이름 : **학생번호 :**

이름 : **학생번호 :**

문제 1 총점(100점)의 7.5%

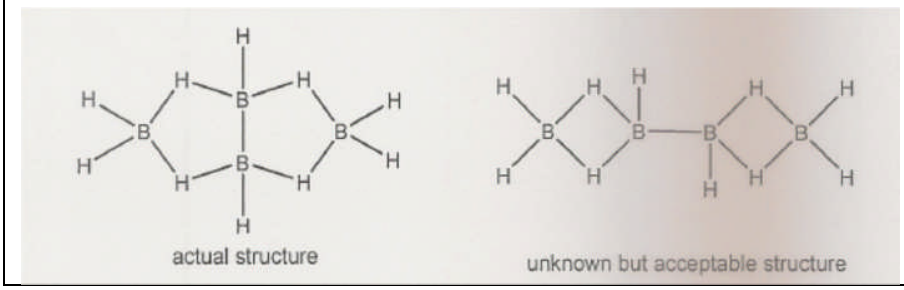
a–i	a–ii	a-iii	b	c	문제 1	7.5%
4	2	2	2	10	20	

a.

i.

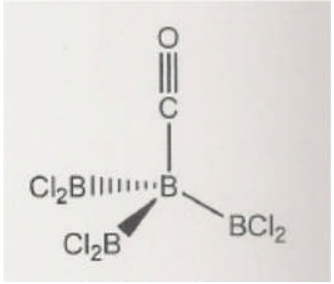
A = _____ B_5H_{11}_____ B = _____ $B_{10}H_{14}$_____

ii.

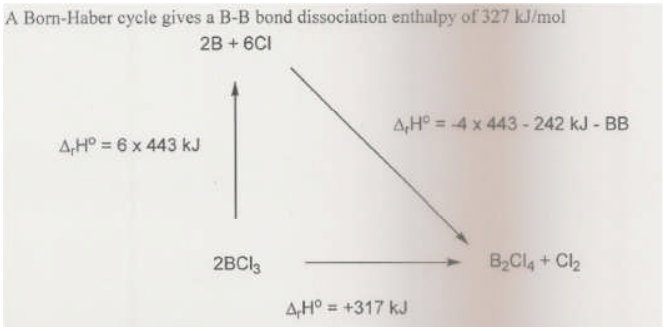


iii.

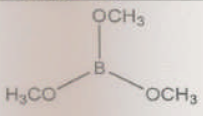
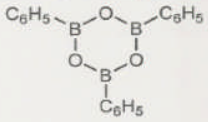
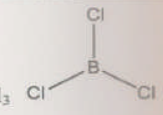
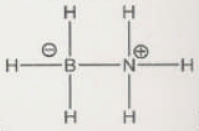
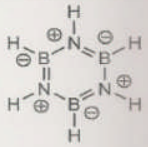
구조:



b.



c.

Number	Molecular Structure of Compound
1	$B(OCH_3)_3$ 
2	 A dimer or tetramer $[C_6H_5BO]_x$ are also acceptable (x = 2, 4).
3	BCl_3 
4	BNH_6  Formal charges not necessary
5	$B_3N_3H_6$  Formal charges not necessary

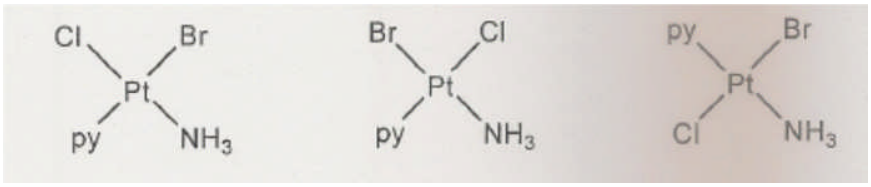
이름 : **학생번호 :**

문제 2 총점(100 점)의 7.8%

a–i	a–ii	b-i	b-ii	c	문제 2	7.8%
4	4	6	1	5	20	

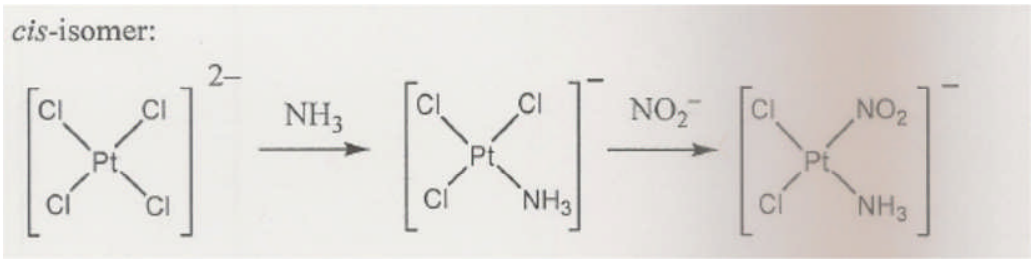
a. 백금(II) 화합물, 이성질체, 트랜스 효과(*Trans* Effect).

i.

