# 항공 열역학 과제

2019 1010174    안용상

4.32  $C_{10}H_{18} + \frac{29}{2} O_2 \rightarrow 10 CO_2 + 9 H_2O$.
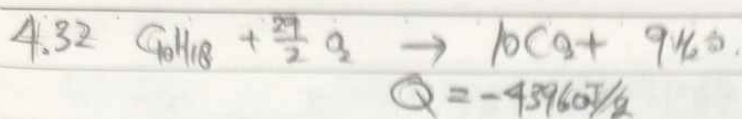
$$Q = -43960 \, J/g$$

$MW_{C_{10}H_{18}} = 138 \, g/mol$

$$Q = -43960 \, J/g \times \frac{138 \, g}{mol} = 6066480 \, J/mol$$

$dH = dU + d(PV)$
$\quad = dU + PdV + VdP$

$dU = dQ + dW$
$\quad = dQ - PdV$

$\Rightarrow dH = dQ - PdV + PdV + VdP$
$\quad = dQ + VdP \Rightarrow dH = Q + VdP$
$\qquad\qquad\qquad = Q + \Delta n \times RT$

$\Delta H^\circ_{298} = Q + \Delta n \times RT$

① $Q = -6066480 \, J/mol$

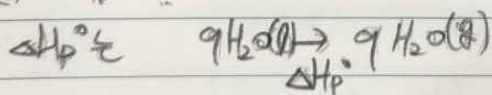② $\Delta n \times RT$ ?           $\Delta H^\circ_{298} = -6057808.498 \, J/mol$

$\Delta n = \frac{7}{2} \, mol$

$\Delta n \times RT = \frac{7}{2} \times 8.314 \times 298$

$\Delta H^\circ = \Delta H^\circ_{298} + \Delta H_P^\circ$

③ $\Delta H_P^\circ = ?$

$\Delta H_P^\circ \quad 9 H_2O(l) \xrightarrow{\quad} 9 H_2O(g)$
$\qquad\qquad\qquad \Delta H_P^\circ$

$\Delta H_P^\circ = 9 \times \left( \Delta H_{f_{H_2O(l)}} - \Delta H_{f_{H_2O(g)}} \right)$

$\quad = 9 \times (285830 - 241818)$

$\quad = 395928 \, J/mol$

$\therefore \Delta H = \Delta H^\circ_{298} + \Delta H_P^\circ = -5661880.498 \, J/mol$

$\qquad\qquad\qquad\qquad = -5661.88 \, kJ/mol$

4.35  320°C   1atm
　　공정 : Ethylene 기체 + 수증기 ★58리운동요

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(l)$$
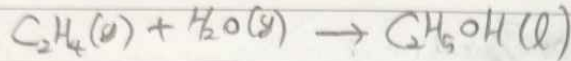
　유출문 : 액체 에탄올
생성 에탄올 (몰기대비 이 공정 전체의 연관된 발전들량은?

$T = 320 + 273.15 = 593.15 \,K$

$p = 1\,atm$

$\Delta H° = \Delta H°_{298} + \Delta H°_p$

① $\Delta H°_{298} = \sum \nu_x \Delta H°_{f_x} = \Delta H_{f_{C_2H_5OH(l)}} - \Delta H_{f_{H_2O}} - \Delta H_{f_{C_2H_4}}$

$$= -277690 + 241818 - 52510$$

$$= -88382 \; J/mol$$

② $\Delta H°_p = R\int_{T_0}^{T} \frac{\Delta C_p}{R} dT = R\left( \Delta A(T-T_0) + \frac{\Delta B}{2}(T^2-T_0^2) + \frac{\Delta C}{3}(T^3-T_0^3) + \frac{\Delta D(T-T_0)}{TT_0} \right)$

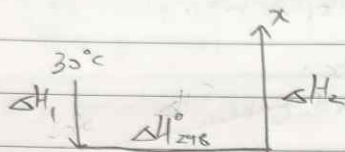| | A | B | C | D |
|---|---|---|---|---|
| $H_2O$ (g) | 3.470 | $1.450 \times 10^{-3}$ | | $0.121 \times 10^5$ |
| $C_2H_4$ (g) | 1.424 | $14.394 \times 10^{-3}$ | $-4.392 \times 10^{-6}$ | |
| $\Delta$ | $\Delta A$ | $\Delta B$ | $\Delta C$ | $\Delta D$ |
| | 4.894 | $15.8 \times 10^{-3}$ | $-4.392 \times 10^{-6}$ | $-0.12 \times 10^5$ |

