

The exam problems will be taken from your HW, Lecture, Lab and this review. There will be more multiple choice questions on this exam than in the past exams.

As always, any material covered on the previous two exams may be part of this exam.

Chapter 6:

1. All of the following sets of quantum numbers are allowed EXCEPT

- a) $n = 5, \ell = 3, m_\ell = +2$ b) $n = 4, \ell = 2, m_\ell = -1$ c) $n = 3, \ell = 3, m_\ell = 0$
 d) $n = 2, \ell = 1, m_\ell = +1$ e) $n = 2, \ell = 0, m_\ell = 0$

Answer: c

2. Which of the following properties is associated with the value of the n quantum number?

- a) the number of electrons in an orbital b) the size of an orbital
 c) the orientation in space of an orbital d) the energy of an orbital
 e) the shape of an orbital

Answer: d

3. What type of orbital is designated $n = 2, \ell = 3, m_\ell = -2$?

- a) 4s b) 4p c) 4d d) 4f e) none

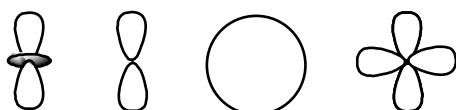
Answer: e

4. Which of the following orbitals might have $m_\ell = -2$?

- a) s b) s and p c) p and d d) d and f e) p, d, and f

Answer: d

5. Which of the following diagrams represent p -orbitals?



- a) 1 only b) 2 only c) 3 only d) 4 only e) 1 and 2

Answer: b

6. Which of the following statements is/are CORRECT?

1. A diamagnetic substance is attracted to a magnetic field.
2. An atom with no unpaired electrons is ferromagnetic.
3. Atoms with one or more unpaired electrons are paramagnetic.

- a) 1 only b) 2 only c) 3 only d) 1 and 2 e) 1, 2, and 3

Answer: c

7. The _____ momentum quantum number is given the symbol ℓ . This quantum number is the primary factor in determining the shape of an orbital.

Answer: angular

Chapter 7:

8. Which of the following sets of quantum numbers is allowed?

- a) $n = 2, \ell = 1, m_\ell = +1/2, m_s = -1/2$ b) $n = 3, \ell = 2, m_\ell = +1, m_s = +1$
 c) $n = 4, \ell = 2, m_\ell = -2, m_s = -1/2$ d) $n = 4, \ell = 4, m_\ell = -1, m_s = +1/2$
 e) $n = 5, \ell = 2, m_\ell = +2, m_s = -1$

Answer: c

9. The procedure by which electrons are assigned to (or built up into) orbitals is known as the _____ principle.

- a) aufbau b) Bohr c) Planck d) Hund e) Pauli

Answer: a

10. Which of the following statements concerning ground state electron configurations is/are CORRECT?

- For a hydrogen atom with one electron, the $2s$ and $2p$ orbitals have identical energies.
- For a lithium atom with three electrons, the $2s$ and $2p$ orbitals have different energies.
- The effective nuclear charge felt by an electron in a $2p$ orbital is greater for a carbon atom than for a boron atom.

- a) 1 only b) 2 only c) 3 only d) 2 and 3 e) 1, 2, and 3

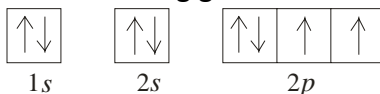
Answer: e

11. Which element has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^2$?

- a) Mg b) Si c) Ge d) Ti e) Ga

Answer: b

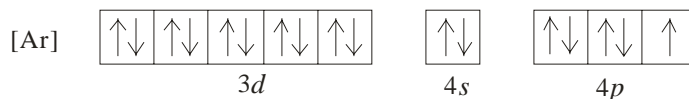
12. Which element has the following ground state electron configuration?