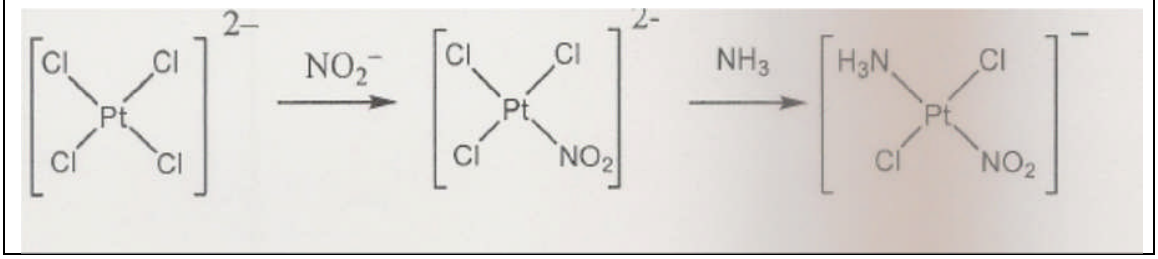


iii.

cis-이성질체:



trans-이성질체:



이름 : **학생번호 :**

b.

i.

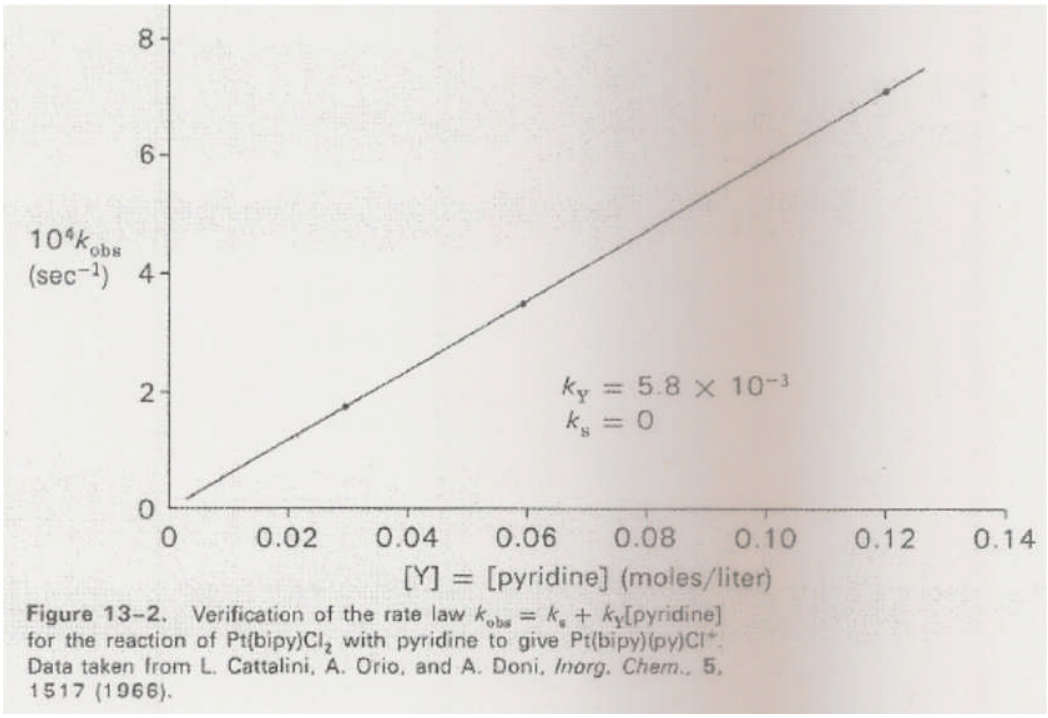


Figure 13–2. Verification of the rate law $k_{obs} = k_s + k_Y$[pyridine] for the reaction of Pt(bipy)Cl_2 with pyridine to give Pt(bipy)(py)Cl^+. Data taken from L. Cattalini, A. Orio, and A. Doni, *Inorg. Chem.*, 5, 1517 (1966).

$k_Y = 5.8 \times 10^{-3}\ s^{-1}M^{-1}$
$k_S = 0\ s^{-1}$ (allow small range of values, $\pm 0.2 \times 10^{-3}$)
6 points
1 point for each unit
1 point for each number
2 points for method

ii.