$= -27149.9 \; J/mol$

$\Delta H° = \Delta H°_{298} + \Delta H_p = -88382 - 27149.9 = -115531.9 \; J/mol$

4.37

$\frac{DEF}{202}$ $\boxed{30°C}$     $\begin{bmatrix} CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \\ C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \end{bmatrix}$

$\begin{cases} CH_4 & 0.75\,mol \\ C_2H_6 & 0.25\,mol \\ O_2 = 4.275\,mol \\ N_2 = 16.082\,mol \end{cases}$ $\xrightarrow{\hspace{1cm}}$ $\begin{array}{ll} CO_2 & 1.25\,mol \\ H_2O & 2.25\,mol \\ O_2 & 1.9\,mol \\ N_2 & 16.082\,mol \end{array}$

30°C

$\Delta H_1 \downarrow$    $\Delta H^°_{298}$    $\uparrow^x$   $\Delta H_2$

① $\Delta H^°_{298} = 0.75\,\Delta H^°_{rxn01} + 0.25\,\Delta H^°_{rxn02}$

$= 0.75 \times \left( \Delta H_{f_{H_2O}} \times 2 + \Delta H_{f_{CO_2}} - \Delta H_{f_{CH_4}} \right) + 0.25 \times \left( \Delta H_{f_{H_2O}} \times 3 + \Delta H_{f_{CO_2}} \times 2 - \Delta H_{f_{C_2H_6}} \right)$

$= 0.75 \times \left( 2 \times (-241818) + (-393509) + 74520 \right) + 0.25 \times \left( 3 \times (-241818) + 2 \times (-393509) + 83820 \right)$

$= -959131 \; J/mol$

⊖ $\Delta H_1 = \int_{303}^{298} \Delta C_p\,dT = R \int_{303}^{298} \Delta C_p\,dT$

| | A | B | C | D |
|---|---|---|---|---|
| $CH_4$ | 1.702 | $9.08 \times 10^{-3}$ | $-2.16 \times 10^{-6}$ | 0 |
| $C_2H_6$ | 1.131 | $1.92 \times 10^{-2}$ | $-5.56 \times 10^{-6}$ | 0 |
| $O_2$ | 3.369 | $5.06 \times 10^{-9}$ | 0 | $-2.27 \times 10^{4}$ |
| $N_2$ | 3.28 | $5.93 \times 10^{-9}$ | 0 | $4.0 \times 10^{3}$ |
| | $\Delta A$ | $\Delta B$ | $\Delta C$ | $\Delta D$ |
| | 68.70541 | 0.023389 | $-3.01 \times 10^{-6}$ | -32722.5 |

$\Delta H_1 =$

$R \times \left( 68.70541 \times (5) \times (-1) + \dfrac{0.023307}{2} \times (298^2 - 303^2) + \dfrac{-3.01 \times 10^{-6}}{3} \times (298^3 - 303^3) + \dfrac{32722.5\,(+5)}{298 \times 303} \right)$

$= -3120 \; J/mol$

$\Delta H_2^\circ = ?$

$\Delta H^\circ = \Delta H_{298}^\circ + \Delta H_1^\circ + \Delta H_2^\circ = -800000 \, J/mol$

$$\Delta H_2^\circ = \int_{298}^{x} \Delta C_p \, dT = -800000 + 3120 + 959132$$
$$= 162252.893 \, J/mol$$

|  | A | B | C | D |
|----|------|----------|---|-----------|
| $O_2$ | 3.369 | $5.06 \times 10^{-4}$ | 0 | $-2.27 \times 10^4$ |
| $N_2$ | 3.28 | $5.95 \times 10^{-4}$ | 0 | $4 \times 13$ |
| $CO_2$ | 5.457 | $1.05 \times 10^{-3}$ | 0 | $-1.16 \times 10^5$ |
| $H_2O$ | 3.47 | $1.45 \times 10^{-3}$ | 0 | $1.21 \times 10^5$ |

| $\Delta A$ | $\Delta B$ | $\Delta C$ | $\Delta D$ |
|-----------|----------|------|--------|
| 173.77225 | 0.015066 | 0 | -9620 |

