

- 一、選擇題（單選題，答案請填於答案卡，每題 3 分，無倒扣，共 90 分）
(D = deuterium)

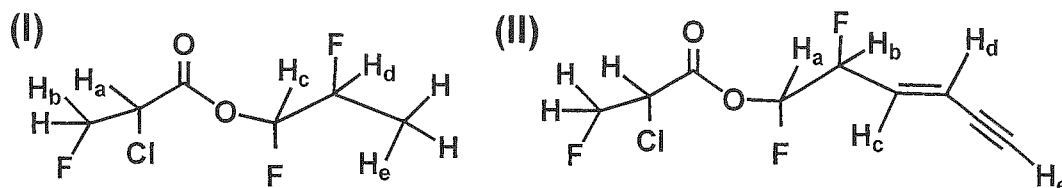
1. Using the following four data to estimate the ring strain in cyclobutane (ΔE_1) and cyclopentane (ΔE_2). If heat of combustion (in kJ/mol) of the following four compounds are:

Compound	cyclobutane	butane	cyclopentane	pentane
Heat of combustion	2800	2900	3500	3550

What is the number of $\Delta E_1 + \Delta E_2$ (in kJ/mol)?

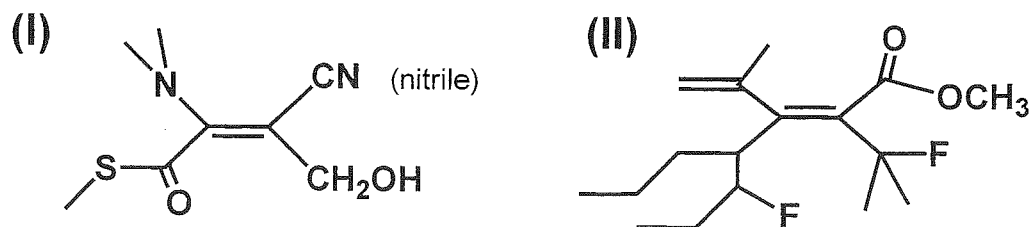
A	400
B	450
C	500
D	550
E	600

2. Select the *most acidic H* in each of the following compounds (I and II),



A	Compound I	H _a	Compound II	H _a
B	Compound I	H _c	Compound II	H _c
C	Compound I	H _c	Compound II	H _a
D	Compound I	H _c	Compound II	H _e
E	Compound I	H _a	Compound II	H _e

3. Select the right configuration assignment (*E* or *Z*) for the following two alkenes.



A	Compound I	<i>E</i>	Compound II	<i>E</i>
B	Compound I	<i>Z</i>	Compound II	<i>Z</i>
C	Compound I	<i>E</i>	Compound II	<i>Z</i>
D	Compound I	<i>Z</i>	Compound II	<i>E</i>
E	None of above assignments is correct.			

4. *trans*-1-*tert*-Butyl-4-isopropylcyclohexane has two conformers. Using the following data to calculate the strain in this two conformers, by how much kJ/mol that one is favored than the other? If,

H-C-C-H eclipsed interaction strain: 4 kJ/mol;

CH₃-C-C-H eclipsed interaction strain: 6 kJ/mol

CH₃-C-C-CH₃ eclipsed interaction strain: 11 kJ/mol;

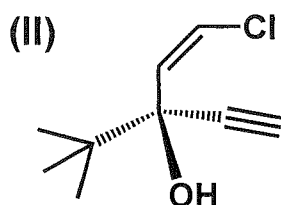
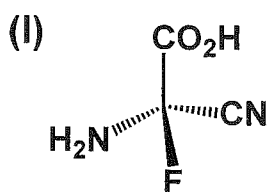
CH₃-C-C-CH₃ gauche interaction strain: 3.8 kJ/mol

Each one strain (S) of 1, 3-X-H diaxial interaction in monosubstituted cyclohexane (kJ/mol):

X (alkyl)	CH ₃	CH ₂ CH ₃	CH(CH ₃) ₂	C(CH ₃) ₃
S (kJ/mol)	3.8	4.0	4.6	11.4

A	9.2
B	22.8
C	32
D	16
E	11.4

5. (6 pts) Select the right configuration assignment (*R* or *S*) for the following two compounds.



