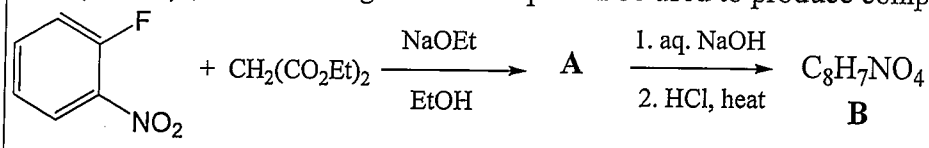
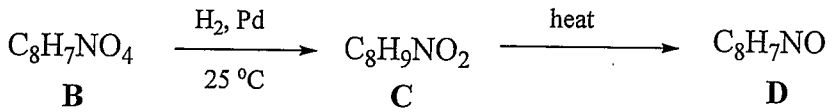
國立中山大學106學年度碩士暨碩士專班招生考試試題

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(問答申論題)　　

1. (Total: 30%) Starting from the substitution reaction between *o*-nitrofluorobenzene and diethylmalonate ($CH_2(CO_2Et)_2$, the following reaction steps can be used to produce compounds A, B, C and D.





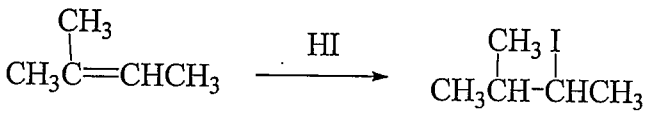
(a) Give structures for compounds A, B, C and D. (20%, each 5%)

(b) Instead of single substitution reaction step, the reaction between *o*-nitrofluorobenzene and diethylmalonate actually involved two mechanistic steps to result in the substituted product of **A**. Why this reaction took place in two steps instead of one? (5%)

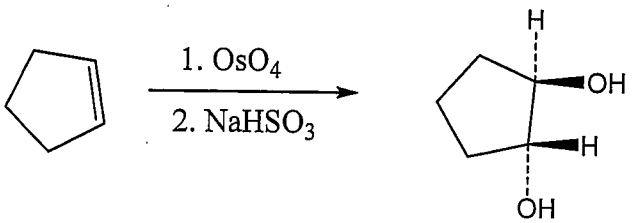
(c) Without the *o*-nitro group, simple fluorobenzene cannot react with diethylmalonate to result in th desired substituted product. The *o*-nitro group of *o*-nitrofluorobenzene is therefore essential for the substitution reaction between *o*-nitrofluorobenzene and diethylmalonate. Why? (5%)

2. (Total: 20%, each 5%) In planning the synthesis of one compound from another, it's just as important to know what not to do as know what to do. The following reactions all have serious drawbacks to them. Explain the potential problems of each:

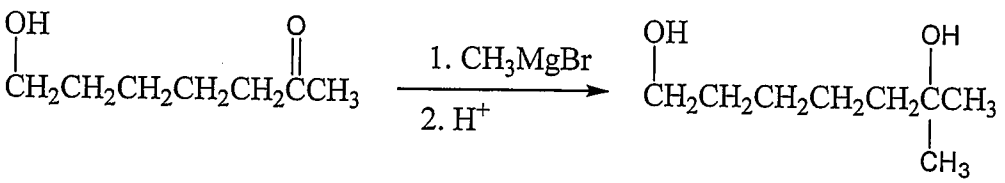
(a) (5%)



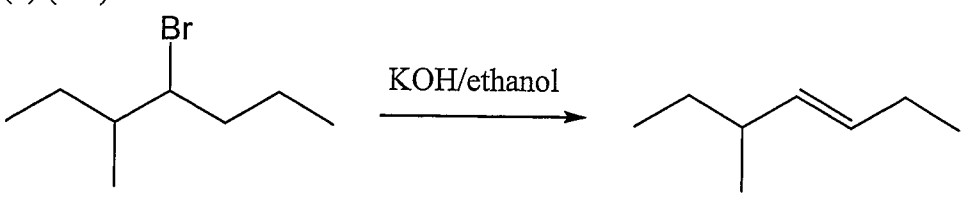
(b) (5%)



(c) (5%)



(d) (5%)



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3. (Total: 20%, each 5%) What are the structures of compounds with the following molecular formula and spectral data in (a) to (d).