- a) P b) S c) O d) N e) F

Answer: c

13. What is a possible set of quantum numbers for the unpaired electron in the orbital box diagram below?



- a) $n = 1, \ell = 1, m_\ell = -1, m_s = +1/2$ b) $n = 3, \ell = 2, m_\ell = -1, m_s = -1/2$
 c) $n = 4, \ell = 2, m_\ell = -2, m_s = +1/2$ d) $n = 4, \ell = 0, m_\ell = 0, m_s = +1/2$
 e) $n = 4, \ell = 1, m_\ell = -1, m_s = +1/2$ Answer: e

14. If the ground state electron configuration of an element is $[\text{Ar}]3d^{10}4s^24p^4$, what is the typical charge on the monatomic anion of the element?

- a) 4+ b) 2+ c) 1- d) 2- e) 3-

Answer: d

15. Which of the following ions have the same ground state electron configuration: Cl^- , P^{3-} , Ca^{2+} , and Ga^+ ?

- a) Cl^- and P^{3-} b) Cl^- , P^{3-} , and Ca^{2+} c) Ca^{2+} and Ga^+ d) P^{3-} and Ga^+
e) Cl^- , P^{3-} , Ca^{2+} , and Ga^+

Answer: b

16. Which of the following cations has the same number of unpaired electrons as Cr^{3+} ?

- a) Ni^{2+} b) Fe^{2+} c) Zn^{2+} d) Mn^{2+} e) Co^{2+}

Answer: e

17. In general, atomic radii

- a) decrease down a group and remain constant across a period.
b) decrease down a group and increase across a period.
c) increase down a group and increase across a period.
d) increase down a group and remain constant across a period.
e) increase down a group and decrease across a period.

Answer: e

18. Place the following atoms in order of increasing atomic radii: K, Mg, Ca, and Rb?

- a) $\text{K} < \text{Mg} < \text{Ca} < \text{Rb}$ b) $\text{K} < \text{Mg} < \text{Rb} < \text{Ca}$ c) $\text{Mg} < \text{Ca} < \text{K} < \text{Rb}$
d) $\text{K} < \text{Rb} < \text{Mg} < \text{Ca}$ e) $\text{Mg} < \text{K} < \text{Ca} < \text{Rb}$

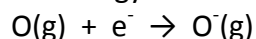
Answer: c

19. Rank Ca, Mg, and Ba in order of increasing first ionization energy.

- a) $\text{Ca} < \text{Mg} < \text{Ba}$ b) $\text{Ca} < \text{Ba} < \text{Mg}$ c) $\text{Mg} < \text{Ca} < \text{Ba}$
d) $\text{Ba} < \text{Mg} < \text{Ca}$ e) $\text{Ba} < \text{Ca} < \text{Mg}$

Answer: e

20. The change in energy for the following reaction is referred to as the _____ for oxygen.



- a) oxidation number b) electron affinity c) electronegativity energy
d) first ionization energy e) second ionization energy

Answer: b

21. Place the following ions in order from smallest to largest ionic radii: Se^{2-} , Sr^{2+} , Y^{3+} , and Br^- .

- a) $\text{Se}^{2-} < \text{Sr}^{2+} < \text{Y}^{3+} < \text{Br}^-$ b) $\text{Se}^{2-} < \text{Br}^- < \text{Sr}^{2+} < \text{Y}^{3+}$ c) $\text{Br}^- < \text{Se}^{2-} < \text{Y}^{3+} < \text{Sr}^{2+}$
d) $\text{Y}^{3+} < \text{Sr}^{2+} < \text{Br}^- < \text{Se}^{2-}$ e) $\text{Sr}^{2+} < \text{Y}^{3+} < \text{Se}^{2-} < \text{Br}^-$

Answer: d

22. Explain why the first ionization energy for oxygen is lower than that for nitrogen.

Answer: Oxygen has a $1s^2 2s^2 2p^4$ electron configuration and nitrogen has a $1s^2 2s^2 2p^3$ electron configuration. Although the $2p$ electrons on an oxygen atom experience a greater effective nuclear charge than those on a nitrogen atom, two of oxygen's $2p$ electrons are paired in a single orbital, whereas each electron occupies its own orbital for nitrogen. The repulsion of these two electrons more than offsets oxygen's larger effective nuclear charge acting on the $2p$ electrons.

