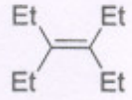
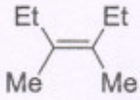
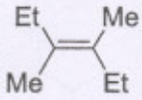
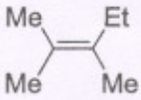
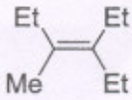
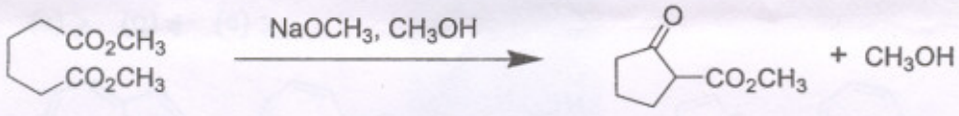
Organic Chemistry (50 points)

I. Multiple Choices (30 points in total; 3 points each) (one answer for each question)

1. Following is a diastereomer of 3-bromo-3,4-dimethylhexane. On treatment with sodium ethoxide in ethanol (NaOEt / EtOH), it gives 3,4-dimethyl-3-hexene as the elimination product. Account for the stereoselectivity of the reaction, which of the compound below would be the correct product?

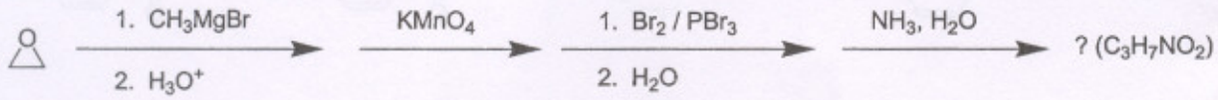
(a)  (b)  (c)  (d)  (e) 

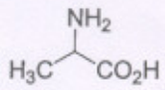
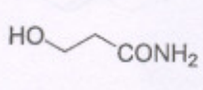
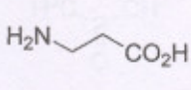
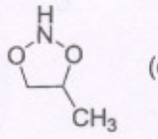
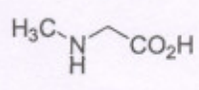
2. The correct name of the following reaction is



(a) Claisen Rearrangement (b) Curtius Rearrangement (c) Gabriel Synthesis (d) Dieckmann Cyclization (e) Hoffmann Rearrangement

3. What would be the structure of the final product of the following synthesis?



(a)  (b)  (c)  (d)  (e) 

4. There are totally nine isomers with the same formula C_7H_{16}. Which of the following isomer's name is incorrect?

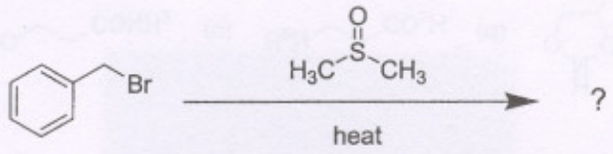
(a) 2,2,3-trimethylbutane (b) 3,3-dimethylpentane (c) 2-methylhexane (d) 2-ethyl-3-methylbutane (e) 2,4-dimethylpentane

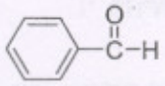
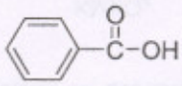
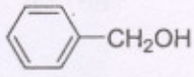
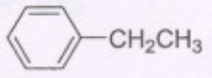
5. Which of the following specific terms has no relation with mass spectrometric analysis of organic compounds?

(a) α-cleavage (b) McLafferty Rearrangement (c) fragment ion (d) coupling constant (e)

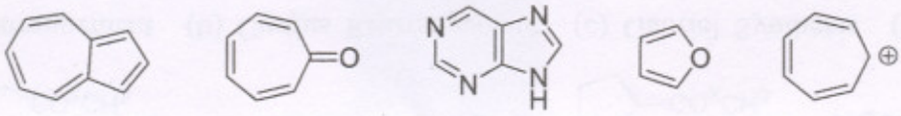
electron impact

6. What product would you expect from the following reaction?



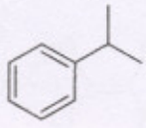
(a)  (b)  (c)  (d)  (e) 

7. How many of the following compounds are expected to be aromatic?



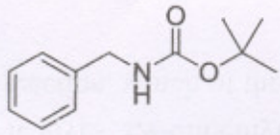
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

8. What is the correct name of the following compound?



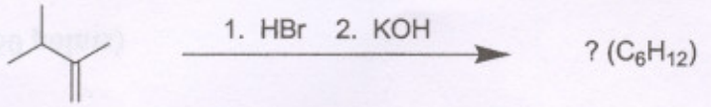
(a) anisole (b) xylene (c) cumene (d) cresole (e) ibuprofen

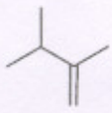
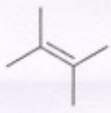
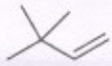
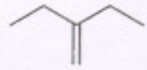
9. How many products are generated, upon treating the following compound with trifluoroacetic acid?