(a) $C_{10}H_{12}O_2$, ^{1}H NMR, δ 1.2 triple (3H), 2.9 quartet (2H), 3.9 singlet (3H), 7.0, 8.0 pair of doublets (4H). (5%)

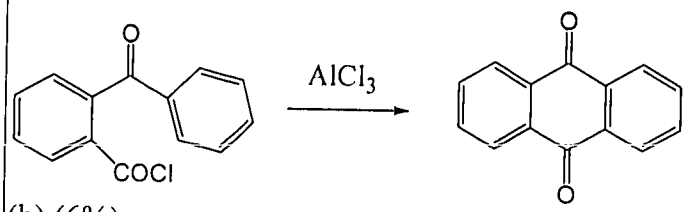
(b) C_4H_8O, ^{1}H NMR, δ 1.1 doublet (6H), 2.4 multiplet (1H), 9.6 finely split doublet (1H). (5%)

(c) $C_7H_{14}O$, ^{1}H NMR, δ 1.1 doublet (12H). 2.8 septet (2H). (5%)

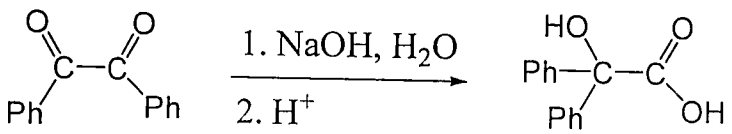
(d) $C_5H_{10}O_2$, FTIR, 1710 cm^{-1} and broad absorbance at 3400 - 2500 cm^{-1}, ^{1}H NMR, δ 1.3 singlet (9H), 11.3 singlet (1H). (5%)

4. (Total: 30%, Each 6%) Write down the mechanistic steps involved in reactions (a) to (e):

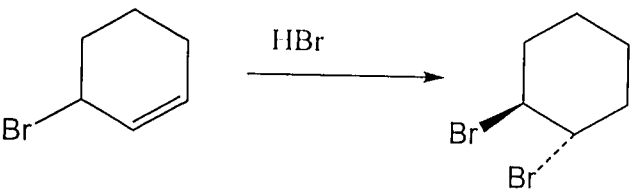
(a) (6%)



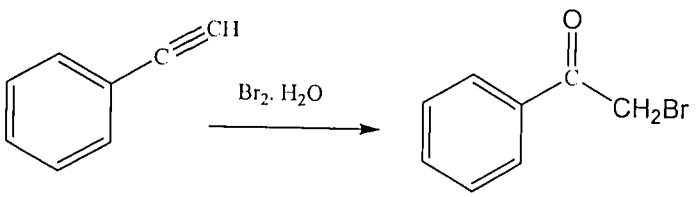
(b) (6%)



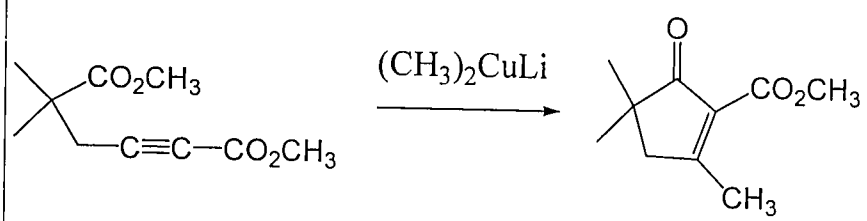
(c) (6%)



(d) (6%)



(e) (6%)



