Physics 2010
Fall 2005
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EXAM 4

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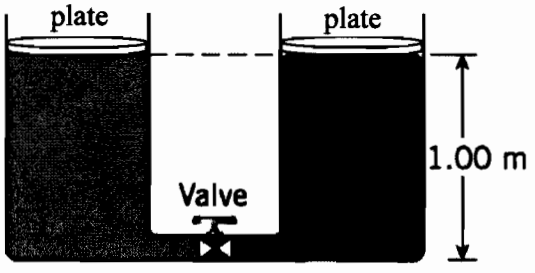
Two identical containers are connected at the bottom via a tube of negligible volume and a valve which is closed. Both containers are filled initially to the same height of 1.00 m, one with chloroform ($\rho_C = 1530$ kg/m^3) in the left chamber and the other with mercury in the right chamber ($\rho_{Hg} = 1.36 \times 10^4$ kg/m^3). Sitting on top of each identical circular container is a massless plate that can slide up or down without friction and without allowing any fluid to leak past. The radius of the circular plate is 12.0 cm. The valve is now opened.



A. *[20 pts.]* What volume of mercury drains into the chloroform container? (Note: $V_{cyl} = \pi r^2 h$) FIRST FIND h_{Hg}, THE HEIGHT OF Hg IN LEFT CHAMBER. $P_{Atm} + \rho_C g h_C + \rho_{Hg} g h_{Hg} = P_{Atm} + \rho_{Hg} g (1.00\text{m} - h_{Hg})$

$\rho_C g h_C + 2\rho_{Hg} g h_{Hg} = \rho_{Hg} g (1.00\text{m})$

$$h_{Hg} = \frac{g(1.00\text{m})(\rho_{Hg} - \rho_C)}{2\rho_{Hg} g} = \frac{(9.8\text{m/s}^2)(1\text{m})(1.36\times10^4 \frac{\text{kg}}{\text{m}^3} - 1.53\times10^3 \frac{\text{kg}}{\text{m}^3})}{(9.8\text{m/s}^2)\,2.72\times10^4 \text{kg/m}^3}$$

$h_{Hg} = 0.444\text{m}$

$V_{Hg} = \pi r^2 h_{Hg} = \pi (.12\text{m})^2 (.444\text{m})$

$$\boxed{V_{Hg} = 2.01\times10^{-2}\,\text{m}^3}$$

B. *[14 pts.]* What mass must be placed on the plate on the chloroform side to force all the mercury, but none of the chloroform, back to the mercury chamber? PRESSURE SUPPLIED BY MASS IS mg/A_{PLATE} $\therefore P_{Atm} + \frac{mg}{A_P} + \rho_C g (1.00\text{m}) = P_{Atm} + \rho_{Hg} g h_{Hg}$

$$m = \frac{\pi r^2 g (\rho_{Hg} - \rho_C)}{g} = \pi r^2 (\rho_{Hg} - \rho_C)(1.00\text{m})$$

$$= \pi (.12\text{m})^2 (1.36\times10^4 \text{kg/m}^3 - 1.53\times10^3 \text{kg/m}^3)(1.00\text{m})$$

$$\boxed{m = 546\,\text{kg}}$$