

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：有機化學及無機化學【化學系碩士班】

題號：422001

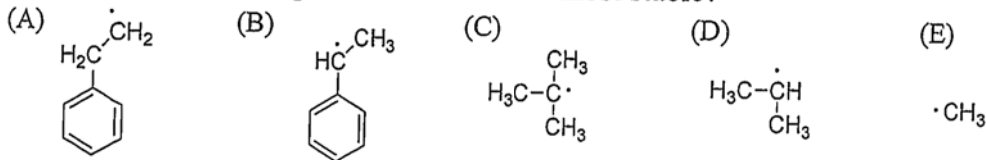
※本科目依簡章規定「不可以」使用計算機(混合題)

共 5 頁 第 1 頁

(一) 選擇題 (50%)

There is only one correct answer for each question. (2% × 25 = 50%)

1. Which of the following radicals will be the most stable?



2. What is the structural relationship between the two molecules below?

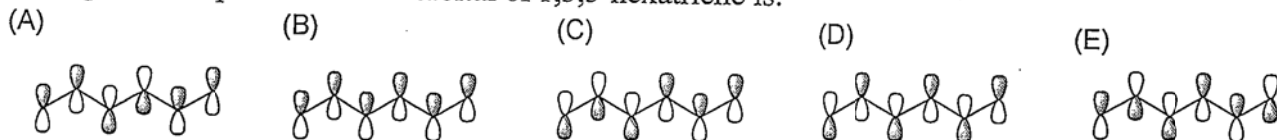


- (A) enantiomers (B) constitutional isomers (C) diastereomers
(D) meso compounds (E) not isomers

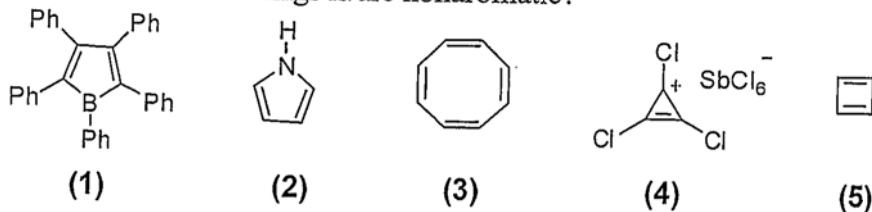
3. Rank the following species in order of increasing nucleophilicity:

- (A) $\text{CH}_3\text{CH}_2\text{S}^- < \text{CH}_3\text{CH}_2\text{O}^- < (\text{CH}_3)_3\text{CO}^- < (\text{CH}_3)_3\text{COH}$
(B) $(\text{CH}_3)_3\text{COH} < \text{CH}_3\text{CH}_2\text{O}^- < (\text{CH}_3)_3\text{CO}^- < \text{CH}_3\text{CH}_2\text{S}^-$
(C) $(\text{CH}_3)_3\text{COH} < \text{CH}_3\text{CH}_2\text{S}^- < (\text{CH}_3)_3\text{CO}^- < \text{CH}_3\text{CH}_2\text{O}^-$
(D) $(\text{CH}_3)_3\text{COH} < \text{CH}_3\text{CH}_2\text{S}^- < \text{CH}_3\text{CH}_2\text{O}^- < (\text{CH}_3)_3\text{CO}^-$
(E) $(\text{CH}_3)_3\text{COH} < (\text{CH}_3)_3\text{CO}^- < \text{CH}_3\text{CH}_2\text{O}^- < \text{CH}_3\text{CH}_2\text{S}^-$

4. The highest occupied molecular orbital of 1,3,5-hexatriene is:



5. Which of the followings is/are nonaromatic?



- (A) 1 and 2 (B) 3 and 5 (C) 3 (D) 4 (E) 4 and 5

6. In electrophilic aromatic substitution reactions, a chloro group of benzene is

- (A) a deactivator and a *m*-director. (B) an activator and a *m*-director.
(C) a deactivator and an *o,p*-director. (D) an activator and an *o,p*-director.
(E) none of the above

7. The pK_a of the most acidic hydrogen in 1,3-diketone is about

- (A) 5 (B) 9 (C) 14 (D) 19 (E) 21

8. Which of the following solvents is the most soluble in water?

- (A) Butan-1-ol (B) Dimethyl sulfoxide (C) Chloroform (D) Hexan-1-ol (E) Ethyl acetate

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

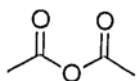
科目名稱：有機化學及無機化學【化學系碩士班】

題號：422001

※本科目依簡章規定「不可以」使用計算機(混合題)

共 5 頁 第 2 頁

9. Which of the following structures is/are not carboxylic acid derivatives?



(1)



(2)



(3)



(4)

(A) 1 (B) 2 (C) 2 and 3 (D) 3 (E) 4

10. Primary amine reacts with acetophenone to yield the

(A) iminium salt. (B) enamine. (C) acetal. (D) amide (E) imine.

