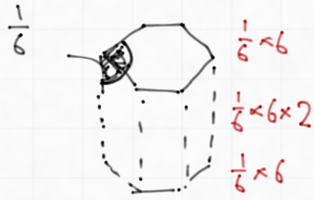
京都大学2023

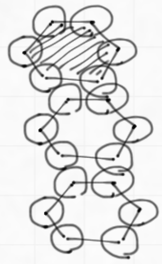


1

問1 ファンデルワールス

問2 体積 $5.1\times 10^{-16}\times 6.7\times 10^{-8}\ \mathrm{cm^3}$ 中に $\frac{1}{6}\times 6\times 4 = 4$コの炭素原子が含まれているので密度は

$$\frac{\cancel{12}^{\,2}}{6.0\times\cancel{10^{23}}}\times 4\times\frac{1\quad\times 10}{5.1\times\cancel{10^{-16}}\times 6.7\times\cancel{10^{-8}}} = \frac{80}{5.1\times 6.7} = 2.34\cdots = \mathbf{2.3\ g/cm^3}$$



問3 3層で $5.1\times 10^{-16}\times 2\ \mathrm{cm^2}$ に対し、$\frac{1}{6}\times 6\times 6 = 6$コの原子

(単位格子と異なり、上、下層の炭素原子が多い)

したがって単位質量あたりの面積は

$$\frac{5.1\times 10^{-16}\times 2}{\frac{12}{\cancel{6.0\times 10^{23}}}\times\cancel{6}} = \frac{5.1}{6}\times 10^{7} = \mathbf{8.5\times 10^{6}}\ \mathrm{cm^2/g}$$

問4

Fe_2O_3	Fe_3O_4	FeO	Fe
$+3$	$+\frac{8}{3}$	$+2$	0

$$3Fe_2O_3 + \overset{a}{1}\cdot\overset{イ}{CO} \rightleftarrows \overset{b}{2}\cdot\overset{ウ}{Fe_3O_4} + \overset{c}{1}\cdot\overset{エ}{CO_2}$$

$$Fe_3O_4 + \overset{d}{1}\cdot CO \rightleftarrows \overset{e}{3}\ FeO + \overset{f}{1}\cdot CO_2$$

$$FeO + \overset{g}{1}\cdot CO \rightleftarrows Fe + \overset{h}{1}\cdot CO_2$$

$$C + \overset{i}{1}\cdot CO_2 \rightleftarrows \overset{j}{2}\ CO$$

問5 $1.0 = \dfrac{P_{CO_2}}{P_{CO}}$, $42\times 10^{3} = \dfrac{P_{CO}^{2}}{P_{CO_2}}$

$P_{CO}\cdots 100\times 10^{3}\times x$, $P_{N_2}\cdots 100\times 10^{3}y$, $P_{CO_2}\cdots 100\times 10^{3}(1-x-y)$

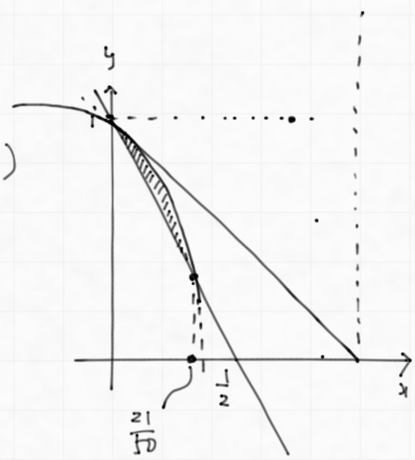
$\dfrac{P_{CO_2}}{P_{CO}} < 1.0$ のとき、$\dfrac{P_{CO_2}}{P_{CO}} = 1.0$ となるように (3)の反応は右にすすむ

$$\frac{P_{CO_2}}{P_{CO}} = \frac{1-x-y}{x} < 1.0 \iff y \overset{オ}{>} -2x\overset{カ}{+1}$$

$\dfrac{P_{CO}^{2}}{P_{CO_2}} < 4.2\times 10^{4}$ のとき、(4)式の反応が右にすすむ

$$\frac{P_{CO}^{2}}{P_{CO_2}} = \frac{100\times 10^{3}x^{2}}{1-x-y} < 4.2\times 10^{4} \iff 10x^{2} < 4.2(1-x-y)$$

$$\iff 1-x-y > \frac{100}{42}x^{2} \iff y \overset{キ}{<} -\frac{50}{21}x^{2}\overset{ク}{-x}+1$$



