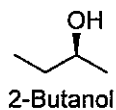


I. Single-Choice Questions [單選題：共 54 分每題 3 分；請於答案卡畫卡作答。]

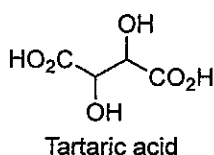
1. According to the CIP nomenclature, the molecule shown below is ____-form 2-butanol.

- A) (D)-form
B) (E)-form
C) (L)-form
D) (R)-form
E) (S)-form

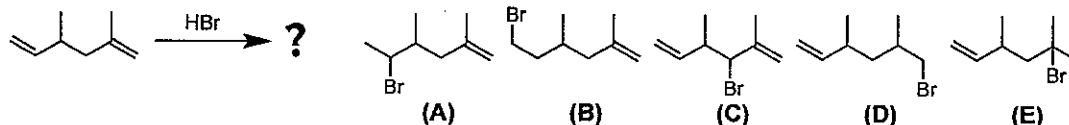


2. The field of stereochemistry began with the study of tartaric acid (shown below) by Louis Pasteur in the 1850s. Tartaric acid has __ (X) __ chiral centers and __ (Y) __ possible stereoisomers.

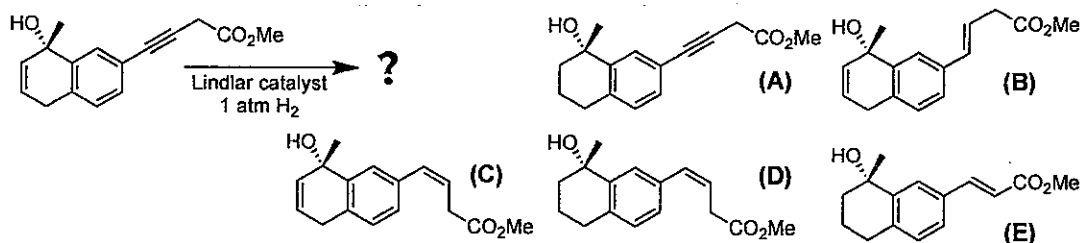
- A) X = 1, Y = 2
B) X = 1, Y = 4
C) X = 2, Y = 2
D) X = 2, Y = 3
E) X = 2, Y = 4



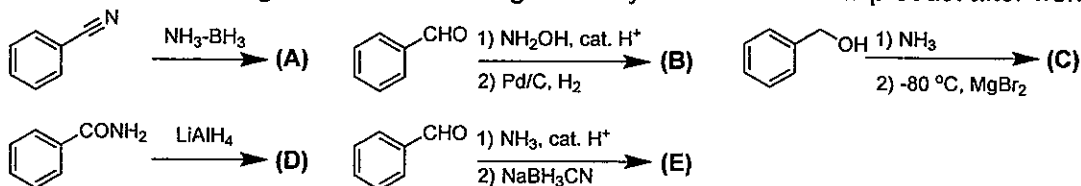
3. What is the most likely product of the following hydrobromination reaction?



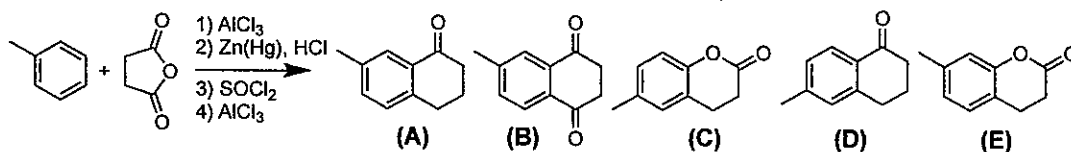
4. What is the most likely product of the following reaction?



5. Which of the following reactions will **NOT** give benzylamine as the final product after workup?



6. What is the most likely product of the following reaction sequence?

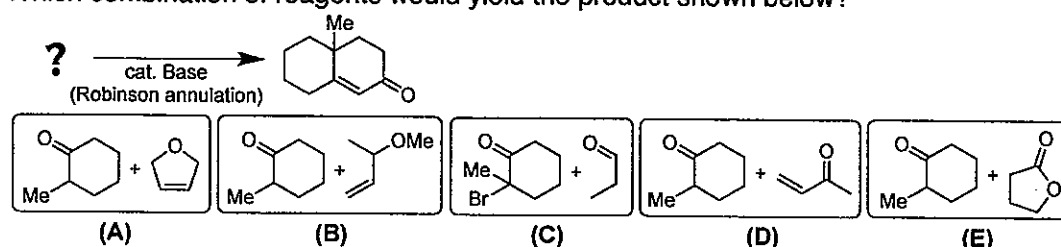


7. What is the name of the reaction in step 1) and 4) shown in Question 6?

- A) Cannizzaro reaction B) Claisen condensation C) Friedel-Crafts reaction
D) Grignard reaction E) Swern oxidation

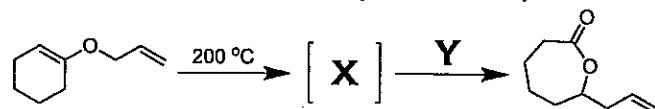
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8. Which combination of reagents would yield the product shown below?