A	None of below assignments is correct.			
B	Compound I	<i>S</i>	Compound II	<i>R</i>
C	Compound I	<i>R</i>	Compound II	<i>S</i>
D	Compound I	<i>R</i>	Compound II	<i>R</i>
E	Compound I	<i>S</i>	Compound II	<i>S</i>

6. Select the right stability order for the following four Hexenes.

Arrange the more stable alkene first.

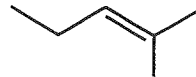
ex : I (if it is your most stable one) > II > III > IV.



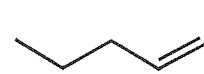
I



II



III



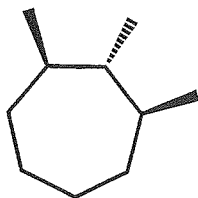
IV

A	I > II > III > IV
B	II > III > I > IV
C	III > II > I > IV
D	IV > I > II > III
E	III > II > IV > I

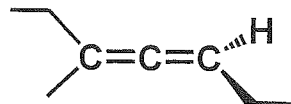
7. The optically pure tosylate of 2,2-dimethyl-1-phenyl-1-propanol ($[\alpha]_D = -50^\circ$) was heated in acetic acid to yield the corresponding acetate ($[\alpha]_D = +10^\circ$). If complete inversion had occurred, the optically pure acetate would have had $[\alpha]_D = +50^\circ$. What percentage racemization occurred in this reaction?

A	80%
B	60%
C	50%
D	40%
E	20%

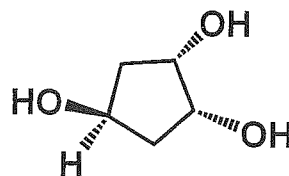
8. For the following three compounds, select the achiral compound(s).



(X)



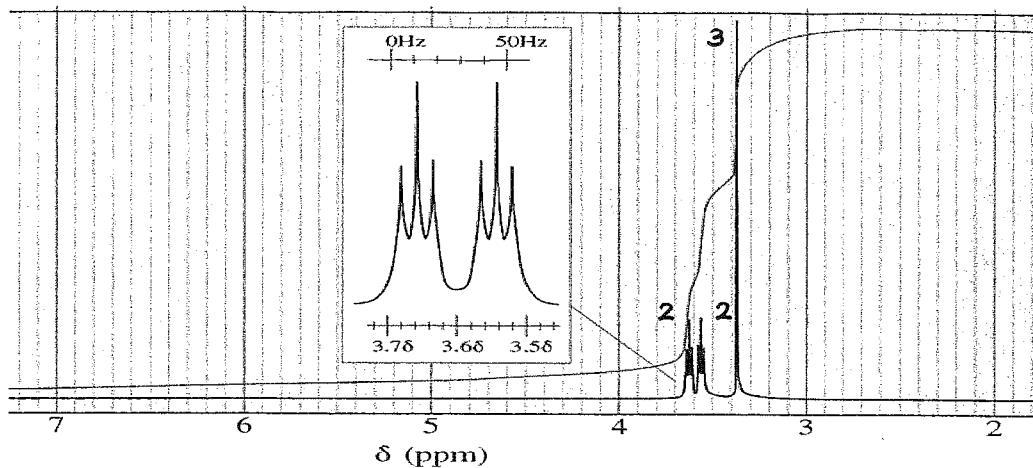
(Y)



(Z)

A	Compounds X and Y
B	Compounds X and Z
C	Compounds Y and Z
D	Only compound X
E	Only compound Z

