

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【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） 共1頁第1頁

1. Write down the mathematical expression and calculate the values for ΔS and ΔG for mixing 2 mole of H_2 with 3 mole of O_2 at 300 K under condition with no chemical reaction occurs. (10%)
2. A polymer chain consists of 10,000 segments, each 0.2 nm long. If the chains were ideally flexible, what would be the root-mean squared separation of the ends of the chain? (10%)
3. Two equal blocks of copper, one at 500 K and the other at 350 K are placed in contact and come to thermal equilibrium. Assume no heat was lost to the surrounding. The heat capacity of copper is 24.4 J/Kmol. Calculate the change of entropy in surrounding, system, and total change of entropy in universe for this procedure. The weight of each block copper is 25.4 gram. The atomic weight of copper is 63.5 gram. (20%)
4. Calculate the change in Gibbs energy when a spherical droplet of water (1 g) disperses into the diameter of 50 nm particles where density of water is $1.0 \times 10^3 \text{ kg.m}^{-3}$ and the surface tension of water is $72 \times 10^{-3} \text{ N.m}^{-1}$ (20%)
5. What would be the minimum pressure of CO_2 required to change CaO to $CaCO_3$ at 25 °C? (20%)
 $CO_{2(g)} + CaO_{(s)} \rightarrow CaCO_{3(s)}$
 ΔG^0 for CO_2 : -364.4 kJ, CaO : -604.0 kJ, and $CaCO_3$: -1128.8 kJ.
6. Derive the rate law for the decomposition of ozone in the reaction $2O_3(g) \rightarrow 3O_2(g)$ on the basis of the following proposed mechanism:
(1) $O_3 \leftrightarrow O_2 + O$ (forward k_1 , reverse k_1')
(2) $O + O_3 \rightarrow 2O_2$ (k_2) (20%)

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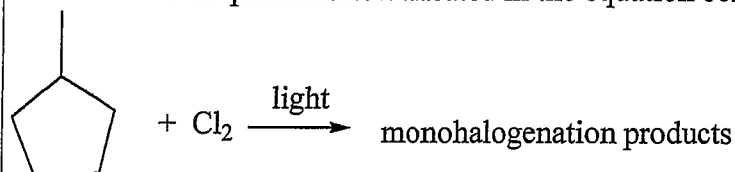
科目名稱：有機化學【材光系碩士班甲組】

題號：439003

※本科目依簡章規定「不可以」使用計算機(問答申論題)

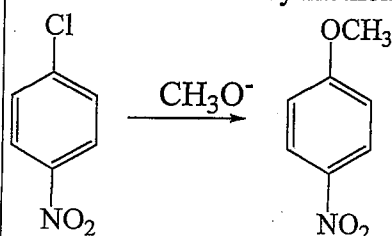
共 2 頁第 1 頁

1) (Total: 20 %) Simple alkyl halides can sometimes be prepared by reaction of an alkane with Cl_2 in the presence of light. Therefore, photoexcitation of chlorine and methylcyclohexane results in several monochlorinated products as indicated in the equation below:

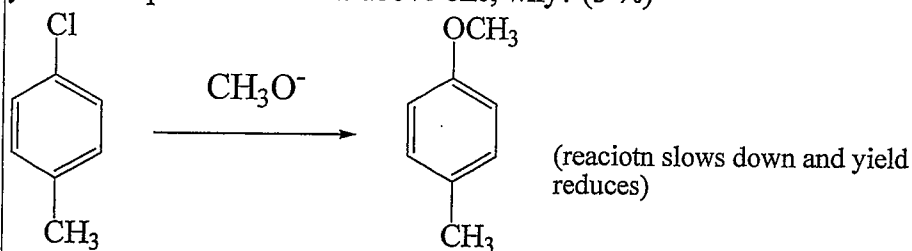


- What is the main species responsible for the above reaction, cation, radical or anion? (2 %)
- Write down the initiation step of the above reaction? (4 %)
- Write down all the possible monochlorinated products. (8 %)
- Which of the products written in (c) is the main product? (2 %) Why? (4 %)