國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：物理化學【材光系碩士班甲組】　　題號：439005

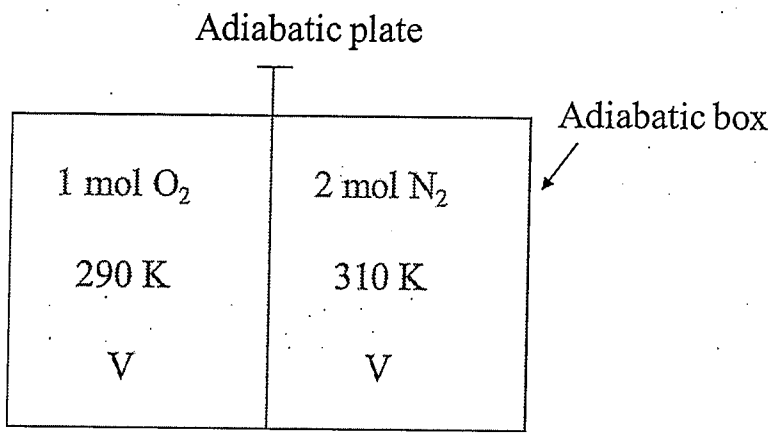
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. For a real gas $P(V-b) = RT$, calculate C_p-C_v? (10%)

2. Sketch the possible form of an AMX NMR spectrum, where A, M, and X are protons with distinctly different chemical shift and the coupling constant of $J_{AM} > J_{AX} > J_{MX}$. (15%)

3. Calculate ΔS (for the system) when the state of 3.00 mol of perfect gas atoms, for which $C_{p,m} = 2.5\ R$, is changed from 25 °C and 1.00 atm to 125 °C and 5.00 atm. (15%)

4. Calculate the entropy change if we remove the adiabatic plate as following Figure. Assume that the $C_{p,m}$ for O_2 and N_2 gases are the same: $C_{p,m} = 29.0$ J/K.mole (20%)



5. Calculate the change in Gibbs energy when a spherical droplet of water (1 g) disperses into the radius of 20 nm particles (r = 20 nm) where density of water is 1×10^3 kg.m^{-3} and the surface tension of water is 72×10^{-3} N.m^{-1} (20%)

6. Derive the rate of reaction ethane of

$C_2H_6 \Leftrightarrow C_2H_4 + H_2$

(1) Initiation: $C_2H_6 \xrightarrow{k_1} 2CH_3$

Chain transfer: $CH_3 + C_2H_6 \xrightarrow{k_2} CH_4 + C_2H_5$

(2)Propagation: $C_2H_5 \xrightarrow{k_3} C_2H_4 + H$

$H + C_2H_6 \xrightarrow{k_4} H_2 + C_2H_5$

(3)Termination: $H + C_2H_5 \xrightarrow{k_5} H_2 + C_2H_4$

We assume that k_1 is very small when compared with other rate constants.

(20%)

國立中山大學106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）（問答申論題）　　

1. Find the general solution of $y' = -\frac{8x^2}{y}$ (10%)

2. Find the general solution of $y''' - 3y'' + 3y' - y = 4\cos x$ (15%)

3. Use the power series method to solve $y'' + 4y = 0$ (15%)

4. Use Laplace transform to solve $y'' - 4y' + 4y = te^{2t}$, $y(0) = 1, y'(0) = 2$ (20%)

5. One-dimensional heat equation: $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$, where the constant c^2 is the thermal diffusivity. Find the temperature $u(x,t)$ in a laterally insulated copper bar of length 100 cm whose ends are kept at temperature 0, assuming that the initial temperature is

$$u(x,0) = \begin{cases} x & if \ \ 0 < x < 50 \\ 100 - x & if \ \ 50 < x < 100 \end{cases}$$

The thermal diffusivity for copper is 1.158 $(\frac{cm^2}{s})$. (20%)

6. Find the Fourier series of the given function $f(x)$, which is assumed to have the period 2π.

$$f(x) = \begin{cases} x + \pi & if \ \ -\pi < x < 0 \\ -x + \pi & if \ \ 0 < x < \pi \end{cases}$$ (20%)