11. The occupancy of body center cubic structure is:

(A) 48.3% (B) 52.4% (C) 68.0% (D) 74.1% (E) 87.4%

12. Which symmetry element is not present in a methane molecule?

(A) C_2 (B) i (C) C_3 (D) σ_d (E) S_4

13. What is the coordination number of Co^{2+} in a spinel Co_3O_4 structure?

(A) 4 (B) 6 (C) 8 (D) 12 (E) None of the above

14. In a two dimensional lattice, which one of the following indices corresponds to the smallest density of lattice points?

(A) (10) (B) (13) (C) (21) (D) (11) (E) (41)

15. What is the point group of 1,3,5,7-tetrafluorocyclooctatetraene?

(A) T_d (B) D_{4h} (C) S_8 (D) C_{4v} (E) S_4

16. Which of the following theory model can explain that nitrogen gas is diamagnetic and molecular oxygen is paramagnetic?

(A) VSEPR
(B) Lewis structure
(C) molecular orbital
(D) Le Chatelier's principle
(E) Ligand field theory

17. How many isomers of diamminediaquadichlorocobalt(III)?

(A) 6 (B) 8 (C) 10 (D) 12 (E) 16

18. What is the **incorrect** statement regarding $p-n$ junction?

(A) Charges flow in both two directions.
(B) No charge is available at the depletion zone while no external potential is applied.
(C) Forward bias results in a current flow.
(D) $p-n$ junction can be used for photovoltaic cells.
(E) All of the above

19. How many IR-active CO stretching bands for $fac-Mo(CO)_3(CH_3CH_2CH_2CN)_3$?

(A) None (B) 1 (C) 2 (D) 3 (E) 4

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：有機化學及無機化學【化學系碩士班】

題號：422001

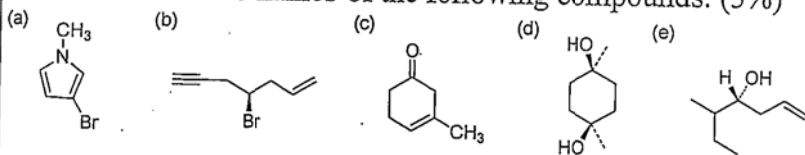
※本科目依簡章規定「不可以」使用計算機(混合題)