9. Select the best fit chemical structure for compound X which with the following ^1H NMR data.

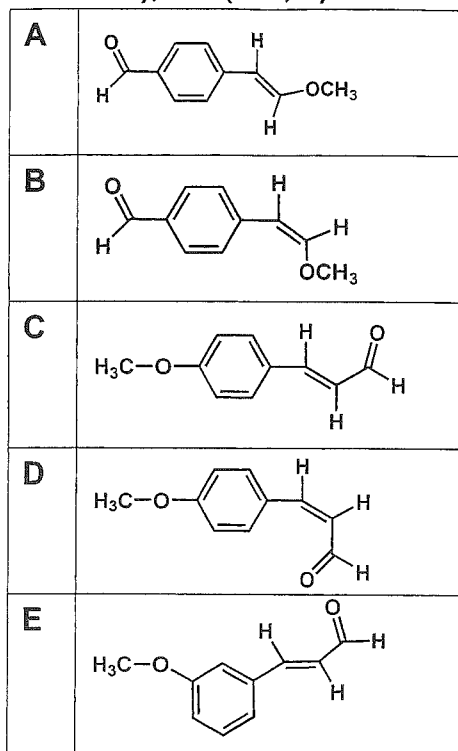


A	<chem>COCCCO</chem>
B	<chem>CCOCCOC</chem>
C	<chem>CCOCOCOC</chem>
D	<chem>COCCOCCOC</chem>
E	<chem>CCOCCOCCOC</chem>

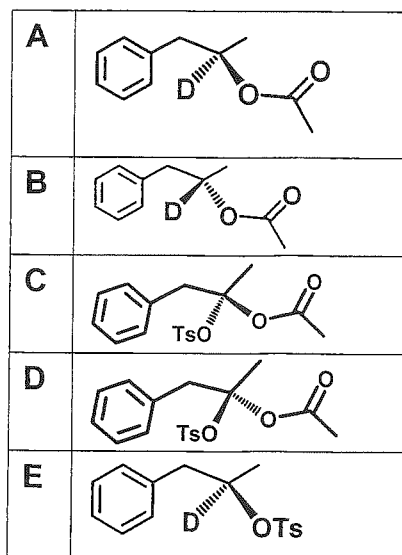
10. If a H exhibits a triplet at δ 1.105, 1.085, and 1.065 ppm, data collected by a 300 MHz NMR. Where will this triplet peaks show up (δ :ppm) if this same sample was measured in a 600 MHz NMR?

A	1.105, 1.085, 1.065
B	1.105, 1.095, 1.085
C	1.115, 1.085, 1.055
D	1.095, 1.085, 1.075
E	1.085, 1.075, 1.065

11. Select the best fit chemical structure for compound $C_{10}H_{10}O_2$ which with the following NMR data. 1H NMR: δ 9.5 (1 H, d, $J = 7$ Hz), 7.5 (2 H, d, $J = 6$ Hz), 7.3 (2 H, d, $J = 6$ Hz), 6.8 (1 H, dd, $J = 14, 7$ Hz), 6.5 (1 H, d, $J = 14$ Hz), 3.6 (3 H, s). ^{13}C NMR: δ 190, 145, 135, 130, 125, 120, 115, 60

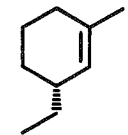
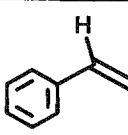
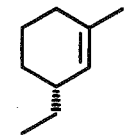
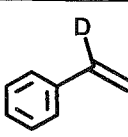
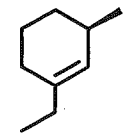
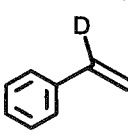
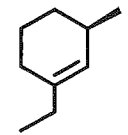
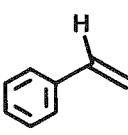
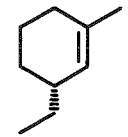
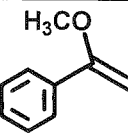