國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：熱力學【材光系碩士班乙組】　　題號：439006

※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）　　

請於答案卷上依序做答，並清楚標明題號

1. **(30%)** **(a, 5%)** Define the partial molar property $\overline{M_i}$, the chemical potential μ_i, the fugacity (f_i), the activity (a_i) and activity coefficient (r_i) of species *i* in a solution. **(b, 5%)** What are the relationships of the chemical potential μ_i of each species in all phases when the multiple phases at the same *T* and *P* are in equilibrium? **(c, 5%)** Draw a schematic A-B binary T-*x* (temperature-composition) phase diagram with a liquid phase and a solid solution phase (label all phase regions). **(d, 5%)** Draw a schematic A-B binary T-*x* phase diagram with a vapor phase, a liquid phase and a minimum azeotrope (label all phase regions). **(e, 5%)** Draw a schematic A-B binary T-*x* phase diagram with a liquid phase, two terminal solid phases (α and β) and a *eutectic* reaction (label all phase regions). **(f, 5%)** Draw a schematic A-B binary T-x phase diagram with a liquid phase, two terminal solid phases (α and β) and a *peritectic* reaction (label all phase regions).

2. **(20%)** **(a, 5%)** The complete differential internal energy **U** can be written in terms of the partial derivative $dU = \left(\frac{\partial U}{\partial V}\right)_T dV + \left(\frac{\partial U}{\partial T}\right)_V dT$, please derive the relation C_p-C_V=R for one mole of ideal gas. **(b, 5%)** Prove that the process path of an ideal gas undergoing a *reversible adiabatic* change of state is described by PV^γ=constant, where P is the pressure, V refers to the volume and $\gamma=C_p/C_v$. **(c)** Air at an initial state of 47° C, 0.2 MPa, fallows a process until it reaches a final state 267° C,0.8MPa. Assume the air is an ideal gas with constant specific heat. The specific heat is C_p=1.017 (KJ/KgK) and gas constant is *R*=0.287 (KJ/KgK). Calculate the entropy change per unit mass during the process, assuming the following **(i, 5%)** The process is reversible. **(ii, 5%)** The process is irreversible.

3. **(10%)** Please prove the following statement: for two given heat reservoirs no engine can have a thermal efficiency higher than that of a Carnot engine.

4. **(20%)** A vessel, divided into two parts by a partition, contains 6 moles of nitrogen gas at 400K and 5 bar on one side and 4 moles of argon gas at 400K and 5 bar on the other side. The molar Gibbs free energies of nitrogen gas and argon gas at 400K and 5 bar are $\overline{G_{N2}}$ and $\overline{G_{Ar}}$, respectively. **(a, 5%)** What is the molar Gibbs free energy of the gas in the vessel? **(b, 5%)** If the partition is removed and the gases mixed adiabatically and completely, what is the molar Gibbs free energy of the gas in the vessel after mixing? **(c, 5%)** What are the entropy of mixing, enthalpy of mixing, and Gibbs free energy of mixing? **(d, 5%)** What are the excess entropy of mixing, excess enthalpy of mixing, and excess Gibbs free energy of mixing? Assume nitrogen to be an ideal gas with C_v=2.5R and Argon to be an ideal gas with C_v=1.5R. R is the gas constant.

5. **(20%)** The melting point T^m and the latent heat of fusing $\triangle H^m$ of Aluminum are 932K and 10.8 (KJ/mole), respectively. The allotropic phase transformation from α-Mn to β-Mn occurs at 1000K and one atmosphere pressure. The entropy change for the phase transformation is 2.25 (J/mole K). Calculate $\triangle S$ for the following reaction at 1400 K and one atmosphere pressure. $MnSiO_{3(S)} + 2Al_{(l)} = Al_2O_{3(S)} + Mn_{(S)} + Si_{(S)}$.

