2013 SPRING Semester Midterm Examination
For General Chemistry I

Date: April 24 (Wed),   Time Limit: 7:00 ~ 9:00 p.m.

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	/6	**6**	/10	**/100**
2	/10	**7**	/10	
3	/10	**8**	/11	
4	/8	**9**	/11	
5	/9	**10**	/15	

** This paper consists of 13 sheets with 10 problems (page 11 & 12: constants & periodic table, page 13: claim form). Please check all page numbers before taking the exam. Write down your work and answers in the Answer 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: ***April 29 (Mon, 6: 30 ~ 7:00 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.

(The claim is permitted only on the period. Keep that in mind! A solution file with answers for the examination will be uploaded on 4/27 on the web.)

2. Final Confirmation

1) Period: May 2 (Thu) – 3 (Fri)
2) Procedure: During this period, you can check final score of the examination *on the website* again.

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

1. (6 pts in total) Take note that ionization energies for the 1s element of the second-row atoms are :

Li	4,820	Be	10,600	B	18,300	C	27,000
N	38,600	O	51,000	F	66,600		$kJ\ mol^{-1}$

Now suppose that a certain substance is bombarded by X-rays having a wavelength of 0.989 nm. If photoelectrons with kinetic energies of (a) 94,000 $kJ\ mol^{-1}$ and (b) 69,900 $kJ\ mol^{-1}$ are ejected from the material, which of the elements listed above must be present in the sample?

(Answer)

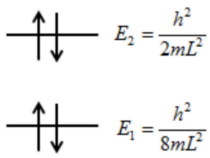
2. (10 pts in total) In the 1D-particle-in-a-box problem, the energy of a particle is given by the formula, $E = n^2h^2/(8mL^2)$ [n = 1, 2, 3, …; L: the length of the box].

(a) What is the energy of a particle, if we extend it to the 2D-particle-in-a-box problem? Each side of the 2D box has the length of L.

(Answer)

(b) Let's try to fill energy levels obtained in (a) with 4 electrons. Assume that though energy levels are not altered by the repulsive potential between electrons, all the other properties of an electron (e.g., Pauli exclusion principle and Hund's rule) should be considered. Draw the ground state electronic configuration as shown in the following example.

Example) In the case of 1D with 4 electrons,

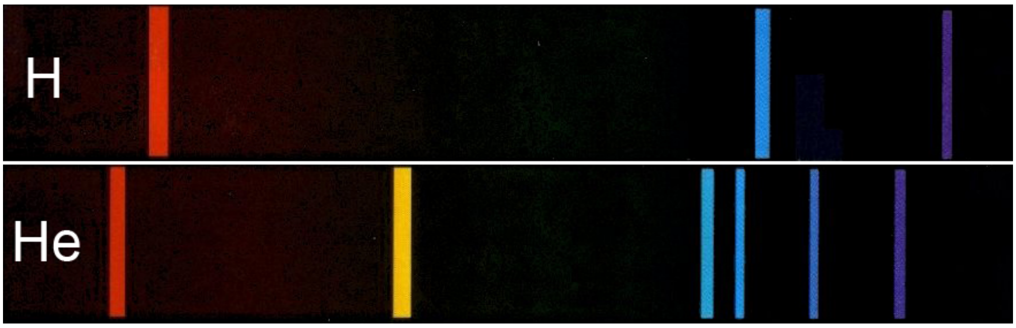


(Answer)

(c) What would be the lowest excitation energy in the case of (b)?

(Answer)

3. (10 pts in total) While the atomic spectrum of hydrogen shows mainly 3 lines in the visible range (420~700 nm), the spectrum of helium shows mainly 6 lines.



(a) Calculate the wavelengths (nm) of three distinct lines of hydrogen and assign them with the orbital energy levels.

(Answer)

(b) Why does the spectrum double the number of lines in helium?

(Answer)

(c) Draw the orbital energy levels of helium based on the above observation.

(Answer)

4. (8 pts in total)

(a) Iridium (Ir) is predicted by the building-up principle to have three unpaired electrons in its ground state outer configuration, but in fact has only one. Write the predicted and actual full electron configurations that explain this fact. You may use short hand noble gas configurations for core electrons.