Chapter 8

23. Which combination of atoms is most likely to produce a compound with covalent bonds?

- a) Na and Cl b) Al and O c) S and Br d) Pb and F e) K and I

Answer: c

24. A selenium atom has _____ valence electrons.

- a) 2 b) 6 c) 16 d) 28 e) 34

Answer: b

25. How many lone pair of electrons are assigned to each carbon atoms in C_2H_2 ?

- a) 0 b) 1/2 c) 1 d) 2 e) 3

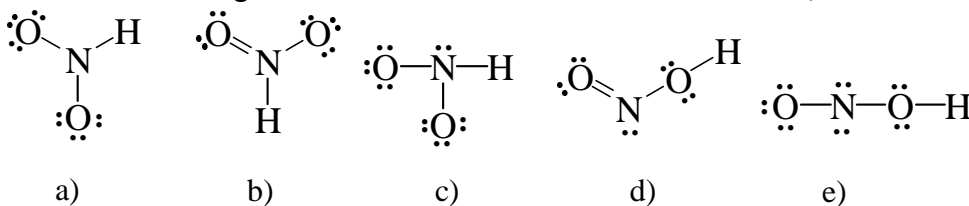
Answer: a

26. Which of the following molecules or ions are isoelectronic: SO_2 , CO_2 , NO_2^+ , ClO_2^- ?

- a) SO_2 and CO_2 b) SO_2 and NO_2^+ c) CO_2 and ClO_2^-
d) CO_2 and NO_2^+ e) SO_2 , NO_2^+ , and ClO_2^-

Answer: d

27. Which of the following is a correct Lewis structure for nitrous acid, HNO_2 ?



Answer: d

28. The central atom in PH_3 is surrounded by

- a) three single bonds and no lone pairs of electrons.
b) three single bonds and one lone pair of electrons.
c) three single bonds and two lone pairs of electrons.
d) two single bonds, one double bond, and no lone pairs of electrons.
e) two single bonds, one double bond, and one lone pair of electrons.

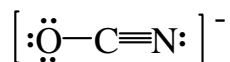
Answer: b

29. What is the formal charge on each atom in chloroform, CHCl_3 ?

- a) C atom = 0, H atom = 0, and each Cl atom = 0
- b) C atom = 0, H atom = +1, one Cl atom = -1, and two Cl atoms = 0
- c) C atom = +4, H = -1, and each Cl atom = -1
- d) C atom = +2, H = +1, and each Cl atom = -1
- e) C atom = -4, H = +1, and each Cl atom = +1

Answer: a

30. One resonance structure for OCN^- ion is drawn below. What is the formal charge on each atom?



- a) O atom = 0, C atom = 0, and N atom = 0
- b) O atom = 0, C atom = 0, and N atom = -1
- c) O atom = -1, C atom = 0, and N atom = 0
- d) O atom = -1, C atom = -1, and N atom = +1
- e) O atom = +1, C atom = 0, and N atom = -2