2) (Total: 20 %) Among all kinds of nucleophilic substitution (S_N) reactions, $\text{S}_\text{N}2$ reactions are particularly designated for those reactions relating to direct attacking of a nucleophile to replace a substituent group in electrophile. A S_N reaction is also characterized by its single-step reaction mechanism and a second order reaction kinetics. Similarly, the reaction shown below looks like a $\text{S}_\text{N}2$ reaction since the whole reaction involves the direct substitution of the chlorine group in 4-chloronitrobenzene by methoxyl group.



- However, the above reaction cannot be a $\text{S}_\text{N}2$ reaction, why? (5 %)
- Write down the possible reaction steps involved in the above reaction. (5 %)
- Starting from benzene, propose a reasonable synthesis scheme for the preparation of the starting 4-chloronitrobenzene of the above reaction. (5 %)
- If we use 4-methyl group to replace the nitro group of 4-chloronitrobenzene, the reaction slows down and yields less product than the above one, why? (5 %)



3) (Each 6 %, total: 24 %) Suggest structures that are consistent with the molecular formula and spectroscopic properties given in the following sets:

- $\text{C}_4\text{H}_7\text{ClO}$, IR (cm^{-1}): 1800; $^1\text{H NMR}$ (δ): 1.0 (3H, triplet), 1.7 (2H, sextet), 2.9 (2H, triplet) (6%)
- $\text{C}_7\text{H}_{14}\text{O}$, IR (cm^{-1}): 1710; $^1\text{H NMR}$ (δ): 1.1 (12H, doublet), 2.8 (2H, septet). (6%)
- $\text{C}_5\text{H}_{10}\text{O}_2$, IR (cm^{-1}): 2750, 1740; $^1\text{H NMR}$ (δ): 1.2 (6H, singlet), 3.5 (3H, singlet), 9.7 (1H, singlet) (6%)
- $\text{C}_5\text{H}_{10}\text{O}_2$, IR (cm^{-1}): broad absorbance at 3400-2800 and 1710; $^1\text{H NMR}$ (δ): 1.3 (9H, singlet), 11.3 (1H, singlet) (6%)

