

with d^2sp^3 hybridization, QF_5 exhibits octahedral geometry. Of the various shapes based on octahedral geometry, only the square pyramidal

1. A compound has a formula of QF_5 where Q is an unknown element. The compound has an even number of valence electrons and the central Q atom is d^2sp^3 hybridized. Which of the following elements could be Q ?

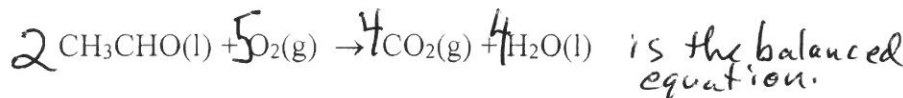
Structure has five bonded atoms. This structure requires

- a) Si b) As c) U d) Br e) Xe

42 valence electrons. So for QF_5 , let $x = \#$ valence e^- of Q :

$$42 = x + 5(7), \quad x = 7; \text{ X is a halogen. Can't be F since we have 12 valence electrons around the central atom. But any other halogen is fine.}$$

2. The products of combustion of acetaldehyde with oxygen are shown in the following equation:



When properly balanced with smallest whole number coefficients, the sum of the coefficients is:

$$2 + 5 + 4 + 4 = 15$$

- a) 12 b) 15 c) 8 d) 18 e) 6

3. Consider two hydrogen atoms. In one atom the electron is in the ground state. In the other atom, the electron is in the $n = 2$ energy state. How do their ionization energies for the two H atoms compare? Ionization energy calculations for H refer to taking the electron to the $n = \infty$ state.

- a) The ionization energy for the ground state electron is 4 times greater than the ionization energy for the electron in the $n = 2$ energy state.
 b) The ionization energy for the ground state electron is 2 times greater than the ionization energy for the electron in the $n = 2$ energy state.
 c) The ionization energy for the $n = 2$ energy state electron is 4 times greater than the ionization energy for the electron in the ground state.
 d) The ionization energy for the $n = 2$ energy state electron is 2 times greater than the ionization energy for the electron in the ground state.
 e) The ionization energies are equal.

IE from ground state ($n=1$):

$$n_1 = 1 \rightarrow n_2 = \infty$$

$$IE = \Delta E = -2.178 \times 10^{-18} \left(\frac{1}{\infty^2} - \frac{1}{1^2} \right) = 2.178 \times 10^{-18} \text{ J}$$

IE from $n=2$ level:

$$n_1 = 2 \rightarrow n_2 = \infty$$

$$IE = \Delta E = -2.178 \times 10^{-18} \left(\frac{1}{\infty^2} - \frac{1}{2^2} \right) = \frac{2.178 \times 10^{-18} \text{ J}}{4}$$

The ionization energy from the ground state is 4 times larger than the IE from $n=2$.

In ionic compounds, P forms 3-
charged ions. From X_3P_2 formula,
X has a 2+ charge.

4. An element's most stable ion forms an ionic compound with phosphorus having the formula X_3P_2 . If the ion of element X has a mass number of 230 and has 86 electrons, how many neutrons does this isotope of X have?

X^{2+} has 86 electrons, so X^{2+} has 88 protons ($X = \text{Pu}$).

- a) 143 neutrons b) 146 neutrons c) 141 neutrons
neutrons = $230 - 88 = 142$ neutrons
d) 144 neutrons e) 142 neutrons

$$\Delta E = -R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = -2.178 \times 10^{-18} \text{ J} \left(\frac{1}{6^2} - \frac{1}{1^2} \right) = 2.1175 \times 10^{-18} \text{ J}$$

5. Does a photon of visible light ($\lambda = 400$ to 700 nm) have enough energy to excite a hydrogen electron from the $n = 1$ energy state to the $n = 6$ energy state?

$$E_{\text{photon}} = \frac{hc}{\lambda}, \lambda = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s} (2.998 \times 10^8 \text{ m/s})}{2.1175 \times 10^{-18} \text{ J}}$$

- a) No, this requires higher energy electromagnetic radiation than the energy of visible light.

b) Yes, if $\lambda = 486$ nm.

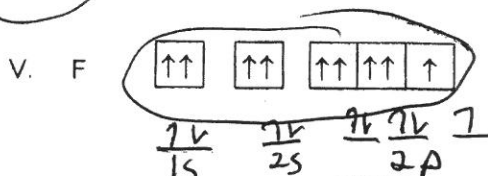
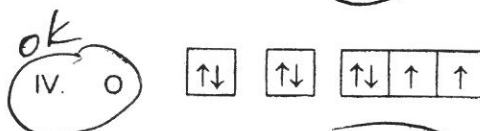
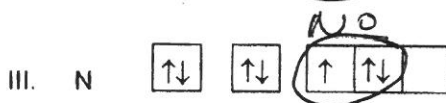
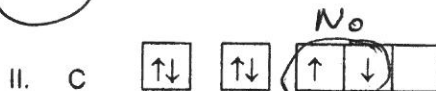
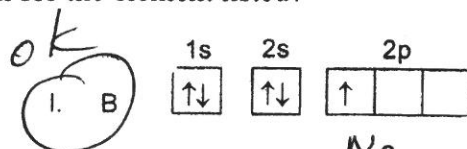
c) Yes, if $\lambda = 656$ nm.

d) Yes, if $\lambda = 526$ nm.

e) No, this requires lower energy electromagnetic radiation than the energy of visible light.

Wavelength required = $9.38 \times 10^{-8} \text{ m} = 93.8 \text{ nm}$
This is not visible light wavelength. Since energy and wavelength are inversely related. We need a shorter wavelength light than visible, which corresponds to higher energy electromagnetic radiation than visible.

