

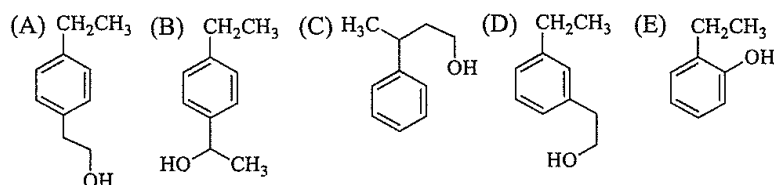
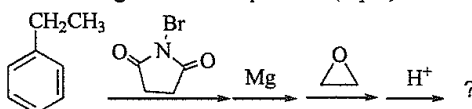
有機無機 (共 100 分)

第一大題選擇題考生應作答於「答案卡」，並先詳閱答案卡上之「畫記說明」。

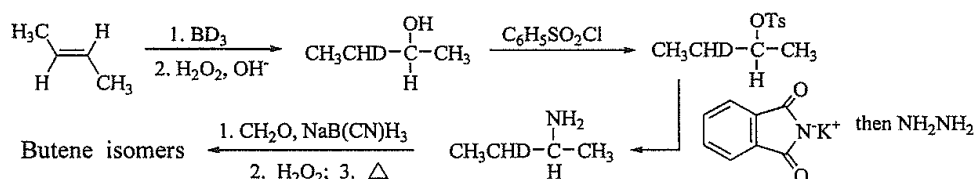
第一大題：單選題 (共 20 題；1-15 題：每題 2 分；16-20 題：每題 3 分)

Part I: Multiple Choice. Choose the most appropriate answer for the following 20 questions. (Q1-Q15: 2 points each; Q16-Q20: 3 points each)

1. What is the major product of the following reaction sequence? (2 pts)



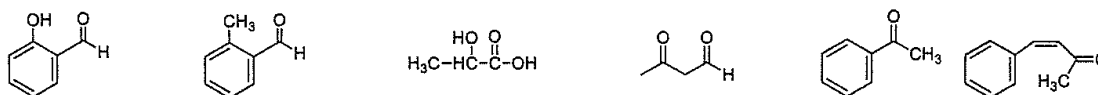
2. In the following sequence of reactions,



Which of butene isomers contain(s) NO deuterium? (2 pts)

- (A) *cis*-2-butene  
 (B) *trans*-2-butene  
 (C) *cis*-2-butene and *trans*-2-butene  
 (D) 1-butene  
 (E) None of the above

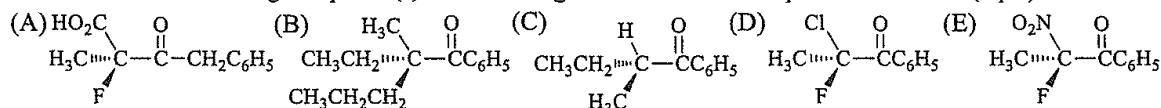
3. Which compounds are named correctly? (2 pts)



*o*-hydroxybenzaldehyde (I) 2-methylbenzaldehyde (II) 2-hydroxypropanoic acid (III) 1,3-butanedione (IV) benzophenone (V) cinnamaldehyde (VI)

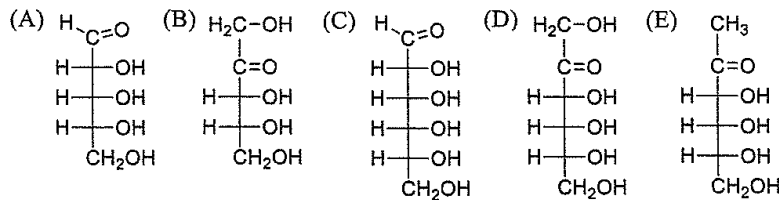
- (A) I, II, III; (B) IV, V, VI; (C) II, IV, V; (D) III, IV, VI; (E) VI, I, V.