共 5 頁第 3 頁

20. Titanium dioxide (TiO_2) is a well-known photosensitive semiconductor for various photocatalysis. What is the **incorrect** statement regarding TiO_2 materials?
- (A) The band gap corresponds to UV-light absorption.
 (B) Generally considered as n-type semiconductor.
 (C) Increased life time of separated photo-charges in TiO_2 results in weaker photocatalytic activities.
 (D) A white color material.
 (E) It has two phases of anatase and rutile stable in ambient conditions.
21. The increased order of $\nu(\text{CO})$ is observed in a series of the following compounds: $\text{Fe}(\text{CO})_4^{2-} < \text{Co}(\text{CO})_4^- < \text{Ni}(\text{CO})_4$. Predict their frequency order of metal-carbon bonds, $\nu(\text{M-C})$:
- (A) $\text{Fe}(\text{CO})_4^{2-} < \text{Co}(\text{CO})_4^- < \text{Ni}(\text{CO})_4$.
 (B) $\text{Ni}(\text{CO})_4 < \text{Co}(\text{CO})_4^- < \text{Fe}(\text{CO})_4^{2-}$.
 (C) $\text{Fe}(\text{CO})_4^{2-} < \text{Ni}(\text{CO})_4 < \text{Co}(\text{CO})_4^-$.
 (D) $\text{Co}(\text{CO})_4^- < \text{Fe}(\text{CO})_4^{2-} < \text{Ni}(\text{CO})_4$.
 (E) None of the above
22. Please select the most likely first-row transition metals (M) in the compound of $[\text{M}(\text{CO})_2(\text{PPh}_3)(\eta^5\text{-Cp})]\text{Cl}_2$?
- (A) Ni (B) Fe (C) Mn (D) Co (E) None of the above
23. Please predict the final product of the following reaction: $\text{trans-}[\text{Pt}(\text{Py})_2(\text{NH}_3)\text{Cl}]^+ + \text{Cl}^- \rightarrow$
- (A) $\text{trans-}[\text{Pt}(\text{Py})_2\text{Cl}_2]$
 (B) $\text{cis-}[\text{Pt}(\text{Py})(\text{NH}_3)\text{Cl}_2]$.
 (C) $\text{trans-}[\text{Pt}(\text{Py})_2(\text{NH}_3)\text{Cl}]^+$
 (D) $\text{trans-Pt}(\text{NH}_3)_2\text{Cl}_2$
 (E) None of the above
24. Which of the following statement regarding zeolite materials is **correct**?
- (A) possessing ion-exchange properties
 (B) aluminosilicate frameworks
 (C) molecular sieves
 (D) selective catalysts for industry
 (E) All of the above
25. The color of iodine varies in different solvents that act as bases, showing the shift of the electronic spectra. By referencing the color of gas-phase I_2 , which of the following solvent environment causes the biggest blue shift?
- (A) Benzene (B) Hexane (C) Methanol (D) Dodecane (E) Cyclohexane

(二) 非選擇題 (50%)

1. Give the IUPAC names of the following compounds. (5%)



2. Give an example for each of the following name reactions. (5%)

- (a) Hofmann elimination (b) Claisen condensation
 (c) Friedel-Crafts acylation (d) Birch reduction
 (e) Michael addition

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

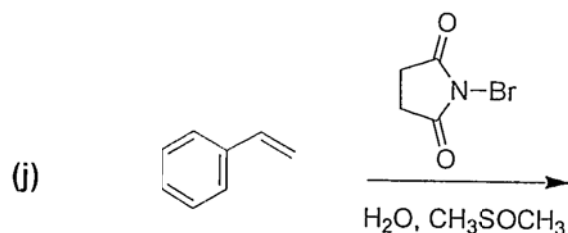
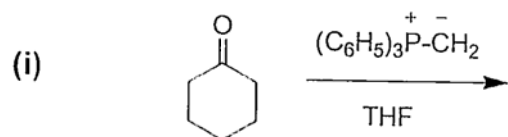
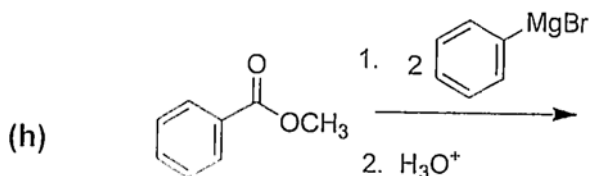
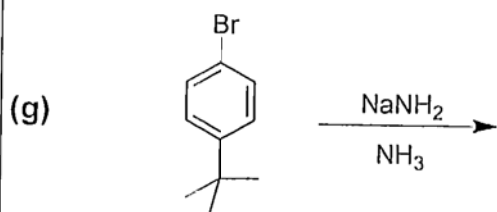
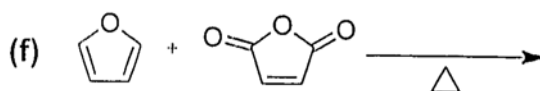
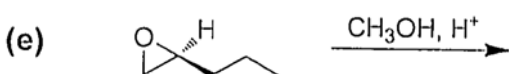
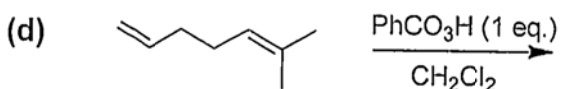
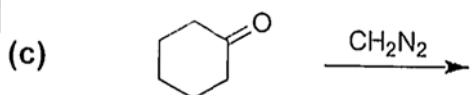
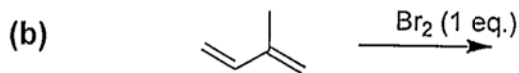
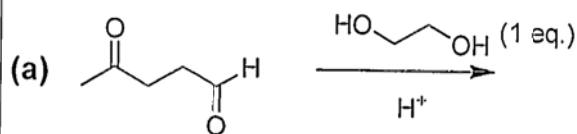
科目名稱：有機化學及無機化學【化學系碩士班】

