

※ 注意：請於答案卷上依序作答，並應註明作答之部份及其題號。

- (1) Please provide the electron configuration and bond order of the following species. 16%
- $[\text{O}_2]^-$
 - $[\text{F}_2]^+$
 - B_2
 - CO
- (2) Given the atomic weight and radius of silver of 107.9 g/mol and 193 pm, respectively. Please calculate the density of silver metal if silver crystallizes in:
- Body centered cubic lattice
 - Face centered cubic lattice
- (3) Please provide the molecular structure and polarity of the following compounds, and the oxidation state of the central atom: 12%
- SeF_4
 - GeH_4
 - PCl_3
 - $[\text{I}_3]^-$

- (4) Given the energy and the normalized wave-function of a particle in a one-dimensional box:

$$E_n = \frac{n^2 h^2}{8 m L^2}$$

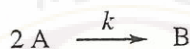
$$\psi_n(x) = \left(\frac{2}{L}\right)^{1/2} \sin\left(\frac{n \pi x}{L}\right)$$

Consider a He atom (4.00 g/mol) confined in a 1-D box with box-length of 100 pm. Please answer the following questions: 12%

- Energy of the He atom at ground state.
 - Wavelength of the light absorbed by the He atom in ground state to reach its first excited state.
 - The probability of finding the He atom in between $x = 0$ and $x = 50$ pm for the $n = 2$ state.
- (5) Consider a buffer solution containing 1.00 M acetic acid ($K_a = 1.8 \times 10^{-5}$ M) and 1.00 M of sodium acetate. 8%
- Please calculate the pH value of the solution
 - Please calculate the pH value after addition of 0.1 mol $\text{HCl}(g)$ to 1.0 L of the buffer solution.
- (6) Please calculate the collision frequency and the mean free path for a hydrogen molecule at 200 K and 1.00 atm. Assume that the diameter of hydrogen molecule is 110 pm. 8%
- $$\text{collision rate } Z = 4 (N/V) d^2 (\pi RT/M)^{1/2}$$
- $$\text{mean free path } \lambda = (1/Z)(8RT/\pi M)^{1/2}$$
- (7) A sample containing NaCl and BaCl_2 is dissolved in water. Half of the solution was allowed to react with excess silver nitrate solution and results in 0.76 g of insoluble solid. The other half was treated with excess sodium sulfate and the mass of the dry precipitate is 0.49 g. Please calculate the molar ratio of NaCl in the solid mixture. 4%
- (8) Please specify the difference between ideal gases and real gases. 4 %

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- (9) A gas sample containing of CO₂ and N₂ in 1:2 molar ratio has a volume of 350 mL at 40 °C with a CO₂ partial pressure of 560 torr. What is the volume of the mixed gases under STP condition? 4 %
- (10) Please indicate the major intermolecular attraction force possessed by the following compounds, and order these compounds according to their boiling point. 6 %
- CH₃CH₂OH, CH₄, and CH₃CH₂CH₂CH₃
 - Trimethylamine, propylamine, acetamide
- (11) Given a reaction constant k of 0.25 and initial concentration of 1.00×10^{-2} M. Please calculate the half-life time of the reaction, if the reaction follows: 6 %
- Zero-order rate law
 - Second-order rate law



- (12) Given below are some examples of the simplified radial functions of hydrogen atom, $R_{n,l}(r)$, in which the normalization constants have been left out. 12%
- Determine nodal locations for 2s and 3p orbitals
 - Depict the 3s and 3p_x orbitals on the xy-plane.

n	l	$R_{n,l}(r)$
1	0	e^{-r/a_0}
2	0	$(2 - \frac{r}{a_0}) e^{-r/2a_0}$
2	1	$\frac{r}{a_0} e^{-r/2a_0}$
3	0	$(27 - 18\frac{r}{a_0} + 2(\frac{r}{a_0})^2) e^{-r/3a_0}$
3	1	$(\frac{r}{a_0})(6 - \frac{r}{a_0}) e^{-r/3a_0}$
3	2	$(\frac{r}{a_0})^2 e^{-r/3a_0}$

Values of selected physical constants:

Constant	Symbol	Value
Avogadro's number	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$
Bohr radius	a_0	$0.53 \times 10^{-10} \text{ m}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Gas constant	R	$8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$ $0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
Planck's constant	h	$6.626 \times 10^{-34} \text{ J s}$

Atomic weight (g/mol):

H: 1.00; He: 4.00; N: 14.01; O: 16.00; Na: 22.99; S: 32.07; Cl: 35.45; Ag: 107.9; Ba: 137.3.

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