4. Which of the following compound(s) would undergo racemization in the presence of base? (2 pts)

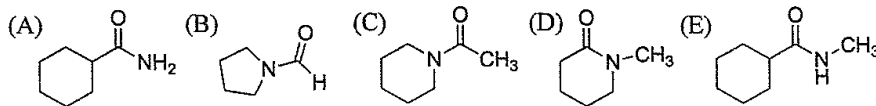


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5. A pyranose form is a cyclic hemiacetal with a six-membered ring. Which of the following compounds cannot exist in a pyranose form? (2 pts)

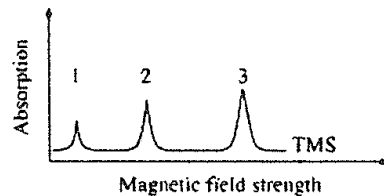


6. Which of the compound can produce a secondary amine with the treatment of  $\text{LiAlH}_4$  in diethyl ether followed by  $\text{H}_2\text{O}$ ? (2 pts)



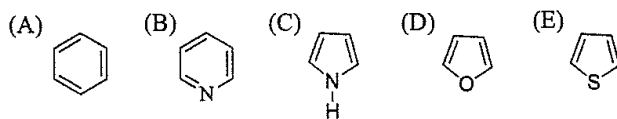
7. Based on the low-resolution proton NMR spectrum of a particular compound shown at the right, which of the following is(are) true? (2 pts)

- I. There are at least three different types of protons in this compound.  
 II. There are more protons of the type corresponding to peak 3 than the type corresponding to peak 1.  
 III. Protons of the type corresponding to peak 2 are more shielded than those corresponding to peak 1.

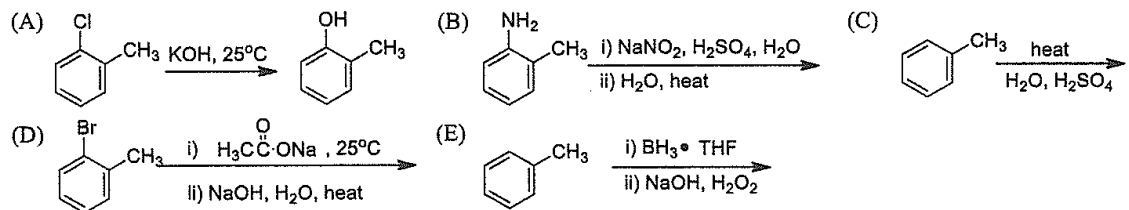


- (A) I only (B) II only (C) III only (D) I and II only (E) I, II, and III.

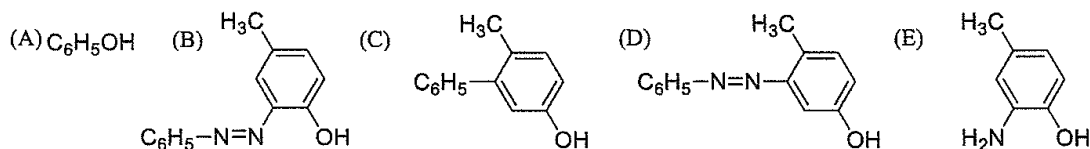
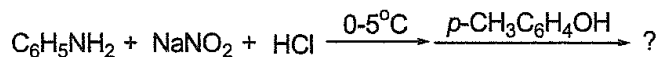
8. Which of the following is the strongest base? (2 pts)



9. Which of the following is a suitable synthesis of *o*-methylphenol? (2 pts)

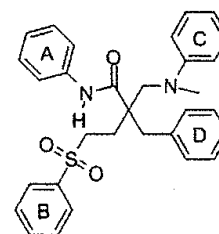


10. Which is the major product of the following reaction? (2 pts)



11. The following compound has four aromatic rings. Rank them in terms of increasing reactivity toward electrophilic aromatic substitution. (2 pts)

