Name: ______________________ Class: __________________ Date: __________________

Past 5-6 years of tests. I do not vouch for any answerkey as I don't use them and sometimes forget to update or change them. Report any mistakes you find.

**Instructions: Answer the following questions. Show ALL work for problems to receive full credit. Make sure to include proper units and significant figures for all answers. You are allowed the use of a molecular model kit.**

[5 pt] 1. Name the scientist associated with each of the following discoveries, experiments or statements. Choices are: Albert Einstein, Christiaan Hugens, Ernest Rutherford, Erwin Schrodinger, James Clerk Maxwell, Louis De Broglie, Max Planck, Niels Bohr, Sir Isaac Newton, Werner Heisenberg, Wolfgang Pauli, and Thomas Young.

(a) Proposed electrons are located in orbitals around the nucleus like planets around the sun 1(a) **Bohr**

(b) Created a mathematical model that described where electrons are found around an atoms called Quantum Mechanics. 1(b) **Schrodinger**

(c) Scientist who proposed that since light can be both a wave and a particle, then an electron can be both a particle and a wave. "Wave-Particle Duality" 1(c) **De Begolie**

(d) His model was the first to place electrons in orbitals and explained line spectra successfully . 1(d) **Bohr**

(e) Protons are in the middle and the electrons are in a cloud around the nucleus 1(e) **Rutherford**

(f) His model explained Line Spectra. 1(f) **Bohr**

[4 pt] 2. Give the associated symbol and what about feature of orbitals/electrons each Quantum Number describes:

(a) Principal quantum number

$n$ - Size of orbital, row in periodic table

(b) Angular-momentum quantum number:

$l$ - Shape of Orbital

(c) The Magnetic quantum number:

$m_l$ - Orientation of orbital / number of sub-orbitals

(d) Electron spin quantum number:

$m_s$ - Spin of electron

[4 pt] 3. Sketch **AND** label an S, P, and D orbital. How many electrons fit into each orbital type?

| | **s-orbital** | **p-orbital** | **d-orbital** |
|---|---|---|---|
| Shape of Orbital | | | |
| # of Sub-Orbitals | | | |
| # electrons in orbital | | | |

Sphere, Dumbbell, and 4 Leaf Clover

[5 pt] 4. Place each letter in the box with the appropriate quantum number. More than one correct answer exists. Some statements may not match any quantum number.

(a) Determines the number of sub-orbitals
(b) Principle Quantum Number
(c) Determines that orbitals hold 2 electrons
(d) Magnetic Quantum Number
(e) Determines the distance of the orbital from the nucleus
(f) Determines the shape of orbitals
(g) Angular Momentum Quantum Number
(h) Determines the orientation of orbitals
(i) Determines the color of the electron
(j) Electron Spin Quantum Number

| | |
|---|---|
| n | l |
| $m_l$ | $m_s$ |

[3 pt] 5. Describe the location of electrons in an atom **AND** sketch a picture of the atom according to Rutherford. Why does the model fail to explain Line Spectra?

Picture should show tiny nucleus with electrons in a cloud any distance from the nucleus

Fails to explain line spectra because the electron can be anywhere and therefore emit any color of light.

[4 pt] 6. Describe the location of electrons in an atom **AND** sketch a picture of the atom according to Bohr. What major improvement to the Rutherford Model did Bohr make? How does this explain line spectra?

Picture should show electrons in well defined orbitals.

Bohr placed the electrons in orbitals instead of randomly around the atom.

[3 pt] 7. Sketch a picture of the atom according to de Broglie. How did the model explain the quantization of orbitals (ie what he most famous for saying)?

Picture should show waves are responsible for the orbitals.

If light can be a wave and particle than electrons can be particles and waves.

[3 pt] 8. In what order are the electron orbitals (1s, 2s etc) from lowest to highest energy, up to the 7s orbital.

1s, 2s, 2p, 3s, 3p, 4s, **3d**, 4p, 5s, 4d, 5p, 6s, **4f**, **5d**, 6p, 7s

[3 pt] 9. What is the significance of each part of the designation 3d$^3$

[6 pt] 10. Give the electron configuration (1s 2s etc.) for the following elements:

(a) C $1s^2, 2s^2, 2p^2$

(b) Cl $1s^2, 2s^2, 2p^6, 3s^2, 3p^5,$

(c) Fe $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

(d) Ca $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

(e) Mn $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^5$

(f) Se $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^4$

(g) As $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^10, 4p^3$

[6 pt] 11. Draw orbital diagrams for the following elements. Ignore any extra boxes provided.

