國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：有機化學【材光系碩士班甲組】　　題號：439003

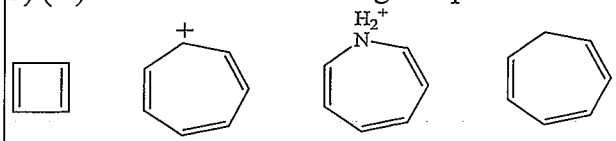
※本科目依簡章規定「不可以」使用計算機(混合題)　　

1. 選擇題 (單選, Each 2%, Total: 40%)

1) ( ) Rank the following substituents in order of priority (from highest to lowest priority).
(I) -CH=CH_2, (II) –CN, (III) -CH_2NH_2, (IV) -CH_2Br.
(a) I > II > III > IV, (b) II > III > I > IV, (c) IV > II > I > III, (d) IV > III > II > I

2) ( ) Which of the following reagents effectively cleaves carbon-carbon double bonds? (a) Br_2 and light, (b) *meta*-chloroperoxybenzoic acid, (c) OsO_4 followed by H_2O_2, (d) O_3 followed by $(CH_3)_2S$.

3) ( ) Which of the following compounds is likely to adopt a planar conformation?



I　　II　　III　　IV　　a) I, b) II, c) III, d) IV.

4) ( ) Rank the following compounds in order of increasing oxidation level (from the highest to lowest)
(I) CH_3CH_2OH, (II) CH_3CHO, (III) CH_3CO_2H, (IV) CH_3-CH_3
(a) I > II > III >IV, (b) III > II > I > IV, (c) II > III > I >IV, (d) III > II > IV > I.

5) ( ) Catalysts alter the kinetics of a reaction by: (a) Making the products more stable, (b) Making the reaction more exothermic, (c) Lowering the energy of activation for the reaction, (d) Providing a source of free radicals to initiate a reaction.

6) ( ) Which of the following compounds is the strongest acid? (a) $CH_3O_2CCH_2CH_3$, (b) $CH_3CH_2O_2CCH_2CO_2CH_2CH_3$, (c) $CH_3CH_2O_2CCH_2CH_2CO_2CH_2CH_3$, (d) $CH_3CO_2CH_2CH_3$.

7) ( ) Which of the following isomers of C_8H_9NO is the weakest base?
(a) *o*-aminoacetophenone, (b) *m*-aminoacetophenone, (c) *p*-aminoacetophenone, (d) acetanilide.

8) ( ) What is the mixed aldol condensation product formed between benzaldehyde and acetone?
(a) C_6H_5CH=CHC(=O)CH_3,　(b) C_6H_5C(=O)CH=$CHCH_3$,　(c) C_6H_5CH=$C(CH_3)_2$,
(d) $C_6H_5CH_2C$(=O)CH= CH_2.

9) ( ) The most effective pair for the preparation of *tert*-butyl ethyl ether is (a) potassium *tert*-butoxide and ethyl bromide, (b) potassium *tert*-butoxide and ethanol, (c) sodium ethoxide and *tert*-butyl bromide, (d) *tert*-butyl alcohol and ethyl bromide.

10) ( ) Which of the following transitions is the highest energy transition? (a) n to σ*, (b) n to π*, (c) σ to σ*, (d) π to π*

11) ( ) Which ion is the strongest base? (a) $CH_3CH_2O^-$, (b) CH_3COO^-, (c) Cl^-, (d) $CH_3CH_2^-$.

12) ( ) Which of the following statements of I-IV correctly describe(s) E1 reactions of alkyl halides (RX)?(I) Rate = k [base]; (II) Rate = k[base][RX]; (III) Rate = k[RX]; (IV) The reactions occur in two distinct steps. (a) I, (b) II and IV, (c) I, II and III, (d) III and IV.

13) ( ) Which of the following compounds can be used to prepare Grignard reagents by reacting with Mg in ether?. (I) CH_3CH=CH-CH_3, (II) CH_3CH_2CH(Br)-CH_3; (III) HO-$CH_2CH_2CH_2CH_2Br$; (IV) HOOC-$CH_2CH_2CH_2CH_2Br$. (a) I; (b) II; (c) III; (d) IV.