Given that the constant-pressure molar heat capacity of various substances as follows:

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國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：熱力學【材光系碩士班乙組】　　題號：439006

※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）　　

$MnSiO_{3(S)}$: S_{298}=89.5 (J/mole K)

$Al_{(S)}$: S_{298}=28.4 (J/mole K)

$Al_2O_{3(S)}$: S_{298}=51.1 (J/mole K)

$Mn_{(S)}$: S_{298}=31.9 (J/mole K)

$Si_{(S)}$:S_{298}=18.9 (J/mole K)

$$C_P(MnSiO_{3(S)}) = 110.0 + 16.1\times10^{-3}T - 25.8\times10^{5}T^{-2}(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(Al_{(S)}) = 20.7 + 12.4\times10^{-3}T(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(Al_{(l)}) = 29(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(Al_2O_{3(S)}) = 106.6 + 7.8\times10^{-3}T - 28.5\times10^{5}T^{-2}(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(\alpha Mn_{(S)}) = 21.6 + 15.9\times10^{-3}T(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(\beta Mn_{(S)}) = 34.9 + 2.8\times10^{-3}T(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

$$C_P(Si_{(S)}) = 24.3 + 2.3\times10^{-3}T - 4.5\times10^{5}T^{-2}(J/moleK) \quad 298\text{K} < T < 1300\text{K}$$

Conversion factor:

Pressure: 1 bar=10^5 $Kgm^{-1}S^{-2}$=10^5Pa=0.986923 atm

Energy: 1J= 1Kgm^2s^{-2}=1 Nm=1 m^3Pa= 0.239006 cal

Gas constant:

R=8.314 J/moleK=8.314 m^3Pa/moleK=1.987 Cal/moleK

國立中山大學106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12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。) Additional information in the Appendix may be useful for answering the questions.

1. The electrical conductivity of silver is $6.2\times10^{7}\ (\Omega\cdot\mathrm{m})^{-1}$. There is a silver wire having a diameter of 100 μm and a length of 10 cm. Find all the range(s) of the electrical resistance (R) of the wire. (a) $10^{-2}\ \Omega < \mathrm{R} < 1\ \Omega$. (b) $10^{-1}\ \Omega < \mathrm{R} < 10\ \Omega$. (c) $1\ \Omega < \mathrm{R} < 100\ \Omega$. (d) $10\ \Omega < \mathrm{R} < 1000\ \Omega$. (e) $100\ \Omega < \mathrm{R} < 10000\ \Omega$. (5 points)

2. A silicon specimen is a cylindrical rod with a 5.0-mm diameter and a 50 mm length. There is a current of 100 mA passing in an axial direction. A voltage of 12.5 V is measured across two probes that separated by 38 mm. Choose all the correct answer(s) for the electrical conductivity (σ) of the specimen. (a) $10^{-2}\ (\Omega\cdot\mathrm{m})^{-1} < \sigma < 1\ (\Omega\cdot\mathrm{m})^{-1}$. (b) $10^{-1}\ (\Omega\cdot\mathrm{m})^{-1} < \sigma < 10\ (\Omega\cdot\mathrm{m})^{-1}$. (c) $1\ (\Omega\cdot\mathrm{m})^{-1} < \sigma < 100\ (\Omega\cdot\mathrm{m})^{-1}$. (d) $10\ (\Omega\cdot\mathrm{m})^{-1} < \sigma < 1000\ (\Omega\cdot\mathrm{m})^{-1}$. (e) $100\ (\Omega\cdot\mathrm{m})^{-1} < \sigma < 10000\ (\Omega\cdot\mathrm{m})^{-1}$. (5 points)

3. There are five wires made of Ag, Al, Au, Cu, and Ni, respectively. Each wire has the same length (1 m), and the same resistance (1 kΩ). Among the five metal wires, find the three wires having the higher weights: (a) Ag (b) Al (c) Au (d) Cu (e) Ni. (5 points)