(a) N: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

(b) Mg: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

(c) Mn: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

(d) Fe: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

(e) Se: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

(f) S: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ][ ]

(g) Ca: [ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ] [ ] [ ][ ][ ][ ][ ] [ ][ ][ ]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| P - | 1s [↑↓] | 2s [↑↓] | 2p [↑][↑][↑] | 3s [ ] | 3p [ ] | 4s [ ] | 3d [ ][ ][ ][ ][ ] | 4p [ ][ ][ ] |
| Mg - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑][↓] | 3p [ ][ ][ ] | 4s [ ] | 3d [ ][ ][ ][ ][ ] | 4p [ ][ ][ ] |
| Mn - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑↓] | 3p [↑↓][↑↓][↑↓] | 4s [↑↓] | 3d [↑][↑][↑][↑][↑] | 4p [ ][ ][ ] |
| Fe - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑↓] | 3p [↑↓][↑↓][↑↓] | 4s [↑↓] | 3d [↑↓][↑][↑][↑][↑] | |
| Se - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑↓] | 3p [↑↓][↑↓][↑↓] | 4s [↑↓] | 3d [↑↓][↑↓][↑↓][↑↓][↑↓] | 4p [↑↓][↑][↑] |
| S - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑↓] | 3p [↑↓][↑][↑] | 4s [ ] | 3d [ ][ ][ ][ ][ ] | 4p [ ][ ][ ] |
| Mg - | 1s [↑↓] | 2s [↑↓] | 2p [↑↓][↑↓][↑↓] | 3s [↑] | 3p [↑↓][↑↓][↑↓] | 4s [↑↓] | 3d [ ][ ][ ][ ][ ] | 4p [ ][ ][ ] |

[4 pt] 12. Define the term Valence electron. Why are they important?

(a) Valence electrons are the outermost electrons in an atom (s and p orbitals)
(b) They are important because they are the only electrons responsible for chemistry (forming ions, forming molecular bonds etc).

[5 pt] 13. Halogens form -1 ions. Write the formation reaction for a Fluorine ion from a Fluorine atom using (1) chemical equation (2) Lewis Structures and (3) electron configurations. What is the driving force (ie why does Fluorine want to form a -1 ion) behind the formation of the ion?

Halogens form -1 ions because they are able to complete octets (noble gas configurations). They all share $s^2p^5$

[3 pt] 14. Why do the Alkali Metals only form +1 cations (lose only one electron)? What electron configuration do they all have in common?

Alkali Metals form +1 ions because they are able to complete octets (noble gas configurations) by losing an electron. They all share $s^1$

[5 pt] 15. Explain using (1) Electron Configurations, (2) Lewis Structures, and (3) Words the driving force (why the reaction occurs) for the reaction $K(s) + F(g) \longrightarrow KF(s)$.

(1) K: $1s^2, 2s^2, 2p6, 3s^2, 3p^6, 4s^1$ + F: $1s^2, 2s^2, 2p^5 \longrightarrow [K]^{+1} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$ and $[F]^{-1}]$ $1s^2, 2s^2, 2p^6$

(2) Too lazy to draw pictures(3) K donates 1 electron to F to complete all elements octets decreasing the overall energy of each ion. An ionic bond forms between the ions dues to Coulombs Law (opposites attract) which also lowers the overall energy.

[6 pt] 16. Explain using (1) Electron Configurations, (2) Lewis Structures, and (3) Words the driving force (why the reaction occurs) for the reaction $Ca(s) + 2F(g) \longrightarrow CaF_2(s)$.

(1) Ca: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$ + 2 F: $1s^2, 2s^2, 2p^5 \longrightarrow [Ca]^{+2} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$ and $[F]^{-1}]$ $1s^2, 2s^2, 2p^6$

(2) Too lazy to draw pictures
(3) Ca donates 2 electrons 1 each to F to complete all elements octets decreasing the overall energy of each ion. An ionic bond forms between the ions dues to Coulombs Law (opposites attract) which also lowers the overall energy.

