



**AP<sup>®</sup> Chemistry**  
**2004 Sample Student Responses**  
**Form B**

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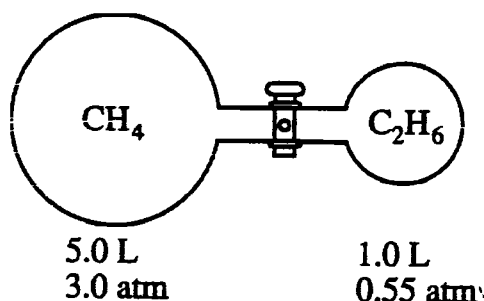
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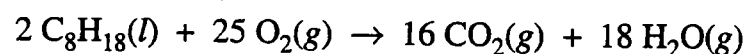
Answer EITHER Question 2 below OR Question 3 printed on page 12. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 20 percent.

2. Answer the following questions related to hydrocarbons.

- (a) Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.
- (b) The density of the hydrocarbon in part (a) is  $2.0 \text{ g L}^{-1}$  at  $50^\circ\text{C}$  and  $0.948 \text{ atm}$ .
- Calculate the molar mass of the hydrocarbon.
  - Determine the molecular formula of the hydrocarbon.
- (c) Two flasks are connected by a stopcock as shown below. The  $5.0 \text{ L}$  flask contains  $\text{CH}_4$  at a pressure of  $3.0 \text{ atm}$ , and the  $1.0 \text{ L}$  flask contains  $\text{C}_2\text{H}_6$  at a pressure of  $0.55 \text{ atm}$ . Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.



- (d) Octane,  $\text{C}_8\text{H}_{18}(l)$ , has a density of  $0.703 \text{ g mL}^{-1}$  at  $20^\circ\text{C}$ . A  $255 \text{ mL}$  sample of  $\text{C}_8\text{H}_{18}(l)$  measured at  $20^\circ\text{C}$  reacts completely with excess oxygen as represented by the equation below.



Calculate the total number of moles of gaseous products formed.

$$2a) \text{ C} = 85.7 \text{ g} / 12.01 = 7.14 \text{ mol} / 7.14 = 1.00$$

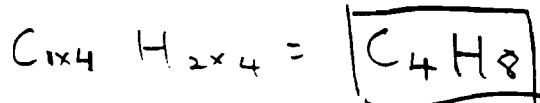
$$\text{ H} = 14.3 \text{ g} / 1.01 = 14.2 \text{ mol} / 7.14 = 2.00$$

$\boxed{\text{CH}_2}$  — empirical

$$b) i) \text{ PV} = nRT \quad 0.948 \times 1 = (2/\text{mm}) (0.0821) (323)$$

$$\text{ mm} = \boxed{55.99/\text{mol}}$$

$$ii) \text{ CH}_2 = 12.01 + 1.01 \times 2 = 14.03 \quad 55.9 / 14.03 = 3.98$$



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## QUESTION 2.

$$c) P_1 V_1 = P_2 V_2$$

$$3.0 \times 5.0L = P \times 6.0L \quad P = 2.5 \text{ atm} - \text{CH}_4$$

$$0.55 \times 1.0L = P \times 6.0L \quad P = 0.092 \text{ atm} - \text{C}_2\text{H}_6$$

$$P_{\text{total}} = 2.5 + 0.092 = \boxed{2.6 \text{ atm}}$$

$$d) 0.703 \times 255 = 179.1 \text{ g}$$

$$179.1 \text{ g} / (12.01 \times 2 + 1.01 \times 8) = 1.57 \text{ mol}$$

$$1.57 \times \frac{16}{2} = 12.56 \text{ mol CO}_2$$

$$1.57 \times \frac{18}{2} = 14.13 \text{ mol H}_2\text{O}$$

$$12.56 + 14.13 = \boxed{26.7 \text{ molS}}$$

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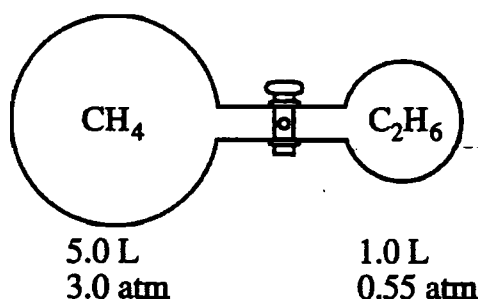
(a) Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.

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

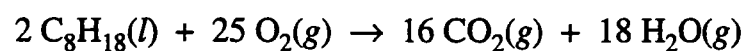
(i) Calculate the molar mass of the hydrocarbon.  $mm = \frac{dRT}{P}$

(ii) Determine the molecular formula of the hydrocarbon.  $\text{P}$

(c) Two flasks are connected by a stopcock as shown below. The  $5.0 \text{ L}$  flask contains  $\text{CH}_4$  at a pressure of  $3.0 \text{ atm}$ , and the  $1.0 \text{ L}$  flask contains  $\text{C}_2\text{H}_6$  at a pressure of  $0.55 \text{ atm}$ . Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.