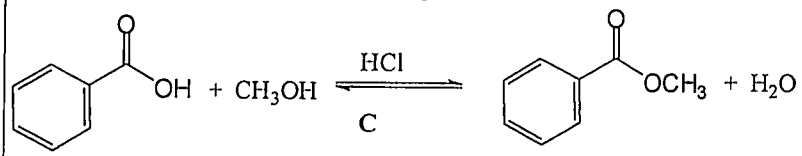
14) ( ) How are reactions between aldehydes and nucleophiles fundamentally different than reactions between acyl chlorides and nucleophiles? (a) Aldehydes are readily oxidized by nucleophiles to carboxylic acids. (b) Acyl chlorides have a leaving group, Cl-, whereas aldehydes do not. (c) Aldehydes do not form tetrahedral intermediates with nucleophiles. (d) Acyl chlorides readily form enol tautomers.

15) ( ) The proton NMR of 1,1-dibromoethane would appear as a: (a) downfield doublet and upfield quartet, (b) downfield quartet and upfield doublet, (c) downfield doublet and upfield triplet, (d) downfield triplet and upfield doublet.

16) ( ) In infrared spectroscopy, absorption of electromagnetic radiation results in transitions between _____ energy levels. (a) vibrational, (b) electronic, (c) rotational, (d) nuclear.

17) ( ) Which alcohol of molecular formula $C_5H_{12}O$ has the fewest signals in its ^{13}C NMR spectrum?
(a) 1-Pentanol, (b) 2-Pentanol, (c) 2-Methyl-2-butanol, (d) 2,2-Dimethyl-1-propanol.

(Questions 18-20) The following esterification reaction concerns questions 18-20:



A　　B　　D

18) (　) The nucleophile in this reaction is (a) A, (b) B, (c) C, (d) D.

19) (　) Compound C (HCl) function as (a) a base scavenger, (b) a solvent, (c) a catalyst, (d) a neutralizer.

20) (　) This esterification reaction is an example of (a) nucleophilic acyl addition, (b) nucleophilic acyl substitution, (c) nucleophilic acyl elimination, (d) nucleophilic acyl rearrangement.

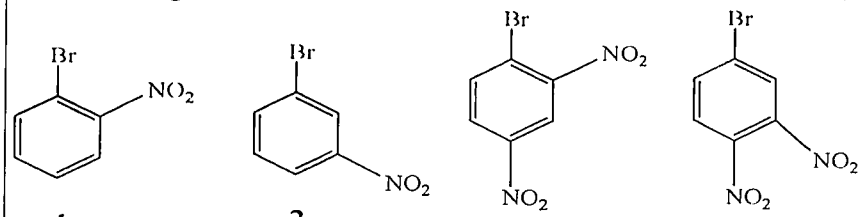
2. (Total: 30%) Answer questions (a) to (d).

1) Nitration of ethyl phenyl ether (EtOPh) belongs to the electrophilic aromatic substitution reactions used to generate aromatic nitro compounds. Nitration of ethyl phenyl ether can be conducted by using HNO_3/H_2SO_4 as the nitration agent.

(a) Identify the active electrophile (the real cationic species leading to nitration) in the nitration reaction. (4%)

(b) The first nitro group can be readily introduced into ethyl phenyl ether readily; in contrast, further nitration to introduce the second nitro groups into ethyl phenyl ether proceeds slowly even sufficient electrophile was used. Why? (8 %)

2) Instead of electrophilic substitution reaction, aromatic nitro-compounds can be also prepared via nucleophilic aromatic substitution reaction. For example, direct attack of ethoxide ion ($CH_3CH_2O^-$) on the following molecules of **1** to **4** results in the substitution on the bromo groups,