[5 pt] 17. For each of the following periodic trends does it (D)ecrease/(I)ncrease/(S)tay the Same?

(a) Atomic radius down a column? 17(a) **I**

(b) Atomic radius across a row? 17(b) **D**

(c) Size of cation formed from a neutral atom? 17(c) **D**

(d) Ionization energy down a column? 17(d) **D**

(e) Ionization energy across a row? 17(e) **I**

[5 pt] 18. Complete each of the the following questions about Periodic Trends using Bigger, Smaller or Same.

(a) A neutral atom is Smaller than a cation.

(b) The size of an atom gets Bigger down a column.

(c) Ionization energy gets Bigger across a row.

(d) An anion is Bigger than a neutral atom.

(e) Ionization energy gets Bigger as you remove more and more electrons.

[6 pt] 19. Answer the following questions about Periodic Trends:

(a) Which is bigger a F atom or Cl atom. Explain. 19(a) **Cl**

Atoms get bigger down a column because each row is a higher principle quantum number and a larger orbital

(b) Which atom has the larger ionization energy Na or Cl? Explain. 19(b) **Cl**

Size decreases across a row therefore ionization energy increases as the electron is closer to the nucleus thus harder to remove.

(c) Which has a larger ionization energy $Mg^{+1}$ or $Mg^{+2}$. Explain. 19(c) $\mathbf{Mg^{+2}}$

It is harder to remove the second electron than the first because it is closer to the nucleus and there are also now more protons than electrons so each electron feels a greater attractive force.

[6 pt] 20. Answer the following questions about Ionization Energy (IE):

(a) Define Ionization Energy

Ionization Energy is the energy required to remove an electron from an atom in the gas state.

(b) Write an equation showing the ionization of a Na atom. Be sure to include energy in the equation.

$Na(s) + Energy \longrightarrow Na^{+1} + 1e^{-}$

(c) Is the reaction Endothermic or Exothermic? Explain why.

Endothermic because it takes energy to separate $+/-$ charges since opposites attract.

21. Explain why the atomic radius of an atom increases as you go down a column. (For example Cs is larger than Li)

22. Explain why the atomic radius of an atom decreases as you go across a row. (For example Li is larger than F)

23. Answer the following questions about Ionization Energy (IE):

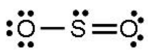
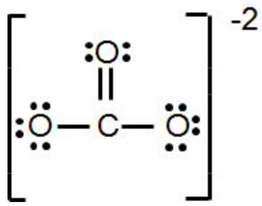
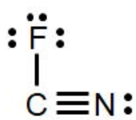
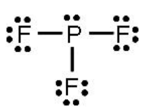
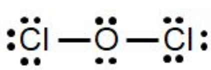
(a) Define Ionization Energy

(b) Write an equation showing what is meant by IE. Be sure to include energy in the equation.

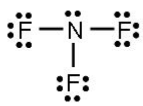
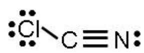
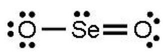
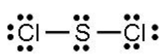
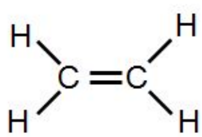
[6 pt] 24. Complete the following table:

| # atoms bonded | # lone pairs | Molecular Shape | Bond Angle |
|---|---|---|---|
| 4 | 0 | Tetrahedral | 109.5 |
| 3 | 1 | Trigonal Pyramidal | 109.5 |
| 2 | 2 | Bent 109.5 | 109.5 |
| 3 | 0 | Trigonal Planar | 120 |
| 2 | 1 | Bent 120 | 120 |
| 2 | 0 | Linear | 180 |

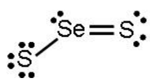
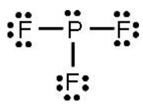
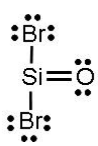
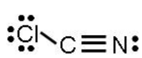
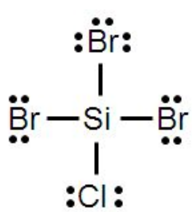
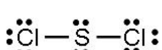
[10 pt] 25. For each of the following molecules indicate the shape (bent, linear, tetrahedral, trigonal planar, trigonal pyramidal) and bond angle (109.5, 120, 180) around the central atom(s). Also indicate whether the molecule is nonpolar (NP) or dipolar (DP).