4. There are five wires made of Ag, Al, Au, Cu, and Ni, respectively. Each wire has the same length (1 m), and the same diameter (0.1 mm). All the five wires are connected in parallel to a 12.5 V voltage source. Find the two wires having higher temperature: (a) Ag (b) Al (c) Au (d) Cu (e) Ni. (5 points)

5. Liquid nitrogen (LN) is nitrogen in a liquid state that can be held at 77 K. Find all the correct description(s) for the materials' conductivity at LN temperature, compared to that at room temperature. (a)Germanium will have higher electrical conductivity at LN temperature. (b)Germanium will have lower electrical conductivity at LN temperature. (c)Silver will have higher electrical conductivity at LN temperature. (d) Silver will have lower electrical conductivity at LN temperature. (e) Germanium will have the same electrical conductivity at both temperatures. (5 points)

6. Lead telluride (PbTe) is a compound semiconductor composed of lead and tellurium. At room temperature the electrical conductivity of PbTe is 550 $(\Omega\cdot m)^{-1}$, whereas the electron and hole mobilities are 0.16 and 0.08 $\mathrm{m^2/V\cdot s}$, respectively. Choose all the correct answer(s) for the carrier concentration (n) in the PbTe crystal at room temperature. (a) $10^{15}\ \mathrm{m^{-3}} < n < 10^{19}\ \mathrm{m^{-3}}$. (b) $10^{17}\ \mathrm{m^{-3}} < n < 10^{21}\ \mathrm{m^{-3}}$. (c) $10^{19}\ \mathrm{m^{-3}} < n < 10^{23}\ \mathrm{m^{-3}}$. (d) $10^{21}\ \mathrm{m^{-3}} < n < 10^{25}\ \mathrm{m^{-3}}$. (e) $10^{23}\ \mathrm{m^{-3}} < n < 10^{27}\ \mathrm{m^{-3}}$. (5 points)

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7. Cuprous oxide (Cu_2O) is a semiconductor with direct bandgap of 2.14 eV, while silicon (Si) is another semiconductor with indirect bandgap of 1.12 eV, at room temperature. Find all the correct description(s) assuming all the crystals having negligible impurities and defects. (a)The electron density in the Cu_2O is lower than the electron density in the Si. (b)The electron density in the Cu_2O is higher than the electron density in the Si. (c)Cu_2O crystal is transparent at 600 nm. (d)Si crystal is transparent at 600 nm. (e)Both crystals are suitable for light-emission applications. (5 points)

8. The macroscopic magnetic properties of the materials are a consequence of their magnetic moments associated with individual electrons. Each electron in an atom has magnetic moments that originate from two sources. One is related to its orbital magnetic moments, and the other is related to its spin magnetic moments. The net magnetic moment of an atom is the vector sum of its orbital and spin magnetic moments. Find the correct description(s) of the individual atoms in gas phase. (a) $_{47}$Ag atom is diamagnetic. (b) $_{47}$Ag atom is paramagnetic. (c) $_{10}$Ne atom is diamagnetic. (d) $_{10}$Ne atom is paramagnetic. (e) $_{1}$H atom is diamagnetic. (5 points)

9. Two silicon crystals (crystal A and B) both have the same concentration of phosphorus (P) impurity $\left(1.2\times10^{16}\ \mathrm{m^{-3}}\right)$. However, crystal B is further doping with boron (B) impurity of $1.0\times10^{16}\ \mathrm{m^{-3}}$ concentration. Find all the correct answer(s). (a) Both crystals are p-type semiconduction. (b) Both crystals are n-type semiconduction. (c) One crystal is n-type, while the other one is p-type. (d)The carrier concentration in crystal A is higher than that in crystal B at room temperature. (e) The carrier concentration in crystal A is lower than that in crystal B at room temperature. (5 points)

