10. VAPOUR PRESSURE

We construct a manometer by fixing the pipe into a "U" shape using the stand, and filling the tube partially with water. With a small trouble we should get the water to the bottom of "U" shape and then we can measure the pressure difference from differences of depth $\Delta p = \rho g \Delta h$. After we attach a bottle to one end, we should let the pressures equalise through a needle hole in the bottle. We then squirt the unknown liquid to the bottle and close the needle hole with tape as fast as possible. We then shake the bottle to hasten the vaporisation and write down the difference of depths Δh after it has reached a stable value. During all this we should be careful to heat the bottle with our body as little as possible.

If the volume would have been fixed we would get the vapour pressure directly from the manometer reading as according to Dalton's law. But since the diameter of the pipe was not that small we should take the relative volume increase to account.

If the depth difference is Δh, we have a relative increase of pressure $n_p = \dfrac{\rho g \Delta h}{p_0}$ and a relative increase of volume $n_V = \dfrac{S \Delta h}{2V_0}$. Assuming an ideal gas, this gives us relative molar increase

$$n_n = \frac{(1+n_p)(1+n_V)p_0V_0 - p_0V_0}{p_0V_0} \approx n_p + n_V.$$

Substituting in the given values we get

$$n_n \approx 0.0987\,\mathrm{m}^{-1} \times h + 0.00471\,\mathrm{m}^{-1} \times h \approx 0.1034\,\mathrm{m}^{-1} \times h.$$

Since all the molar increase is due to the vapour, we can get the vapour pressure (partial pressure exerted by vapour) by multiplying the pressure with the molar fraction of vapour $p_x = (p_0 + \Delta p)\dfrac{n_n}{1+n_n}$.

The unknown liquid was ethanol with vapour pressure of $p_x = 6.52\,\mathrm{kPa}$ at $21.6\,^\circ\mathrm{C}$. However, the grading scheme was not insistent on the exact value as it proved technically quite difficult to get it correct.