9. The first step in the reaction sequence shown below is a heat-promoted rearrangement to generate intermediate [X]. It contains a new functional group (Z) not seen in the starting material. Z = ?

- A) Aldehyde B) Carboxylate C) Ester D) Ketone E) Peroxide



10. What reagent (Y) should be used in the second step of the reaction shown in Question 9?

- A) HBpin B) H₂O₂ / BF₃ C) I₂ D) KOH / 14-crown-4 E) Pd(OAc)₂

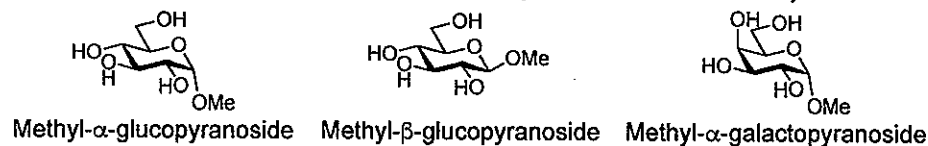
Question 11 & 12 are about sugars. The chemical formula for all three structures shown below are C₇H₁₄O₆. Choose the term that correctly describes the relationship between these stereoisomers.

11. Methyl- α -glucopyranoside and methyl- α -galactopyranoside are a pair of _____.

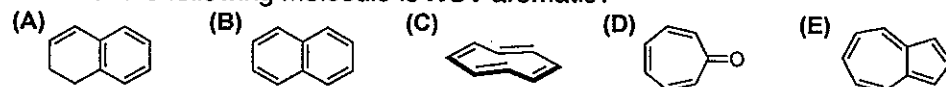
- A) anomers B) epimers C) enantiomers D) tautomers E) the same

12. Methyl- α -glucopyranoside and methyl- β -glucopyranoside are a pair of _____.

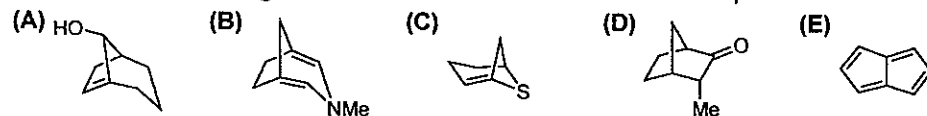
- A) anomers B) epimers C) enantiomers D) tautomers E) the same



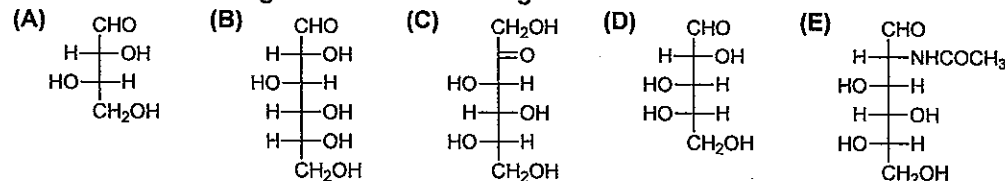
13. Which of the following molecule is **NOT** aromatic?



14. Which of the following molecules is stable in air at room temperature?

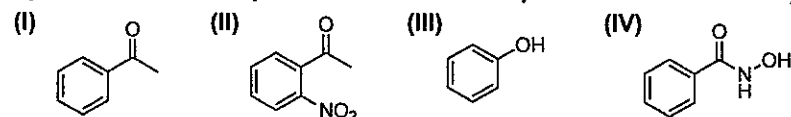


15. Which of the following molecules is a D-sugar?



16. Rank the acidity of the most acidic proton in the following molecules (from strongest to weakest).

- A) I > II > III > IV B) IV > III > II > I C) III > IV > II > I D) III > II > I > IV

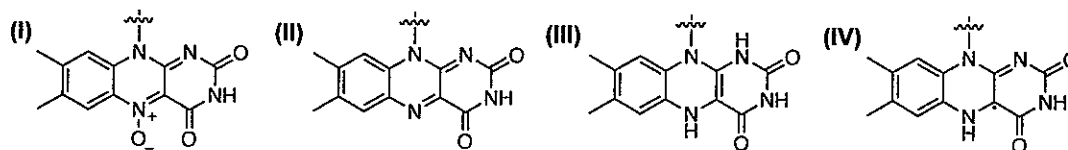


17. Which of the following descriptions about phosphatidylcholine is **NOT** correct?

- A) It is a common lipid in biological membranes
- B) It is zwitterionic under physiological conditions
- C) It contains a phosphodiester moiety
- D) It contains two ester moieties
- E) It contains a tertiary amine

18. Flavin is an important cofactor that mediates electron transfer in enzymes that catalyze redox reactions. It can exist in various forms (I to IV). Rank them from highest to lowest oxidation state.