	대부분의 피리딘 생성물은 용매-도움(k_s) 치환반응 경로에 의하여 생성된다.
v	대부분의 피리딘 생성물은 직접 치환반응(k_Y) 경로에 의하여 생성된다.
	동등한 양의 생성물이 두 반응경로에 의하여 생성된다.
	두 반응경로에 의해 생성되는 생성물의 상대적인 양은 결정할 수 없다.

이름 : **학생번호 :**

c. 화학요법제

백금 질량

a) Amount of Pt used = (1.0 x 10^{-6} mol/1000 mL)(1.0 mL) = 1.0 x 10^{-9} mol Pt

This is equivalent to **2.0 x 10^{-7} g Pt**

금 질량

b) (90 groups/nanoparticle)(0.98 Pt bound complexes)

= 88 Pt complexes/nanoparticle or 88 Pt atoms per nanoparticle

c) 1.0 x 10^{-9} mol Pt is equivalent to 6.0 x 10^{14} Pt atoms

d) (6.0 x 10^{14} Pt atoms)(1 nanoparticle/88 Pt atoms) = 6.8 x 10^{12} nanoparticles

e) Size of gold nanoparticles:

Radius = 6.5 x 10^{-7} cm and volume of gold nanoparticle = 1.2 x 10^{-18} cm^3

Mass of gold nanoparticle = 2.3 x 10^{-17} g

Amount of gold in a nanoparticle = 1.2 x 10^{-19} mol

Atoms of gold in a nanoparticle = 7.1 x 10^{4} atoms

f) Mass of gold:

Total number of gold atoms = (6.8 x 10^{12} particles)(7.1 x 10^{4} atoms/particle)

= 4.8 x 10^{17} atoms of gold

Equivalent to **1.5 x 10^{-4} g gold**

이름 : **학생번호 :**

문제 3 총점(100 점)의 7.5%

a	b	c-i	c-ii	문제 3	
4	12	6	12	34	7.5%

a.

Multiplying the mass action laws for the four given reactions produces:

$$\frac{MoO_4^{2-}(H_2S)^4}{MoS_4^{2-}} = \frac{1\times10^{-7}(1\times10^{-6})^4}{MoS_4^{2-}} = 1.4\times10^{-20}$$

$[MoS_4^{2-}]$ = 7×10^{-12} Units: M

3 pts for correct MoS_4^{2-} answer; 1 pt correct units

b.

MoS_4^{2-} concentration is determined by absorbance at 468 nm:
$0.365 = (11870)(10.0)(MoS_4^{2-})$. $(MoS_4^{2-}) = 3.08\times10^{-6}$ M 4 pt

From conservation of Mo,
$(MoOS_3^{2-}) + (MoO_2S_2^{2-}) = Mo_{Total} - (MoS_4^{2-}) = 6.0\times10^{-6} - 3.08\times10^{-6} = 2.9\times10^{-6}$

By rearrangement,
$(MoO_2S_2^{2-}) = 2.9\times10^{-6} - (MoOS_3^{2-})$

From optical absorbance at 395 nm,

$0.213 = (120)(10.0)(3.08\times10^{-6}) + (9030)(10.0)(MoOS_3^{2-}) + (3230)(10.0)(MoO_2S_2^{2-})$
$0.213 = (120)(10.0)(3.08\times10^{-6}) + (9030)(10.0)(MoOS_3^{2-}) + (3230)(10.0)(2.9\times10^{-6} - (MoOS_3^{2-}))$
$(MoOS_3^{2-}) = 2.0\times10^{-6}$ M 4 pt

$(MoO_2S_2^{2-}) = 2.9\times10^{-6} - (MoOS_3^{2-}) = 0.9\times10^{-6}$ M

$(MoO_2S_2^{2-}) = 0.9\times10^{-6}$ M 4 pt

$MoO_2S_2^{2-}$ 0.9 X10^{-6}
$MoOS_3^{2-}$ ~~0.9 X10~~ 2.0 X10^{-6}
MoS_4^{2-} 3.08 X10^{-6}

c.

i.

Mass balance for Mo:

$2.0\times10^{-7} = (MoS_4^{2-}) + (MoOS_3^{2-}) + (MoO_2S_2^{2-}) + (MoO_3S^{2-}) + (MoO_4^{2-})$ 2 pt

Mass balance for S:

$8.0\times10^{-7} = 4(MoS_4^{2-}) + 3(MoOS_3^{2-}) + 2(MoO_2S_2^{2-}) + (MoO_3S^{2-}) + (H_2S)$ 2 pt

Equilibrium constants:

$1.3\times10^{-5} = (MoOS_3^{2-})(H_2S)/(MoS_4^{2-})$
$1.0\times10^{-5} = (MoO_2S_2^{2-})(H_2S)/(MoOS_3^{2-})$
$1.6\times10^{-5} = (MoO_3S^{2-})(H_2S)/(MoO_2S_2^{2-})$
$6.5\times10^{-6} = (MoO_4^{2-})(H_2S)/(MoO_3S^{2-})$
0.5 pt each = 2

ii.

