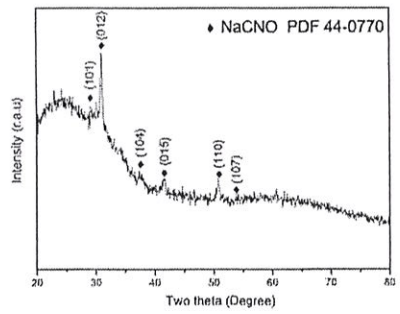
國立臺灣科技大學 104 學年度碩士班招生試題

系所組別：材料科學與工程系碩士班丙組

科　　目：材料導論

(總分為 100 分)

1. The following background-subtracted X-ray diffraction pattern was taken from the special biomaterial.



(1) Using the pattern, please select the suitable type of this biomaterial from the following list: metal, ceramic, polymer, glass or glass ceramic. **(5 points)**

(2) Please define the above material. **(10 points)**

(3) Choose the correct ionic, covalent, or metallic bonding for the crystalline phase of this biomaterial. **(5 points)**

2. Please use the information of the following table to calcuate to deterimine the crstayl structures (simple cubic, body centered cubic or face centered cubic) of elements A and B. **(10 Points)**

Element	Dnesity (g/mol)	Atomic Weight (g/cm^3)	Atomic Radius (Å)
A	10.49	107.8	1.45
B	9.19	209.0	1.35

3. Strengthening mechanisms are very important for metal materials. Please explain the common strengthening mechanisms of grain size reduction and solid-solution. **(10 points)**

4. The refractive index (n) at optical frequencies and the low frequency (LF) relative permittivity (ε_r) are 2.41 and 5.7 for diamond, and 1.71 and 9.83 for MgO, respectively.

(1) Give the relation of refractive index (n) and relative permittivity (ε_r) for transparent non-magnetic materials at optical frequencies. **(3 points)**

(2) Calculate the refractive indices (n) of diamond and MgO by using their LF relative permittivity (ε_r). **(2 points)**

(3) Compare the calculated refractive index (n) and the listed refractive index (n) for diamond and for MgO, respectively. What is your conclusion? **(5 points)**

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5. The energy gap (E_g), electron mobility (μ_e), hole mobility (μ_h) and room-temperature electrical resistivity (ρ) for intrinsic germanium are 0.67 eV, 0.38 $m^2/V{\cdot}s$, 0.18 $m^2/V{\cdot}s$ and 0.45 $\Omega{\cdot}m$. Boltzmann constant (k_B) is 8.617×10^{-5} eV/K and electron charge is 1.6×10^{19} C.
   (1) How to obtain the energy gap of Ge from the variation of intrinsic carrier concentration against temperature? **(5 points)**
   (2) At what temperature will *n*-type germanium having 10^{22} donor atoms/m^3 become intrinsic? **(5 points)**

6. A typical solar cell is made of a *pn* junction that converts light to electricity.
   (1) Draw current–voltage (*I–V*) characteristics for a solar cell in dark and under an illumination. **(5 points)**
   (2) Indicate open circuit voltage V_{OC}, short circuit current I_{SC} and the operating point for the maximum power output P_{Max} in your drawing. Also define the fill factor (*FF*), which is a figure of merit for the solar cell. **(5 points)**

7. (1) Please write down the solution of the diffusion equation for carburization according to the conditions below **(8 points)**

   $C_{(X=0)} = C_S$, $C_{(X=\infty)} = C_0$, C_s: solubility of carbon in iron, C_x: carbon concentration at distance x at time t

   (2) Given that C_0=0.2 wt%, C_s=1.0 wt%, *erf*(0.4772)=0.5, $D=2.98\times10^{-11}m^2/s$. How long will it take to achieve C_x=0.6 wt% at a position 1 mm beneath the surface? **(7 points)**

8. Draw and write down the three invariant reactions (peritectic, eutectic, eutectoid) in the Fe-Fe_3C phase diagram. **(15 points)**