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, and 1 atmospheric pressure corresponds to 10.33 m H_2O.

(1) A balloon made of a heat conductive material was filled with 0.1 mol of He at 90 m below the water surface of a huge aquarium tank kept at 27 °C. How many meters the balloon has to rise in the tank for its diameter to be twice of that on the ground? Assuming that the process was done reversibly, calculate the heat q and work w that entered or exited from the system during the process (with appropriate signs), and also calculate enthalpy change (ΔH), internal energy change (ΔU) and entropy change (ΔS) of the system during this process.

(2) Two silver ingots, 107.9 g (1 mol) each, were heated to 100.0 °C and 50.0 °C, respectively, and placed together in an insulated vacuum box. Describe the condition of the ingots after the achievement of thermal equilibrium within the box, and quantitatively explain why that happens. Use 25.49 J $K^{-1}mol^{-1}$ as silver's heat capacity at constant pressure.

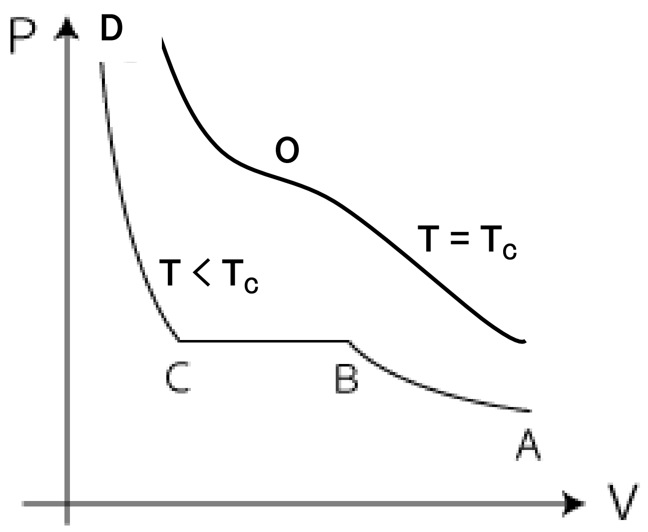
Question 2

Figure below shows isotherms of a fluid. Answer the following questions.

(1) Describe the phase change as the fluid is compressed from A to B to C to D.

(2) What is the point O?

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



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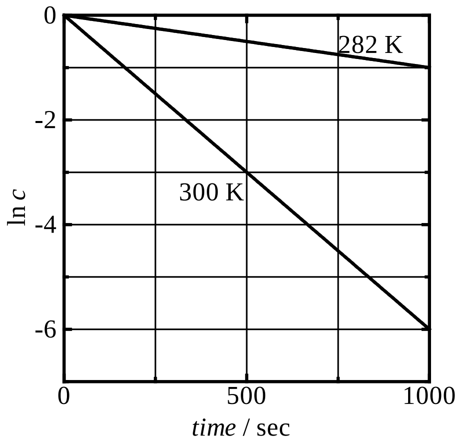
Question 3

A right-hand side figure shows concentration change of a chemical reaction with reaction time at 282 and 300 K. Answer the following questions

(1) Estimate the order of the reaction.

(2) Calculate the activation energy of this reaction (kJ/mol). If necessary, use R = 8.3 J·K^{-1}·mol^{-1}, ln 2 = 0.7 and ln 3 = 1.1.



Question 4

Answer the following questions

(1) Following table indicates ionization energy (kJ/mol) of alkali or alkali earth elements. Moving top to bottom down the periodic table, the atomic number increases. Answer the elements, (a), (b), (c) and (d) in this table. Describe each features of the ionization energy of alkali and alkali earth elements.

element	first	second	third	fourth	fifth
(a)	520	7298	11815		
Na	496	4562	6910	9543	13354
(b)	419	3052	4420	5877	7975
(c)	590	1145	4912	6491	8153
Rb	403	2633	3860	5080	6850
(d)	550	1064	4138	5500	6910
Ba	203	965	3600		

Alkali

Alkali earth

(2) Write electron configuration of the following elements and ions. (ex. Sn : [Kr]4d^{10}5s^{2}5p^2)

(a) Ti
(b) Ti^{3+}
(c) Ni
(d) Te
(e) Bi
(f) Bi^{3+}

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57-71 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn

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Entrance Examination

No 1/2

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

Question 1

At 20 ˚C, α-Fe is body centered cubic (bcc) structure with lattice parameter, a = 0.2866 nm, while at 950 ˚C, γ-Fe is face centered cubic (fcc) structure with a = 0.3656 nm. Answer the following questions. If necessary, you can use the atomic weight of Fe = 55.85 g/mol and Avogadro constant = 6.02×10^{23} /mol.

(1) Calculate the density of both Fe.

(2) Calculate the atomic radius of both Fe.

Question 2

Answer the following questions.

(1) Draw electron energy band structures with Fermi level for (a) metal, (b) intrinsic semiconductor, (c) n-type semiconductor, and (d) p-type semiconductor under zero bias.

(2) Draw an electron energy band structure with Fermi level for p-n junction with the identical semiconducting material (for example, p-n junction of semiconducting Si crystal) under zero bias.

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Use the following values if necessary: Faraday constant, F = 96500 C mol^{-1}; molar gas constant, R = 8.31 J mol^{-1} K^{-1}.

Question 3
The standard potentials at 25 °C are
+0.33 V for $Cu^{2+} + 2e^{-} \rightarrow Cu$
and
–0.77 V for $Zn^{2+} + 2e^{-} \rightarrow Zn$.
a) Calculate the standard electromotive force E° for $Zn|Zn^{2+}||Cu^{2+}|Cu$ at 25°C.
b) Calculate the Gibbs free energy change for cell reaction $Zn + Cu^{2+} = Zn^{2+} + Cu$.
c) When the activity of Zn^{2+} is 0.6, this cell shows the electromotive force of E = 1.086 V at 25°C. Calculate the activity of Cu^{2+}.

Question 4
Describe what determines the electric conductivities of a strong electrolyte and a weak electrolyte.

Question 5
Describe the definition of a primary cell, a secondary cell and a fuel cell. Then, choose one, draw a schematic diagram of that, and describe its principle using the diagram.