

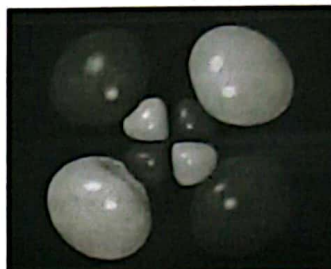
B11 General Chemistry (C) Midterm-B

(I) Multiple choice questions (3 points each, total 72 points)

*There are at least 1 correct option.

1. Identify the orbital in the follow illustration:

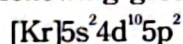
- (a) 3p
- (b) 3d
- (c) 4p
- (d) 4d
- (e) 5p



2. Electromagnetic radiation with a wavelength of 120 nm hits a metal surface. The maximum velocity of electrons ejected from the surface is 1.63×10^6 m/s. What is the metal?

- (a) Copper
- (b) Lead
- (c) Platinum
- (d) Aluminum
- (e) Calcium

3. The following ground-state electron configuration corresponds to which element?

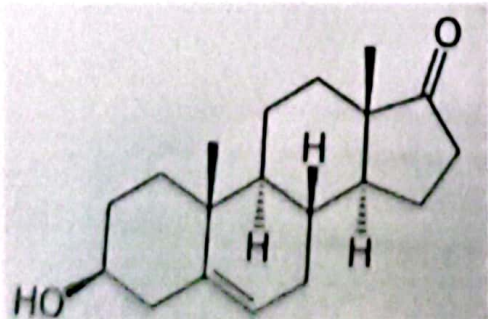


- (a) Sn
- (b) Sb
- (c) Pb
- (d) Bi
- (e) Te

4. Which of the following statements is **False**?

- (a) At 400 K, the average speed of molecules of H_2 (g) is higher than that of N_2 (g).
- (b) Kinetic molecular theory (KMT) assumes that gas particles occupy no volume.
- (c) The average speed of gas particles increases as temperature increases.
- (d) For a mixture of ideal gases, the total pressure is dependent on the molecular masses of each of the gases in the mixture.
- (e) Intermolecular attractions between gas particles lead to non-ideal behavior of gases at high concentrations.

5. Which of the following statements is **true**?
- Molecules containing polar bonds must be polar molecules.
 - Hydrogen bonding is generally stronger than ionic bonding.
 - London dispersion forces are only present between non-polar molecules.
 - Resonance structures of a molecule interchange in rapid, reversible, equilibrium.
 - Liquid methanol (CH_3OH) exhibits intermolecular hydrogen bonding interactions.
6. Which of the following statements is **false**?
- Z_{eff} is greater for valence electrons of Br than for Si.
 - Rb is larger in size than Li.
 - N is more electronegative than Ca.
 - The H 1s orbital is smaller than the Na 1s orbital.
 - Iodide anion is larger than fluoride anion.
7. In which of these molecules does carbon have an oxidation state of (+IV)?
- F_3COH
 - CS_2
 - H_2CO
 - CH_4
 - CHCl_3
8. What is the empirical formula of a compound with the following composition by **mass**?
C: 54.94%; H: 9.99 %; N: 10.68 %; O: 24.39%
- $\text{C}_6\text{H}_5\text{NO}_2$
 - $\text{C}_6\text{H}_5\text{NO}$
 - $\text{C}_4\text{H}_9\text{NO}_2$
 - $\text{C}_4\text{H}_5\text{NO}$
 - $\text{C}_6\text{H}_{11}\text{NO}_2$
9. Below is the structure of dehydroepiandrosterone (DHEA), a hormone in humans:



Which of the following statements is correct?

- DHEA does not contain any CH_3 groups.
- The carbons of the $\text{C}=\text{O}$ groups are sp^2 hybridized.

- (c) The carbon atoms of DHEA are sp^2 and sp^3 hybridized only.
- (d) The oxygen atoms in DHEA do not have any lone pair electrons.
- (e) The empirical formula of DHEA is $C_{18}H_{28}O_2$.

10. Which of the following statements is or are correct?

- (a) bond order of O_2^+ is $3/2$
- (b) bond order of C_2^+ is $3/2$
- (c) bond order of O_2 is $5/2$
- (d) bond order of N_2^+ is $5/2$
- (e) Be_2^{2+} is paramagnetic

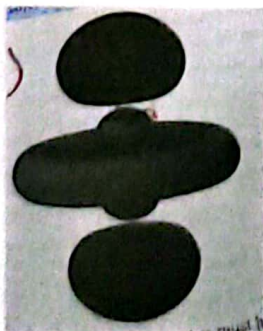
11. Which of the following statements about chemical bonding is (are) correct?

- (a) In O_2 molecule, electrons are shared equally between O atoms to form stable compounds.
- (b) As for formal charge, the bonding was fully covalent, regardless of relative electronegativity.
- (c) The shared electrons in a covalent bond are assumed to be delocalized.
- (d) Electrons are completely transferred from metal to nonmetal atom in a metallic bond, and the resulting charged atoms are held together by electrostatic attractions.
- (e) BF_3 molecules that have permanent dipoles are attracted to each other.