問6 $x>0$, $y>0$, $1-x-y>0$

$-\frac{50}{21}x^{2}-x+\cancel{1} = -2x+\cancel{1} \iff 50x^{2}-21x=0$ $x = 0, \frac{21}{50}$

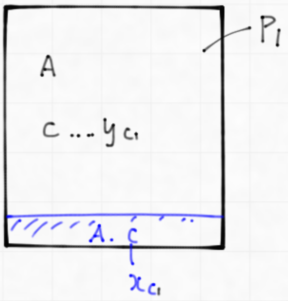
$x=\frac{21}{50}$ のとき $y=\frac{4}{25}$ ∴ $y<\frac{4}{25}=0.16$ のとき、条件を満たす気体組成は存在しない

2

問1 蒸気圧降下

問2 イ. $\Delta P = x_c P_A$　ウ $P = P_A - \Delta P = (1-x_c)P_A$　エ $x_c P_c$

問3



$$\begin{cases} P_1 = (1-x_{c_1})P_A + x_{c_1}P_c \\ \dfrac{x_{c_1}P_c}{P_1} = y_{c_1} \end{cases} \Leftrightarrow \quad y_{c_1} = \overset{(オ)}{\frac{P_c}{P_1}} x_{c_1}$$

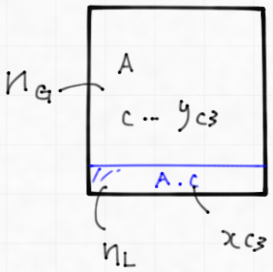
上の式より

$$x_{c1} = \frac{P_1 - P_A}{P_c - P_A} \text{ を代入} \quad y_{c1} = \frac{P_c}{P_1} \times \overset{(カ)}{\frac{P_1 - P_A}{P_c - P_A}}$$

最終的には $y_{c1} \to x_{c0}$ となるので $x_{c0} = \dfrac{P_c}{P_2} \times \dfrac{P_2 - P_A}{P_c - P_A}$

問4　$(P_c + x_{c0}P_A - x_{c0}P_c)P_2 = P_cP_A$

$$P_2 = \frac{\overset{(キ)}{P_cP_A}}{P_c - \underset{(ク)}{(P_c - P_A)}x_{c0}}$$



問5

$$n_G y_{c3} + n_L x_{c3} = (n_G + n_L)x_{c0}$$

$$y_{c3} + \frac{n_L}{n_G}x_{c3} = x_{c0} + \frac{n_L}{n_G}x_{c0}$$

$$\frac{n_L}{n_G} = \frac{y_{c3} - x_{c0}}{x_{c0} - x_{c3}} \quad (ケ)$$

$n_G = n_L$ のとき　$y_{c3} - x_{c0} = x_{c0} - x_{c3}$

$$y_{c3} = 2x_{c0} - x_{c3} = \frac{P_c}{P_3} \times \frac{P_3 - P_A}{P_c - P_A}$$

これを P_3 の式に代入

$$P_3 = (1 - x_{c3})P_A + x_{c3}P_c$$

$$= P_A + (P_c - P_A) \times \left(2x_{c0} - \frac{P_c}{P_3} \times \frac{P_3 - P_A}{P_c - P_A}\right)$$

$$= P_A + 2x_{c0}(P_c - P_A) - \frac{P_c}{P_3}(P_3 - P_A)$$

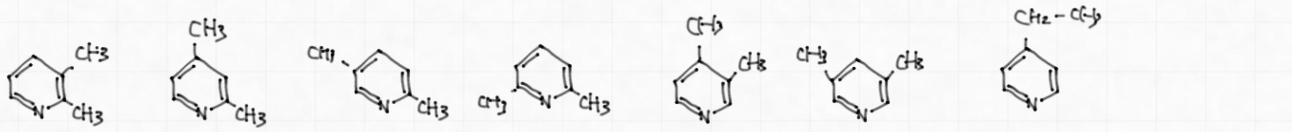
$$P_3^2 = P_AP_3 + 2x_{c0}P_3(P_c - P_A) - P_c(P_3 - P_A)$$

