2014

Interdisciplinary Graduate School of Medicine and Engineering, Master Course, University of Yamanashi

Entrance Examination

Course or Program	Special Doctoral Program for Green Energy Conversion Science and Technology	Subject	Chemistry A

Question 1

Answer the following questions. Use 8.314 J K^{-1} mol^{-1} as a gas constant.

(1) Calculate q, w, ΔU, and ΔH for the following process. A sample of 1.00 mol nitrogen is expanded isothermally at 0 ºC from 10 to 20 L reversibly.

(2) In general, phase transition of a substance is accompanied by a change in entropy.

(a) Explain the reason why entropy of a substance changes with phase transitions.

(b) The phase transition of graphite to diamond occurs at 2000 K. The enthalpy change of the transition is 1.9 kJ mol^{-1}. Calculate the entropy change of the transition.

Question 2

(1) The vapor pressure of ethanol at 40 ºC is 133 mmHg and its enthalpy of vaporization is 41.8 kJ mol^{-1}. Estimate the temperature at which its vapor pressure is 350 mmHg.

(2) Draw a temperature-pressures phase diagram of carbon dioxide and explain it briefly.

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Question 3

Derive an integrated expression for a second-order rate law $\frac{\mathrm{d[A]}}{\mathrm{d}t} = -k[\mathrm{A}][\mathrm{B}]$ for a reaction of stoichiometry A + B → C. Let the initial concentrations of A, B and C be $[\mathrm{A}]_0$ $[\mathrm{B}]_0$, and zero, respectively. ($[\mathrm{A}]_0 \neq [\mathrm{B}]_0$)

Note: *x* may be used as the concentration of C at some later time in the derivation process.

Question 4

(1) Write the electron configuration of F atom. (Ex. Li: $1s^2s^1$)

(2) Sketch the molecular orbital energy level diagram of HF and deduce its ground-state electron configurations: Refer to the following figure.

(3) Explain whether there are lone pair electrons by using schematic figures of overlap of orbitals.

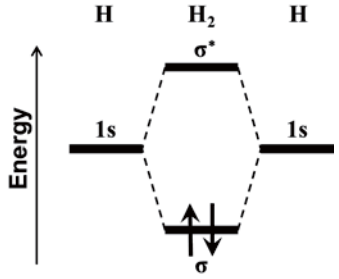

Fig.1. Molecular orbital energy level diagram of H_2 with ground-state electron configurations.

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Question 1

Answer the following questions.

(1) Write Bragg equation and explain Bragg's condition of diffraction by illustration.

(2) On measurement of powder XRD pattern of Cu with FCC structure, three diffraction lines are confirmed at θ = 21.6, 25.2 and 37.0 degree in the pattern. Assign these diffraction lines with Miller indices. Use λ = 0.154 nm, if necessary. The atomic radius of Cu is 0.128 nm. (One combination should be answered for one diffraction angle.)

Question 2

(1) Draw illustrations of relationship between band gap, valence band, conduction band and Fermi level of the intrinsic and extrinsic semiconductors, n and p-type.

(2) Explain temperature dependence of the electronic conductivity of the intrinsic semiconductor and the reason of the dependence.

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Entrance Examination

Course or Program	Special Doctoral Program for Green Energy Conversion Science and Technology	Subject	Chemistry B

Question 3

(1) Explain the "law of independent migration of ions" for the conductivity of an electrolyte at infinite dilution.

(2) NH_4OH is a weak electrolyte. Calculate the molar conductivity at infinite dilution of NH_4OH aqueous solution from the molar conductivity at infinite dilution of NH_4Cl, NaOH and NaCl. The molar conductivity at infinite dilution of NH_4Cl, NaOH and NaCl are 1.49×10^{-2}, 2.48×10^{-2}, 1.25×10^{-2} S m^2 mol^{-1}. ($S=\Omega^{-1}$)

(3) The molar conductivity at infinite dilution and molar conductivity at 0.1 mol dm^{-1} of CH_3COOH are 3.88×10^{-2} S m^2 mol^{-1} and 5.20×10^{-4} S m^2 mol^{-1}, respectively. Calculate the fractional dissociation (α) and pH of the CH_3COOH.

Question 4

(1) Write the cathodic and anodic half-cell reaction of the galvanic cell reaction (A) below;

$$Zn+Cu^{2+}{}_{aq}\rightarrow Cu+Zn^{2+}{}_{aq} \quad (A)$$

(2) Write the Nernst equation of the cell reaction (A) using the cell potential at standard-state conditions (E^o), Faraday's constant (F), gas constant (R), absolute temperature (T), activity of Zn^{2+} ($a_{Zn^{2+}}$) and activity of Cu^{2+} ($a_{Cu^{2+}}$).

(3) Calculate the Gibbs free energy ($\triangle G$) and electromotive force (E) at 25°C of the cell reaction (A), in which the mean activities of $Cu^{2+}{}_{aq}$ and $Zn^{2+}{}_{aq}$ are 0.0200 and 0.0400, respectively. The standard electrode potential at 25°C of $Zn \mid Zn^{2+}$ and $Cu \mid Cu^{2+}$ are -0.763 V and +0.337 V, respectively.