

# 國立臺灣師範大學 109 學年度碩士班招生考試試題

科目：無機化學

適用系所：化學系

注意：1.本試題共 2 頁，請依序在答案卷上作答，並標明題號，不必抄題。2.答案必須寫在指定作答區內，否則依規定扣分。

1. Explain the following terms: (12 points)

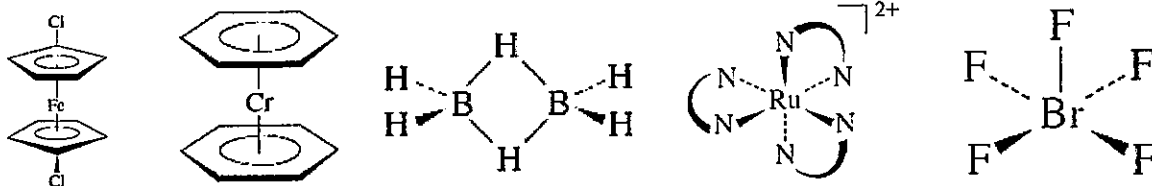
(a) Lewis acid (b) Brønsted acid (c) Electronegativity.

2. The ion  $\text{NO}^-$  can react with  $\text{H}^+$  to form a chemical bond. Which structure is more likely, HON or HNO? Explain your reasoning. (8 points)

3. Briefly describe the following terms: (12 points)

(a) Semiconductor (b) CVD (c) quantum dot.

4. Determine the point groups for: (10 points)



5. Determine the point group and the number of IR- and Raman-active C–O stretching vibrations for  $\text{Fe}(\text{CO})_5$ . (8 points)

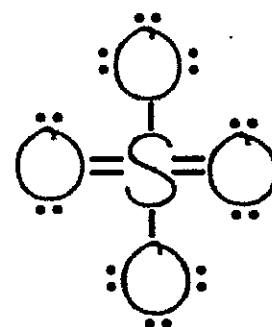
$D_{3h}$	$E$	$2C_3$	$3C_2$	$\sigma_h$	$2S_3$	$3\sigma_v$		
$A_1'$	1	1	1	1	1	1		$x^2 + y^2, z^2$
$A_2'$	1	1	-1	1	1	-1	$R_z$	
$E'$	2	-1	0	2	-1	0	$(x, y)$	$(x^2 - y^2, xy)$
$A_1''$	1	1	1	-1	-1	-1		
$A_2''$	1	1	-1	-1	-1	1	$z$	
$E''$	2	-1	0	-2	1	0	$(R_x, R_y)$	$(xz, yz)$

6. Allotropes are different structural modifications of an element. Diamond, graphite, graphene, carbon nanotubes, graphyne and fullerene are allotropes of carbon. (10 points)

- Which material has been awarded by Nobel Prize in Chemistry? (2 points)
- Which material has been awarded by Nobel Prize in Physics? (2 points)
- Which material is composed of carbon-carbon triple bond? (2 points)
- Which materials can be semiconductors? (4 points)

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7. Draw Lewis structures (see example) with reasonable molecular shapes and then assign steric numbers (SN) of sulfur atoms for thiosulfate ( $S_2O_3^{2-}$ ), dithionite ( $S_2O_4^{2-}$ ), and peroxodisulfate ( $S_2O_8^{2-}$ ). (12 points)



An example:  $SO_4^{2-}$   
(SN=4)

8. Cobalt (II) chloride ( $CoCl_2 \cdot nH_2O$ , for  $n = 0-9$ ) solids can be blue (anhydrous,  $n=0$ ) or purple (hydrates,  $n=6$ ). (14 points)
- Anhydrous  $CoCl_2$  is octahedrally coordinated. What is the coordination number(s) of chlorine (Cl)? Calculate or rationalize it. (2 points)
  - Hexahydrated  $CoCl_2$  is purple and also octahedrally coordinated. Draw all possible structures with coordinated hydrates. (4 points)
  - Use spectrochemical series ( $H_2O \gg Cl^-$ ) to explain origin of color difference between anhydrous (blue) and hydrated  $CoCl_2$  (purple). (4 points)
  - Besides UV-vis, give one technique (or instrumentation) that can be used to distinguish anhydrous and hydrated  $CoCl_2$  solids? Explain. (4 points)
9. Carbon monoxide is a common ligand in organometallic chemistry. CO can bond to a single metal or bridge between two ( $\mu_2$ -CO) or more metals. (14 points)
- Draw the structures of  $Fe_2(CO)_9$  and  $Mn_2(CO)_{10}$ . (4 points)
  - Predict which of the complex  $[V(CO)_6]^-$ ,  $[Cr(CO)_6]$ ,  $[Mn(CO)_6]^+$  has the shortest C-O bond? (4 points)
  - Which ligand ( $NO^+$ ,  $NO$ , or  $NO^-$ ) is isoelectronic with CO? (2 points)
  - Cyanide ( $CN^-$ ) is isoelectronic with CO but tends to bond to the metals having higher oxidation states. Explain why  $CN^-$  is a stronger  $\sigma$ -donor but weaker  $\pi$ -acceptor than CO. (4 points)