2013 FALL Semester Midterm Examination
For General Chemistry II (CH103)

Date: October 24 (Thu),   Time Limit: 14:30 ~ 17:00

Write down your information neatly in the space provided below; print your Student ID in the upper right corner of every page.

Professor Name	Class	Student I.D. Number	Name

Problem	points	Problem	points	TOTAL pts
1	/13	**7**	/12	**/100**
2	/6	**8**	/9	
3	/14	**9**	/6	
4	/7	**10**	/9	
5	/13	**11**	/5	
6	/6			

** This paper consists of 13 sheets with 11 problems (page 11: fundamental constants, page 12: claim form, page 13: periodic table). Please check all page numbers before taking the exam. Write down your work and answers in the sheet.

Please write down the unit of your answer when applicable. You will get 30% deduction for a missing unit.

NOTICE: SCHEDULES on RETURN and CLAIM of the MARKED EXAM PAPER.

(채점답안지 분배 및 이의신청 일정)

1. Period, Location, and Procedure
   1) Return and Claim Period: ***October 28 (Mon, 6:30 ~ 7:30 p.m.)***
   2) ***Location: Room for quiz session***
   3) Procedure:

      Rule 1: Students cannot bring their own writing tools into the room. (Use a pen only provided by TA)

      Rule 2: With or without claim, you must submit the paper back to TA. (Do not go out of the room with it)

   If you have any claims on it, you can submit the claim paper with your opinion. After writing your opinions on the claim form, attach it to your mid-term paper with a stapler. Give them to TA.

2. Final Confirmation
   1) Period: October 31 (Thu) – November 1 (Fri)
   2) Procedure: During this period, you can check the final score of the examination *on the website.*

***** For further information, please visit General Chemistry website at www.gencheminkaist.pe.kr.***

1. (Total 13 pts) The normal boiling point of iodomethane, CH_3I, is 42.43 ^oC, and its vapor pressure at 0.00 ^oC is 140 Torr.

(a) (6 pts) Calculate the standard enthalpy of vaporization of iodomethane.

(Answer)

(b) (3 pts) Calculate the standard entropy of vaporization of iodomethane.

(Answer)

(c) (4 pts) Calculate the vapor pressure of iodomethane at 25.0 ^oC.

(Answer)

2. (Total 6 pts)

(a) (3 pts) Compare ΔS^o_{vap} for CH_3CH_3, CH_3F, and CH_3OH as calculated from ΔH^o_{vap} and T_b (boiling temperature) of the compounds.

	CH_3CH_3,	CH_3F	CH_3OH
ΔH^o_{vap} (kcal mol^{-1})	3.51	3.99	8.42
T_b (K)	184.5	194.8	337.7

(Answer)

(b) (3 pts) Which of these compounds (CH_3CH_3, CH_3F, and CH_3OH) shows the most ordered liquid state and the least ordered liquid state? Explain why.

(Answer)

3. (Total 14 pts)

(a) (4 pts) When 5.50 g of biphenyl ($C_{12}H_{10}$) is dissolved in 100.0 g of benzene, the boiling point increases by 0.903 ^{o}C. Calculate K_b for benzene.

(Answer)

(b) (4 pts) When 6.30 g of an unknown hydrocarbon is dissolved in 150.0 g of benzene, the boiling point of the solution increases by 0.597 ^{o}C. What is the molar mass of the unknown substance?

(Answer)

(c) (6 pts) A 0.40 g sample of a polypeptide dissolved in 1.0 L of an aqueous solution at 27 ^{o}C gave rise to an osmotic pressure of 3.74 Torr. What is the molar mass of the polypeptide?

(Answer)

4. (Total 7 pts) Solid ammonium chloride is in equilibrium with ammonia and hydrogen chloride gases:

$NH_4Cl(s) \rightleftarrows NH_3(g) + HCl(g)$

The equilibrium constant at 275 ^{o}C is 1.04×10^{-2}. We place 0.980 g of solid NH_4Cl into a closed vessel with volume 1.000 L and heat to 275 ^{o}C.

(a) (1 pt) In what direction does the reaction proceed?

(Answer)

(b) (3 pts) What is the partial pressure of each gas at equilibrium?

(Answer)

(c) (3 pts) What is the mass of solid NH_4Cl at equilibrium?

(Answer)

5. (Total 13 pts)

(a) (3 pts) What is the standard enthalpy of a reaction for which the equilibrium constant is doubled, when the temperature is increased by 10 K at 298 K?