10. A hydrogen atom is an electrically neutral atom containing a single positively charged proton and a single negatively charged electron bound to the nucleus by the Coulomb force. Assume that the separation between the proton and the electron is $5.3\times10^{-11}\,\mathrm{m}$, choose all the correct description(s) for the attraction force (F) between the proton and electron in a hydrogen atom.
(a)$10^{-5}\mathrm{N} > F > 10^{-8}\mathrm{N}$. (b)$10^{-6}\mathrm{N} > F > 10^{-9}\mathrm{N}$. (c)$10^{-7}\mathrm{N} > F > 10^{-10}\mathrm{N}$. (d)$10^{-8}\mathrm{N} > F > 10^{-11}\mathrm{N}$.
(e)$10^{-9}\mathrm{N} > F > 10^{-12}\mathrm{N}$. (5 points)

11. DVD (an abbreviation of "digital video disc") is a digital optical disc storage format invented and developed by Philips, Sony, Toshiba, and Panasonic in 1995. The laser diode used in DVD is a red laser with 650 nm wavelength. Choose all the correct answers for the laser light. (a) Its photon energy is higher than 1.8 eV. (b) Its photon energy is less than 1.8 eV. (c) The optical frequency is larger than $5\text{x}10^{14}$ Hz. (d) The optical frequency is less than $5\text{x}10^{14}$ Hz. (e) The optical frequency is equal to $5\text{x}10^{14}$ Hz. (5 points)

12. A capacitor is a passive two-terminal electrical component used to store energy electrostatically in an electric field. There is a parallel-plate capacitor having area of 100 $\mathrm{cm^2}$ and spacing of 1 mm, which is applied a voltage of 10 V in between. Find the correct answer(s) of the density of the charge (Q) stored in the capacitance. (a)$10^{7}\,e/\mathrm{m^2} < Q < 10^{9}\,e/\mathrm{m^2}$. (b)$10^{8}\,e/\mathrm{m^2} < Q < 10^{10}\,e/\mathrm{m^2}$.
(c)$10^{9}\,e/\mathrm{m^2} < Q < 10^{11}\,e/\mathrm{m^2}$. (d) $10^{10}\,e/\mathrm{m^2} < Q < 10^{12}\,e/\mathrm{m^2}$. (e) $10^{11}\,e/\mathrm{m^2} < Q < 10^{13}\,e/\mathrm{m^2}$. (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（13、14、15）與子題號（a、b）。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。

13. There is a pure metal "A" with a density of 10.0 g/cm^3 . At room temperature, the electrical conductivity and the electron mobility of metal A are $5.0\times10^7\ (\Omega\cdot m)^{-1}$ and 0.0050 $m^2/V\cdot s$, respectively. Assuming all the electrical conductivity is contributed by the free electrons in the metal. (a)(8 points) Compute the number of free electrons per cubic meter for the metal A at room temperature. (b)(8 points) What is the number of free electrons per atom of the metal A? (sub-total 16 points)

14. Fermat's principle is the principle that the path taken between two points by a ray of light is the path that can be traversed in the least time. Displayed in Fig. 1, the path taken by light in going from some point A to a point B via a reflecting mirror surface. Assume that the path passing point "O" on the mirror is the shortest possible one. The distance between point A and the mirror is a, while that between point B and the mirror is b. The vertical distance between A and O is set as x. Derive the Law of Reflection using Fermat's principle. (10 points)

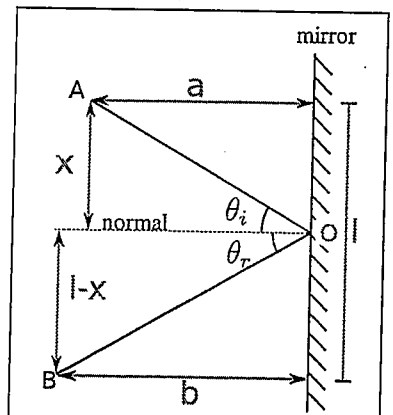

Fig. 1

15. There is a green He-Ne laser with wavelength 543 nm, optical power 2.0 mW, and laser beam diameter of 0.83 mm. (a)(6 points) What is the photon energy (in eV) of the laser light? (b)(8 points) What is the photon flux ($\frac{\#\text{ of photons}}{m^2\cdot s}$) of the laser beam? (sub-total 14 points)