12. Select the major product in the following reaction:

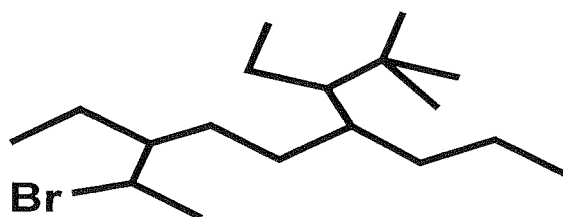


13. Select the major product in the following two reactions:



A	Compound I		Compound II	
B	Compound I		Compound II	
C	Compound I		Compound II	
D	Compound I		Compound II	
E	Compound I		Compound II	

14. Select the correct IUPAC name for the following compound.



A	2-bromo-3-ethyl-6-propyl-7-t-butylnonane
B	2-bromo-3,7-diethyl-6-propyl-8,8-dimethylnonane
C	2-bromo-3,7-diethyl-8,8-dimethyl-6-propylnonane
D	8-bromo-2,2-dimethyl-3,7-diethyl-4-propylnonane
E	8-bromo-3,7-diethyl-2,2-dimethyl-4-propylnonane

15. Select the major product in the following two reactions:



A	Compound I	<chem>CCCC(=O)C</chem>	Compound II	<chem>CCCCCC=O</chem>
B	Compound I	<chem>CCCCC=O</chem>	Compound II	<chem>CCCC(=O)C</chem>
C	Compound I	<chem>CCCC(=O)C</chem>	Compound II	<chem>CCCC(=O)C</chem>
D	Compound I	<chem>CCCCC=O</chem>	Compound II	<chem>CCCCC=O</chem>
E	Compound I	<chem>CCC(=O)CC</chem>	Compound II	<chem>CCCC(=O)C</chem>

16. Which of the following statements about the π molecular orbital description of cyclobutadiene is not correct?

A	Cyclobutadiene has two degenerate nonbonding π molecular orbitals.
B	Cyclobutadiene has a single bonding π molecular orbital.
C	Cyclobutadiene has two electrons in nonbonding π molecular orbitals.
D	Cyclobutadiene has one electron in an antibonding π molecular orbital which makes it antiaromatic.
E	none of the above

17. What is the best method for the preparation of *p*-chlorotoluene in high yield?

A	start with benzene; methylate; chlorinate
B	start with benzene; chlorinate; methylate
C	start with toluene; chlorinate
D	start with chlorobenzene; methylate
E	start with <i>p</i> -aminotoluene; NaNO_2/HCl , 0°C ; CuCl

18. Predict the major organic product of the reaction between *N*-methylbenzamide and sodium propanoate in propyl alcohol at room temperature.

A	<i>N</i> -propylbenzamide
B	propyl benzoate
C	phenyl propanoate
D	benzoic propanoic anhydride
E	no reaction

19. Which of the following amines will react with cyclopentanone to form an enamine?

A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
B	$(\text{CH}_3)_3\text{N}$
C	pyridine
D	$(\text{CH}_3)_3\text{CNH}_2$
E	none of the above

20. Which of the following reagent will quantitatively convert an enolizable ketone to its enolate salt?

A	lithium hydroxide
B	lithium diisopropylamide
C	methyllithium
D	diethylamine
E	pyridine

21. Which of the following could result from the dehydration of an aldol?

A	4-methyl-3-penten-2-one
B	4-methyl-4-penten-2-one
C	4-methyl-5-hexen-2-one
D	4-methyl-4-hexen-2-one
E	3-methyl-4-penten-2-one

22. Which of the following reagents would reduce carboxylic acids and esters into alcohols?

A	H ₂ /Raney Ni
B	1. LiAlH ₄ /2. H ₃ O ⁺
C	Na/NH ₃
D	1. NaBH ₄ /2. H ₃ O ⁺
E	Zn(Hg)/H ⁺

23. What results when cis-2-butene is subjected to the following reaction sequence?

(i) Cl₂, H₂O; (ii) NaOH; (iii) H₃O⁺

A	a meso epoxide
B	a 1:1 mixture of enantiomeric epoxides
C	a meso diol
D	a 1:1 mixture of enantiomeric diols
E	2-butanol

24. Give the halide that is the most reactive as a nucleophilic catalyst.

A	iodide
B	bromide
C	chloride
D	fluoride
E	All react equally.