| **Molecule** | **Shape** | **Angle** | **NP or DP** |
|---|---|---|---|
|  | bent 120 | 120 | DP |
|  | Trigonal Planar | 120 | NP |
|  | Linear | 180 | DP |
|  | Trigonal Pyramidal | 109.5 | DP |
|  | Bent 109.5 | 109. | DP |

[10 pt] 26. For each of the following molecules indicate the shape (bent, linear, tetrahedral, trigonal planar, trigonal pyramidal) and bond angle (109.5, 120, 180) around the central atom(s). Also indicate whether the molecule is nonpolar (NP) or dipolar (DP).

| **Molecule** | **Shape** | **Angle** | **NP or DP** |
|---|---|---|---|
|  | Trig. Pyr | 109.5 | DP |
|  | Linear | 180 | DP |
|  | Bent | 120 | DP |
|  | Bent | 109.5 | DP |
|  | Trig. Planar | 120 | NP |

27. Complete the following table:

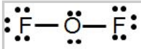
| Molecule | Molecular Shape | Bond Angle | Dipolar or Nonpolar |
|---|---|---|---|
|  | | | |
|  | | | |
|  | | | |
|  | | | |
|  | | | |
|  | | | |

[10 pt] 28. Draw the lewis structure for the following molecules (all of which obey the octet rule).

| | |
|---|---|
| (a) $C_2H_2$ | (b) $CH_3COOH$ |
| (c) $CH_2Cl_2$ | (d) $SF_2$ |
| (e) $NaNO_3$ | |

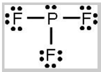
[10 pt] 29. Draw the lewis structure for the following molecules (all of which obey the octet rule).

29(a) $SF_2$



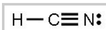
Bent 109.5 Dipolar

29(b) $PF_3$



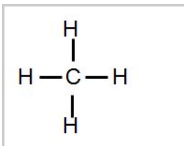
Trigonal Pyramidal 109.5 Dipolar

29(c) HCN



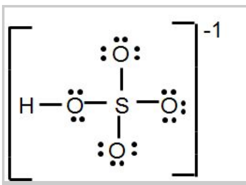
Linear - 180 Dipolar

29(d) $SiH_4$



Tetrahedral - 109.5 Nonpolar

29(e) $HSO_4^-$

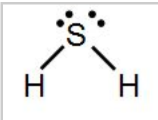


Tetrahedral 109.5 and Bent 109.5 Dipolar

LS - 2 points
shape/angle - 1 point
polarity - 1 point

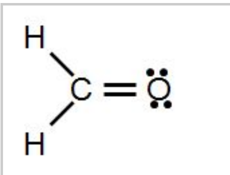
[20 pt] 30. Draw the Lewis Structure for the following molecules (all of which obey the octet rule). Next to each picture predict the molecular shape, bond angle, for all atoms with shapes and determine the molecular polarity (Dipolar or Nonpolar).

30(a) $H_2S$



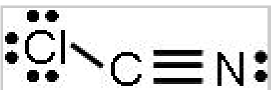
Bent 109.5 Dipolar

30(b) $CH_2S$



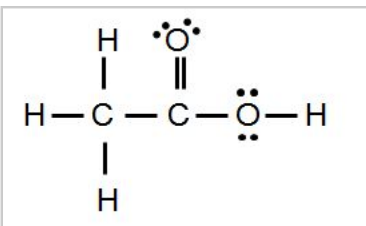
Trigonal Planar 120 Dipolar

30(c) FCP



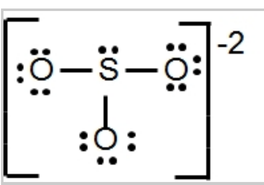
Linear - 180 Dipolar

30(d) $C_2H_4O_2$



Tetrahedral - 109.5 AND Trigonal Planar 120 AND Bent 109.5 Dipolar

30(e) $SeO_3^{-2}$

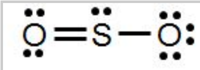


Trigonal Pyramidal 109.5 Dipolar

LS - 2 points
shape/angle - 1 point
polarity - 1 point

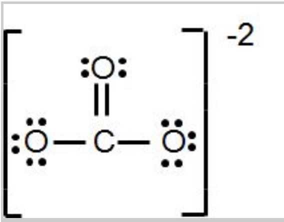
[20 pt] 31. Draw the Lewis Structure for the following molecules (all of which obey the octet rule). Next to each picture predict the molecular shape, bond angle, and polarity (Dipolar or Nonpolar).

