## [pex17] Arrhenius behavior of viscosity of water

The viscosity $\eta$ of a fluid has been described to depend on temperature $T$ according to the relation,

$$\eta = \frac{G_0}{\nu}\, e^{\epsilon/k_B T},$$

where $\nu$ is a characteristic frequency of vibration, $\epsilon$ is a characteristic energy barrier for hopping processes, and $G_0$ is the shear modulus for the elastic response at high frequencies. Investigate the usefulness of this relation in the face of the following empirical data:

- Eleven data points (temperature in units of °C, viscosity in units of $10^{-4}$Pa s):
  (0,17.93), (10,13.07), (20,10.02), (30,7.98), (40,6.53), (50,5.47),
  (60,4.67), (70,4.04), (80,3.54), (90,3.15), (100,2.82).
- Shear modulus $G_0 \simeq 4 \times 10^9$Pa, the value of ice at 0°C.

(a) Plot $\ln \eta$ versus $1/k_B T$ along with a linear-model fit. Comment on the quality of the fit.
(b) Extract from the slope and the intercept estimates for $\nu$ and $\epsilon$.
(c) Does the value for $\nu$ make any sense?
(d) Compare the value of $\epsilon$ with the latent heat of vaporization $L_{\rm v}$ or the latent heat of melting $L_{\rm m}$ (per $H_2O$ molecule). Comment on your finding.

[adapted from Jones 2002]

**Solution:**