25. Describe a Claisen rearrangement.

A	[3,3] sigmatropic rearrangement of a 1,5-diene
B	[1,3] sigmatropic rearrangement of an alkene
C	[3,3] sigmatropic rearrangement of an allyl vinyl ether
D	[1,5] sigmatropic rearrangement of a 1,3-diene
E	[2,3] sigmatropic rearrangement of an alkene

26. Which of the following compounds is least reactive in the nucleophilic aromatic substitution reaction with NaOH?

A	2,4-dinitrochlorobenzene
B	<i>m</i> -nitrochlorobenzene
C	<i>o</i> -nitrochlorobenzene
D	<i>p</i> -nitrochlorobenzene
E	3,5-dinitrochlorobenzene

27. Which of the following will not undergo an aldol condensation reaction?

A	butanal
B	2-methylbutanal
C	2, 2-dimethylbutanal
D	3, 3-dimethyl-2-butanone
E	All will undergo an aldol condensation.

28. Which of the following is not correct?

A	Tautomers are constitutional isomers.
B	Tautomers rapidly interconvert.
C	The enol form is generally more stable.
D	Tautomerization is catalyzed by both acids and bases.
E	All of the above are correct with respect to tautomers.

29. Which of the following would not undergo racemization in base?

A	(R)-4-methyl-2-heptanone
B	(R)-3-methyl-2-heptanone
C	(R)-3-methyl-4-heptanone
D	(R)-2,4-dimethyl-3-heptanone
E	All of the above will undergo racemization in base

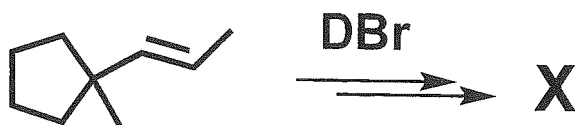
30. What final product is expected when toluene is subjected to the following reaction sequence?

(i) $\text{KMnO}_4, \text{NaOH}$; (ii) H_3O^+ ; (iii) SOCl_2 ; (iv) NH_3 ; (v) Br_2, NaOH

A	$\text{C}_6\text{H}_5\text{CONH}_2$
B	$\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2$
C	$p\text{-CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NH}_2$
D	$\text{C}_6\text{H}_5\text{NH}_2$
E	$p\text{-CH}_3\text{C}_6\text{H}_4\text{NH}_2$

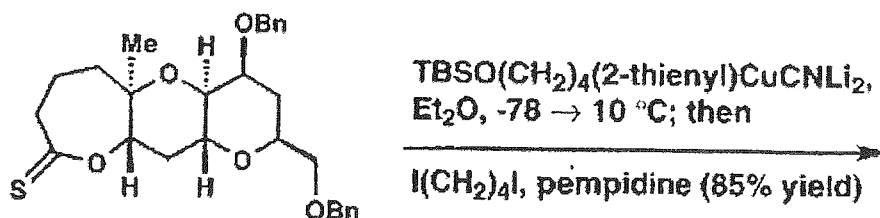
二、非選擇題 (共 10 分)

(一) (5 分) For the following DBr addition reaction (D; deuterium), a cyclohexyl halide product (X) was obtained. Use “curved arrow” to show the details of the reaction mechanism of the formation of this product (X). Need to include the formation of intermediate(s) in your answer.



(二) (5 分) Predict the major product (3 分，全對才給分) and offer a mechanistic explanation (2 分，全對才給分)

Hint: addition, $\text{S}_{\text{N}}2$, cyclization, and then elimination.



TBS = $\text{Si}t\text{-BuMe}_2$