$\langle \Delta C_p \rangle_R (x - 298) = 162252.893$

$x = 298 + \dfrac{162252.893}{\langle \Delta C_p \rangle_R} \quad \cdots \quad ①$

$\langle \Delta C_p \rangle_R = R \times \left( \Delta A + \dfrac{\Delta B}{2}(x+298) + \dfrac{\Delta C}{3}(x^2 + 298x + 298^2) + \dfrac{\Delta D}{298x} \right)$

⇒ 휴대용계산기를 이용해서 반복계산 $\langle \Delta C_p \rangle_R$ 를 ① 속에 연량대후

⇒ $x = 543.44$

∴ $T = 543.4 k = 1℃,$

4.40

| 공급/wc | 3mol | 8 | 6mol 8 | | 생성물 100몰기준 | |
|---|---|---|---|---|---|---|
| C 0.85 | 14.8mol | 1017.6 | 208.74 | | $CO_2$ | 3mol |
| $H_2$ 0.12 | 12.536mol | | | | CO | 11.8mol |
| $N_2$ 0.03 | 0.1992mol | | | | $O_2$ | $x=5.88$ |
| $H_2O$ 0.01 | 0.116mol | | | | $N_2$ | $100-14.8-x$ $=85.2-x=79.17$ |

공기:
$O_2$ $x+8.9+12.536/2 = x+15.168 = 21.048$
$N_2$ $85.2-x+0.1492 = 85.0508-x = 79.1708$
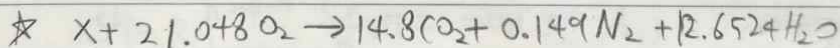$H_2O$ 3.23 mol

$H_2O(g)$ $3.23+0.116+12.5364$
$= 15.8824$

Dry Air $= x+15.168+85.0508-x$
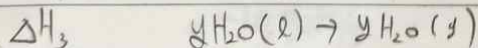$= 100.2188$ mol

$x+15.168 = 100.2188 \times 0.21$

$x = 5.88$

압력 1atm    Humidity $= \dfrac{\text{포화수증기압}}{\text{대기압}-\text{포화수증기압}} = \dfrac{H_2O \text{ mole}}{\text{Dry Air mole}}$

$H_2O$ mole $= 100.2188 \times \left(\dfrac{3.166}{101.325-3.166}\right) = 3.23$ mol.

증기로 증발하는 $H_2O$를 날리하고

$X + 15.168\, O_2 \rightarrow 3\,CO_2 + 11.8\,CO + 0.149\,N_2 + 12.6524\,H_2O$
$11.8\,CO + 5.9\,O_2 \rightarrow 11.8\,CO_2$
☆ $X + 21.048\, O_2 \rightarrow 14.8\,CO_2 + 0.149\,N_2 + 12.6524\,H_2O$
↳ $\Delta H_1 = Q = -19000\ BTU/lb_m$

$\Delta H_2$    $11.8\,CO_2 \rightarrow 11.8\,CO + 5.9\,O_2$
$\Delta H_3$    $y\,H_2O(l) \rightarrow y\,H_2O(g)$
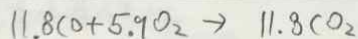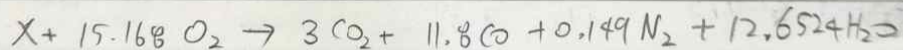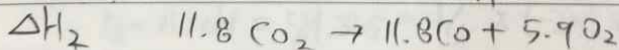
$\Delta H_{298} = \Delta H_1 + \Delta H_2 + \Delta H_3 = -3.913\times10^6 + 1.436\times10^6 + 1.89\times10^4 y$

$Q = \Delta H = \Delta H_{298} + \Delta H_P$

$-0.3\times19000\ \dfrac{BTU}{lb_m} \times 209.1327\,lb_m = -1.192\times10^6\ BTU$