Answer: c

31. Which of the following are resonance structures for formate ion, HCO_2^- ?

- a) 1 and 2
- b) 2 and 3
- c) 3 and 4
- d) 1, 3, and 4
- e) 2, 3, and 4

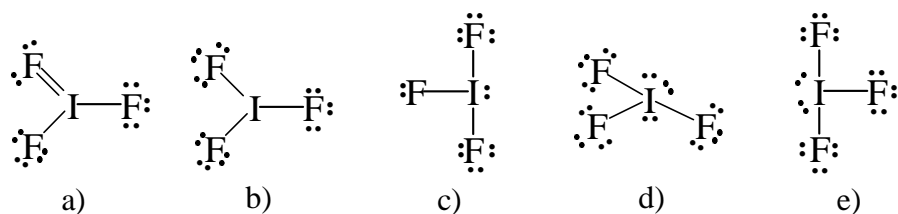
Answer: c

32. Which of the following elements is most likely to form a molecular structure that disobeys the octet rule?

- a) B
- b) C
- c) N
- d) O
- e) F

Answer: a

33. What is the correct Lewis structure for IF_3 ?



Answer: e

34. The central atom in PF_5 is surrounded by

- a) five single bonds and no lone pairs of electrons.
- b) five single bonds and one lone pair of electrons.
- c) four single bonds, one double bond, and no lone pairs of electrons.
- d) four single bonds, one double bond, and one lone pair of electrons.
- e) three single bonds, two double bonds, and no lone pairs of electrons.

Answer: a

35. Use VSEPR theory to predict the electron-pair geometry and the molecular geometry of sulfur dioxide, SO_2 .

- a) The electron-pair geometry is trigonal-planar, the molecular geometry is trigonal-planar.
- b) The electron-pair geometry is trigonal-planar, the molecular geometry is bent.
- c) The electron-pair geometry is tetrahedral, the molecular geometry is bent.
- d) The electron-pair geometry is tetrahedral, the molecular geometry is linear.
- e) The electron-pair geometry is trigonal-bipyramidal, the molecular geometry is linear.

Answer: b

36. Use VSEPR theory to predict the molecular geometry around either carbon atom in acetylene, C_2H_2 .

- a) linear
- b) bent
- c) trigonal-planar
- d) tetrahedral
- e) octahedral

Answer: a

37. Use VSEPR theory to predict the molecular geometry of BrF_5 .

- a) tetrahedral
- b) see-saw
- c) trigonal-bipyramidal
- d) square-pyramidal
- e) octahedral

Answer: d

38. What are the approximate I-N-I bond angles in NI_3 ?

- a) 109.5°
- b) 120°
- c) 109.5° and 120°
- d) 90° and 120°
- e) 90° and 180°

Answer: a

39. What is the O-C-N bond angle in OCN^- ?

- a) 90°
- b) 107°
- c) 109.5°
- d) 120°
- e) 180°

Answer: e

40. Electronegativity is a measure of

- a) the ability of a substance to conduct electricity.
- b) the charge on a polyatomic cation.
- c) the charge on an polyatomic anion.
- d) the ability of an atom in a molecule to attract electrons to itself.
- e) the oxidation number of an atom in a molecule or polyatomic anion.

Answer: d

41. Predict which of the following compounds has covalent bond(s) that are the most polar.

- a) HF
- b) Cl_4
- c) H_2S
- d) NBr_3
- e) HI

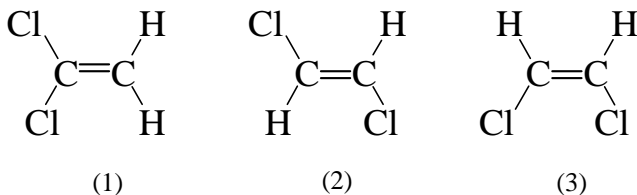
Answer: a

42. Which one of the following molecules is polar?

- a) CO_2
- b) SF_4
- c) XeF_2
- d) XeF_4
- e) SO_3

Answer: b

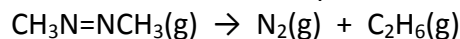
43. Three possible structures of $C_2H_2Cl_2$ are shown below. Which of these molecules are polar?



- a) 1 only b) 2 only c) 3 only d) 1 and 3 e) 2 and 3

Answer: d

44. When heated, azomethane decomposes into nitrogen gas and ethane gas.



Bond	Bond Enthalpy (kJ/mol·rxn)	Bond	Bond Enthalpy (kJ/mol·rxn)
C-H	413	N-N	163
C-N	305	N=N	418
C-C	346	N≡N	945

Using average bond energies, calculate the enthalpy of reaction.

- a) -611 kJ b) -527 kJ c) -429 kJ d) -313 kJ e) -263 kJ

Answer: e

45. Which of the following statements is/are CORRECT?

- The overlap between an s orbital and a p orbital is called a pi-bond.
- The overlap of two s orbitals in H_2 is called a sigma bond.
- HF is formed from the overlap of a hydrogen $1s$ orbital with a fluorine $2s$ orbital.

