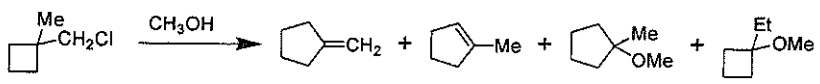
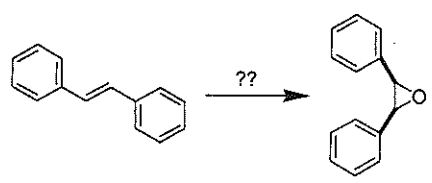
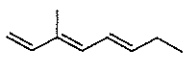
1. (4 points) Solvolysis of 1-(chloromethyl)-1-methylcyclobutane in methanol gives a complex product mixture of the following four compounds. Tell whether each of the product is likely to be S_N1, S_N2, E1, E1cB, or E2:



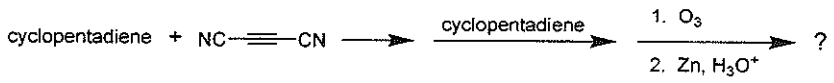
2. (1 point) Give a specific example for the Mitsunobu reaction.
3. (3 points) Give structure each of the following names: (a) indole, (b) *m*-xylene, (c) anisole, (d) acetophenone, (e) styrene, and (f) toluene.
4. (2 points) How would you carry out the following transformation? More than one step is needed.



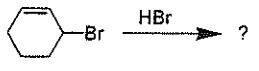
5. (2 points) What is the IUPAC name for the below compound?



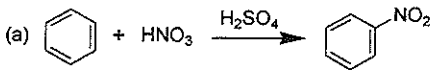
6. (2 points) Give the final product of the below synthesis:

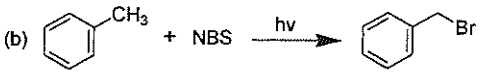


7. (2 points) Propose a structure for the compound that fits the below proton NMR spectral data:
   C_7H_{12}; δ 2.28 (t, 4H), 1.71 (s, 6H), 1.50 (m, 2H)
8. (2 points) Give the product of the following reaction. Make sure you indicate the stereochemistry, if applicable.



9. (4 points) Give reaction mechanism for each of the below substitution reactions:



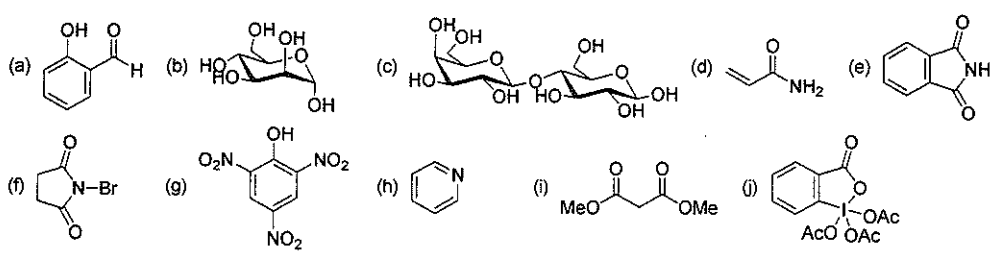


10. (4 points) Propose a structure for each of the compound that fits the following proton NMR spectral data:
    (a) $C_7H_{11}NO$; δ 2.50 (t, 2H), 2.45 (t, 2H), 2.44 (t, 2H), 1.49 (m, 2H), 0.96 (t, 3H)
    (b) $C_8H_4Cl_2$; δ 7.43 (s, 1H), 7.30 (d, 1H), 7.25 (d, 1H), 7.17 (dd, 1H)
11. (2 points) Give correct structure of Asp-Phe-OCH_3 that has a trade name as Equal®. Both Asp and Phe are in their natural L form.

