Chemistry 236 -- Quiz 9

Lab Day ___

October 31, 2007 — Thermal Expansivity

Pledge and signature:

Note: If you want your paper returned folded (*i.e.*, score concealed), please print your name on the back.

1. (2) A pycnometer is fitted with a capillary extension (like those in our laboratory) having an internal diameter of 1.00 mm. In the initial calibration with water, the capillary height is 17.7 mm above the zero level. Calculate the volume of water (cm^3) in the capillary.

   $0.0139\ cm^3$

2. (6) The apparent mass of the empty pycnometer and capillary extension is 22.379 g. Filled with water to capillary height 17.7 mm (as above), the apparent mass is 47.912 g. At the temperature of these measurements, the density of water is 0.998011 g/cm^3. The density of air may be taken as 1.19 mg/mL. Calculate the volume V_0 (*i.e.*, to the zero mark) (a) neglecting the buoyancy of air, and (b) taking it into account.

   (a) $m_{app} = 25.533$ g $\rightarrow$ $V_{app} = 25.584$ mL $\rightarrow$ $V_{0,app} = 25.570$ mL

   (b) $m_{air} = 0.0304$ g $\rightarrow$ $m = 25.563$ g $\rightarrow$ $V = 25.614$ mL $\rightarrow$ $V_0 = 25.600$ mL

3. (4) An unknown liquid is placed in this pycnometer, giving a capillary reading of 17.7 mm when the system is equilibrated at 27.43°C. When it is reequilibrated at 29.12°C, the capillary level is 47.1 mm. (a) Calculate the average α for this liquid over this temperature range. (b) What would be the best temperature to record for this estimate of α?

   (a) $\Delta V = \Delta h\, \pi\, r^2 = 0.02309$ mL

   $$\alpha = 1/V\,(\partial V/\partial T)_P \approx \frac{\Delta V}{V\ \Delta T} = \frac{0.02309}{25.6\ (1.69\ \mathrm{K})} = 5.34 \times 10^{-4}\ \mathrm{K}^{-1}$$

   (b) 28.28°C

4. (3) If each of the capillary measurements in (3) above is uncertain by 0.3 mm, and if this is the only significant source of uncertainty, what is the % uncertainty in the estimated value of α?

   $s_{\Delta h} = (0.3^2 + 0.3^2)^{1/2} = 0.42$ mm $\rightarrow$ rel. err in α = rel. err in Δh = 0.42/29.4 = 1.4%

5. (1) If the density of a fluid is represented as $\rho = \rho_0 \exp(bx + cx^2)$, where $x = t(°C) - 25°C$, what is the physical meaning of ρ_0?

   ρ_0 is the value of ρ when $x = 0$, i.e. $t = 25°C$.