- a) 1 only b) 2 only c) 3 only d) 2 and 3 e) 1, 2, and 3

Answer: b

46. Which of the following statements concerning hybrid orbitals is/are CORRECT?

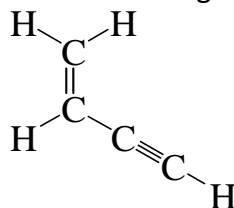
- The number of hybrid orbitals equals the number of atomic orbitals that are used to create the hybrids.
- When atomic orbitals are hybridized, the s orbital and at least one p orbital are always hybridized.
- To create octahedral structures, two d orbitals must be hybridized along with the s and all three p orbitals.

- a) 1 only b) 2 only c) 3 only d) 2 and 3 e) 1, 2, and 3

Answer: e

47. How many sigma (σ) bonds and pi (π) bonds are in the following molecule?

- seven σ and three π
- seven σ and two π
- five σ and five π
- five σ and three π
- five σ and two π



Answer: a

48. What is the hybridization of either carbon atom in acetylene, C_2H_2 ?

- a) sp b) sp^2 c) sp^3 d) sp^3d e) sp^3d^2

Answer: a

49. What is the hybridization of the central nitrogen atom in nitrite ion, NO_2^- ?

- a) sp b) sp^2 c) sp^3 d) sp^3d e) sp^3d^2

Answer: b

50. For which of the following molecules does the central carbon atom have sp^2 hybridization?

- a) Cl_2CO b) $CHCl_3$ c) CS_2 d) CH_2Cl_2 e) HCN

Answer: a

51. What is the molecular geometry around a central atom that is sp^3 hybridized and has two lone pairs of electrons?

- a) bent b) linear c) trigonal-planar d) trigonal-pyramidal
e) trigonal-bipyramidal

Answer: a

52. What is the molecular geometry around a central atom that is sp^2 hybridized, has three sigma bonds, and one pi bond?

- a) trigonal-planar b) trigonal-pyramidal c) bent d) T-shaped
e) tetrahedral

Answer: a

53. Upon heating, $CaCO_3$ decomposes to CaO and CO_2 . What change in the hybridization of carbon occurs in this reaction?

- a) sp to sp^2 b) sp^2 to sp^3 c) sp^3 to sp d) sp^2 to sp e) no change

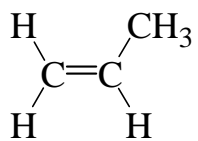
Answer: d

54. Which of the following hybridized atoms is not possible?

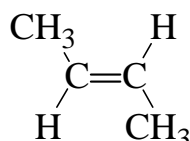
- a) an sp hybridized carbon atom
b) an sp^2 hybridized sulfur atom
c) an sp^3 hybridized phosphorus atom
d) an sp^3d hybridized oxygen atom
e) an sp^3d^2 hybridized xenon atom

Answer: d

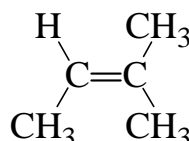
55. For which of the following compounds is it possible for *cis* and *trans* isomers to exist?



(1)



(2)



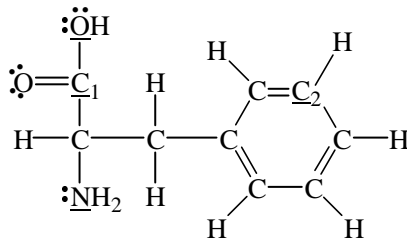
(3)