$2.0\times10^{-7} = (MoO_3S^{2-}) + (MoO_4^{2-})$ (Mo mass balance)
$8.0\times10^{-7} = (MoO_3S^{2-}) + (H_2S)$ (S mass balance)

Subtracting the first from the second and rearranging gives:

$$(MoO_4^{2-}) = (H_2S) - 6.0\times10^{-7}$$

Likewise, the S mass balance can be rearranged,

$$(MoO_3S^{2-}) = 8.0\times10^{-7} - (H_2S)$$

Employing the equilibrium constant for the reaction involving MoO_4^{2-} and MoO_3S^{2-}:

$$6.5 \times 10^{-6} = \frac{(MoO_4^{2-})(H_2S)}{(MoO_3S^{2-})} = \frac{[(H_2S) - (6.0 \times 10^{-7})](H_sS)}{[(8.0 \times 10^{-7}) - (H_2S)]}$$

Rearrangement and solution by the quadratic formula gives (H_2S). Back substitution gives the remaining concentrations.

H_2S 7.8×10^{-7} M MoO_4^{2-} 1.8×10^{-7} M MoO_3S^{2-} 2.1×10^{-8} M

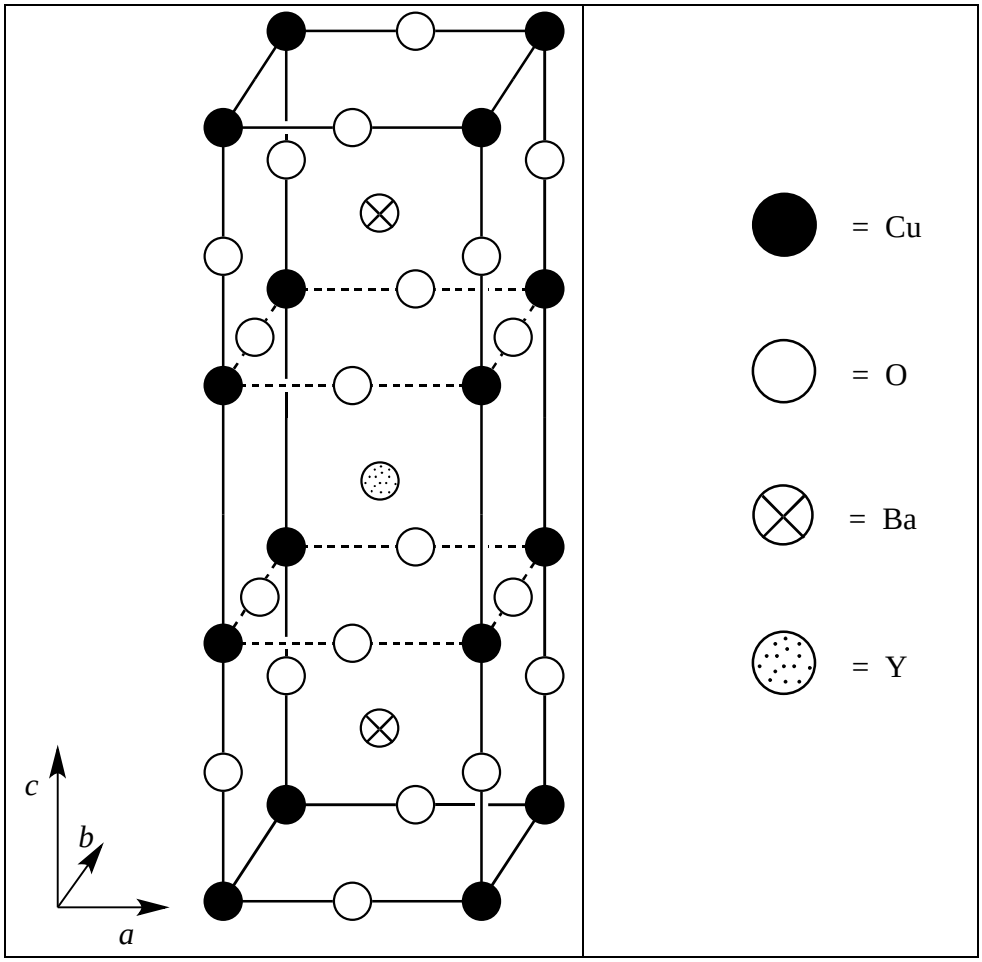
$MoO_2S_2^{2-}$ 1.0×10^{-9} M $MoOS_3^{2-}$ 8.1×10^{-11} M MoS_4^{2-} 4.9×10^{-12} M