- (A)  $\text{D} < \text{C} < \text{B} < \text{A}$   
 (B)  $\text{C} < \text{B} < \text{D} < \text{A}$   
 (C)  $\text{C} < \text{D} < \text{B} < \text{A}$   
 (D)  $\text{B} < \text{D} < \text{A} < \text{C}$   
 (E)  $\text{A} < \text{D} < \text{C} < \text{A}$

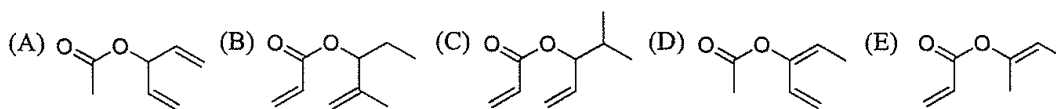
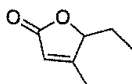


12. Which is the order of increasing bond stretching frequency (lowest first)? (2 pts)

I)  $\text{C}=\text{N}$ ; II)  $\text{C}=\text{O}$ ; III)  $\text{C}=\text{C}$ ; IV)  $\text{C}=\text{S}$

- (A) II, I, IV, III; (B) I, II, IV, III; (C) III, I, II, IV; (D) IV, III, I, II; (E) III, IV, I, II.

13. Which diene can be used to prepare the following product by alkene metathesis? (2 pts)

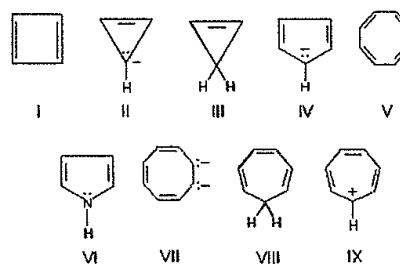


14. Grignard reagent does **NOT** react with (2 pts)

- (A) 1-methoxycyclohexene (B) 1-butyne (C) cyclohexanol (D) cyclohexanone (E) 2-ethyloxirane

15. On the basis of molecular orbital theory and Huckel's rule, which molecules and/or ions should be aromatic? (2 pts)

- (A) I and V  
 (B) III and VIII  
 (C) IV, VII and IX  
 (D) IV, VI, VII and IX  
 (E) II and IV



16. How many of the following statement(s) about the term symbol of a  $d^2$  system is(are) correct? (3 pts)

- (a) The total number of microstates of the  $d^2$  system is 45.
- (b) The maximum  $M_L$  number is 4.
- (c) The minimum  $M_L$  number is 0.
- (d) The maximum  $M_S$  number is 2.
- (e) The minimum  $M_S$  number is 0.
- (f)  $^1G_4$  is a ground state.
- (g)  $^1S_0$  has the highest energy.
- (h) The  $^3P$  term can be further split into  $^3P_4$ ,  $^3P_3$ , and  $^3P_2$ .
- (i) The  $^3F$  term can be further split into  $^3F_4$ ,  $^3F_3$ , and  $^3F_2$ .
- (j) The  $^3F$  term contains 21 microstates.

(A) 4 (B) 5 (C) 6 (D) 7 (E) 8

17. Which of the following descriptions about the acid-base chemistry in an aqueous solution is correct? (3 pts)

- (A) 0.1 M of HBr is a weaker acid than 0.15 M of  $H_3O^+$
- (B) 0.1 M of HBr has a higher pH value than 0.05 M of HI
- (C) 0.1 M of  $CH_3COOH$  is a stronger acid than 0.15 M of  $H_3O^+$
- (D) 0.1 M of  $CH_3COOH$  has a lower pH value than 0.05 M of HI
- (E) None of the above.