1　　**2**　　**3**　　**4**

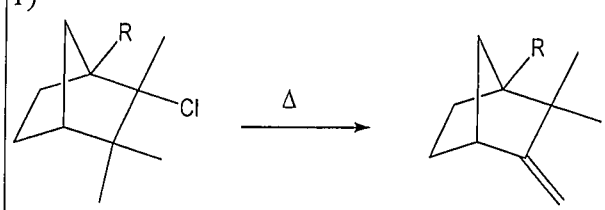
(c) Single-step substitution reaction (in other words, a SN2 reaction) is prohibited for the nucleophilic substitution reactions between molecules **1-4** and ethoxide ion. Instead, the aromatic substitution of molecules **1- 4** proceeds with two steps, addition and the following elimination. Why single-step substitution (SN2) reaction is prohibited for molecules of **1- 4**? (10%)

(d) List the order of reaction rate (from highest to lowest) between molecules **1-4** and ethoxide ion. (8%)

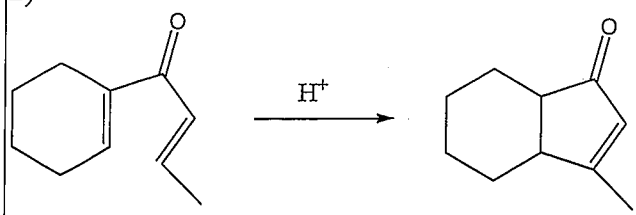
3. (Total: 10%) When treated with aqueous acid, substance **A** forms dimethylformamide ($(CH_3)_2NC(=O)H$) and 2 equiv of ethanol. **A** exhibits the following spectrum (^{1}H NMR, δ): 1.2 triplet (6H), 2.3 singlet (6H), 3.5 quartet (4H), 4.5 singlet (1H). What is the structure of A?

4. (Total: 20 %, each 5%) Write down the reaction steps involved in each of the following reactions from 1) to 4).

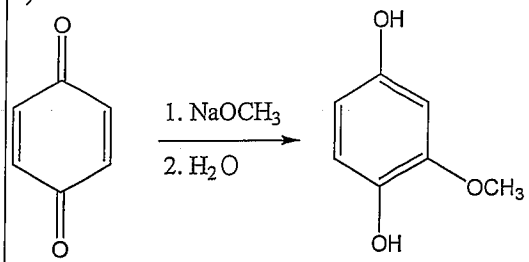
1)



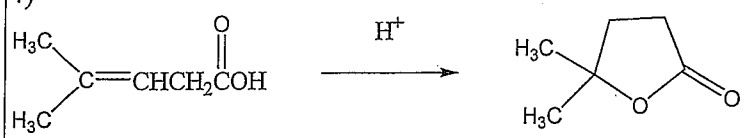
2)



3)



4)



-The end-

國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【材光系碩士班乙組】　　題號：439001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. Find the general solution of $y^{iv}+4y=0, y(0)=\frac{1}{2}, y'(0)=-\frac{3}{2}, y''(0)=\frac{5}{2}, y'''(0)=-\frac{7}{2}$ (10%)

2. Solve the differential equation of $y'=\frac{1}{x}y^2+\frac{1}{x}y-\frac{2}{x}$ (15%)

3. Find the recurrence relation of $(1-x^2)y''-2xy'+n(n+1)y=0$ at $x=0$. n is a real number. (15%)

4. Solve the general solution in terms of J_v and Y_v for $x^2y''+(1-2v)xy'+v^2(x^{2v}+1-v^2)y=0$ (15%)

5. Solve the inverse Laplace transform of $\frac{s^2+2}{s^4-6s^3+32s}$. (10%)

6. Solve $\frac{\partial^2 u}{\partial r^2}+\frac{1}{r}\frac{\partial u}{\partial r}+\frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2}=0$ in the disk $r < R$ with $u(R,\theta)=f(\theta)$ (20%)

7. Solve by Laplace transforms: $\frac{\partial w}{\partial x}+2x\frac{\partial w}{\partial t}=2x, w(x,0)=1$ and $w(0,t)=1$ (15%)

國立中山大學104學年度碩士暨碩士專班招生考試試題

科目名稱：光電概論【材光系碩士班丙組】　　題號：439002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）　　

Section A: 多選題(第1題至第8題，每題有5個選項，其中至少有一個是正確的選項，請將正確選項畫記在答案卡之「選擇題答案區」。各題之選項獨立判定，所有選項均答對者，得5分；答錯1個選項者，得3分；答錯2個選項者，得1分；答錯多於2個選項或所有選項均未作答者，該題以零分計算。) Some additional information in the Appendix is required for answering the questions.