$\Delta H_P = Q - \Delta H_{298} = 134500 - 1.89\times10^4 y$

$$\Delta H_p = \int_{298}^{477} C_p \, dT = R \int_{298}^{477} \frac{C_p^\circ}{R} \, dT$$

|       | A      | B             | C | D              |
|-------|--------|---------------|---|----------------|
| $CO_2$ | 5.457 | $0.45\times10^{-3}$ | | $-1.157\times10^5$ |
| $CO$  | 3.376  | $0.557\times10^{-3}$ | | $-0.031\times10^5$ |
| $O_2$ | 3.639  | $0.506\times10^{-3}$ | | $-0.227\times10^5$ |
| $N_2$ | 3.280  | $0.593\times10^{-3}$ | | $0.040\times10^5$ |
| $H_2O$ | 3.470 | $1.450\times10^{-3}$ | | $0.121\times10^5$ |

|  $\Delta A$  |  $\Delta B$  |  $\Delta D$  |
|-------------|--------------|--------------|
| 342.9384 | $82.74\times10^{-3}+$ | $0.0733\times10^5$ |
| $+3.47y$ | $1.45\times10^{-3}y$ | $+0.121\times10^5y$ |

$$\therefore \Delta H_p = 632581.8 + 6126.942 y$$

$$(632581.8 + 6126.942y) \times 453.59237 y$$

$$= (286934277.9 + 2779134.143y) \, J$$

$$= (271796.183 + 2643.110552y) \, BTU$$

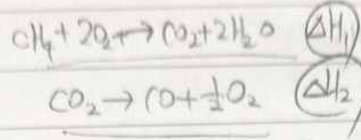$$\therefore 134500 - 1.89\times10^4 y = 271796.183 + 2643.110552 y$$

$$y = 49.824173$$

$$\therefore 49.824173 \, lb_m \; H_2O가 \; 증발$$

4-44

$410°F = (410-32) \times \frac{5}{9} + 273 = 483 K$

$CH_4$ 0.94

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$  $\Delta H_1$

$N$ 0.06

$CO_2 \rightarrow CO + \frac{1}{2}O_2$  $\Delta H_2$

$\begin{cases} CO_2 & 0.658 \\ CO & 0.282 \\ H_2O & 1.88 \\ N_2 & 9.6 \\ O_2 & 0.658 \end{cases}$

$O_2$  $(0.94 \times 2) \times 1.35$
$= 2.538$

$N_2 = 9.54$

$T_0 = 77°F = 298 K$

표 읽어 열량 받는 경량 $Q$, $203F = \frac{(203-32)}{9} \times 5 + 273 = 368$

$$\dot{Q} = R \int_{298}^{368} \frac{C_p}{R} dT = R\left(A(70) + \frac{B}{2}(368^2-298^2) + \frac{C}{3}(368^3-298^3) + \frac{D(70)}{368 \times 298}\right)$$

| $H_2O$ | A | B | C | D |
|---|---|---|---|---|
| | 8.712 | $1.25 \times 10^{-3}$ | | $-0.18 \times 10^{6}$ |

$\therefore -\dot{Q} = \dot{n}\Delta H° = \dot{n}(-802625 + 74675)$
$= -5300.8$

$\dot{Q} = 5300.8 \text{ J/mol}$   $\dot{n} = 7.28 \times 10^{-3} \text{ mol/s}$

$\dot{Q} = Q \times \dot{m} = 5300.8 \frac{J}{mol} \times \frac{1500 \text{m}}{s} \times \frac{1 \text{mol}}{18 \text{g}} \times \frac{453.592 \text{g}}{1 \text{lbm}} = 10016.823 \text{ kJ/s}$

$\dot{Q} = \dot{n}\Delta H° = \dot{n}(\Delta H_{298} + \Delta H_p°)$

$\frac{10016823}{674.6 - 114}$   $10135 Pa$   $\times 298$

① $\Delta H_{298}° = \Delta H_1 \times 0.94 + \Delta H_2 \times 0.94 \times 0.3$

$\Delta H_1 = 2\Delta H_{f_{H_2O}} + \Delta H_{f_{CO_2}} - \Delta H_{f_{CH_4}} = 2 \times (-241818) + (-393509) + 74520$
$= -802625 \text{ J/mol}$