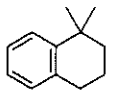
12. (2 points) Show all product structures for the ninhydrin reaction with glycine.
13. (2 points) Propose a structure for a nonapeptide that show the composition Asp, Glu, Gly_3, Ile, Leu, Pro, Tyr on amino acid analysis. Edman analysis shows a glycine N-terminal group and glycine is the C-terminal group. Specific enzyme cleavage gives the following peptide fragments:

Pro-Leu, Ile-Gln-Asn, Gly-Tyr-Ile, Asn-Gly-Pro

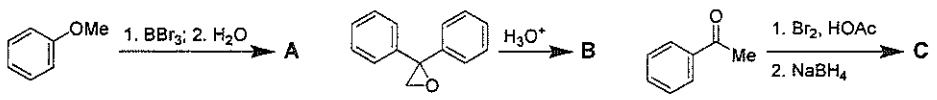
14. (5 points) What are common names of the following compounds:



15. (2 points) Starting from benzene, how would you synthesize the following substances? Assume that *ortho* and *para* isomers can be chromatographically separated.

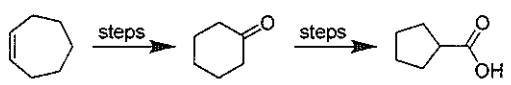


16. (2 points) Benzyl bromide can be converted into benzaldehyde by treatment with nitromethane and a base. The reaction involves initial conversion of nitromethane into its anion, followed by substitution reaction of the anion with benzyl bromide and subsequent elimination reaction. Write the reaction mechanism in detail.
17. (2 points) An unknown D aldopentose can be oxidized to an optically inactive aldaric acid. On Kiliani-Fischer chain extension, this aldopentose is converted into two diastereoisomeric aldohexoses; both aldohexoses are oxidized to optically active aldaric acids. What is the Fischer structure of this unknown D aldopentose?
18. (3 points) Give the structure of product for each of the following three reactions:



19. (2 points) Using the Wittig reaction, how would you accomplish the following reaction transformation?

20. (2 points) How would you achieve the below reaction transformation?



科目：無機化學

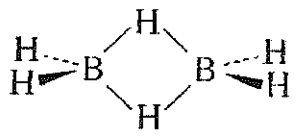
共22題，1—19題每題2分，20—22題每題4分，合計50分。
第1-19題只需寫出答案，20—22題需列出詳細推演。

1. How many radial nodes does the $5d_{xy}$ have?

2. Which one of the following ions has the smallest radius: Se^{2-}, Rb^{+}, Cs^{+}, and Sr^{2+}?

3. On the basis of VSEPR, predict the shape of XeO_3.

4. Determine the point group for diborane shown as below.



5. Compare the bonding in O_2^{2-}, O_2^{-}, O_2, and O_2^{+}, which one has the strongest bond strength?

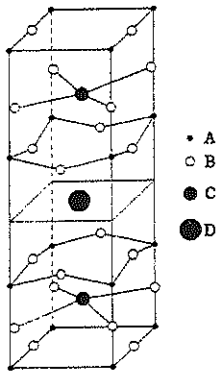
6. Which one of the following species is the strongest base when reacting with BMe_3, pyridine, 2-methylpyridine, 2-methoxypyridine, and 4-methylpyridine?

7. Which one of the following ionic compounds:, KF, CaF_2, ZnS and CaO, has the highest melting point?

8. Give an example of the superacid.

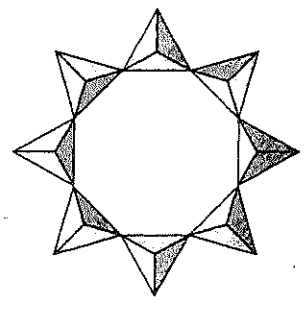
9. The following reaction can be conducted as a titration in liquid BrF_5:
$2Cs^{+}[\quad\quad]^{-} + [\quad\quad]^{+}[Sb_2F_{11}]^{-} \longrightarrow 3BrF_5 + 2CsSbF_6$
Write down the most likely formulas of these ions.

10. The orthorhombic unit cell of a solid compound consisted of four elements: A, B, C, and D is shown below. Write down the formula for this compound.