이름 : **학생번호 :**

문제 4 총점(100 점)의 7.8%

a	b	c	d-i	d-ii	d-iii	d-iv	e-i	e-ii	문제 4	7.8%
12	14	10	4	2	2	4	4	8	60	

a.



b.

$$\sin\theta = n\lambda/2d$$
$$d = (1)(154.2\text{ pm})/2\sin(3.725°)$$
$$d = 1187\text{ pm}$$

Lowest-angle => d = longest axis = c

$$c = 1187\text{ pm}$$
$$a = c/3 = 396\text{ pm}$$

+8 for calculating d; 6/8 if student uses θ in radians and reports a positive value (0/8 if negative distance); 6/8 if uses 2θ instead of θ.
+6 for correctly assigning a and c

14 pts total

$a = 396$ pm

$c = 1187$ pm

c.

$$V_{\text{unit cell}} = a \times b \times c = 3a^3 = 3(396\text{ pm})^3 = 1.863 \times 10^{-22}\text{ cm}^3$$
$$m_{\text{unit cell}} = (1/N_A)(88.91 + 2\times137.33 + 3\times63.55 + 6.75\times16.00)$$
$$m_{\text{unit cell}} = (662.22\text{ g/mol})/(6.0221 \times 10^{23}\text{ mol}^{-1}) = 1.100 \times 10^{-21}\text{ g}$$
$$\text{Density} = (1.100 \times 10^{-21}\text{ g})/(1.863 \times 10^{-22}\text{ cm}^3) = 5.90\text{ g cm}^{-3}$$

+4 pts. for V
+4 pts. for $m_{\text{unit cell}}$
+2 pts. for ρ
Full credit for using a = 500 pm [$\rho = 11.9\text{ g cm}^{-3}$], a = 396 pm, or whatever values were given for a and c in part (b).

Density = 5.90 g cm^{-3}

밀 도 = 5.90 g cm^{-3}

이름 : **학생번호 :**

d.

i.

$$YBa_2Cu_3O_{7-\delta}\,(s) + 13\,H^+\,(aq) \rightarrow Y^{3+}\,(aq) + 2\,Ba^{2+}\,(aq) + 3\,Cu^{2+}\,(aq) + (0.25[1-2\delta])O_2\,(g) + 6.5\,H_2O\,(l)$$

ii.

$$2\,Cu^{2+}\,(aq) + 5\,I^-\,(aq) \rightarrow 2\,CuI\,(s) + I_3^-\,(aq)$$

–or–

$$2\,Cu^{2+}\,(aq) + 4\,I^-\,(aq) \rightarrow 2\,CuI\,(s) + I_2\,(aq)$$

iii.

$$I_3^-\,(aq) + 2\,S_2O_3^{2-}\,(aq) \rightarrow 3\,I^-\,(aq) + S_4O_6^{2-}\,(aq)$$

–or–

$$I_2\,(aq) + 2\,S_2O_3^{2-}\,(aq) \rightarrow 2\,I^-\,(aq) + S_4O_6^{2-}\,(aq)$$

iv.

$$YBa_2Cu_3O_{7-\delta}\,(s) + (14-2\delta)\,H^+\,(aq) + (9-3\delta)\,I^-\,(aq) \rightarrow Y^{3+}\,(aq) + 2\,Ba^{2+}\,(aq) + 3\,CuI\,(s) + (7-\delta)\,H_2O\,(l) + (2-\delta)\,I_3^-\,(aq)$$

–or–

$$YBa_2Cu_3O_{7-\delta}\,(s) + (14-2\delta)\,H^+\,(aq) + (7-2\delta)\,I^-\,(aq) \rightarrow Y^{3+}\,(aq) + 2\,Ba^{2+}\,(aq) + 3\,CuI\,(s) + (7-\delta)\,H_2O\,(l) + (2-\delta)\,I_2\,(aq)$$

e. .

i.

$n_{Cu} = n_{thiosulfate}$ in the first titration

$n_{Cu} = 1.542 \times 10^{-4}$ mol

ii.

