

1. (10 %) Describe or explain the following terms.

- (1) fcc lattice, (2) Fermi level, (3) Boltzmann distribution law,  
 (4) p-type semiconductor, (5) van der Waals forces.

2. (10 %)  $\Delta G = \Delta H - T\Delta S$  is an equation of the second thermodynamics.

Please describe the relationship between this equation and chemical reaction.

3. (10 %) (i) What does the five letters of *laser* stand for in English?

(ii) Brief describe how lasers are produced and the characteristics of the laser light.

4. (10 %) Derive the expression for the half-life of a reaction with the rate law:

$$-d[A]/dt = k[A]^{1/2}$$

5. (10 %) (i) State the Arrhenius law. (ii) A second-order reaction in solution has a rate constant ( $k$ ) of  $5.7 \times 10^{-5} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  at  $25^\circ\text{C}$  and of  $16.4 \times 10^{-5} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  at  $40^\circ\text{C}$ . Calculate the activation energy ( $E$ ) and the preexponential factor ( $A$ ), assuming the Arrhenius law to apply.

( $R$  is the gas constant, equal to  $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ )

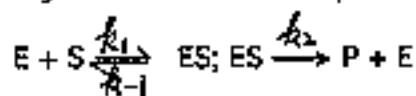
6. (10 %) Cthe electromotive force of the cell

$\text{Pd}_{(s)} \mid \text{PdSO}_4(aq) \mid \text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}_{(sat)} \mid \text{Hg}_2\text{SO}_4(s) \mid \text{Hg}_{(l)}$   
 is  $0.9647 \text{ V}$  at  $25^\circ\text{C}$ . The temperature coefficient is  $1.74 \times 10^{-4} \text{ VK}^{-1}$ .

(1) What is the cell reaction?

(2) What are values of  $\Delta_r G$ ,  $\Delta_r H$ ?

7. (20 %) An enzymatic reaction is represented as



The concentration of enzyme-substrate complex [ES] is assumed to maintain at a constant value throughout the reaction.

Please derive an equation to express the reaction rate.

8. (20 %) What is X-ray? How can X-ray be produced by electronic transition between shells? Derive Bragg's law and explain how X-ray diffraction can be used to determine the interplanar spacing in crystals.