11. Which one of the following semiconductor has the smallest band gap: GaP, GaAs, GaSb?

12. Determine the formula of the silicate ion as shown below.



13. Determine the ground term for the configurations in high-spin d^6 (O_h symmetry)

14. Determine the number of IR-active carbonyl (CO) stretching bands for *fac*-$FeCl_3(CO)_3$.

15. Use the standard voltage in the Latimer diagram for oxygen to determine the free energy change ΔG^o for the disproportionation of H_2O_2 in acidic solution. (Faraday's constant: 96500 C/mol)

$$O_2 \xrightarrow{0.695\ V} H_2O_2 \xrightarrow{1.763\ V} H_2O$$

16. How many isomers are there of the complex $[Co(en)_2Cl_2]^+$. (en: ethylenediamine)

17. On the basis of the 18-electron rule, determine the charge for the compound $[(OC)_3Ni—Co(CO)_3]^z$.

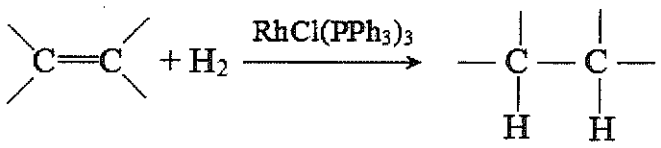
18. Predict the transition metal-containing product of the reaction $H_3C—Mn(CO)_5 + PMePh_2 \longrightarrow$ (no gases are evolved)

19. Classify the borane $B_5H_8^-$ as *closo*, *nido*, *arachno*, or *hypho*.

20. Apply the group theory treatment to predict the possible hybridization for the Pt atom in a square planar species $PtCl_4^{2-}$

21. Calculate the electron affinity of Cl from the following data for NaCl.
Cl_2 bond energy = 239 kJ/mol, ΔH_f(NaCl) = -413 kJ/mol, ΔH_{sub}(Na) = 109 kJ/mol, IE(Na) = 496 kJ/mol
lattice energy for NaCl U = 861 kJ/mol

22. Wilkinson's catalyst $RhCl(PPh_3)_3$ is used as the catalyst for alkene hydrogenation:



Propose a reasonable mechanism for this reaction.

C_{2v}	E	C_2	$\sigma_v(xz)$	$\sigma_v'(yz)$		
A_1	1	1	1	1	z	x^2, y^2, z^2
A_2	1	1	−1	−1	R_z	xy
B_1	1	−1	1	−1	x, R_y	xz
B_2	1	−1	−1	1	y, R_x	yz

C_{3v}	E	$2C_3$	$3\sigma_v$		
A_1	1	1	1	z	$x^2 + y^2, z^2$
A_2	1	1	−1	R_z	
E	2	−1	0	$(x, y), (R_x, R_y)$	$(x^2 - y^2, xy), (xz, yz)$

T_d	E	$8C_3$	$3C_2$	$6S_4$	$6\sigma_d$		
A_1	1	1	1	1	1		$x^2 + y^2 + z^2$
A_2	1	1	1	−1	−1		
E	2	−1	2	0	0		$(2z^2 - x^2 - y^2, x^2 - y^2)$
T_1	3	0	−1	1	−1	(R_x, R_y, R_z)	
T_2	3	0	−1	−1	1	(x, y, z)	(xy, xz, yz)

D_{4h}	E	$2C_4$	C_2	$2C_2'$	$2C_2''$	i	$2S_4$	σ_h	$2\sigma_v$	$2\sigma_d$		
A_{1g}	1	1	1	1	1	1	1	1	1	1		$x^2 + y^2, z^2$
A_{2g}	1	1	1	−1	−1	1	1	1	−1	−1	R_z	
B_{1g}	1	−1	1	1	−1	1	−1	1	1	−1		$x^2 - y^2$
B_{2g}	1	−1	1	−1	1	1	−1	1	−1	1		xy
E_g	2	0	−2	0	0	2	0	−2	0	0	(R_x, R_y)	(xz, yz)
A_{1u}	1	1	1	1	1	−1	−1	−1	−1	−1		
A_{2u}	1	1	1	−1	−1	−1	−1	−1	1	1	z	
B_{1u}	1	−1	1	1	−1	−1	1	−1	−1	1		
B_{2u}	1	−1	1	−1	1	−1	1	−1	1	−1		
E_u	2	0	−2	0	0	−2	0	2	0	0	(x, y)	