18. How many of the following point groups do *NOT* have an inversion center? (3 pts)

- (a)  $C_1$  (b)  $C_i$  (c)  $C_2$  (d)  $C_{4v}$  (e)  $C_{4h}$  (f)  $S_6$  (g)  $S_8$  (h)  $I_h$  (i)  $O$  (j)  $O_h$

(A) 4 (B) 5 (C) 6 (D) 7 (E) 8

19. The anion  $XeF_5^-$  shows only a single  $^{19}F$  NMR peak over a wide temperature range (ignoring coupling to  $^{129}Xe$ ). Which geometry is consistent with this data? (3 pts)

- (A) Trigonal bipyramidal (B) square pyramidal (C) pentagonal planar (D) cubic (E) None of the above

20. How many of the following statement(s) about characterization techniques is(are) correct? (3 pts)

- (a) Paramagnetic compounds can be characterized by EPR (ESR).
- (b) Powder samples cannot generate diffraction patterns while using X-ray as the light source.
- (c) To determine protein structures via cryoEM crystalline materials are required.
- (d) Infrared spectroscopy is a useful tool to determine bond strengths of organic functional groups.
- (e) All NMR active compounds do not have unpaired electron(s).
- (f) X-ray photoelectron spectroscopy (XPS) is a surface-sensitive quantitative spectroscopic technique.
- (g) X-ray absorption spectroscopy (XAS) can be used to determine the oxidation state of metal complexes.

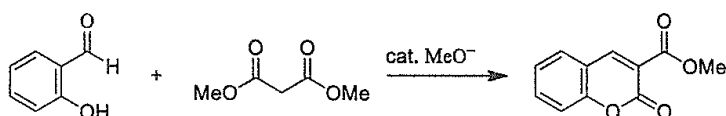
(A) 6 (B) 5 (C) 4 (D) 3 (E) 2

第二大題問答題考生應依題號順序於「非選擇題作答區」內作答，並應註明作答之部分及題號。

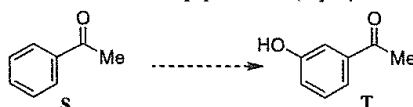
第二大題：問答題 (共 55 分)

Part II: Questions and Answers (Please provide an adequate answer to each of the following questions; Total 55 points)

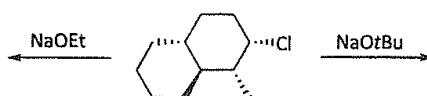
21. Provide a mechanism for the following transformation. Please show all arrow pushing. (6 pts)



22. Provide a synthesis that will selectively convert S to T. Show all of the key intermediates and furnish all of the important reagents. Hint: This is not a one-step process. (8 pts)



23. Consider both regioselectivity and stereoselectivity to predict the products for the eliminations below, and draw complete mechanisms. (6 pts)



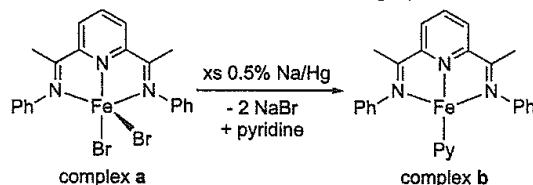
24. What are the advantages and disadvantages of the following bonding theory? (Please use specific examples to support your answers) (10 pts)

(a) VSEPR Theory, (b) Valence Bond Theory, (c) Molecular Orbital Theory

25. Explain the following terms (Total 10 pts; 2 pts each):

(a) turnover frequency, (b) turnover number, (c) selectivity, (d) catalyst, and (e) catalytic cycle

26. An iron complex (b) bearing a redox-active pyridine-diimine ligand was synthesized by the procedure shown below. Please answer the following questions. (Total 15 pts)



(a) What would you call this reaction? (1 pt)

(b) What is the d-orbital splitting diagram of complex a and complex b. (Please label each orbital) (2 pts)

(c) Provide a detailed description of the electronic structures of complex b? (You should include oxidation state, number of unpaired electrons and spin state, etc.) (2 pts)

(d) What characterization technique(s) would you use to prove your assignment about the electronic structure of complex b in question (c). (Please include a detailed explanation in your answer) (10 pts)