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$$mm = \frac{dRT}{P} \quad \text{ass. } \text{P}$$

Calculate the total number of moles of gaseous products formed.

2.

$$\begin{aligned} \text{a) C: } & 85.7\text{g}/12.0\text{g} = 7.14 / 7.14 = 1 \\ \text{H: } & 14.3\text{g}/1.01 = 14.16/7.14 = 2 \end{aligned} \quad \boxed{\text{CH}_2} = \text{empirical}$$

$$\text{b) i) } mm = \frac{dRT}{P} = \frac{(2.0\text{g/L})(0.08206)(50+273)}{(0.948)} = \boxed{56. \text{g}}$$

ii)  $\text{CH}_2$

$$mm = 14.02$$

$$56/14.02 = 4$$

$$\text{molecular} = \boxed{\text{C}_4\text{H}_8}$$

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## ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

$$c) P_T = P_{CH_4} + P_{C_2H_6}$$

$$P_T = (3.00 \text{ atm} / 5.00 \text{ L}) + (0.55 \text{ atm} / 1.00 \text{ L})$$

$$P_T = 0.6 + 0.55$$

$$P_T = 1.15 \text{ atm in 6 L of gas}$$

$$1.15 \times 6 = \boxed{6.9 \text{ atm}}$$

$$d) \frac{0.703 \text{ g}}{1 \text{ mL}} \times 255 \text{ mL} = 179.3 \text{ g } C_8H_{18}$$

$$\text{mm } C_8H_{18} = 114.2$$

$$179.3 \text{ g} / 114.2 \text{ g} = 1.57 \text{ moles } C_8H_{18}$$

$$1.57 \text{ moles } C_8H_{18} \times \frac{16 \text{ moles } CO_2}{2 \text{ moles } C_8H_{18}} = 12.56 \text{ moles } CO_2$$

$$1.57 \text{ moles } C_8H_{18} \times \frac{18 \text{ moles } H_2O}{2 \text{ moles } C_8H_{18}} = 14.13 \text{ moles } H_2O$$

$$\text{Total moles} = CO_2(g) + H_2O(g)$$

$$= 12.56 + 14.13$$

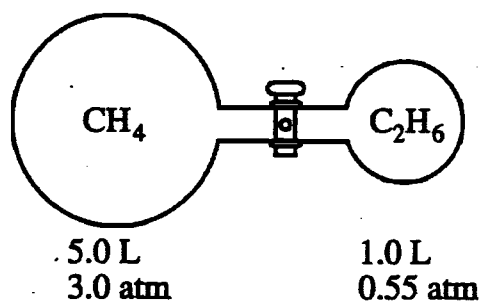
$$= \boxed{26.7 \text{ moles}} \text{ of gaseous products formed}$$

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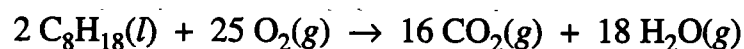
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Calculate the total number of moles of gaseous products formed.

(a) Hydrocarbon  $\rightarrow$  Carbon and Hydrogen atoms

85.7 percent Carbon  $\rightarrow$  85.7 g C

$$85.7 \text{ g C} \times \frac{1 \text{ mol C}}{12 \text{ g C}} = 7.14 \text{ mol C} / 7.14 = 1 \text{ mol C}$$

$$14.3 \text{ g H} \times \frac{1 \text{ mol H}}{1 \text{ g H}} = 14.3 \text{ mol H} / 7.14 = 2 \text{ mol H}$$

Empirical Formula  $\Rightarrow$   $\text{CH}_2$

Cycloalkane

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## ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

(b)

(i) Density = 2.0 g/L

$T = 50^\circ\text{C} + 273 = 323\text{K}$

$P = 0.948\text{ atm}$

$$D = \frac{(P)(MM)}{(R)(T)}$$

$$(2.0\text{ g/L}) = \frac{(0.948\text{ atm})(MM)}{(0.082)(323)}$$

$$MM = \frac{(2.0)(0.082)(323)}{(0.948)} = 55.9\text{ g}$$

$$MM = 55.9\text{ g}$$

(ii) Molecular Formula

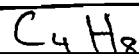
$C = 12\text{ g}$

$\text{CH}_2 = 14\text{ g}$

$H = 1\text{ g}$

$\text{C}_3\text{H}_6 = 42\text{ g}$

$\text{C}_4\text{H}_8 = 4(12) + 8(1) = 56$



(c)  $PV = nRT$

$V = 6.0\text{ L}$

$$P = \frac{nRT}{V}$$

(d)  $\text{C}_x\text{H}_y$ 

$D = 0.703\text{ g/mL}$

$V = 255\text{ mL}$

$T = 20^\circ\text{C}$

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