31(a) $SO_2$



Bent 120 Dipolar

31(b) $CO_3{}^{-2}$

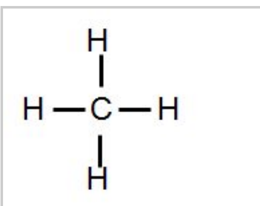


Trigonal Planar 120 Nonpolar

31(c) CNCl

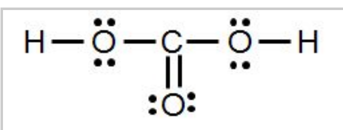
Linear - 180 Nonpolar (tough, but both ends have same EN)

31(d) $CH_2Cl_2$



Tetrahedral - 109.5 Dipolar

31(e) $F_2CS_3$

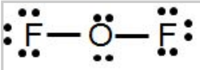


Trigonal Planar 120 and Bent 109.5 Dipolar

LS - 2 points
shape/angle - 1 point
polarity - 1 point

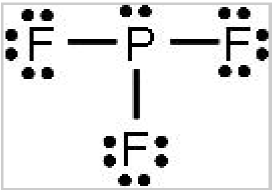
[20 pt] 32. Draw the lewis structure for the following molecules (all of which obey the octet rule). Next to each picture predict the molecular shape, bond angle, and polarity (Dipolar or Nonpolar).

32(a) $SF_2$



Bent 109.5 Dipolar

32(b) $PF_3$

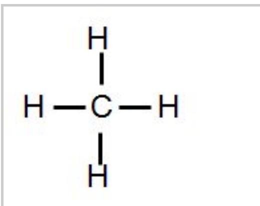


Trigonal Pyramidal 109.5 Dipolar

32(c) HCN

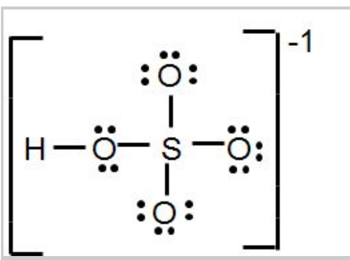
Linear - 180 Dipolar

32(d) $SiH_4$



Tetrahedral - 109.5 Nonpolar

32(e) $HSO_4^-$



Tetrahedral 109.5 and Bent 109.5 Dipolar

LS - 2 points
shape/angle - 1 point
polarity - 1 point

33. Draw the lewis structure for the following molecules (all of which obey the octet rule). Next to each picture predict the molecular shape, bond angle, and polarity (Dipolar or Nonpolar).

33(a) $OBr_2$

33(b) $NF_3$

33(c) HCN

33(d) $SiH_4$

33(e) $CO_3{}^{-2}$

[6 pt] 34. How does Quantum Mechanics lead to the shape of the periodic table?

(a) What is different about the 4 major regions of the periodic table (ie why are they 2, 6, 10 and 14 elements wide)?

Each region is associated with a different shape of orbital (and each shape holds a different number of electrons depending on how many orientations there are.)
s = 2, p = 6, d = 10 and f = 14 electrons.
Additionally the missing portions of the periodic table are because no 1p orbital exists (therefore only H and He in first row). There is also no 2d orbitals and the d-orbitals lag so there is no transition metal columns in the first 3 rows of the periodic table. This also extends to the placement of the lanthanides and actanides (f-orbitals).

(b) What is the same about each row?

Each row has the same principle quantum number thus the size of the shell/atoms are similar.

(c) What is the same about each column?

Each column has the same valence shell electron configuration ($s^x p^y$) resulting in all elements in a column having similar physical and chemical properties.

[4 pt] 35. What are the major differences (give at least 2) between classical mechanics and quantum mechanics. Use complete sentences.

1. Waves or Particle vs Waves and Particles
2. Macroscopic vs Nanoscopic
3. Continuous vs Quantized