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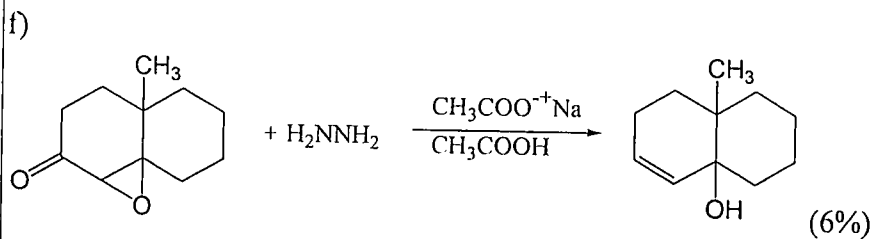
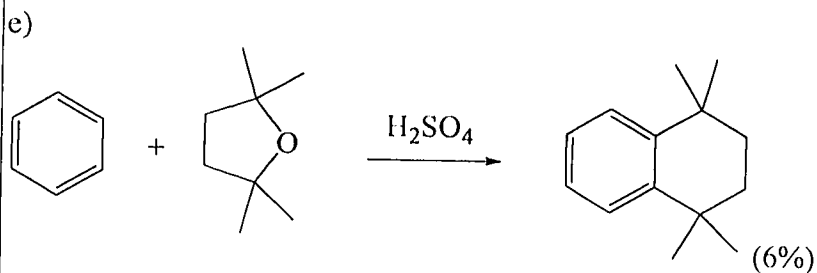
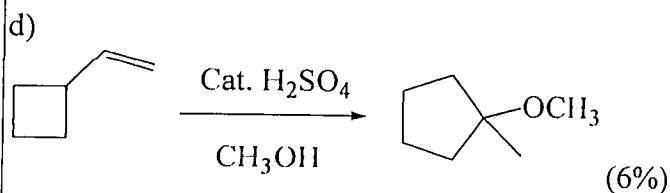
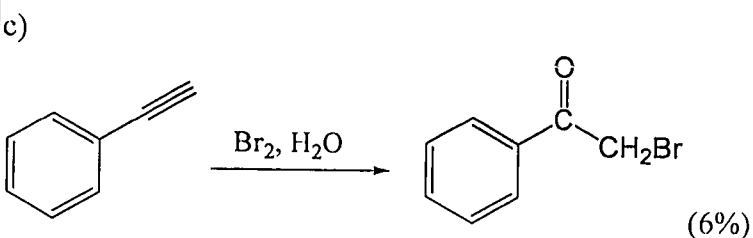
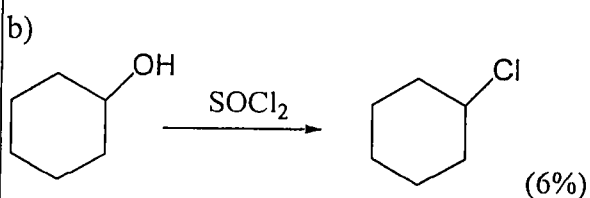
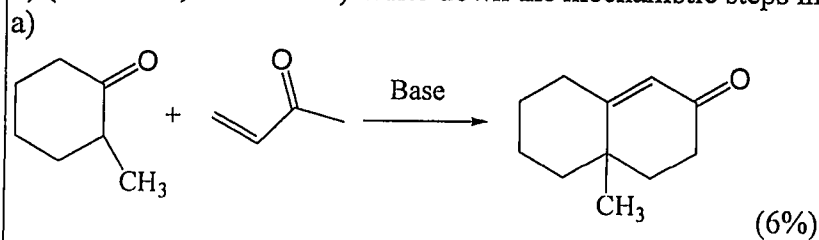
科目名稱：有機化學【材光系碩士班甲組】

題號：439003

※本科目依簡章規定「不可以」使用計算機(問答申論題)

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4) (Each 6%, total: 36%) Write down the mechanistic steps involved in the following reactions.



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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）

共 1 頁第 1 頁

請於答案卷上依序作答，並清楚標明題號

1. Please describe the meaning of (a) Gibbs-Duhem equation, (b) partial molar quantities, (c) a-function and (d) the critical temperature in regular solution.
(每小題 5%, 共 20%)
2. Please describe the explosive behavior of fire-work (爆竹) based on the view point of thermodynamic principle. (10%)
3. When one mole of argon is bubbled through a large volume of an Fe-Mn melt of $X_{Mn} = 0.6$ at 1860 K evaporation of Mn into the Ar causes the mass of the melt to decrease by 1.60 g. The gas leaves the melt at a pressure of 1 atm. Calculate the activity coefficient of Mn in the liquid alloy. (20%)
Vapor pressure Mn, $\ln P_{Mn} = -33440/T - 3.02 \ln T + 37.68 \text{ atm}$
Atomic weight of Mn = 55.0 g/mole
4. According to the following thermodynamic data, calculate the enthalpy, entropy and Gibbs free energy of the reaction
 $Pb + 1/2 O_2 = PbO$ at 1000 K. (30%)

$$H_{PbO(298)} = -219,000 \text{ J/mole}$$

$$S_{Pb(298)} = 65 \text{ J/K mole}$$

$$S_{PbO(298)} = 66.3 \text{ J/K mole}$$

$$S_{O_2(298)} = 205 \text{ J/K mole}$$

$$C_{p,Pb(s)} = 23.6 + 9.75 \cdot 10^{-3} T \text{ J/K from } 298 \text{ K to } T_m, Pb$$

$$C_{p,Pb(l)} = 32.4 - 3.1 \cdot 10^{-3} T \text{ J/K from } T_m, Pb \text{ to } 1200 \text{ K}$$