1. A tungsten wire has a uniform cross-sectional area of 100 μm^2, and a length of 10 cm. The electrical resistance of the wire would be: (a) less than 1 ohm. (b) between 1 and 100 ohm. (c) larger than 100 ohm. (d) between 0.1 and 10 ohm. (e) between 10 and 1000 ohm. (5 points)

2. If the tungsten wire in Problem 1 is connected across the terminals of a 9.0 V battery, the heat generated in a period of 60 s would be: (a) < 1 J. (b) < 10 J. (c) > 3 J. (d) > 30 J. (e) > 300 J. (5 points)

3. There are five wires made of gold, iron, tungsten, silver, and zinc, respectively. Each wire has the same volume (0.1 cm^3), and the same length (1 meter). Among the five metal wires, find the top three metals having higher resistance: (a) gold, (b) iron, (c) tungsten, (d) silver (e) zinc. (5 points)

4. There are five wires made of aluminum, copper, gold, magnesium, and silver, respectively. Each wire has the same weight (1 g), and the same length (1 meter). Among the five metal wires, find the top two metals having higher electrical conductance: (a) aluminum, (b) copper, (c) gold, (d) magnesium (e) silver. (5 points)

5. A He-Ne laser is a type of gas laser whose gain medium consists of a mixture of helium and neon (10:1) inside of a small bore capillary tube, usually excited by a DC electrical discharge. The pressure inside the tube is 1 mm of Hg. The best-known and most widely used HeNe laser operates at a wavelength of 632.8 nm in the red part of the visible spectrum. Find all the correct description(s). (a) Its photon energy is higher than 2 eV. (b) Its photon energy is less than 2 eV. (c) The optical frequency is larger than $5x10^{14}$ Hz. (d) The optical frequency is less than $5x10^{14}$ Hz. (e) The optical frequency is equal to $5x10^{14}$ Hz. (5 points)

6. Find all the correct description(s) of the properties of silicon: (a) The bandgap is higher than germanium's. (b) When adding a small amount of boron, it becomes an n-type semiconductor. (c) When adding small amount of boron, the hole density becomes higher than the electron density. (d) The electrical conductivity of the intrinsic silicon at low temperature is higher than the conductivity at room temperature. (e) Silicon is a direct-gap semiconductor. (5 points)

7. For the parallel-plate capacitors have the same area and the same spacing, and use a dielectric material inserted within the plates. Find all the correct answer(s): (a) The capacitor using fused silica will have higher capacitance than the capacitor using polystyrene. (b) The capacitor using fused silica can be operated to a higher voltage than the capacitor using polystyrene. (c) Some capacitors operated at 60 Hz, and 1 MHz, will have different capacitance values. (d) Two identical capacitors are operated at different alternating current (AC) frequency with the same peak voltage V. The higher frequency capacitor stores more charge at the peak voltage than the lower frequency one. (e) The capacitor using soda-lime glass can have higher capacitance than the one using fused silica. (5 points)

8. Find all the correct description(s): (a) The conductivity of silicon is very sensitive to the impurities, and the impurity concentration. (b) The conductivity of copper is very sensitive to the impurities, and the impurity concentration. (c) The conductivity of gallium arsenide is very sensitive to the impurities, and the impurity concentration. (d) The conductivity of soda-lime glass is very sensitive to the impurities, and the impurity concentration. (e) The conductivity of polystyrene is very sensitive to the impurities, and the impurity concentration. (5 points)