- A) I > II > III > IV B) IV > III > II > I C) I > II > IV > III D) I > III > II > IV



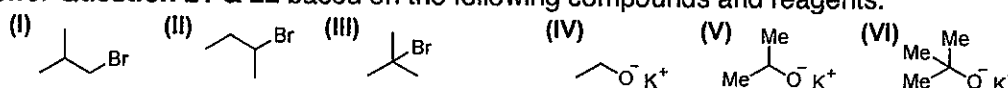
II. Mechanisms and Structures [簡答題：共 46 分，配分見各題標示；請於答案卷手寫作答。]

Question 19 & 20 are about cysteine proteases. The active site of these enzymes usually consist of three key amino acid residues that are in spatial proximity, referred to as the *catalytic triad*.

19. The *catalytic triad* of a cysteine protease usually contains (X), (Y), and cysteine (name of amino acids). Hint: The acid dissociation constants (pK_a) of the side-chain functional groups of these amino acids are approximately 4.0 (X), 6.0 (Y), and 8.3 (cysteine). [二分]

20. Draw the structures of the two amino acids in the previous question. [二分]

Answer **Question 21 & 22** based on the following compounds and reagents.



21. Bromoalkane can undergo substitution or elimination when it reacts with a base. Choose the combination that yields the of highest ratio of elimination product. [三分，全對才給分]

21.1 Choose a bromoalkene from compound [I, II, or III]

21.2 Choose a base from reagent [IV, V, or VI]

21.3 Choose to run the reaction at [High or Low] temperature

22. Draw the structure of the elimination product. [三分]

Question 23 & 24 are about Diels-Alder reactions, a type of [4+2] cycloaddition reaction.

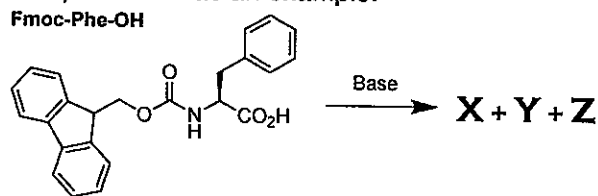


23. Draw the product (**P**) for the reaction shown above. Clearly indicate stereochemistry. [三分]

24. The starting material (**S**) underwent an *intramolecular* Diels-Alder reaction to generate compound (**I**). Draw the structure of (**S**). Clearly indicate stereochemistry. [三分]

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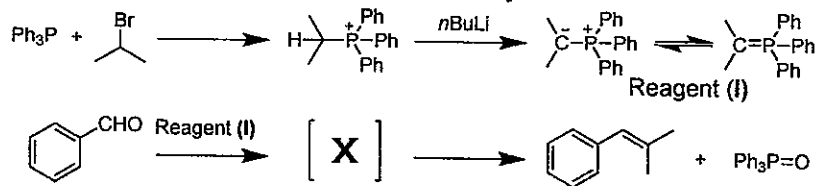
Questions 25 & 26 are about the "Fmoc" (fluorenylmethoxycarbonyl) protecting group. It is often used as the amine protecting group in solid-phase peptide synthesis. Fmoc protected phenylalanine (**Fmoc-Phe-OH**) is shown as an example.



25. Draw the products (**X**, **Y**, and **Z**) of **Fmoc-Phe-OH** deprotection. [三分]

26. Draw the arrow-pushing mechanism of **Fmoc-Phe-OH** deprotection. [三分]

Question 27 & 28 are about Wittig reaction. It was first reported in 1954 by Georg Wittig, who was awarded the Nobel Prize in Chemistry in 1979 for his discovery and research of this reaction. It is a useful method to synthesize alkenes from aldehydes or ketones.

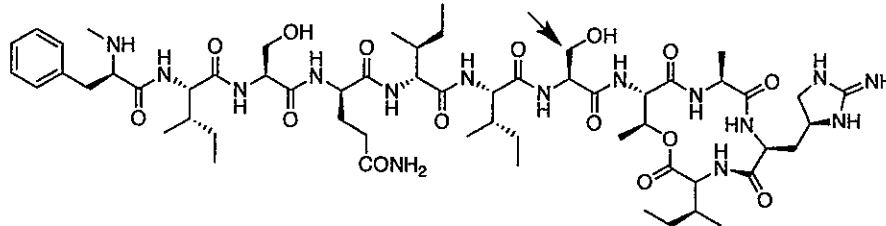


27. Reagent (**I**) is formally a carbanion directly attached to a positively charged phosphorus atom. This type of neutral dipolar molecules is called a _____. [三分]

28. Draw the structure of the key oxaphosphetane intermediate **[X]**. [三分]

Question 29 to 32 are about NMR spectroscopy knowledge.

