2022

Integrated Graduate School of Medicine, Engineering, and Agricultural Sciences, Master Course, University of Yamanashi

Entrance Examination

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

Question 1

The Gibbs function is defined as $G = U - TS + PV$, where U is internal energy, T is temperature, S is entropy, P is pressure, and V is volume.

(1) Explain the first law of thermodynamics.

(2) Show that: $dG = -SdT + VdP$

(3) Using the equation in 2, show that: $S = -\left(\frac{\partial G}{\partial T}\right)_P$

Question 2

Choose the right answer from a) to d).

(1) How is the distribution among two or more phases at equilibrium determined?
- a) Via the application of entropy
- b) Via the application of internal energy
- c) Via the application of Gibbs free energy
- d) Via the application of thermodynamic work

(2) At equilibrium, the chemical potential of a species is:
- a) Different in all phases
- b) Same in each phase and different in different phases
- c) Same in all phases
- d) None of the above

(3) Saturated liquid or saturated vapor can be found
- a) Along the liquid-vapor equilibrium curve
- b) Along the liquid-solid equilibrium curve
- c) Along the solid-vapor equilibrium curve
- d) None of the above

(4) Vapor at temperature and pressure exceeding those at saturation is:
- a) Superheated vapor
- b) Supercooled vapor
- c) Below critical point vapor
- d) All of the above

2022

Integrated Graduate School of Medicine, Engineering, and Agricultural Sciences, Master Course, University of Yamanashi

Entrance Examination

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

Question 3

Answer the following questions related to the irreversible first order reaction, A → B.

(1) Show the time (t) required for this reaction to proceed to 99.9% completion using the half-life $(\tau_{1/2})$.

(2) When the reaction temperature increases from 25 °C to 35 °C, by what factor does the reaction rate at 35 °C exceed that at 25 °C? The activation energy of the reaction is 60.0 kJ mol^{-1}, which maintains constant in this temperature range. If necessary, the following values can be used: molar gas constant, $R = 8.31$ J K^{-1} mol^{-1} and 0 °C = 273 K.

Question 4

The normalized wave function ($\psi_n(x)$) of a free particle of mass m constrained to lie along the x-axis between $x = 0$ and $x = a$ is

$$\psi_n(x) = \sqrt{\frac{2}{a}} \sin\frac{n\pi}{a}x \quad 0 \le x \le a \quad (n = 1, 2, 3, \cdots)$$

The energy (E_n) is

$$E_n = \frac{n^2h^2}{8ma^2} \quad 0 \le x \le a \quad (n = 1, 2, 3, \cdots)$$

Here, $\psi_n(x)$ and E_n are considered between $x = 0$ and $x = a$.

(1) Calculate the probability that the free particle is found to be between $x = 0$ and $x = a/2$.

(2) Calculate the x value where the highest probability of finding the particle is when $n = 2$.

(3) A free particle in a three-dimensional box is a simple extension of the one-dimensional case. Describe the first four energy levels using a schematic illustration for a particle in a three-dimensional box when three sides have the following relationship: $a = b = 1.5c$. A set of n_x, n_y, and n_z values $((n_x, n_y, n_z))$ and the numerical value of the degeneracy of each energy level should be included in the illustration.

【 December 2021 】

2022

Integrated Graduate School of Medicine, Engineering, and Agricultural Sciences, Master Course, University of Yamanashi

Entrance Examination

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

Question 1

At room temperature, Pt has the fcc crystal structure. The lattice parameter is 0.392 nm.

1. Draw Pt(111), (100), and (110) plane structures. In the structural images, write down the distances between the nearest-neighbor Pt atoms.

2. If the Cu K-α radiation (wavelength 0.154 nm) is used, what is the glancing angle for the first-order diffraction from the Pt(111) planes?

Question 2

1. Explain each type of bonding listed below:
   Metallic bonding
   Covalent bonding
   Ionic bonding
   van der Waals bonding

2. How are carbon atoms bonded in graphite and diamond?

2022

Integrated Graduate School of Medicine, Engineering, and Agricultural Sciences, Master Course, University of Yamanashi

Entrance Examination

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

Question 3

Fig. 1 shows the molar conductance (Λ) of several electrolytes plotted against the square root of the molar concentration ($c^{1/2}$) at a fixed temperature (25 °C). There are two types of behaviors, which can be classified as strong and weak electrolytes.

(1) Explain the reason of such a dependency on $c^{1/2}$ for both types of electrolytes.
(2) For the type of electrolyte that shows essentially a linear plot, a limiting molar conductance (Λ°) can be deduced by the extrapolation of the plot to infinite dilution. However, it is clear that no reliable value can be determined by a graphical extrapolation for the other type of electrolyte, which shows a tangential dependency at infinite dilution. Explain how to find the limiting molar conductance for the latter type of electrolyte on the basis of what law/concept. For example, explain how to find the limiting molar conductance of acetic acid in Fig. 1 and why.

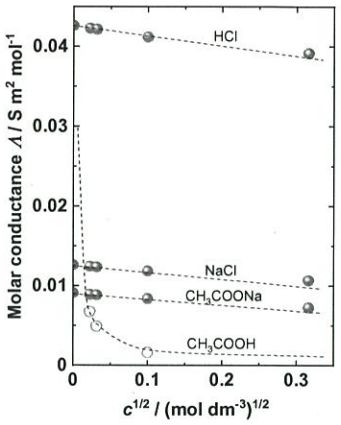

Fig.1: The molar conductance versus the square root of the molar concentration for several electrolytes in water at 25°C.

Question 4

Answer the following questions for an electrochemical cell

$$\mathrm{Zn\ (s)\ |\ ZnCl_2\ (}c\mathrm{),AgCl\ (s)\ |\ Ag(s)}$$

at 25 °C where the standard electrode potentials are given as Zn^{2+} | Zn: -0.7626 V and AgCl | Ag + Cl^-: +0.2223 V. If necessary, use the following constants: R = 8.314 J K^{-1} mol^{-1}, F = 96500 C mol^{-1}.

(1) What are (a) the anode reaction, (b) the cathode reaction, and (c) the overall cell reaction?
(2) Calculate the standard electromotive force (E^0) found in this particular cell, and the free-energy change if all reagents are in their standard states.
(3) Describe the dependence of the electromotive force (E) on the concentration (c) and the mean-activity coefficient ($\gamma^{\pm}$) by using the Nernst equation.
(4) Write down the ionic strength of $ZnCl_2$ aqueous solution using the value of its concentration (c).
(5) Describe the necessary experimental plan to deduce the value of the standard electromotive force (E^0) of this cell.

【 December 2021 】

2022

Integrated Graduate School of Medicine, Engineering, and Agricultural Sciences, Master Course, University of Yamanashi

Entrance Examination

Course or Program	Special Educational Program for Green Energy Conversion Science and Technology	Subject	English

In early November of this year, the United Nations Climate Change Conference (COP26) was held in Glasgow UK. Among a number of leaders from ca. 200 countries, Japan's prime minister, Fumio Kishida, also made a speech during the conference. Based on his statement, the Climate Action Network (CAN), a global network of more than 1,500 environmental non-governmental organizations (NGOs) in over 130 countries, bestowed Japan with the "Fossil of the Day" award.

Question 1. Why did Japan win this award?

Question 2. If you were Japan's prime minister, what policy would you claim? Your answer should discuss the impact of your policy on the environment quantitatively, based on current and developing energy-related technology.