Total Cu = 1.542×10^{-4} mol

Cu(III) = $(1.696 \times 10^{-4}$ mol$) - (1.542 \times 10^{-4}$ mol$) = 1.54 \times 10^{-5}$ mol

So 90% of Cu is Cu(II), 10% is Cu(III)

For charge balance, $2(7 - \delta) = 3 + 2\times2 + 3\times(0.90\times2 + 0.10\times3) = 13.30$

$\delta = 0.35$

Alternatively, using the balanced equations in (d):

In the 1st titration, each mol YBCO = 1.5 mol I_3^- = 3 mol $S_2O_3^{2-}$

In the 2d titration, each mol YBCO = $(2-\delta)$ mol I_3^- = $(4-2\delta)$ mol $S_2O_3^{2-}$

So $(1.542 \times 10^{-4}$ mol$)/(1.696 \times 10^{-4}$ mol$) = 3/(4-2\delta) = 1.5/(2-\delta)$

$2-\delta = 1.650$

$\delta = 0.35$

$\delta = 0.35$

이름 : **학생번호 :**

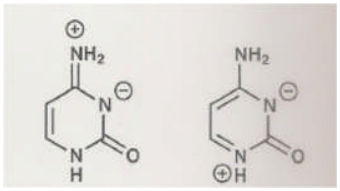
문제 5 전체(100 점)의 7.0 %

a-i	a-ii	b	c	d	e	f	문제 5	
2	4	4	2	12	6	4	34	**7.0%**

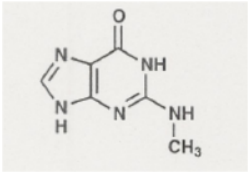
(i)

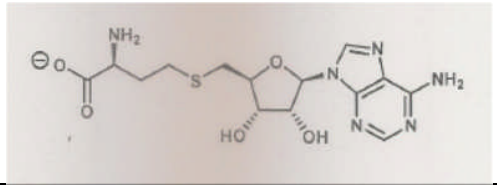
ii.

(ii)

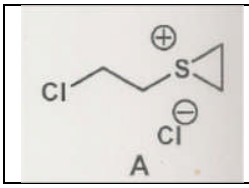


b.





c.



이름 : **학생번호 :**

d.

i.

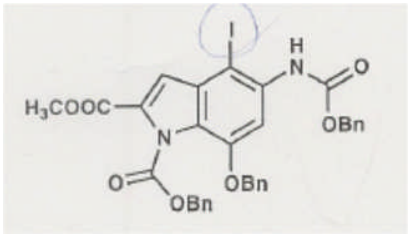
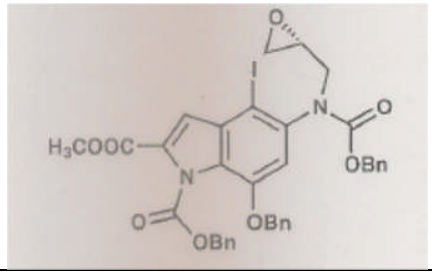
반응성이 가장 큰 것 : II **반응성이 가장 작은 것: I**

ii.

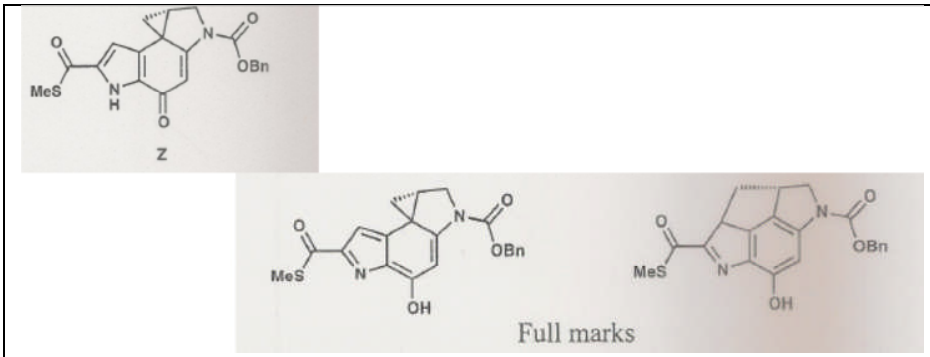
반응성이 가장 큰 것 : I **반응성이 가장 작은 것: III**

반응성이 가장 큰 것 : II **반응성이 가장 작은 것: I**

e.

J 	**K** 

f.



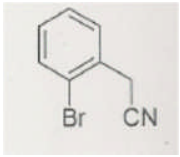
이름 : **학생번호 :**

문제 6 전체(100 점)의 6.6 %

a	b	c	d	문제 6	6.6%
2	4	6	8	20	

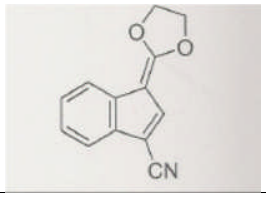
a.

A



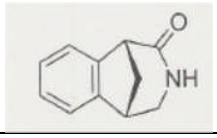
b.

B

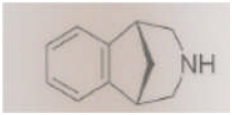


c.

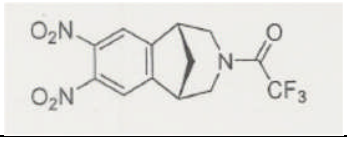
C



D

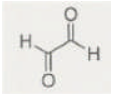


F



d.