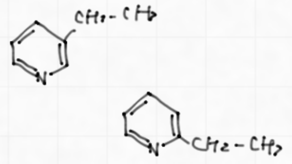
$$P_3^2 - \left(2x_{c0}(P_c - P_A) + P_c - P_A\right)P_3 - P_AP_c = 0$$

$$P_3 = \frac{\overset{(コ)}{(2x_{c0}+1)}(P_c - P_A) + \sqrt{(2x_{c0}+1)^2(P_c - P_A)^2 + 4P_AP_c}}{2}$$

3 問1 安息香酸

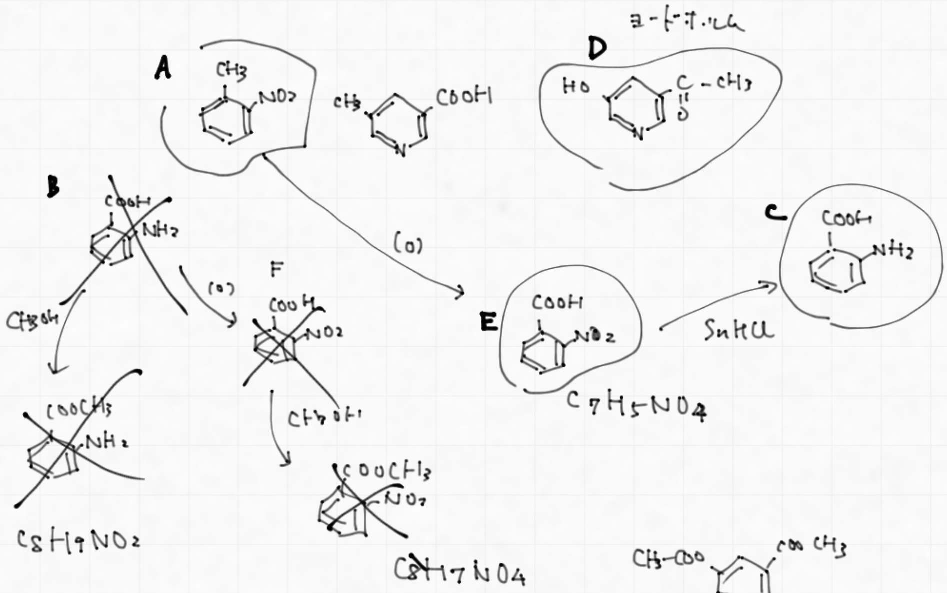
問2

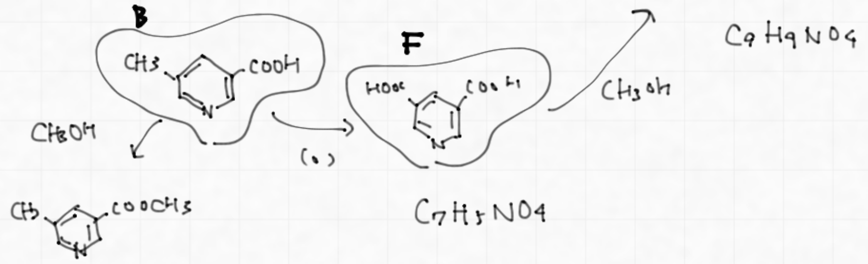




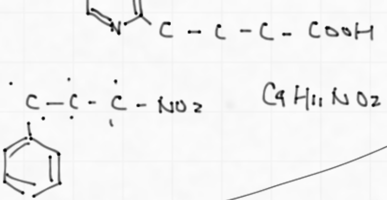
9コ

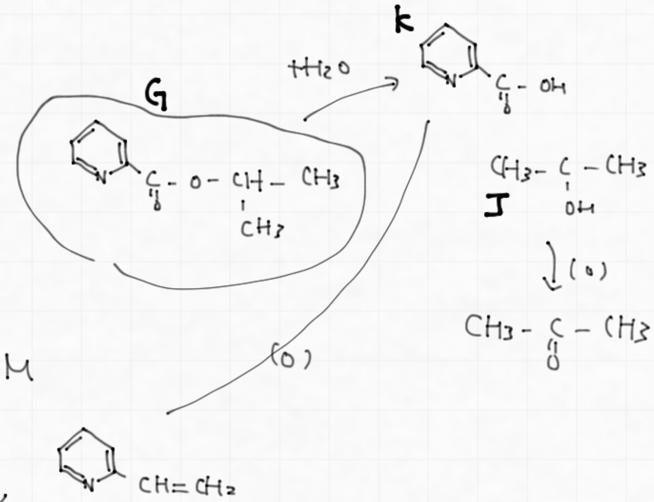
問3

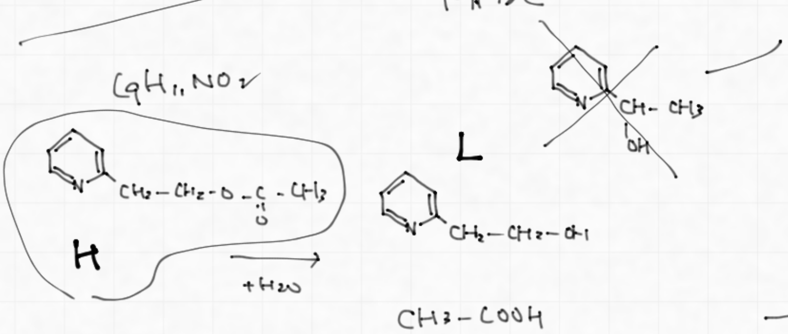




試しに書いてみる…

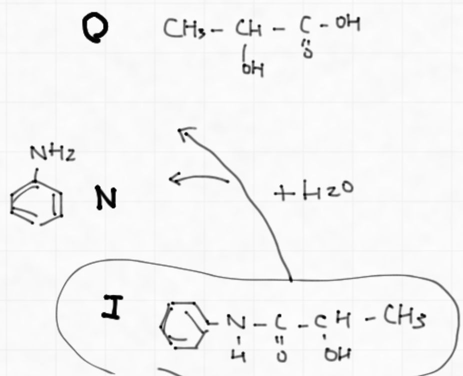






$C_3H_6O_3$ 不斉 ⇒ 乳酸

$C_9H_{11}NO_2$
+) H_2O
−) $C_3H_6O_3$
C_6H_7N



4

問1

$C-C-C-COOH$ (1 2 3)

$C-C(COOH)-C$ (4 5 4)

4 $CH_3-CH(COOH)-CH_2-NH_2$

5 $CH_3-C(NH_2)(COOH)-CH_3$

1 $H_2N-CH_2-CH_2-CH_2-COOH$

2 $\left(CH_3-CH(NH_2)-CH_2-COOH \right)$

3 $CH_3-CH_2-CH(NH_2)-COOH$

問2

A $\underbrace{H_2N-CH(R_1)-CONH-CH(R_2)-COOH}$