(Answer)

(b) (3 pts) What is the standard enthalpy of a reaction for which the equilibrium constant is halved, when the temperature is increased by 10 K at 298 K?

(Answer)

(c) (7 pts) Suppose that nitrogen dioxide (NO_2) gas was allowed to dimerize into N_2O_4 gas until the reaction reached equilibrium 1.00 atm at 25^{o}C. What are the partial pressure of NO_2 and N_2O_4? The equilibrium constant K is 8.06×10^5 at -75^{o}C and the standard enthalpy change for this reaction (ΔH^o) is -57.2 $kJmol^{-1}$.

(Answer)

6. (Total 6 pts) Arrange the followings in order of acid strength and briefly explain your answer.

(a) (3 pts) CH_3COOH, $ClCH_2COOH$, Cl_3CCOOH

(Answer)

(b) (3 pts) ClOH, BrOH, IOH

(Answer)

7. (Total 12 pts) Ascorbic acid (Vitamin C) is a diprotic acid, $H_2C_6H_6O_6$. The acid ionization constants are $K_{a1} = 7.9\times10^{-5}$ and $K_{a2} = 1.6\times10^{-12}$.

(a) (6 pts) What is the pH of a 0.1 M solution?

(Answer)

(b) (6 pts) What is the concentration of ascorbate ion, $C_6H_6O_6^{2-}$?

(Answer)

8. (Total 9 pts) Calculate the equilibrium concentrations of H_2CO_3, HCO_3^-, CO_3^{2-}, and H_3O^+ in a saturated aqueous solution of CO_2, in which the original concentration of H_2CO_3 is 0.034 M. K_{a1} and K_{a2} are 4.3×10^{-7} and 4.8×10^{-11}, respectively.

(Answer)

9. (Total 6 pts) Zinc hydroxide ($Zn(OH)_2$) is sparingly soluble base ($K_{sp} = 4.5 \times 10^{-17}$).

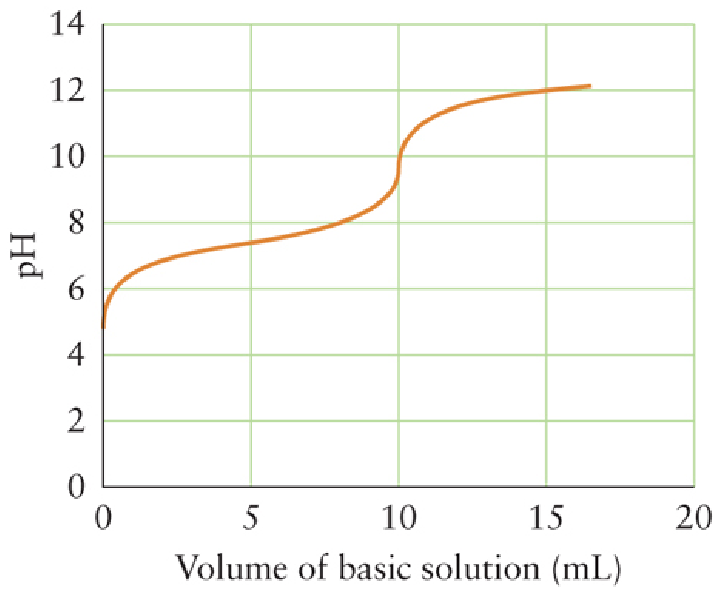
(a) (3 pts) A 1.0 g sample of solid $Zn(OH)_2$ is shaken with 0.5 L of water. Calculate the mass (grams) of $Zn(OH)_2$ that dissolves.

(Answer)

(b) (3 pts) Compare the solubility in pure water with that in a solution buffered at pH 6.00.

(Answer)

10. (Total 9 pts) Following is the titration curve for the neutralization of 25 mL of a monoprotic acid with a strong base. Answer the following questions about the reaction and explain your reasoning in each case.



(a) (2 pts) What is K_a for the acid?

(Answer)

(b) (4 pts) What is the initial concentration of the acid?

(Answer)

(c) (3 pts) What is the concentration of base in the titrant?

(Answer)

11. (5 pts) Describe briefly the names and their achievements of the Nobel Laureates in Chemistry 2013.