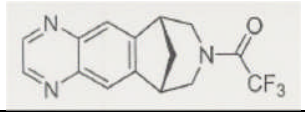
X



Y

NaOH 수용액 또는 아마이드 가수분해 시약

H



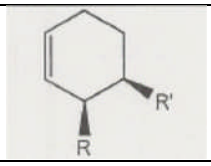
이름 : **학생번호 :**

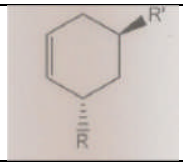
문제 7 전체(100 점)의 7.5 %

a	b	c	d	e	f	문제 7	7.5%
9	15	8	6	8	6	52	

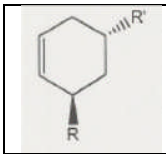
a.

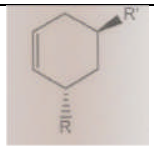
i.



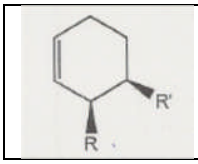


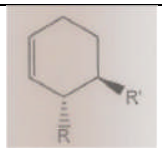
ii.





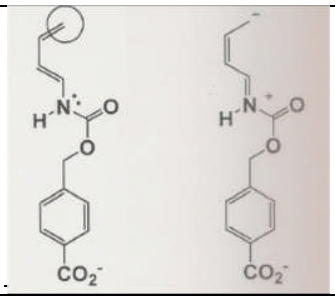
iii.





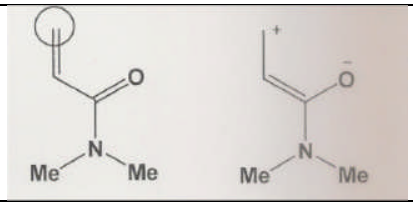
b.

i.

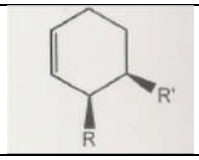


이름 : **학생번호 :**

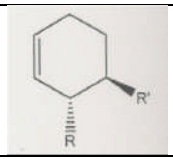
ii. .



iii.



c.



d.

i.

맞음(True) **틀림(False)**

ii.

맞음(True) **틀림(False)**

iii.

맞음(True) **틀림(False)**

e.

Enzyme 번호: Ⅱ

f.

친다이엔체(Dienophile) 번호: 5

이름 : **학생번호 :**

문제 8 총점 (100 점)의 8.3%

a	b-i	b-ii	b-iii	b-iv	b-v	c-i	c-ii	c-iii	문제 8	8.3%
2	3	4	6	4	2	5	8	2	36	

anthracene 의 수평축 길이, d_a = $3(240\ pm) = 720\ pm$

pentacene 의 수평축 길이, d_p = $5(240\ pm) = 1200\ pm$

b.

i.

$$E = \left(\frac{n_y^2}{d^2} + \frac{n_x^2}{w^2 d^2}\right)\frac{h^2}{8m_e} = \left(n_y^2 + \frac{n_x^2}{w^2}\right)\frac{h^2}{8m_e d^2}$$

ii.

Anthracene:

__(__;__)

__(_6_;_1_) __(_3_;_2_)

↑↓(_2_;_2_)

↑↓(_1_;_2_)

↑↓(_5_;_1_)

↑↓(_4_;_1_)

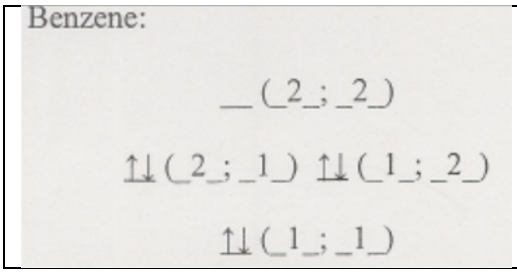
↑↓(_3_;_1_)

↑↓(_2_;_1_)

↑↓(_1_;_1_)

이름 : **학생번호 :**

iii. 같은 모델을 이용하여 벤젠의 에너지 다이어그램을 만들고 적당한 에너지 레벨들을 전자로 채워라. 에너지 레벨을 최저 비점유 에너지 레벨까지 표시하고 각 에너지 레벨에 해당하는 양자수 (n_x; n_y)로 나타내라. 벤젠을 기술하는 모델이 바뀌면 에너지 레벨도 바뀌게 되므로, (이 문제에서 사용하는) 2 차원 상자 속 입자 모델이 다른 모델과 같은 에너지 레벨을 가지게 될 것으로 가정하지 않도록 하라.



iv.

