AP® CHEMISTRY
2004 SCORING GUIDELINES (Form B)

Question 2

2. Answer the following questions related to hydrocarbons.

(a) Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.

$n_C = 85.7 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 7.14 \text{ mol C}$ $n_H = 14.3 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 14.2 \text{ mol H}$ $\frac{7.14 \text{ mol C}}{7.14} : \frac{14.2 \text{ mol H}}{7.14}$	1 point for moles of C and moles of H
1 mol C : 1.99 mol H	1 point for ratio of moles of C to moles of H
The empirical formula is CH_2	1 point for correct formula

(b) The density of the hydrocarbon in part (a) is 2.0 g L^{-1} at 50°C and 0.948 atm.

(i) Calculate the molar mass of the hydrocarbon.

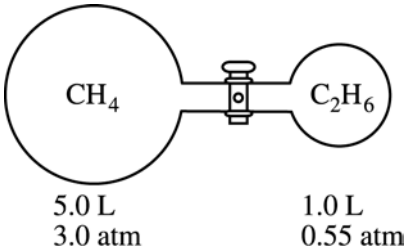
$PV = nRT = \frac{\text{mass}}{\text{molar mass}} RT$ $\text{molar mass} = \frac{\text{mass}}{V} \times \frac{RT}{P} = \text{density} \times \frac{RT}{P}$ $\text{molar mass} = 2.0 \text{ g L}^{-1} \times \frac{0.0821 \frac{\text{L atm}}{\text{mol K}} \times 323 \text{ K}}{0.948 \text{ atm}}$	1 point for correct substitution
molar mass = 56 g mol^{-1}	1 point for the answer

(ii) Determine the molecular formula of the hydrocarbon.

empirical mass $\times n$ = molar mass empirical mass for CH_2 = 14 g mol^{-1} 14 g $mol^{-1} \times n$ = 56 g mol^{-1} $n = 4$ The molecular formula is C_4H_8.	1 point for correct formula

Question 2 (cont'd.)

(c) Two flasks are connected by a stopcock as shown below. The 5.0 L flask contains CH_4 at a pressure of 3.0 atm, and the 1.0 L flask contains C_2H_6 at a pressure of 0.55 atm. Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.



P_f of $CH_4 = \frac{P_iV_i}{V_f} = \frac{(3.0\text{ atm})(5.0\text{ L})}{6.0\text{ L}} = 2.5\text{ atm } CH_4$	1 point for final pressure of CH_4 or C_2H_6
P_f of $C_2H_6 = \frac{P_iV_i}{V_f} = \frac{(0.55\text{ atm})(1.0\text{ L})}{6.0\text{ L}} = 0.092\text{ atm } C_2H_6$	
$P_T = P_f CH_4 + P_f C_2H_6 = 2.5\text{ atm} + 0.092\text{ atm} = 2.6\text{ atm}$	1 point for the total pressure

(d) Octane, $C_8H_{18}(l)$, has a density of 0.703 g mL^{-1} at 20°C. A 255 mL sample of $C_8H_{18}(l)$ measured at 20°C reacts completely with excess oxygen as represented by the equation below.

$$2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$$

Calculate the total number of moles of gaseous products formed.

$n_{\text{products}} = 255\text{ mL } C_8H_{18} \times \frac{0.703\text{ g } C_8H_{18}}{1\text{ mL } C_8H_{18}} \times \frac{1\text{ mol } C_8H_{18}}{114\text{ g } C_8H_{18}} \times \frac{34\text{ mol products}}{2\text{ mol } C_8H_{18}} = 26.7\text{ mol products}$	1 point for substitution of any of these conversion factors 1 point for the correct answer