12. Identify each statements as true or false (A) Mg^{2+} is smaller than Al^{3+} . (B) Cl^- is smaller than S^{2-} . (C) lattice energy of LiCl is smaller than RbCl.

- (a) true; true; false
- (b) true; false; true
- (c) false; true; false
- (d) false; false; true
- (e) false; true; true

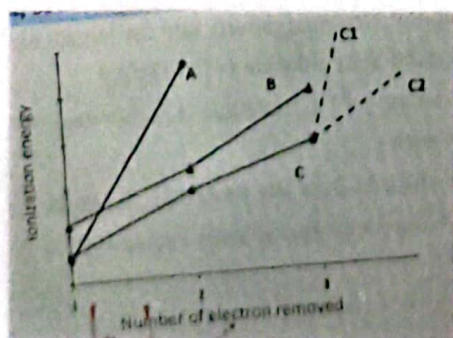
13. For the following p orbital, which of the following statements is INCORRECT?



- (a) Any two adjacent lobes must have opposite signs.
- (b) The electrons in this orbital must obey the Pauli exclusion principle.
- (c) This orbital must have lower energy than the 3d orbital of the same atom.
- (d) The magnetic quantum number of this orbital must be 1, 0, and -1.

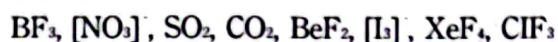
- (e) This orbital must be filled up by electrons for an unexcited copper atom (Cu).
14. Two students determine the percentage of lead in a sample as a laboratory exercise. The true percentage is 22.52%. The students' results for three determinations are as follows:
 Student I: 22.64, 22.58, 22.62.
 Student II: 22.52, 22.48, 22.54.
 (A) Which student is more accurate? (B) Which student is more precise?
 (a) Student I; Student I
 (b) Student II; Student II
 (c) Student I; Student I
 (d) Student II; Student I
 (e) Student II; The same
15. Which of the following statement(s) is or are correct?
 (a) In H atom, the energy level: $3s < 3d$
 (b) In Mg atom, the energy level: $2s < 2d$
 (c) In N_2 molecule, the π bond is weaker than σ bond.
 (d) The C-C bond length in C_2H_4 is larger than C_2H_2
 (e) In O_2 molecule, there are two π bonds.
16. Which of the following statements about bonding is (are) correct?
 (a) In sp^3 hybridization, quantum mechanics allow mixing of s orbital and the p orbitals to generate three equivalent orbitals.
 (b) Hybridization involves only the valence orbitals, the orbitals associated with the occupied highest principal quantum number level.
 (c) Valence bond theory cannot explain the magnetic properties for some molecules.
 (d) π - Bonds- electron density lies on the axis between the nuclei.
 (e) Benzene ring is a typical π -conjugated system, where resonance is employed to describe the delocalized electrons.
17. There are four 1L containers at STP. Container A is filled with H_2 (2 g/mol), container B is filled with He (4g/mol), container C is filled with CO_2 (44 g/mol), and container D is filled with H_2O (18 g/mol). Which of the following description is/are correct?
 (a) Container A has more gas particles.
 (b) Gas molecules in container C have the smallest average kinetic energy.
 (c) Gas molecules in container D have the smallest root mean square velocity because of hydrogen bonding interaction.
 (d) If the temperature is raised to 500K, the pressure of container B will be doubled.
 (e) None of the above.

18. Consider a photoelectron experiment using Lithium metal (work function = 279.7 kJ/mol) as the cathode, which of the following statements are correct?
- It requires 279.7 kJ of energy to eject an electron from Li.
 - A 400 nm light carries an energy of 1.7×10^{-19} J and can eject photoelectron from Li cathode.
 - The electron ejected using 400 nm light has a kinetic energy lower than 19.5 kJ/mol.
 - The electron ejected using 400 nm light has a de Broglie wavelength of 2.7×10^{-9} m.
 - The first ionization energy of Li is 279.7 kJ/mol.
19. Order the following atoms and molecules according to their first ionization energy :
- $\text{Li} > \text{Na} > \text{K} > \text{Cs}$
 - $\text{Cs} > \text{K} > \text{Na} > \text{Li}$
 - $\text{O}_2 > \text{O} > \text{N} > \text{N}_2$
 - $\text{N}_2 > \text{N} > \text{O} > \text{O}_2$
 - $\text{Cl} > \text{F} > \text{Br} > \text{I}$
20. Which of the following description(s) of N_2 molecule is(are) correct? (Assume the N-N bond is along the x-axis.)
- The $p_x + p_x$ linear combination is the σ bonding MO.
 - The $p_y + p_y$ linear combination is the π bonding MO.
 - The higher energy of σ_{2p} than π_{2p} is a result of s-p hybridization.
 - There are six electrons in bonding MO.
 - None of the above.
21. The following graph plots the first, second and third ionization energy for Li, B and N.