29. Teixobactin was discovered in 2015 and is a promising antibiotic candidate. Answer the following questions about its NMR properties based on its structure shown below.



29.1) How many carbons in ^{13}C NMR do you expect to see in the $\delta > 100$ ppm range? [一分]

29.2) Among the carbons in 29.1, how many of them are sp^3 hybridized? [一分]

29.3) How many protons in ^1H NMR do you expect to see in the $\delta < 2.0$ ppm range? [一分]

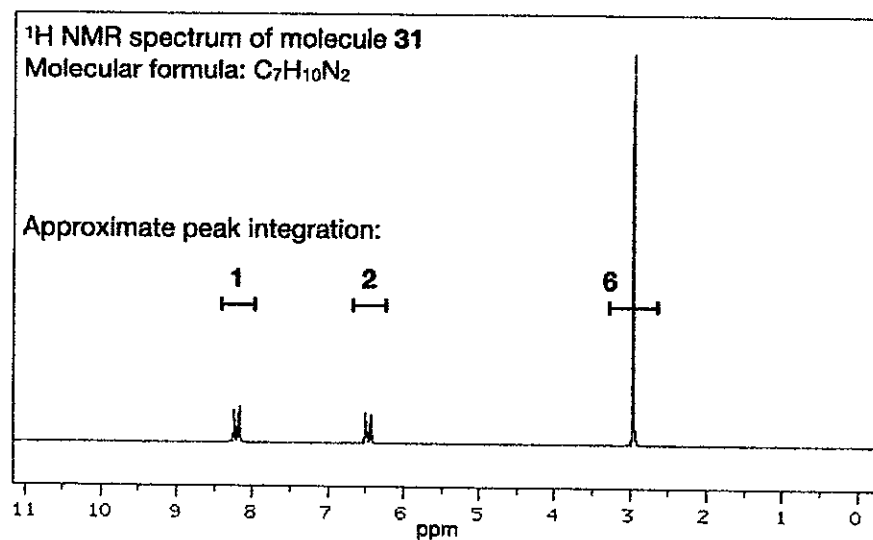
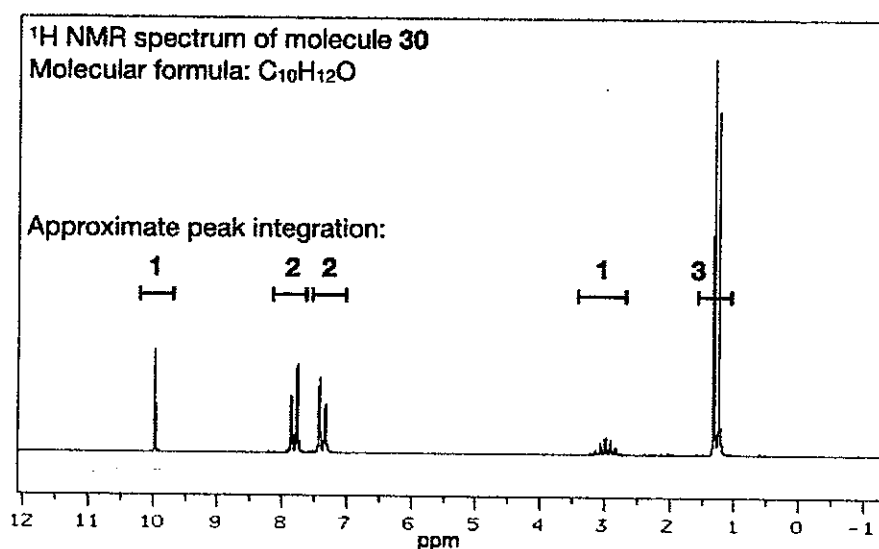
29.4) Among the protons in 29.3, how many of them split into doublets? [一分]

29.5) The arrow points to two protons. Will they have the same chemical shift? [一分]

29.6) The arrow points to two protons. Will they have the same splitting pattern? [一分]

30. The molecular formula of this molecule **30** is $C_{10}H_{12}O$. Its 1H NMR spectrum is shown below. Draw the most likely structure of this molecule. [三分]

31. The molecular formula of this compound **31** is $C_7H_{10}N_2$. Its 1H NMR spectrum is shown below. Draw the most likely structure of this molecule. [三分]



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32. Match the ¹H NMR spectra below to amino acid structures are shown below. All spectra were obtained in D₂O using a 600 MHz instrument with tetramethylsilane (TMS) as the internal standard. [共六分]

- 32.1 Spectrum (I) correspond to _____ (name of amino acid). [二分]
 32.2 Spectrum (II) correspond to _____ (name of amino acid). [二分]
 32.3 Spectrum (III) correspond to _____ (name of amino acid). [二分]