$\Delta H_2 = \Delta H_{f_{CO}} - \Delta H_{f_{CO_2}} = -110525 + 393509 = +282984 \text{ J/mol}$

$\Delta H_{278}° = -674666.012 \text{ J/mol}$

② $\Delta H_p = R \int \frac{\langle \Delta C_p \rangle_i}{R} dT = 74675 \text{ J/mol}$

| | | A | B | C | D |
|---|---|---|---|---|---|
| 0.658 | $CO_2$ | 5.457 | $1.045 \times 10^{-3}$ | | $-1.157 \times 10^{5}$ |
| 0.282 | $CO$ | 3.376 | $0.557 \times 10^{-3}$ | | $-0.031 \times 10^{5}$ |
| 1.88 | $H_2O$ | 3.47 | $1.45 \times 10^{-3}$ | | $0.121 \times 10^{5}$ |
| 9.6 | $N_2$ | 3.28 | $0.593 \times 10^{-3}$ | | $0.04 \times 10^{5}$ |
| 0.658 | $O_2$ | 3.639 | $0.506 \times 10^{-3}$ | | $-0.227 \times 10^{5}$ |
| | | 45.02 | $9.59 \times 10^{-3}$ | | $-0.3079 \times 10^{5}$ |

$$R\left(45.02(483-298) + \frac{9.59 \times 10^{-3}}{2}(483^2-298^2) - 0.3079 \times 10^{5} \times \frac{483-298}{483 \times 298}\right) = 74675 \text{ J/mol}$$

$$\therefore -\dot{Q} = \dot{n} \left( \Delta H_p^{\circ} + \Delta H_{298}^{\circ} \right)$$

$$-1016.823 = \dot{n} \left( 174.675 + (-674.67) \right)$$

$$\dot{n} = 16.695 \, mol/s$$

$$V = \frac{\dot{n}RT}{P} = \frac{16.695 \times 8.314 \times 298}{101325 \, pa} \left[ \frac{mol}{s} \cdot \frac{pa \cdot m^3}{k \cdot mol} \cdot k \right]$$

$$= 0.40798 \, m^3/s \quad 이다$$

4.47 (a)

$\underline{PV = nRT}$

$T_0 = 307.594$     $T = 293.15k$

$R = 1.61 \times 10^{-3} atm \cdot ft^3/mol \cdot Runkine$

$n = \dfrac{PV}{RT_0} = 0.1237 \, lbmol/s$

$\quad\quad\quad A \quad\quad B \quad\quad C \quad\quad D$

$ATr = \overset{ln=}{3.355} \quad 0.575 \times 10^{-3} \quad\quad -0.016 \times 10^{5}$

$\Delta H = R \displaystyle\int_{307.594}^{293.15} \dfrac{C_p}{R} \, dT = -423.613 \, J/gmol$

$-423.613 \, J/gmol \times \dfrac{9.47 \times 10^{-4} BTU}{1J} \times \dfrac{1g}{2.2 \times 10^{-3} lb_m} = -182.346 \, BTU/lbmol$

$Q = n \times \Delta H = 0.1237 \, lbm/s \times (-182.346 \, BTU/lbmol) = -22.5562 \, BTU/s$

(b) $T_0 = 308.15k$     $T = 298.15k$

$R = 0.205 \times 10^{5} \, atm \cdot m^3/mol \cdot k$

$V = 1.5 m^3/sec$

$n = \dfrac{PV}{RT_0} = 59.325 \, mol/s$

위의 걸과 똑같기 떄문

$\Delta H = R \displaystyle\int_{278.15}^{308.15} \dfrac{C_p}{R} \, dT = -291.979 \, J/mol$

$Q = n \times \Delta H = 59.325 \, mol/s \times (-291.979 \, J/mol) = -17321.7 \, J/s$

$\quad\quad\quad = -17.32 \, kJ/s$

5) (a) $T_s = 298.15k$    $T = 523.15k$    $Q = 11500 J/mol$

| | A | B | C | D |
|---|---|---|---|---|
| $CH_4$ | 1.702 | $9.081 \times 10^{-3}$ | $-2.16 \times 10^{6}$ | |
| $C_2H_6$ | 1.131 | $19.225 \times 10^{-3}$ | $-5.561 \times 10^{6}$ | |