Section B: 非選擇題: 答案必須寫在「答案卷」上，並於題號欄標明大題號（9、10、11）與子題號（a、b、c）。作答時不必抄題，但必須寫出計算過程或理由，否則將酌予扣分。

9. A transparent rod, with a refractive index of 1.5, has a radius r and a length h ($h>>r$) (shown in Fig. 1). The rod is standing vertically in the air. A laser beam is incident to the top with an incident angle θ. (a) (8 points) What is the maximum θ that the beam entering the top of the rod having no loss to the surrounding medium? (Assuming that the length h is approaching to infinity) (b) (6 points) What would be the maximum θ having no loss to the surrounding, if the surrounding of the rod is embedded in a medium with a refractive index 4/3, but the top end is still in air? (c) (6 points) What would be the maximum θ having no loss to the surrounding, if the surrounding of the rod, including the top, is all immersed in a medium with refractive index 4/3? (sub-total 20 points)

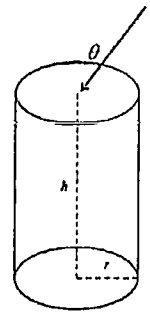


Figure 1

10. A conducting wire (negligible diameter) with a uniform charge density of $\lambda\,(C/m)$ is located at (x=2m, y=1m) (shown in Fig. 2). (a) (8 points) Find the force on a point charge $+q$ located at a position $r=(x,y,z)$. (b) (6 points) If a grounded conducting plane is located at y=0, what is the electric filed at position $\vec{r}=(x,y,z)$; $\vec{E}(x,y,z)=?$ (c) (6 points) Two semi-infinite grounded conducting planes meet at right angle. One is located at x=0, and the other at y=0. Find the electric potential at $\vec{r}=(x\geq 0, y\geq 0, z)$. (sub-total 20 points)

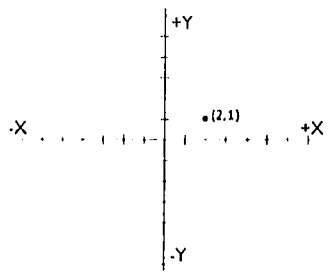


Figure 2

11. A capacitor is a passive two-terminal electrical component used to store energy electrostatically in an electric field. (a) (8 points) Find the capacitance of a "parallel-plate capacitor" containing of two metal surfaces of area A held a distance d apart. The potential of the two plates are 0 and $+V$, respectively. (b) (6 points) If the storage charges in the capacitor remain the same, but a medium with dielectric constant ε_r is inserted within the plates. What is the eventually potential difference between the plates? (c) (6 points) If the charges in the capacitor remain the same, but a stack of equally spaced N layers is inserted with the plates. Each layer has a dielectric constant ε_r with conducting coating on the surface, and having a thickness of d/N. (the coating thickness is negligible) Find the eventually potential difference between the plates. (sub-total 20 points)

Appendix: The following information might be useful for your answering the questions.

- Planck constant $h = 6.626 \times 10^{-34}\ J \cdot s = 4.136 \times 10^{-15}\ eV \cdot s$
- The speed of light in a vacuum $c = 299792458\ m/s$

Table 1: Electrical conductivity (σ) and density (g/cm^3) for some metals

Material	$\sigma\ (\Omega \cdot m)^{-1}$	(g/cm^3)
Ag	6.2×10^7	10.5
Al	3.5×10^7	2.70
Au	4.1×10^7	19.3
Be	2.8×10^7	1.85
Cu	6.0×10^7	8.96
Fe	1.0×10^7	7.87
Mg	2.1×10^6	1.74
Ni	1.4×10^7	8.90
W	1.8×10^7	19.3
Zn	1.7×10^7	7.00

Table 2: Dielectric constants and strengths for some dielectric materials

Materials	Dielectric constant		Dielectric strength
	60 Hz	1 MHz	(V/2.5mm)
Fused silica	4.0	3.8	250
Mica	–	5.4 – 8.7	1000 – 2000
Nylon 6,6	4.0	3.6	400
Polystyrene	2.6	2.6	500 – 700
Soda-lime glass	6.9	6.9	250