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. If necessary, use the value 1 atm = 101.3 kPa = 1.013 bar

(1) When the volume of the ideal gas at 1 atm is compressed to half, the temperature raises from 273 to 293 K. Calculate the pressure.

(2) Calculate the work *W*, when the ideal gas expands under a constant external pressure of 1 atm from 10.1 to 10.3 m^3.

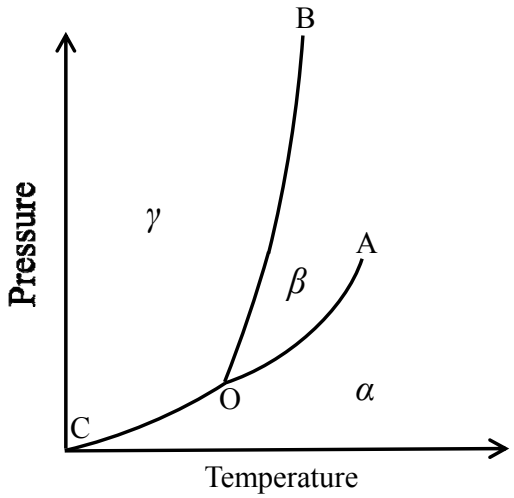
Question 2

Figure below shows the phase diagram of carbon dioxide. Answer the following questions.

(1) Describe the phase of carbon dioxide in regions α, β, and γ.

(2) What is point O?

(3) Calculate the degree of freedom at the points A, O, and line A-O.



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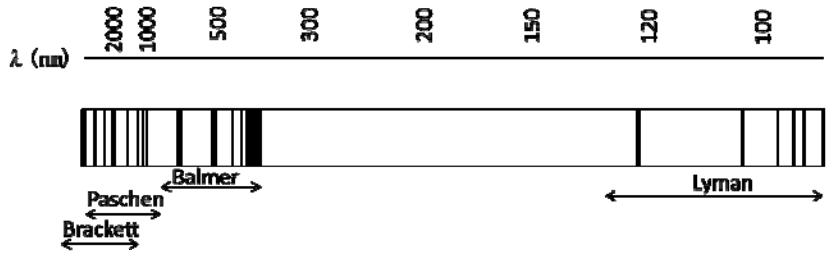
Question 3

Answer the following questions.
For a first-order reaction, the conversion of the reactant was 40% at 30 min after initiation of the reaction.
(1) Calculate the rate constant for the reaction.
(2) What is the percentage of the reactant that will remain at 180 min after initiation of the reaction?

Question 4



As seen in the upper figure, when electric discharge was passed through gaseous hydrogen, emit light of discrete frequencies (atomic hydrogen spectrum) was observed.
Answer the following questions.
(1) Describe the reason why such spectrum was produced.

(2) The wavenumbers ν of the lines in the spectrum fit the following expression. Calculate the wavelength λ of the transition with n_1=5 and n_2=6.

$$\nu = R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right), \qquad R_H = 109677\ \mathrm{cm}^{-1}$$

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

Question 1

Bragg's law gives the angles for diffraction from a crystal lattice. Answer the following questions If necessary, Avogadro constant, $N_A = 6.02\times10^{23}$ mol^{-1} may be used.

1. Let n be an integer (n>0), λ the wavelength of incident wave, d the spacing between the planes in the atomic lattice, and θ the angle between the incident ray and the scattering planes.
Using the parameters given above, write down Bragg's law.

2. The density of NaCl is 2.18 g cm^{-3}. When the Pd Kα X-ray was irradiated onto an NaCl crystal, the diffraction from the (100) plane appeared at 6.0°.

1) Draw the crystal structure of NaCl and draw its (100) plane.
2) How many Na^+ and Cl^- ions are there in a unit cell of NaCl? Calculate the mass of a unit cell in grams.
3) Calculate the volume of the unit cell in nm^3. Calculate the spacing between the (100) planes.
4) Calculate the wavelength of the Pd Kα X-ray.

Question 2

What are insulators, semiconductors, and conductors? Explain using illustrations.

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Question 3

Calculate the molar conductivity Λ_m of 0.100 mol dm^{-3} KCl aqueous solution with the conductivity of 1.00 S m^{-1}. Draw a graph for the relation between the Λ_m and the square root of concentration c ($c^{1/2}$) for the KCl solution. Explain the reason of such a dependency.

Question 4

Answer the following questions for an electrochemical cell Cu | Cu^{2+} || Ag^{+} | Ag
where the standard electrode potentials at 25°C are given as Cu^{2+} | Cu 0.34 V, Ag^{+} | Ag 0.80 V.

(1) What are (a) the anode reaction, (b) cathode reaction, and (c) the overall cell reaction?

(2) Calculate the standard electromotive force at 25°C.

(3) Can we expect the overall cell reaction to be spontaneous? Describe the reason.