$CH_4$   $\Delta H = 8.314 \left[ 1.1702 \Delta T + \frac{9.081 \times 10^{-3}}{2}(523.15^2 - 298.15^2) + \frac{-2.16 \times 10^{6}}{3}(523.15^3 - 298.15^3) \right]$

$= 9459.99 \; J/mol$

$C_2H_6$   $\Delta H = 15085.88 J/mol$

$Q = 11500 J/mol = 9459.99 \times x + 15085.886 \times (1-x)$

$5625.896 x = 3585.886$

$x = 0.631739$

∴ $CH_4 = 0.631739$

∴ $C_2H_6 = 0.36261$


4.52   $\dot{m}_{H_2O} \Delta H_{H_2O} = -\dot{n}_{Air} \Delta H_{Air}$

$T_{H_1} = 1273.15 k$    $T_{H_2} = 308.15k$

$T_{v_1} = 298.15k$    $T_{out} = 373.15k$

(H₂O)   $\Delta H = \Delta H_{liquid} + \Delta H_{vapor} + \Delta H_{evap}$

| | A | B | C |
|---|---|---|---|
| $H_2O$ | 8.712 | $1.25 \times 10^{-3}$ | $-0.18 \times 10^{-6}$ |

$\Delta H_{liquid} = 8.314 \left[ 8.712 (373.15 - 298.15) + \frac{1.25 \times 10^{-3}}{2}(373.15^2 - 298.15^2) \right.$

$\left. - \frac{0.18 \times 10^{-6}}{3}(373.15^3 - 298.15^3) \right]$

$= 5681.288 J/mol$

$\Delta H_{vap} = 0$

$\Delta H_{evap} = 40626 J/mol$

$\Rightarrow \Delta H = 46307.288 J/mol$

(Air)        A         B         C         D
        3.355    0.575×10⁻³    0    −0.016×10⁷

$$\Delta H = 8.314\left[3.355(308.15-1273.15)+\frac{0.575\times10^{-3}}{2}(308.15^2-1273.15^2)\right.$$
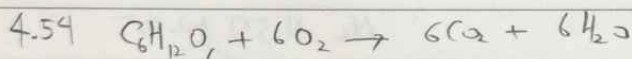$$\left.+(-0.016\times10^5)\left(\frac{1}{1273.15}-\frac{1}{308.15}\right)\right]=-30531.73\ J/mol$$

$$\frac{\dot{m}_{H_2O}}{\dot{n}_{Air}}=\frac{-\Delta H_{Air}}{\Delta H_{H_2O}}=\frac{-30531.93}{46277.28}=0.6593$$

(b) 배기결과에서 공기의 1273.15k를 1773.15k로 비교 주어

$$\Delta H_{Air}=-14146.3415\ J/mol$$

$$\Delta H_{H_2O}=5681.288\ J/mol$$

$$\therefore\quad \frac{\dot{m}_{H_2O}}{\dot{n}_{Air}}=\frac{+14146.3415}{5681.288}=0.30548\ g$$

4.54   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

$$\Delta H_{rxn}=6\times\Delta H_{fH_2O}+6\times\Delta H_{fCO_2}-\Delta H_{fC_6H_{12}O_6}$$

(a)    $=-2801.6\ kJ/mol$

b)  $150^{kJ}/hr \times 57hy=8550\ kJ$

$$\frac{8550\ kJ}{2801.6\ kJ/mol}=3.0518\ mol$$

$$3.0518\ mol\times180.16\ g/mol=549.812\ g$$

(C)   Glucose 3.0518 mol 로부터 $CO_2$ 18.3168 mol 배출

$18.3108\times44=805.6752\ g$

Total $CO_2$ 배출량 : $805.6752\ g\times2.75\times10^8$

$$=2.217\times10^8\ g\ /day$$

4.55

(a)    $CH_4$   $0.85 mol$    $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \cdots ①$    $H_2O$

     $C_2H_6$   $0.10 mol$    $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \cdots ②$    $CO_2$