(Answer)

(b) Write the electron configuration of Sc and Sc^{+}, given that they are both paramagnetic. You may use short hand noble gas configurations for core electrons.

(Answer)

(c) Identify the element of period 2 that possesses the ionization energies (I in kJ mol^{-1}) in the table below.

I_1	I_2	I_3	I_4	I_5	I_6
1090	2350	4610	6220	37800	47000

(Answer)

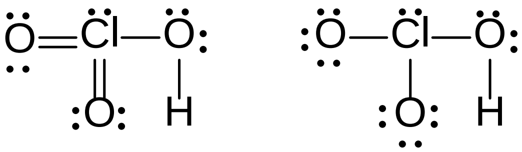
5. (9 pts in total)

(a) In the P_4 molecule, each atom has a complete octet. Figure out the structure of P_4.

(Answer)

Determine the formal charge on each atom in the following molecules. Identify the structure of lower energy in each pair.

(b)



(c)

(d)

6. (10 pts in total)

For each pair, determine which compound has bonds with greater ionic character:

(a) HCl or HI

(b) CH_4 or CF_4

(c) CO_2 or CS_2

(d) Arrange the anions Cl^-, Br^-, N^{3-}, and O^{2-} in order of increasing polarizability and give reasons for your decisions.

7. (10 pts in total) Predict the geometry of the following molecules, using the VSEPR method.

(a) SF_4

(b) BF_3

(c) ClF_3 (Cl = chlorine)

(d) XeF_2

(e) C_2H_2

(f) Acrylonitrile, CH_2CHCN, is used in the synthesis of acrylic fibers (polyacrylonitriles), such as Orlon. Write the Lewis structure of acrylonitrile and describe the hybrid orbitals on each carbon atom. What are the approximate values of the bond angles?

8. (11 pts in total) To explain molecular geometries of a water molecule, H_2O,

(a) Write the electron configurations of H and O atoms.

(Answer)

(b) Use the VSEPR theory to sketch and name the molecular geometry of H_2O.

(Answer)

(c) Use the valence bond (VB) theory to predict the hybridization of atomic orbitals of the oxygen atom. Give the number and name of hybridized orbitals, occupied electrons, and bonding electrons.

(Answer)

(d) How many molecular orbitals (MOs) do we need to explain electron spreading over a water molecule?

(Answer)

9. (11 pts in total)

(a) On the basis of the configuration of the neutral molecule F_2, write the molecular orbital configuration of the valence molecular orbitals for (1) $\mathbf{F_2^-}$; (2) $\mathbf{F_2^+}$; (3) $\mathbf{F_2^{2-}}$.

(b) For each species, give the expected bond order.

(c) Which are paramagnetic, if any?

(d) Is the highest-energy orbital that contains an electron σ or π in character?

10. (15 pts in total)

(a) Suggest two Lewis structures that contribute equally to the resonance structure for sulfur dioxide, SO_2 molecule.

(b) Use a valence bond approach to describe the geometry, hybridization, and bonding.

(c) Construct three molecular orbitals using the p orbitals of O and S atoms perpendicular to the plane of the molecule.

(d) Among the three molecular orbitals, which one is HOMO?

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·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·mol^{-1}
Gas constant	$R = N_A k$	8.314 47 J·K^{-1}·mol^{-1}
		8.314 47 L·kPa·K^{-1}·mol^{-1}
		$8.205\,74 \times 10^{-2}$ L·atm·K^{-1}·mol^{-1}
		62.36 37 L·Torr·K^{-1}·mol^{-1}
		$8.314\,47 \times 10^{-2}$ L·bar·K^{-1}·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·s
	$\hbar = h/2\pi$	$1.054\,57 \times 10^{-34}$ J·s
Rydberg constant	$\mathcal{R}$	$3.289\,84 \times 10^{15}$ Hz
Speed of light	c	$2.997\,92 \times 10^{8}$ m·s^{-1}
Standard acceleration of free fall	g	9.806 65 m·s^{-2}
Vacuum permittivity	ε_0	$8.854\,19 \times 10^{-12}$ J^{-1}·C^2·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)	2.83×10^{-2} m^3 (28.3 L)
	1.00 qt (qt = quart)†	9.46×10^{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·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 $= \frac{9}{5} \times$ (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.