

國立臺灣科技大學103學年度碩士班招生試題

系所組別： 機械工程系碩士班戊組

科 目： 材料原理

(總分為100分)

1. Silicon (Si) and Carbon (C) are members of the same group (IVA), so the same band diagram and the same filling applies to silicon as applies to diamond. In nature, diamond is a transparent and colorless gem, but Si is opaque and either black or very reflective if highly polished. Please describe why diamond is transparent, Si is opaque. (10 %)
2. A p-n junction diode is constructed from p-type and n-type materials and the flow of electrons across the junction is easily regulated by applying voltage. Please describe the diode I-V relationship in details. (10 %)
3. Iron metals are intrinsically oxidized into the red rust under the moist atmosphere. Rust consists of a mixture of FeO and Fe₂O₃, and also hydrates to form Fe(OH)₂. Meanwhile, the existence of pitting is also observed at the surface of rusted iron. Please describe the electrochemical reactions of iron corrosion, and the reason of flaking rust. (10 %)
4. In the tensile test, the yield strengths of ceramic materials can approach the ideal strength (σ_{th}), whereas the yield strengths of metallic materials are much smaller than the value of σ_{th} . Please describe the difference between these two materials in details. (10 %)
5. The unit cell for uranium has orthorhombic symmetry, with a, b, and c lattice parameters of 0.286, 0.587, and 0.495 nm, respectively. If its density, atomic weight, and atomic radius are 19.05 g/cm³, 238.03 g/mol, and 0.1385 nm, respectively, please compute the atomic packing factor. (10 %)



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6. (10%) The following solids are bonded by mixed bonding. Indicate their main primary bonds, and, if any, their secondary bonds. (2% each)
 (a) KF, (b) SiC, (c) FeNi₃, (d) Polyethylene (CH₂-CH₂)_n, (e) Na
7. (10%) The diffusivity of silver atoms in solid silver is $1.0 \times 10^{-17} \text{ m}^2/\text{s}$ at 500°C and $7.0 \times 10^{-13} \text{ m}^2/\text{s}$ at 1000°C . Calculate the activation energy (joules per mole) for the diffusion of Ag in Ag in the temperature range 500°C to 1000°C . $R = 8.314 \text{ J/mole}\cdot\text{K}$
8. (10%) Which of the following semiconducting materials of single crystal at 302K are fully transparent to visible light (380 nm – 750 nm)? Their band gaps at 302K respectively are:
 $\text{GaN} = 3.4 \text{ eV}$, $\text{Si}_3\text{N}_4 = 5 \text{ eV}$, $\text{Cu}_2\text{O} = 2.1\text{eV}$, $\text{GaP} = 2.26\text{eV}$, $\text{GaAs} = 1.43 \text{ eV}$
 $h = 6.62 \times 10^{-34} \text{ J}\cdot\text{s}$, $c = 3 \times 10^8 \text{ m/s}$, $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$.
9. (10%) The strength of lithium (Li) glass is greatly increased by dipping the glass into a potassium (K) ion solution, where ion exchange takes place. Explain the reasons why this ion-exchanged glass is called high strength glass or even unbreakable glass.
10. (10%) A galvanic cell consists of an electrode of zinc in a 1M ZnSO₄ solution and another of nickel in a 1M NiSO₄ solution. These two electrodes are separated by a porous wall so that mixing of the solution is prevented. An external wire with a switch connects the two electrodes. When the switch is just closed at 25°C : (2% each)
 (a) At which electrode does oxidation occur?
 (b) Which electrode is the anode of the cell?
 (c) Which electrode corrodes?
 (d) What is the emf of this galvanic cell when the switch is just closed?
 (e) What happens when the switch is closed for a very long time?
 $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^- \quad E_0 = -0.763 \text{ V}$
 $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^- \quad E_0 = -0.250 \text{ V}$