     $N_2$   $0.05 mol$      $N_2$

$\Delta H^\circ_{c,298} = 0.85 \times \Delta H^\circ_① + 0.1 \times \Delta H^\circ_②$
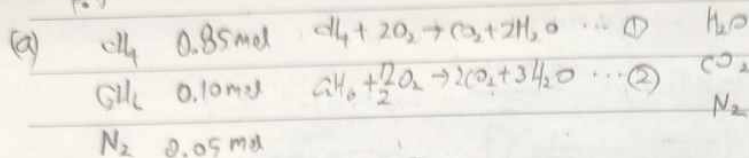
$= 0.85 \times \left( \Delta H_{f_{CO_2}} + 2\Delta H_{f_{H_2O}} - \Delta H_{f_{CH_4}} \right) + 0.1 \times \left( 2\Delta H_{f_{CO_2}} + 3\Delta H_{f_{H_2O}} - \Delta H_{f_{C_2H_6}} \right)$

$= 1.05 \Delta H_{f_{CO_2}} + 1.25 \Delta H_{f_{H_2O}} - 0.85 \Delta H_{f_{CH_4}} - 0.1 \Delta H_{f_{C_2H_6}}$

$= 1.05(-393509) + 1.25 \times (-241818) - 0.85(-74520) - 0.1(-83820)$

$= -825.096 \text{ kJ/mol}$
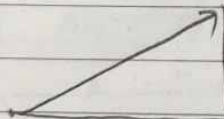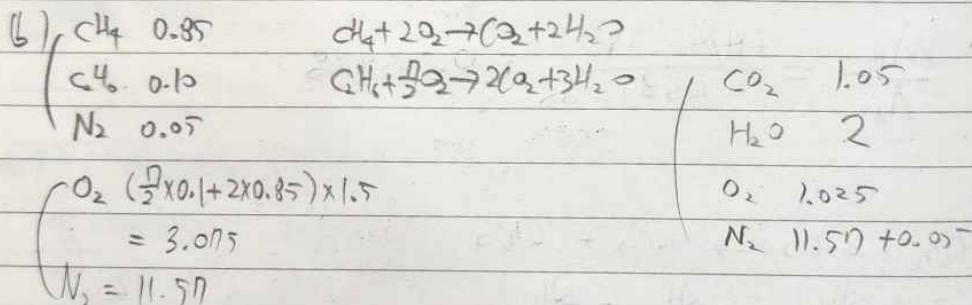
(b) $\begin{cases} CH_4 & 0.85 \\ C_2H_6 & 0.10 \\ N_2 & 0.05 \end{cases}$    $\begin{array}{l} CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \\ C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O \end{array}$    $\begin{array}{ll} CO_2 & 1.05 \\ H_2O & 2 \end{array}$

$\begin{cases} O_2 \; (\frac{7}{2} \times 0.1 + 2 \times 0.85) \times 1.5 \\ \quad = 3.075 \\ N_2 = 11.57 \end{cases}$      $\begin{array}{ll} O_2 & 1.025 \\ N_2 & 11.57 + 0.05 \end{array}$



| | A | B | C | D |
|---|---|---|---|---|
| $CO_2$ | 5.457 | $1.045 \times 10^{-3}$ | | $-1.157 \times 10^5$ |
| $H_2O$ | 3.47 | $1.45 \times 10^{-3}$ | | $0.121 \times 10^5$ |
| $O_2$ | 3.639 | $0.506 \times 10^{-3}$ | | $-0.227 \times 10^5$ |
| $N_2$ | 3.28 | $6.593 \times 10^{-3}$ | | $0.04 \times 10^5$ |

$\Delta H^\circ = \Delta H^\circ_{298} + \Delta H^\circ_P$

$\oplus \Delta H^\circ_P = ?$

| | $\Delta A$ | $\Delta B$ | | $\Delta D$ |
|---|---|---|---|---|
| | $=7.5069$ | $=0.0114$ | | $=-174080.5$ |

$R \int_{298}^{873} \frac{\left( \frac{C_p}{R} \right)}{R} dT =$

$8.314 \left( 7.5069 \left( 873 - 298 \right) + \frac{0.0114}{2} (873^2 - 298^2) - \frac{174080.5 (873 \times 298)}{873 \times 298} \right)$

$= 291129.499 \text{ J/mol}$

$Q = \Delta H^\circ_{298} + \Delta H^\circ_P = -825.096 + 291.1295 = -533.9665 \text{ kJ/mol}$