CollegeBoard
Advanced Placement Program

AP® Chemistry
2004 Sample Student Responses
Form B

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.

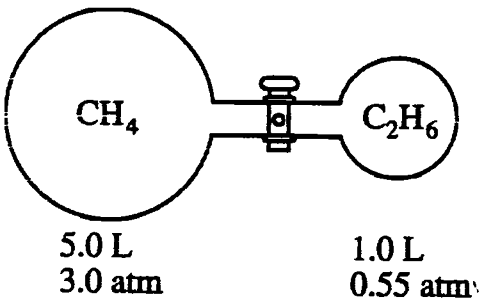
   (a) Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.

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

      (i) Calculate the molar mass of the hydrocarbon.

      (ii) Determine the molecular formula of the hydrocarbon.

   (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.



   (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.

2a) C - 85.7g / 12.01 = 7.14 mol / 7.14 = 1.00

H - 14.3g / 1.01 = 14.2 mol / 7.14 = 2.00

CH_2 - empirical

b) i PV = nRT 0.948 × 1 = (2/mm)(0.0821)(323)

mm = 55.9 g/mol

ii CH_2 = 12.01 + 1.01×2 = 14.03 55.9 / 14.03 = 3.98

$C_{1\times4}\ H_{2\times4}$ = C_4H_8

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QUESTION 2.

c) $P_1V_1 = P_2V_2$

$3.0 \times 5.0L = P \times 6.0L$ $P = 2.5atm - CH_4$

$0.55 \times 1.0L = P \times 6.0L$ $P = 0.092atm - C_2H_6$

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

d) $0.703 \times 255 = 179.g$

$179g / (12.01 \times 8 + 1.01 \times 18) = 1.57 mol$

$1.57 \times 16/2 = 12.56 mol\ CO_2$

$1.57 \times 18/2 = 14.13 mol\ H_2O$

$12.56 + 14.13 = \boxed{26.7 mols}$

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

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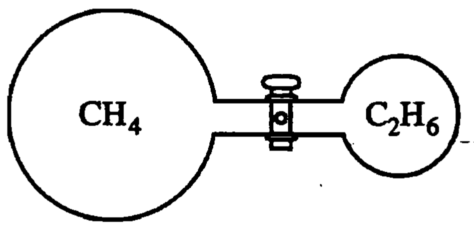

5.0 L
3.0 atm

1.0 L
0.55 atm

(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.

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mm= $\frac{dRT}{P}$

Calculate the total number of moles of gaseous products formed.

2.

a) C: 85.7g/12.0g = 7.14 /7.14 = 1

H: 14.3g/1.01 = 14.16/7.14 = 2

CH_2 = empirical

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

ii) CH_2

mm= 14.02 56/14.02 = 4

molecular = C_4H_8

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

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

$P_T = (3.00 atm / 5.00 L) + (0.55 atm / 1.00 L)$

$P_T = 0.6 + 0.55$

$P_T = 1.15$ atm in 6L of gas

$1.15 \times 6 =$ 6.9 atm

d) $\frac{0.703 g}{1 mL} \times 255 mL = 179.3 g$ C_8H_{18} mm C_8H_{18} = 114.2

179.3g / 114.2g = 1.57 moles C_8H_{18}

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

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

total moles = $CO_{2(g)} + H_2O_{(g)}$

= 12.56 + 14.13

= 26.7 moles of gaseous products formed

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2C,

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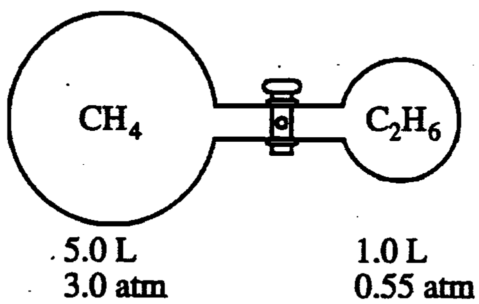

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Calculate the total number of moles of gaseous products formed.

(a) Hydrocarbon -> Carbon and Hydrogen atoms

∴ 85.7 percent Carbon -> 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 => CH_2 Cycloalkane

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2.

(b)

(i) Density = 2.0 g/L

T = 50°C + 273 = 323 K

P = 0.948 atm

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

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

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

MM = 55.9 g

(ii) Molecular Formula

C = 12 g $CH_2 = 14g$

H = 1 g $C_3H_6 = 42g$

$C_4H_8 = 4(12) + 8(1) = 56$

C_4H_8

(c) PV = nRT V = 6.0 L

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

(d) C_8H_{18}

D = 0.703 g/mL V = 255 mL

T = 20°C

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