$$C_{p,PbO(s)} = 37.9 + 26.8 \cdot 10^{-3} T \text{ J/K from } 298 \text{ K to } T_m, PbO$$

$$C_{p,O_2(g)} = 29.96 + 4.18 \cdot 10^{-3} T - 1.67 \cdot 10^{-5} T^2 \text{ J/K from } 298 \text{ K to } 3000 \text{ K}$$

$$DH_{m,Pb} = 4810 \text{ J at } T_{m,Pb} = 600 \text{ K}$$

$$T_{m,PbO} = 1159 \text{ K}$$

5. According to the following figure, (a) describe the meaning of point d and e; (b) write down the triple points of stable and metastable phase equilibria.
(每小題 10%, 共 20%)

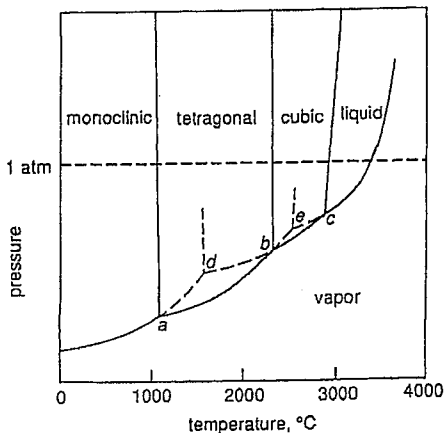


Figure 7.15 A schematic phase diagram for zirconia, ZrO_2 .

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科目名稱：工程數學【材光系碩士班乙組】

(問答申論題)

題號：439001

※本科目依簡章規定「可以」使用計算機(廠牌、功能不拘)

共 1 頁第 1 頁

1. Use the power series method to solve $xy'' + y = 0$ (20%)
2. Find the general solution of $y' + 2y = e^x(3\sin 2x + 2\cos 2x)$ (10%)
3. Solve the general solution of $9x^2y'' + 9xy' + (36x^4 - 16)y = 0$ (15%)
4. Use the Laplace transform to solve $y'' + 5y' + 6y = \delta(t - 2) + u(t - 1)$, $y(0) = 0, y'(0) = 1$ (15%)
5. Solve the eigenvalues and eigenfunctions of the differential equation:
 $y'' + \lambda y = 0, y(-L) = y(L), y'(-L) = y'(L)$ (15%)
6. Find $u(x, t)$ of the 1-D heat equation, $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$, for an infinite bar satisfying $u(x, 0) = \frac{1}{(1+x^2)}$ (15%)
7. Determine A^{-1} of $\begin{bmatrix} -1 & 1 & 2 \\ 3 & -1 & 1 \\ -1 & 3 & 4 \end{bmatrix}$ by Gauss-Jordan elimination (10%)

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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）

共 1 頁第 1 頁

- (1) Discuss the relationship between processing, property and microstructure. 10 points
- (2) Describe your knowledge about atomic diffusion in crystalline materials. 10 points
- (3) Describe your knowledge about strength of materials. 10 points
- (4) Give schematic drawing of engineering stress-strain curves of (a) pure copper, 2 points; (b) rubber, 2 points, (c) aluminum oxide, 3 points; and (d) carbon steel, 3 points. 10 points
- (5) Explain the following terms: (a) tempered glass, 2 points; (b) fracture toughness, 2 points; (c) twin boundary, 2 points; (d) anisotropy, 2 points; (e) level rule, 2 points; (f) spheroidizing, 2 points; (g) slip plane, 2 points; (h) Hall effect, 2 points. 16 points
- (6) Give a schematic drawing of a binary phase diagram, which consists of both eutectic and peritectic reactions. 10 points
- (7) Discuss the effect of second phase particles on recrystallization process. 10 points
- (8) What is “dielectric breakdown”? 4 points
- (9) 以下為從網路上所引用之文句：
“我的一個朋友將一杯水放在微波爐加熱到沸騰的程度，他將水拿出來，在把咖啡倒入水中那瞬間，那杯水在他的臉上爆開來……他整個臉上都起了水泡，至少有一度及二度的灼傷……他的左眼也可能會損失部分的視力。在醫院中，醫生說這是相當普遍的意外事件。水絕對不能在微波爐中單獨加熱，不只是水，純液體都會這樣。”請用相變化理論來討論上述事件。 10 points
- (10) Explain why the jumping frequency of vacancies is dependent on both the migration and formation energy of vacancies? 10 points