벤젠 ΔE:

ΔE for benzene: $\Delta E = E(2;2) - E(1;2) = 3\dfrac{h^2}{8m_e d^2} = 3.14\times10^{-18}\,J$

Alternate solution:

$\Delta E = E(3;2) - E(2;2) = 5\dfrac{h^2}{8m_e d^2} = 5.23\times10^{-18}\,J$

anthracene ΔE:

ΔE for anthracene: $\Delta E = E(6;1) - E(2;2) = \dfrac{5}{9}\dfrac{h^2}{8m_e d^2} = 5.81\times10^{-19}\,J$

Alternate solution:

$\Delta E = E(3;2) - E(2;2) = \dfrac{5}{9}\left(\dfrac{h^2}{8m_e d^2}\right) = 5.81\times10^{-19}\,J$

pentacene ΔE:

ΔE for pentacene: $\Delta E = E(3;2) - E(9;1) = \dfrac{3}{25}\dfrac{h^2}{8m_e d^2} = 1.26\times10^{-19}\,J$

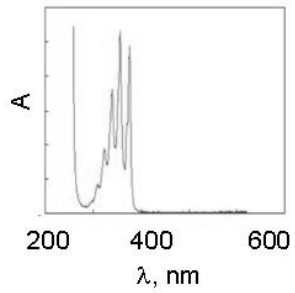
벤젠 (**B**), anthracene (**A**), pentacene (**P**)을 반응성이 증가하는 순서로 순위를 매겨라. 각 분자에 해당하는 문자들(**B, A, P**)을 왼쪽부터 오른쪽으로 상자에 나열하라.

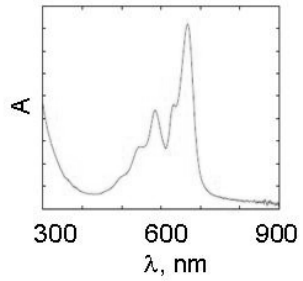
이름 : **학생번호 :**

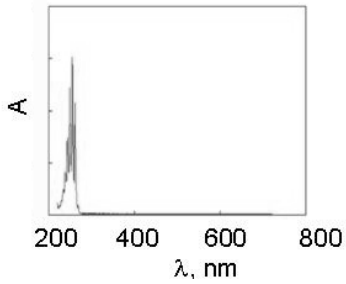
B A P

반응성이 가장 작다 ----------> 반응성이 가장 높다

v.







c.

i.

The number of hexagonal units in the graphene sheet:

$$N_{units} = \frac{Area_{graphene}}{Area_{unit}} = \frac{(25000\,pm)^2}{52400\,pm^2} = 12000\,units$$

2pts

Since each carbon atom in a graphene sheet is shared by three hexagonal units, each unit of the area 52400 pm^2 contains 6/3=2 carbon atoms contributing 2 π-electrons total.

2pts

Therefore, 12000 units contribute 12000 pairs of π-electrons.

Answer: 24,000 electrons.

ii.

Two electrons fill each state, so the Fermi level has 12000 filled levels. This corresponds to the number of (n_x,n_y) pairs that are occupied.

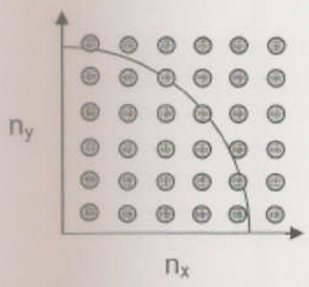
Since $L_x=L_y$ and the lowest energy level's energy is approximated as zero,

$$\Delta E = E_{highest\_occupied} = \left(n_x^2 + n_y^2\right)\frac{h^2}{8m_eL^2}$$

1 pt

This is rearranged to the equation of a circle.

$$R^2 = \left(n_x^2 + n_y^2\right) = \frac{E8m_eL^2}{h^2} = \text{constant}$$



2 pts

The area of the populated grid is $\text{Area}_{grid} = \frac{\pi R^2}{4}$.

The area of each quantum number pair is 1.

1 pt

Therefore, the number of points is given as

$$N_{points} = \frac{\text{Area}_{grid}}{\text{Area}_{pair}} = \frac{\pi R^2}{4} = N_{states} = 12000.$$

1 pt

Rearranging and solving for energy yields the Fermi energy.

$$N_{states} = \frac{\pi R^2}{4} = \frac{\pi 8m_eL^2E}{4h^2} = 12000$$

$$E = \frac{4h^2(12000)}{\pi 8m_eL^2} = 1.48\times10^{-18}\,J$$

Alternate solution

$$N_{states} = \frac{\pi R^2}{4} = \frac{\pi 8m_eL^2E}{4h^2} = 1000$$

$$E = \frac{4h^2(1000)}{\pi 8m_eL^2} = 1.23\times10^{-19}\,J$$

이름 : **학생번호 :**

iii.

작다(less)	같다(equal)	크다(greater)