題號：422001

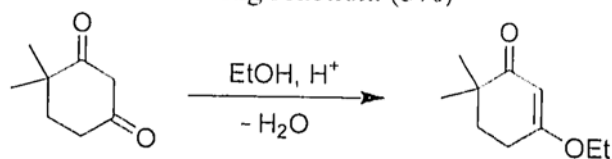
※本科目依簡章規定「不可以」使用計算機(混合題)

共 5 頁 第 4 頁

3. Predict the major products. (10%)



4. Draw reasonable mechanism for the following reaction. (5%)



5. How would you synthesize 3,5-dibromotoluene from toluene? (5%)

6. Please describe the diffraction equation of Bragg's law, and predict the changes of d spacing in a crystals if two theta decreases (under a fixed-wavelength X-ray irradiation)? (5%)

7. A natural MnO_2 mineral has a mixed valence comprised of Mn^{3+} and Mn^{4+} . The elemental analysis shows the presence of Mg, K, and Mn with a mole ratio of 2:1:32. Give the average oxidation state of Mn in this mineral. (10%)

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：有機化學及無機化學【化學系碩士班】

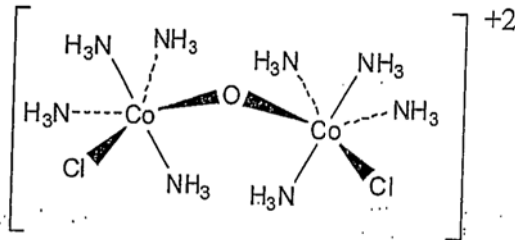
題號：422001

※本科目依簡章規定「不可以」使用計算機(混合題)

共 5 頁第 5 頁

8. Please answer the following questions. (5%)

(a) Give the IUPAC name of the following molecule



(b) Predict which compound of AgI and AgCl has higher solubility in water, and give a brief explanation.

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：物理化學及分析化學【化學系碩士班】

題號：422002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題） 共 1 頁第 1 頁

分析化學部分

- 1) Calculate the wavelength (nm) of a light that is able to ionize a sodium (Na) atom. The ionization energy of the Na atom is 118.5 Kcal/mole, 1Kcal/mole = 6.95×10^{-14} erg/atom, the Planck's constant = 6.63×10^{-27} erg-sec. (10%)
- 2) Define effective bandwidth ($\Delta\lambda_{\text{eff}}$). How does this term relate with the reciprocal linear dispersion (D^{-1}) and the slit width (w)? How do you judge the performance of a spectroscopy based on effective bandwidth? (10%)
- 3) Define LASER? You must describe the English words of each letter of LASER. Describe the principle of laser in details based on its mechanisms. (10%)
- 4) How to prepare 200 mL of 0.01 M solution of NaOH (10%)
- 5) Discuss the principle of a FT-IR. Please draw the instrumental design of a Michael interferometer, and derive the equation for how to detect the optical frequency (ω) of the FT-IR from the frequency (f) of a Michael interferometer. The moving mirror has a constant velocity v (10%)

物理化學部分

- 6) For the particle in a cubic box with the length of every side = a, what is the degree of degeneracy of the energy levels with $E = 27h^2/8ma^2$? Show your calculation explicitly. (10%)
- 7) The ground state wavefunction of a hydrogenic atom is $\psi = (1/\pi a_0^3)^{1/2} e^{-r/a_0}$. Calculate the mean potential energy of an electron in the ground state of this atom.
$$\int_0^\infty r^n e^{-ar} dr = \frac{n!}{a^{n+1}} \quad (15\%)$$
- 8) The concentration of species B in the rate process
 $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ is given by (when $k_1 \neq k_2$) $[B] = \frac{[A]_0 k_1}{k_2 - k_1} (e^{-k_1 t} - e^{-k_2 t})$. Find the time t, in terms of k_1 and k_2 , at which B has its maximum concentration. (15%)
- 9) The first law of thermodynamics states that the internal energy of an isolated system is constant. Please discuss why people sometimes say that "the direction of a spontaneous reaction is driven by energy", which is against the first law of thermodynamics. Under what conditions can energy be applied to determine the direction of a spontaneous change of a process? (10%)

