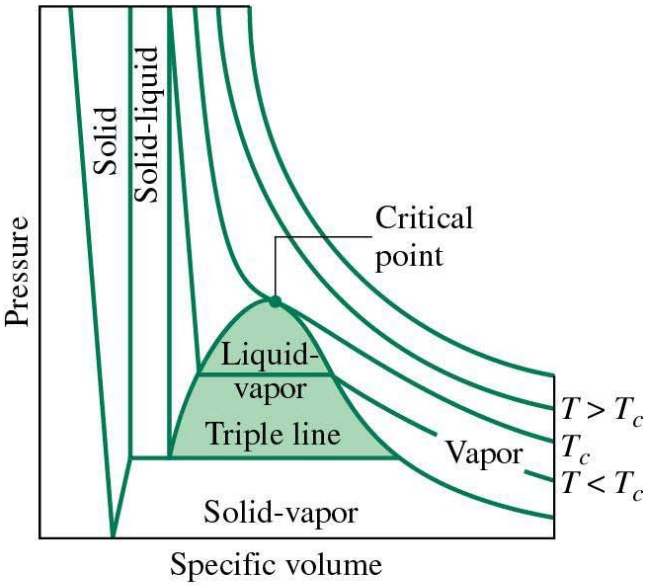


Diagrama PVT



(b)





(c)

PVT da água (esquemático)