(Answer)

FUNDAMENTAL CONSTANTS

Name	Symbol	Value
Atomic mass constant	m_u	$1.660\ 54 \times 10^{-27}$ kg
Avogadro's constant	N_A	$6.022\ 14 \times 10^{23}\ mol^{-1}$
Boltzmann's constant	k	$1.380\ 65 \times 10^{-23}\ J{\cdot}K^{-1}$
Fundamental charge	e	$1.602\ 18 \times 10^{-19}$ C
Faraday's constant	$F = N_A e$	$9.648\ 53 \times 10^{4}\ C{\cdot}mol^{-1}$
Gas constant	$R = N_A k$	$8.314\ 47\ J{\cdot}K^{-1}{\cdot}mol^{-1}$
		$8.314\ 47\ L{\cdot}kPa{\cdot}K^{-1}{\cdot}mol^{-1}$
		$8.205\ 74 \times 10^{-2}\ L{\cdot}atm{\cdot}K^{-1}{\cdot}mol^{-1}$
		$62.36\ 37\ L{\cdot}Torr{\cdot}K^{-1}{\cdot}mol^{-1}$
		$8.314\ 47 \times 10^{-2}\ L{\cdot}bar{\cdot}K^{-1}{\cdot}mol^{-1}$
Mass of electron	m_e	$9.109\ 38 \times 10^{-31}$ kg
Mass of neutron	m_n	$1.674\ 93 \times 10^{-27}$ kg
Mass of proton	m_p	$1.672\ 62 \times 10^{-27}$ kg
Planck's constant	h	$6.626\ 08 \times 10^{-34}\ J{\cdot}s$
	$\hbar = h/2\pi$	$1.054\ 57 \times 10^{-34}\ J{\cdot}s$
Rydberg constant	$\mathcal{R}$	$3.289\ 84 \times 10^{15}$ Hz
Speed of light	c	$2.997\ 92 \times 10^{8}\ m{\cdot}s^{-1}$
Standard acceleration of free fall	g	$9.806\ 65\ m{\cdot}s^{-2}$
Vacuum permittivity	ε_0	$8.854\ 19 \times 10^{-12}\ J^{-1}{\cdot}C^{2}{\cdot}m^{-1}$

RELATIONS BETWEEN UNITS*

Property	Common unit	SI unit
Mass	2.205 lb (lb = pound)	1.000 kg
	1.000 lb	453.6 g
	1.000 oz (oz = ounce)	28.35 g
	1.000 ton (= 2000 lb)	907.2 kg
	1 t (t = tonne, metric ton)	**10^3 kg**
Length	1.094 yd (yd = yard)	1.000 m
	0.3937 in. (in. = inch)	1.000 cm
	0.6214 mi (mi = mile)	1.000 km
	1 in.	**2.54 cm**
	1 ft (ft = foot)	**30.48 cm**
	1.000 yd	**0.9144 m**
	1 Å (Å = ångström)	**10^{-10} m**
Volume	**1 L (L = liter)**	**$10^3\ cm^3$, 1 dm^3**
	1.000 gal (gal = gallon)†	3.785 dm^3 (3.785 L)
	1.00 ft^3 (ft^3 = cubic foot)	$2.83 \times 10^{-2}\ m^3$ (28.3 L)
	1.00 qt (qt = quart)†	$9.46 \times 10^{2}\ cm^3$ (0.946 L)
Time	**1 min (min = minute)**	**60 s**
	1 h (h = hour)	**3600 s**
	1 day	**86 400 s**
Pressure	**1 atm (atm = atmosphere)**	**$1.013\ 25 \times 10^5$ Pa**
	1.000 Torr or 1.000 mmHg	133.3 Pa
	1.000 psi (psi = pounds per square inch)	6.895 kPa
	1 bar	**10^5 Pa**
Energy	**1 cal**	**4.184 J**
	1 eV	1.60218×10^{-19} J; 96.485 $kJ{\cdot}mol^{-1}$
	1 C·V	**1 J**
	1 kWh (kWh = kilowatt hour)	**3.600×10^3 kJ**
	1 L·atm	**101.325 J**

Temperature conversions
(Fahrenheit temperature)/°F = $\frac{9}{5}$ × (Celsius temperature)/°C + 32
(Celsius temperature)/°C = $\frac{5}{9}$ + {(Fahrenheit temperature)/°F − 32}
(Kelvin temperature)/K = (Celsius temperature)/°C + 273.15

*Entries in boldface type are exact.
†The European and Canadian Imperial quart and gallon are 1.201 times as large.