- a) 1 only b) 2 only c) 3 only d) 1 and 2 e) 1, 2, and 3

Answer: b

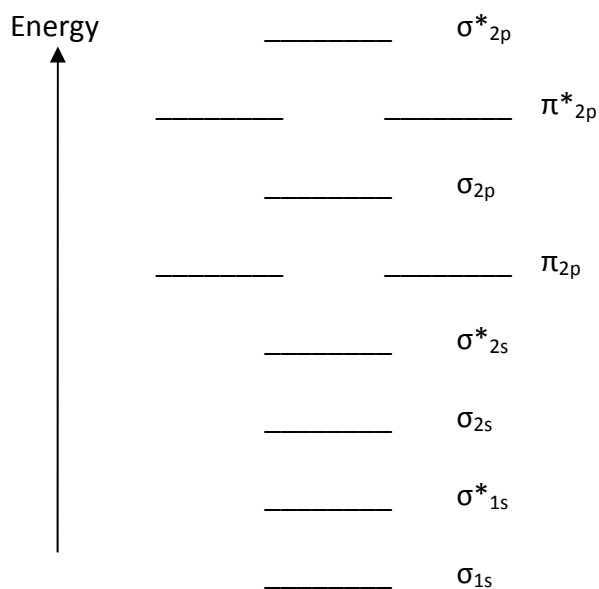
56. Which of the underlined atoms (C_1 , C_2 , N, and O) are sp^2 hybridized?

- a) C_1 and C_2
- b) C_1 , N, and O
- c) N and O
- d) O and C_2
- e) O only



Answer: a

The following molecular orbital diagram may be used for problems 35-48. For oxygen and fluorine, the σ_{2p} orbital should be lower in energy than the π_{2p} . However, the diagram will still yield correct bond order and magnetic behavior for these molecules.



57. According to molecular orbital theory, which of the following species is the most likely to exist?

- a) H_2^{2-}
- b) He_2
- c) Li_2^{2-}
- d) Be_2
- e) Be_2^{2-}

Answer: e

58. According to molecular orbital theory, which of the following species is least likely to exist?

- a) Be_2
- b) F_2^{2+}
- c) C_2^{2-}
- d) Li_2
- e) B_2^{2-}

Answer: a

59. According to molecular orbital theory, which of the following species has the highest bond order?

- a) F_2
- b) F_2^{2+}
- c) C_2^{2-}
- d) Li_2
- e) B_2^{2+}

Answer: c

60. According to molecular orbital theory, what is the bond order of oxygen, O_2 ?

- a) 1
- b) $3/2$
- c) 2
- d) $5/2$
- e) 3

Answer: c

61. According to molecular orbital theory, what is the bond order of N_2^- ?

- a) 1 b) 3/2 c) 2 d) 5/2 e) 3

Answer: d

62. Use molecular orbital theory to predict which ion is paramagnetic.

- a) F_2^{2+} b) O_2^{2-} c) O_2^{2+} d) N_2^{2+} e) B_2^{2-}

Answer: a

63. What is the molecular orbital configuration of F_2 ?

- a) [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2 (\sigma_{2p}^*)^2$
 b) [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2 (\sigma_{2p})^2 (\pi_{2p}^*)^2$
 c) [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\pi_{2p}^*)^4$
 d) [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2 (\pi_{2p}^*)^6$
 e) [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2 (\pi_{2p}^*)^4$

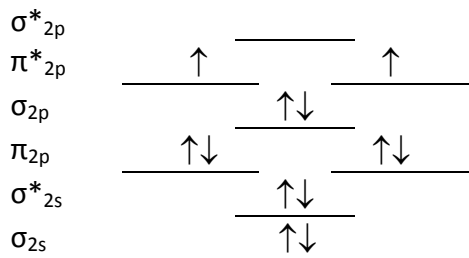
Answer: e

64. Assuming that the molecular orbital energy diagram for a homonuclear diatomic molecule applies to a heteronuclear diatomic molecule, determine which of the following species has the highest bond order.

- a) NO^- b) OF^- c) CN^- d) O_2 e) NO

Answer: c

65. The following valence molecular orbital energy level diagram is appropriate for which one of the listed species?



- a) B_2^{2-} b) C_2^{2-} c) N_2^{2-} d) O_2^{2-} e) F_2^{2-}

Answer: c