$$\begin{array}{l} C_7H_{12}N_2O_5 \\ C_4H_6N_2O_3 \leftarrow \\ \hline C_3H_6O_2 \end{array}$$

$-COOH$ あり… X_1は酸性アミノ酸.

$$\begin{array}{l} C_5H_9NO_4 \\ +)\ H_2O \times 2 \\ -)\ CH_4O \times 2 \\ \hline C_3H_5NO_4 \end{array}$$

X_1 $H_2N-CH(COOH)-COOH$

問3

Aは不斉炭素を1つしか持たないので

X_1の$COOH$でペプチド結合していない.

$HOOC-CH(COOH)-NH-C(=O)-CH(CH_2-CH_3)-NH_2$

$$\begin{array}{l} C_3H_6O_2 \\ -)\ COOH \\ \hline C_2H_5 \end{array}$$

X_2 $H_2N-CH(CH_2-CH_3)-COOH$

問4

B … 289 　 $Y_1,\ Y_2,\ Y_2$

$$\begin{array}{l} C_4H_9NO_2 \\ +)\ H_2O \\ -)\ CH_4O \\ \hline C_3H_7NO_2 \\ \quad = 89 \end{array}$$

Y_1 $H_2N-CH_2-CH_2-COOH$

$$1 \times \frac{250}{1000} \times 2 = n \times 0.1 + 1 \times \frac{300}{1000} \times 1$$

$$0.1n = \frac{200}{1000} \qquad n = 2 \ \ldots \ NH_2 \times 2$$

$$\frac{289 + 18 \times 2 - 89}{2} = 118$$

Y_2 $H_2N-CH(CH_2-CH_2-NH_2)-COOH$

$H_2N-CH-COOH$ … 74

$CH_2-CH_2-NH_2$ … 44

118