UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATIONS, DECEMBER 1998

CHE 112P - CHEMISTRY

Examiner • F.R. Foulkes
Time allowed: 2.5 hours

Be sure to PRINT your name on every page!

General Instructions:

1. All calculations are to be made on the special pages supplied, which are to be handed in.
2. One question and solution per page. No marks will be assigned for material on other pages.
3. Use the back of the same page, if necessary.
4. Write all final answers in the rectangular boxes provided.
5. Marks will be deducted for answers not reported with a reasonable number of significant
figures, and for failure to report answers in the units requested.
6. Programmable calculators are not permitted.
7. An equation sheet is provided.

1. Calculate the pH of a solution made by adding 1.00 mole of NaOH and 3.00 moles of acetic acid to a beaker, followed by the addition of sufficient water to bring the total volume to 1.000 L at 25°C. You may neglect activity coefficients for this calculation. The acid dissociation constant at 25°C for aqueous acetic acid is 1.75×10^{-5}, and for water at 25°C, K.= 1.00×10^{-14}. [15 marks]

2. 1.00 mole of steam, 1.00 mole of CO, 1.00 mole of CO_2, and 1.00 mole of H_2 are held at 900 K until the following equilibrium is established:

$H_2O_{(g)}$,+CO(g) <==> CO_2(g)+H_2(g)

What is the volume percent of H, in the final equilibrium mixture? At 900 K, the equilibrium constant for the reaction is K = 2.00. [7 marks]

3. At 25°C the solubility of $Ca(OH)^2$ in water is 0.0215 mol L^{-1}. Taking account of activity coefficients, calculate the solubility product of$Ca(OH)_2$ at 25°C. For saturated aqueous calcium hydroxide solution it may be assumed that the molality of the solution is the same as the molarity. [10 marks]

4. At its melting point (1083°C), the molar heat of fusion of metallic copper is 13.03 kJ mol^{-1}. The heat capacity of solid copper varies with temperature according to the equation

$c_p = 22.6 + 6.3 \times 10^{-3} T$,
where c is in J mol^{-1} K^{-1}, and T is in kelvins.

For the process:
(1. 00 mol solid copper [25°C, 1atm])→(1.00 mol liquid copper[25°C, 1atm])

calculate

(a)ΔH,in kJ [5 marks]

(b) ΔS, in J K^{-1}. [7 marks]

5. Sodium chlorate ($NaClO_3$) can be made by bubbling chlorine dioxide gas through an aqueous solution of NaOH according to the following balanced chemical (redox) reaction:

$2ClO_{2\,(g)} + 2NaOH_{\,(aq)} \rightarrow NaClO_{3\,(aq)} + NaClO_{2\,(aq)} + H_2O$

For the above reaction,

(a) which chemical species is oxidized? Explain. [3 marks]

(b) which chemical species is reduced? Explain. [2 marks]

(c) write the balanced oxidation half-reaction. [2 marks]

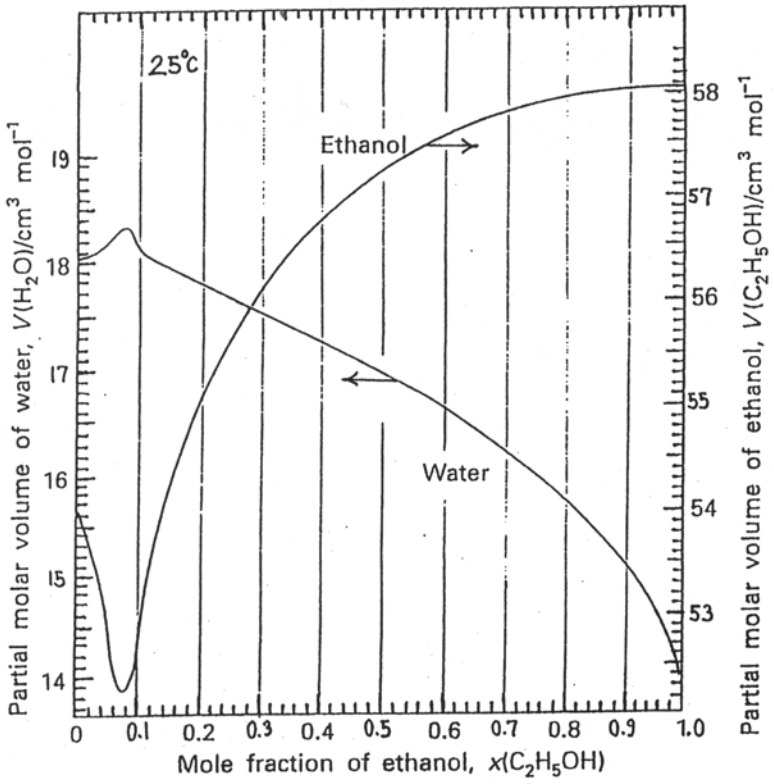
(d) write the balanced reduction half-reaction. [2 marks]

6. Using the partial molar volume plots provided on page 3, calculate the final volume at 25°C of a solution that is made by adding 555.6 cm^3 of ethanol (C_2H_5OH) to 444.4 cm^3 of water.

All liquids are at 25°C. Report the answer in cm^3. [7 marks]

Densities of pure components at 25°C: H_2O = 997.07 kg m^{-1}; C_2H_5OH = 785.22 kg m^{-3}
Molar masses: H_2O= 18.015 g mol^{-1}; C_2H_5OH = 46.07 g mol^{-1}

[Total Marks 50]


25°C
Ethanol
Water
Partial molar volume of water, $V(H_2O)/cm^3\ mol^{-1}$
Partial molar volume of ethanol, $V(C_2H_5OH)/cm^3\ mol^{-1}$
Mole fraction of ethanol, $x(C_2H_5OH)$
14
15
16
17
18
19
53
54
55
56
57
58
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0