

The University of Calgary  
Department of Chemical & Petroleum Engineering

ENCH 501: Transport Processes Quiz #7

December 3, 2002

Time Allowed: 45 mins.

Name: \_\_\_\_\_

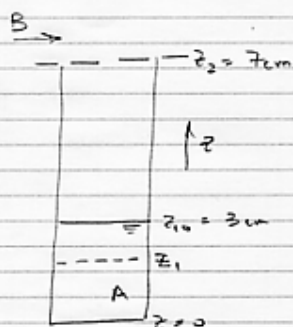
In a poorly organized laboratory, pure hydrocarbon liquids were placed in four unlabelled containers. From inventory, it is known that the liquids are isooctane, cyclohexane, benzene and n-hexane. You have been asked to identify one of the liquids poured into a test tube to a depth of 3 cm. The test tube is 7 cm long, is flat bottomed and it is placed vertically in a holder. A wire gauze is placed over the rim so that there are no convection currents in the tube. Air is blown across the mouth of the tube and this quickly diluted the diffusing vapor to a negligible concentration. The room and all its contents are maintained at a constant temperature of 20°C. The pressure is 680 mm Hg.

You noticed that after 34 hrs and 40 minutes the level of the liquid had dropped to 2 cm. The data below are also available in the laboratory. Determine which substance (of the list) would most likely be in the test tube. Assume the gas phase diffusion occurred at steady state and the liquid is fully saturated with air.

**Data:** Temperature equals 20°C.

Chemical Name	Formula	Mol. Wt. Kg/kmol	Liq. Density kg/m <sup>3</sup>	Vap. Pres mm Hg	Diffusivity m <sup>2</sup> /s
<i>iso-octane</i>	C <sub>8</sub> H <sub>18</sub>	114.224	702.2	10.46	6.3(10 <sup>-6</sup> )
<i>n-hexane</i>	C <sub>6</sub> H <sub>14</sub>	86.172	654.8	121.23	7.53(10 <sup>-6</sup> )
<i>cyclohexane</i>	C <sub>6</sub> H <sub>12</sub>	84.156	778	77.52	7.4(10 <sup>-6</sup> )
<i>benzene</i>	C <sub>6</sub> H <sub>6</sub>	78.108	889	65.78	9.2(10 <sup>-6</sup> )

Universal Gas Constant,  $R = 0.08205 \text{ (m}^3 \text{ atm)/(kmol.K)}$



This is a problem involving diffusion through a stagnant medium - air.

Let unknown liquid  $\equiv A$  and Air  $\equiv B$

Assume the rate of evaporation is slow and system is at steady state

From Notes, p 174, eq. 6.116, the material balance is

$$C D_{AB} \ln \frac{y_{B2}}{y_{B1}} = - \frac{P}{M_A} \frac{dz_1}{dt}$$

$$\text{or } (z_2 - z_1) \frac{dz_1}{dt} = \bar{r} \quad \text{where } \bar{r} = \frac{M_A C D_{AB}}{P} \ln \frac{y_{B2}}{y_{B1}}$$

subject to the initial condition

$$t=0 \quad z_1 = z_{1,0}$$

$$\text{Integrate to obtain } (z_1 - z_2)^2 - (z_{1,0} - z_2)^2 = 2 \bar{r} t$$

$$z_{1,0} = 0.03 \text{ m}, \quad z_1 = 0.02 \text{ m}, \quad z_2 = 0.07 \text{ m}, \quad t = 34 \text{ hrs } 40 \text{ min.}$$

$$\text{Substitute } \bar{r} = 3.6058 (10^{-9}) \text{ m}^2/\text{s} \quad \text{or } 124,800 \text{ s}$$

Now to identify the compound

$$c = \frac{P}{RT} = \frac{680/760}{0.08205(293.15)} = 0.0372 \frac{\text{kmol}}{\text{m}^3}$$

$$y_{A2} \approx 0 \quad (\text{with dilution}) \Rightarrow y_{B2} \approx 1$$

$$y_{A1} = P_{VP}/P \quad (\text{Raoult's Law}) \Rightarrow y_{B1} = 1 - P_{VP}/P$$

Substitute values for each chemical and calc.  $\bar{r}$

iso octane	$5.51 (10^{-9})$
n-hexane	$7.24 (10^{-9})$
cyclohexane	$3.604 (10^{-9})$
benzene	$3.059 (10^{-9})$

from this table, the most likely substance in tube is cyclohexane.