(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

10. The reaction shown below is expected to produce which compound as the major product?

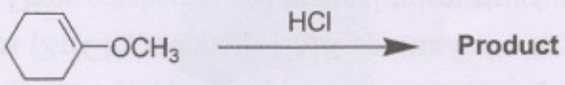


(a)  (b)  (c)  (d)  (e) 

II. Reaction, Synthesis, Organic NMR Spectroscopy (20 points in total; 4 points each)

11. An inexperienced graduate student was asked to prepare 1-chloro-1-cyclobutylpentane starting from cyclobutylchloride and other necessary reagents. He first took the starting alkylchloride to convert to the corresponding Grignard reagent, had it reacted with the needed aldehyde [$CH_3(CH_2)_3CHO$] followed by an acidic water (H_3O^+) treatment, and finally treated the isolated alocohol with HCl. He happily placed the reaction mixture in the flask and left for a Christmas party. When he returned from the party, he discovered that the actual product isolated was not the desired1-chloro-1-cyclobutylpentane molecule but an isomer of it. Suggest a structure for the product.

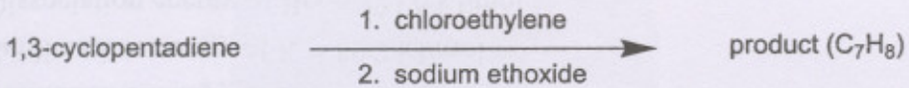
12. Provide the structure of the product of the following reaction.



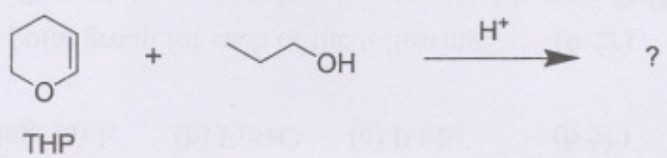
13. Propose a structure for the compound (formula C_5H_8O) that fits the following proton NMR data. All chemical shift values are in δ.

NMR data: 1.55 (singlet, 6H), 2.27 (broad singlet, 1H), 2.46 (singlet, 1H)

14. Give the structure of the final product of the following 2-step synthesis.



15. Tetrahydropyran (THP) is commonly used as a protecting group for alcohols. Give the product of the following reaction.



二、無機化學試題（8 大題共 50 分）

1. Write a reasonable electron dot structure and assign formal charges for each of the following: (a) I_3^- (b) F_2SeO (c) $IO_2F_2^-$ (6 分)

2. Assign the point group for each of the following: (6 分)
(a) TeF_4 (b) cyclohexane in chair form (c) diborane, B_2H_6

3. Given the following data, calculate the lattice energy of KBr. (4 分)
Formation enthalpy of KBr = -393.8 kJ/mol
Sublimation energy of K = 89.2 kJ/mol
Dissociation energy of Br_2 = 223.6 kJ/mol
Ionization energy of K = 418.4 kJ/mol
Electron affinity of Br = 324.6 kJ/mol

4. Find the number of unpaired electrons for each of the following species: (4 分)
(a) $[Cr(CN)_6]^{4-}$ (b) $[FeCl_4]^-$ (c) $[Fe(CN)_6]^{3-}$ (d) $[RhF_6]^{3-}$.

5. The reaction of $[ZrCl_4(dppe)]$ (dppe is a bidentate phosphine ligand) with $Mg(CH_3)_2$ gives $[Zr(CH_3)_4(dppe)]$. NMR spectra indicate that all methyl groups are equivalent. Draw octahedral and trigonal prism structures of the complex and show how the conclusion from NMR supports the trigonal prism assignment. (4 分)

6. Draw all the possible products and predict the product distribution for the reaction of *cis*-$CH_3Mn(CO)_4(^{13}CO)$ with PR_3 ($R = C_2H_5$). (6 分)

7. Predict the products of the following reactions. (6 分)

(a) $Co_2(CO)_8 + H_2 \rightarrow$

(b) $K[Re(CO)_5] + CH_3I \rightarrow$

(c) $(C_5H_5)_2Fe + (n\text{-}C_4H_9)Li \rightarrow$

8. Octahedral $ML_3(CO)_3$ is expected to have *mer* and *fac* isomers, which can be differentiated by the stretching mode analysis of vibrational spectra. If it is known that $Mo(CO)_3[P(OCH_3)_3]_3$ adopts a *mer*-structure and exhibits three stretching bands at 1993 cm^{-1}, 1919 cm^{-1} and 1890 cm^{-1}, please answer the following questions.

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	$(x,z)\ (R_x, R_y)$	$(x^2-y^2, xy)(xz,yz)$

(a) Draw the structures of *mer* and *fac* isomers for $ML_3(CO)_3$. (4 分)

(b) Based on the given character tables, deduce the irreducible symmetry representations of the stretching vibrational modes for $Mo(CO)_3[P(OCH_3)_3]_3$. (6 分)

(c) Which modes are IR-active? (2 分)

(d) Which modes are Raman-active? (2 分)