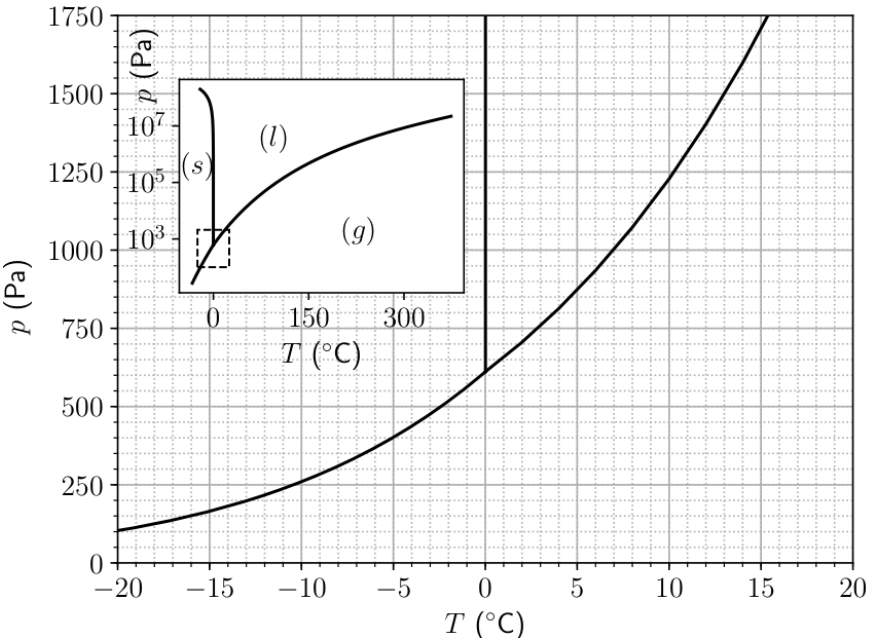
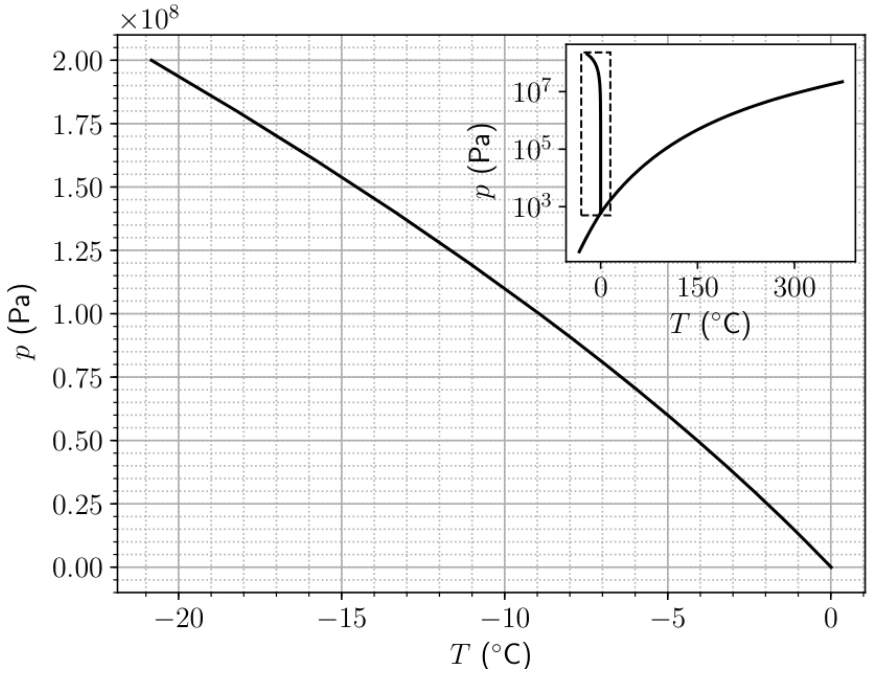
1. Phases of water (6 points) — *Johan Runeson.*

In this problem we will look at the phase diagram of water (see graphs on a separate page). The first figure shows the phase diagram in a region close to the triple point [(s) – solid, (l) – liquid, (g) – gas], while the second figure shows the melting curve. When two phases α and β are in equilibrium, the phase transition curve follows the law of Clausius–Clapeyron:

$$\frac{\mathrm{d}p}{\mathrm{d}T} = \frac{1}{T}\,\frac{H_\beta - H_\alpha}{V_\beta - V_\alpha},$$

where H_α is the specific enthalpy (enthalpy per mass) of phase α, and V_α is the specific volume (volume per mass).





i) *(1.5 points)* Using that $V_g \gg V_l$, find an expression for the liquid-gas transition curve $p(T)$ in terms of the latent heat of evaporation $\Delta H_{lg} \equiv H_l - H_g$, the pressure p_0 at any reference point along the curve, the gas constant R and the molar mass μ.

ii) *(1.5 points)* Approximate the Earth as a system of a homogeneous atmosphere, consisting of air and water vapor, in equilibrium with a sea of liquid water. If the

atmospheric temperature rises by 3 °C, by what percentage does the water vapor pressure rise? (The current temperature of the Earth is 15 °C.) You may need the values $R = 8.314\,\mathrm{J\,mol^{-1}\,K^{-1}}$ and $\mu = 18.015\,\mathrm{g\,mol^{-1}}$.

iii) *(3 points)* Use reasonable approximations and calculate $V_l - V_s$, the difference in specific volume between liquid water and ice, at atmospheric pressure.