- A, B and C are Li, B and N.
- Atomic radius follows $\text{A} > \text{C} > \text{B}$
- Element B has the highest electron affinity
- For element C, the 4th ionization data point is Cl.
- None of the above.

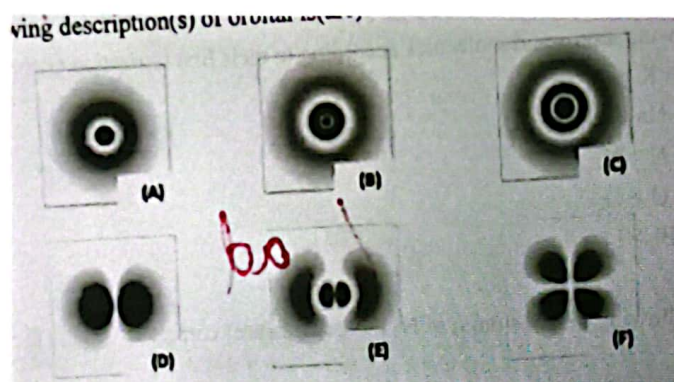
22. Consider the following molecules and ions:



Which of the following descriptions are correct?

- (a) There are four linear molecules/ions
- (b) $[\text{NO}_3]^-$ has three isolable resonance structures.
- (c) BF_3 , BeF_2 , XeF_4 and ClF_3 are non-polar molecules
- (d) There are three molecules/ions containing a sp^2 hybrid central atom
- (e) There are two molecules/ions containing a dsp^3 hybrid central atom

23. Which of the following description(s) of orbital is(are) correct?



- (a) Orbital A and C have the same number of angular node.
- (b) Orbital D and E have the same number of radial node.
- (c) Orbital B and F have the same principal quantum number.
- (d) If these are atomic orbitals of Na, B is lower in energy than E.
- (e) For nitrogen atom, orbital B-F are all empty.

24. Which of the following description(s) of halogen atoms and ions is(are) correct?

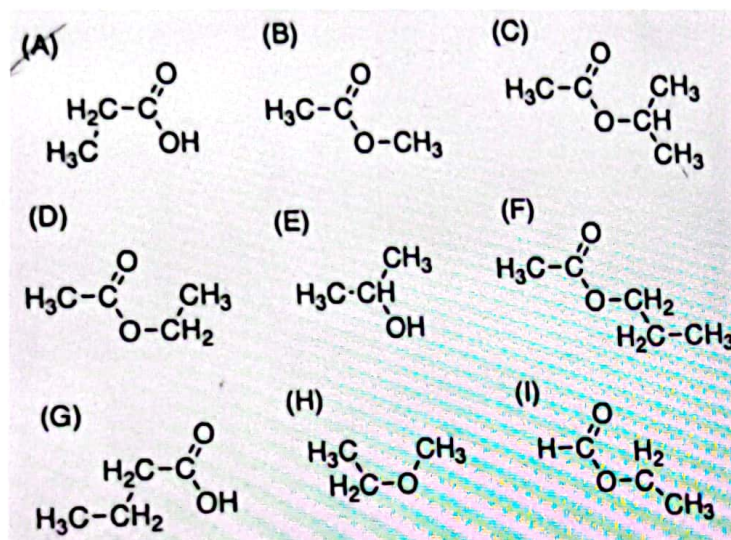
- (a) Fluorine has the highest electronegativity and the largest electron affinity among them.
- (b) The electron configuration of chloride is $[\text{Ne}]3\text{s}^23\text{p}^6$
- (c) The first ionization energy of Cl_2 molecule is higher than that of Cl atom because the electron of Cl_2 is shared by two Cl nuclei.
- (d) After removing one electron from Br_2 molecule, the Br-Br bond order of $[\text{Br}_2]^+$ increased.
- (e) I_2 has the highest boiling point among them because of its strong dipole-dipole interaction.

(II) Hand-writing questions (10 points each, total 30 points)

Please write down the answer and process including reasons and calculations for all the questions.

1. Consider a compound containing 48.6% C, 8.11% H, 43.2% O: (10 pts)

(a) Please choose all possible compounds among the options. (3pts)



(b) Please choose the one with highest boiling point among the answers you provided in (a).
What is the reason? (4 pts)

(c) After full combustion of 1.00 mole of the compound, what is the volume of the product under 1.00 atm, 127 °C? (Please take significant figure in consideration, 3pts)

2. Consider S, Cl, K, and Ca atoms: (10pts)

(a) Please write down the electron configuration of these atom and their most common ions using the appropriate noble-gas core abbreviations. (4 pts)

(b) Please list their most common ions in order of increasing size and write down the reason behind the trend. (3 pts)

(c) Please give the trend of their second ionization energy and the reason behind it. (3 pts)

3. Consider the BN molecule:

(a) Please draw the MO diagram of it and calculate its bond order. (6 pts)

(b) If we add an electron to BN molecule and get BN^- anion, how would its bond order change?
What if we remove one electron to get BN^+ cation? (4 pts)