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

- The permittivity of free space, $\varepsilon_0 = 8.85\times10^{-12}\frac{C^2}{N\cdot m^2} = 8.85\times10^{-12}\frac{F}{m}$
- The electric charge carried by a single electron $e = 1.602\times10^{-19}C$.
- Planck constant $h = 6.626\times10^{-34}\ J\cdot s = 4.136\times10^{-15}\ eV\cdot s$
- The speed of light in a vacuum $c = 299792458\ m/s$
- The Avogadro constant $N_A = 6.022\times10^{23}\ mol^{-1}$.

Table 1: Electrical conductivity (σ), density (**g/cm^3**), and atomic weight ***(g/mole)*** for some metals

Material	***σ (Ω·m)$^{-1}$***	***(g/cm^3)***	***(g/mole)***
Aluminum	3.5×10^7	2.70	26.98
Beryllium	2.8×10^7	1.85	9.012
Copper	6.0×10^7	8.96	63.55
Gold	4.1×10^7	19.3	196.97
Iron	1.0×10^7	7.87	55.85
Magnesium	0.21×10^7	1.74	24.31
Nickel	1.4×10^7	8.90	58.69
Silver	6.2×10^7	10.5	107.87
Tungsten	1.8×10^7	19.3	183.84
Zinc	1.7×10^7	7.00	65.38

Table 2: Dielectric constants and strengths for some dielectric materials

Materials	Dielectric constant		Dielectric strength
	60 Hz	1 MHz	(V/2.5*mm*)
Fused silica	4.0	3.8	250
Mica	8.7	5.4	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

國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：材料科學【材光系碩士班丙組】　　題號：439004

※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）　　

(1) Explain what is work hardening rate? What information you can obtain from this parameter? 6 points

(2) Describe the factors which can affect the recrystallization process of a metal. Explain the reasons. 9 points

(3) Explain the following terms: (a) Graphene, 3 points; (b) Schockley partials, 3 points; (c) Schottky defect, 3 points; (d) Eutectoid reaction, 3 points; (e) Fracture toughness, 3 points; (f) Flexural strength, 3 points; (g) Thermal fatigue, 3 points; (h) Extrinsic semiconductor, 3 points; (i) Glass transition temperature, 3 points; (j) Partially stabilized zirconia, 3 points. 30 points

(4) Consider a single crystal of some hypothetical metal that has the BCC crystal structure and is oriented such that a tensile stress is applied along a **[1 1 2]** direction. If slip occurs on a **(0 1 1)** plane and in a **[1 -1 1]** direction, compute the stress at which the crystal yields if its critical resolved shear stress is 9.2 MPa 7 points

(5) Ni and Ni_3Al have the same FCC structure, but the X-ray diffraction peaks from them are quite different. Explain the reason for this. Note: in Ni_3Al, Al atoms occupy the face centered positions. 7 points

(6) List the names of 6 phases which are often formed in steels. 7 points

(7) Give schematic drawings of (a) coherent, 2 points; (b) semicoherent, 2 points; and (c) incoherent interface, 2 points. 6 points

(8) Over the last few decades, the production of jet engine turbine blade was developed from polycrystalline grains, to orientated columnar grains, then to single crystal. Explain the reason for this development. 7 points

(9) Describe the preparation procedure of a specimen, which is for metallographic observation under an optical microscope. 7 points

(10) Yield drop may occur in the stress-strain curve of some materials. Why yield drop occurs? 7 points

(11) There are two types of nucleation process during phase transformation, one is homogeneous nucleation and the other one is heterogeneous nucleation. Use no formula to explain why heterogeneous nucleation is always easier than homogeneous nucleation. 7 points