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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）

共 3 頁 第 1 頁

Section A: 多選題 (第 1 題至第 10 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. Two equal charges, $q = +e$, are separated by a distance $a = 10 \text{ nm}$. What is the net force between each other. (a) $F \leq 10^{-20} \text{ N}$ (b) $10^{-25} \text{ N} < F \leq 10^{-15} \text{ N}$ (c) $10^{-20} \text{ N} < F \leq 10^{-10} \text{ N}$ (d) $10^{-15} \text{ N} < F \leq 10^{-5} \text{ N}$ (e) $10^{-10} \text{ N} < F \leq 10^0 \text{ N}$. (5 points)
2. Six equal charges, $q = +e$, are situated at the corners of a regular 6-sided polygon (for instance, one on each even numeral of a clock face) with length of each side $a = 1 \text{ nm}$. What is the net force on a test charge $Q = 10 e$ at the center? (a) $F \leq 10^{-20} \text{ N}$ (b) $10^{-25} \text{ N} < F \leq 10^{-15} \text{ N}$ (c) $10^{-20} \text{ N} < F \leq 10^{-10} \text{ N}$ (d) $10^{-15} \text{ N} < F \leq 10^{-5} \text{ N}$ (e) $10^{-10} \text{ N} < F \leq 10^0 \text{ N}$. (5 points)

3. Two wires, made of Al and Ni respectively, both have uniform cross-sectional areas of $100 \mu\text{m}^2$, and lengths of 10 cm. Now the wires are connected in series to a voltage supply $E = 10 \text{ V}$, as shown in Fig. 1. Find all the correct answer(s). (a) The heating rate on the Al wire is higher than the Ni wire. (b) The heating rate on the Al wire is lower than the Ni wire. (c) The voltage across each ends of the two wires are equal. (d) The voltage across Al wire ends is higher. (e) The voltage across Ni wire ends is higher. (5 points)

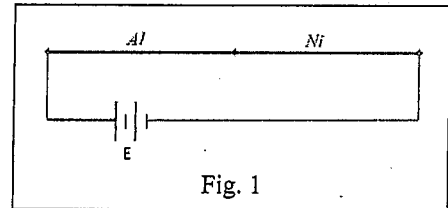


Fig. 1

4. If the two wires in Problem 2 are connected in parallel, as shown in Fig. 2. Find all the correct answer(s). (a) The heating rate for the Al wire is higher than that Ni wire. (b) The heating rate for the Al wire is lower than that Ni wire. (c) The voltage across each ends of the two wires are equal. (d) The voltage across Al wire ends is higher. (e) The voltage across Ni wire ends is higher. (5 points)

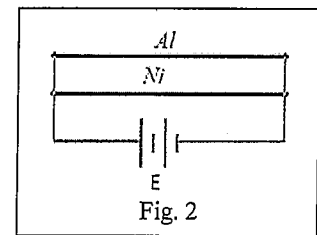


Fig. 2

5. There are five wires made of Ag , Al , Au , Cu , and Ni respectively. Each wire has the same weight (1 g), and the same resistance (1 k Ω). Among the five metal wires, find the two wires having the longest lengths: (a) Ag (b) Al (c) Au (d) Cu (e) Ni . (5 points)
6. 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 He-Ne laser operates at a wavelength of 632.8 nm in the red part of the visible spectrum. However, the He-Ne laser can also be operated at other wavelength, such as 1152.6 nm. Now there is one 1152.6 nm He-Ne laser, find all the correct description(s). (a) Its photon energy is higher than 1 eV. (b) Its photon energy is less than 1 eV. (c) The optical frequency is larger than $3 \times 10^{14} \text{ Hz}$. (d) The optical frequency is less than $3 \times 10^{14} \text{ Hz}$. (e) The optical frequency is equal to $3 \times 10^{14} \text{ Hz}$. (5 points)

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：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）

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7. Find all the correct description(s) for the properties of the semiconductors at room temperature. (a)The resistivity for an intrinsic silicon is higher than the resistivity for an extrinsic silicon. (b)The resistivity for an intrinsic silicon is lower than the resistivity for an extrinsic silicon. (c)Silicon has a bandgap higher than germanium. (d) Silicon has a bandgap lower than germanium. (e)When adding a small amount of boron, silicon becomes an n-type semiconductor. (5 points)
8. A capacitor is a passive two-terminal electrical component used to store energy electrostatically in an electric field. For the parallel-plate capacitors have the same area and the same spacing, and use a dielectric material inserted within the plates. If all the capacitors are adjusted to store the same energy, find all the correct answer(s). (a)The capacitor using fused silica operated at a higher voltage than the capacitor using mica. (b)The capacitor using fused silica operated at a lower voltage than the capacitor using mica. (c)Some capacitors operated at 60 Hz, and 1 MHz, will have different capacitance values. (d)When two identical capacitors operated at different alternating current (AC) frequency, the voltage for the lower frequency one is no less than the voltage for the higher frequency one. (e)The capacitor with soda-lime glass operated at higher voltage than the one with fused silica. (5 points)
9. Find all the correct description(s) for the materials' conductivity at 500 K, compared to that at room temperature. (a)Silicon will have higher conductivity at 500 K. (b)Silicon will have lower conductivity at 500 K. (c)Copper will have higher conductivity at 500 K. (d) Copper will have lower conductivity at 500 K. (e) Copper will have the same conductivity at both temperature. (5 points)
10. Two direct gap semiconductor crystals, zinc selenide (ZnSe) and zinc sulfide (ZnS), have the intrinsic gaps of 2.5 eV (ZnSe) and 3.54 eV (ZnS), at room temperature. Find all the correct description(s) if the crystals have negligible impurities and defects. (a)The electron density in the ZnS is lower than the electron density in the ZnSe. (b)The electron density in the ZnS is higher than the electron density in the ZnSe. (c)ZnSe is a colorless crystal. (d)ZnS is a colorless crystal. (e)Both crystals are transparent at 600 nm. (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（11、12、13）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。

11. Three particles, each of mass m and having charge, q , are suspended by very thin nonconducting strings of length l from a common point P . If the size of the particles is so small, compared to the separation. Find the angle θ that each string makes with the vertical. (10 points)
12. At room temperature the electrical conductivity and the electron mobility for silver are $6.2 \times 10^7 (\Omega \cdot m)^{-1}$ and $56 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$ respectively. (a) (10 points) Compute the number of free electrons per cubic meter for silver at room temperature. (b) (10 points) What is the number of free electron per silver atom? (sub-total 20 points)
13. For a blue light 413 nm, each photon carries 3 eV energy. When the light is illuminated uniformly with a density of 100 mW/cm^2 , (a) (10 points) Calculate the photon numbers per unit area per unit time. (b) (10 points) Si photo-receiver can be used to measure the optical power. If the photo-receiver has an active area of 0.8 cm^2 , and a quantum efficiency (incident photon to converted electron ratio) = 0.8 at the wavelength. Find the photo-current. (sub-total 20 points)

背面有題

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

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

- The permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$
- The electric charge carried by a single electron $e = 1.602 \times 10^{-19} C$.
- 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 $c = 299792458 m/s$
- The Avogadro constant $N_A = 6.022 \times 10^{23} mol^{-1}$.

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

<i>Material</i>	$\sigma (\Omega \cdot m)^{-1}$	(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 (V/2.5mm)
	60 Hz	1 MHz	
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