6. How many of the following five box diagrams correctly represent the ground state electron configuration for the element listed?



Spin parallel
 $\uparrow\uparrow$ — or $\downarrow\downarrow$ —

$\uparrow\uparrow\uparrow$ or $\downarrow\downarrow\downarrow$
Spin parallel, then pair up

Spin opposite when paired.
or $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$
2p

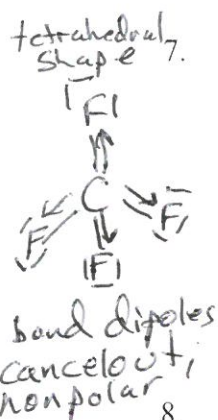
a) 0 (None are correct.)

b) 1

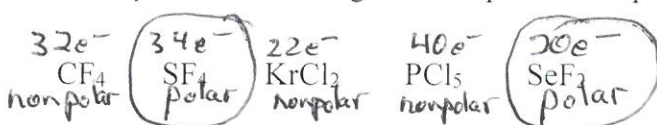
c) 2

d) 4

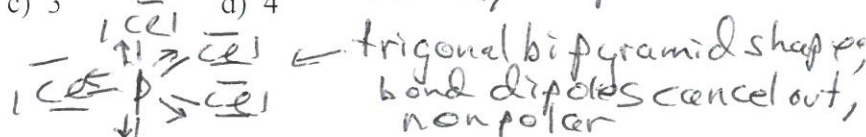
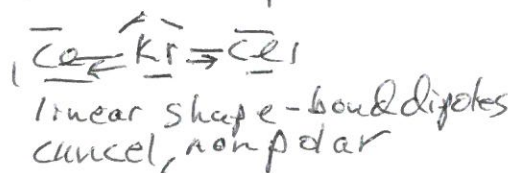
e) 5 (All are correct.)



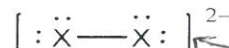
How many of the following five compounds are polar?



- a) 1
b) 2
c) 3
d) 4
e) 5 (All are polar.)



Which of the following ions has this Lewis structure:



There are 14 valence electrons in this Lewis structure.

- a) B₂²⁻ 8e⁻
b) C₂²⁻ 10e⁻
c) N₂²⁻ 12e⁻
d) O₂²⁻ 14e⁻
e) F₂²⁻ 16e⁻

Only O₂²⁻ has 14 valence e⁻.

9. How many of the following four name/formula combinations (I-IV) is/are correct?

NO I. ammonium chromate, NH₄(Cr₂O₇)₂

NOI. hydrochloric acid, HClO₄

NOIII. phosphorus sulfite, P₂S₅
diphosphorus pentasulfide

NOIV. iron(II) nitrate, FeNO₃

a) 0 (none)

b) 1

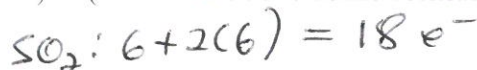
c) 2

d) 3

All combos have something wrong with them.

e) 4 (All of the above name/formula combinations are correct.)

This is iron(II) nitrate.



10. Consider the following bond lengths: S-O 150 pm; S=O 130 pm; S≡O 110 pm.

Which of the following statements is true concerning the bonding in SO₂? Assume all atoms in SO₂ obey the octet rule.

a) The two sulfur-oxygen bonds in SO₂ should have a bond length equal to 150 pm.

b) The two sulfur-oxygen bonds in SO₂ should have a bond length somewhere between 130 pm and 150 pm.

c) The two sulfur-oxygen bonds in SO₂ should have a bond length equal to 130 pm.

d) The two sulfur-oxygen bonds in SO₂ should have a bond length somewhere between 110 pm and 130 pm.

e) The two sulfur-oxygen bonds in SO₂ should have a bond length equal to 110 pm.



Average S-O bond = 1.5

When resonance structures can be drawn, the actual bond lengths in SO₂ are an average of the resonance structures. We would expect the bond to be between a single (150 pm) and a double (130 pm) in length. We say the π electrons are delocalized over the entire surface of SO₂. Hence the S-O bonds are all equal.

11. Which of the following statements is false?

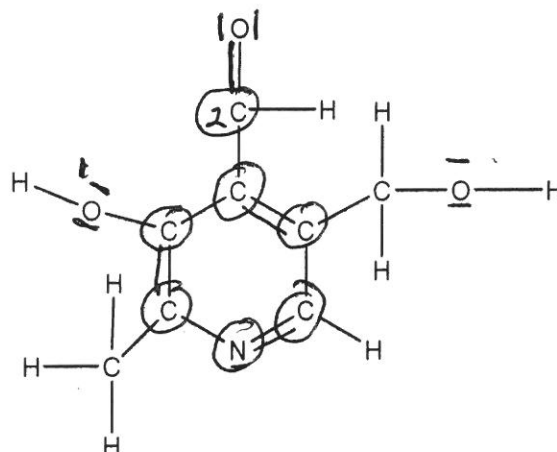
- See SO₂ molecule in previous problem*
- T a) In general, molecules that exhibit resonance also exhibit delocalized pi (π) bonding.
- T b) *This is VSEPR model decree.* The central atom in a covalent molecule has the bonded atoms and lone pairs arranged around itself so to minimize electron-electron repulsions.
- T c) *Molecule below has 2 sp³-sp² sigma bonds. Hybrids always go to form sigma bonds.* When an sp³ hybrid orbital overlaps with an sp² hybrid orbital on another atom, a sigma (σ) bond results.

T d) When the difference in electronegativity between two atoms is large, the bond most likely to form between the two atoms is an ionic bond.

H has electronegativity identical to P. So H-Cl is a polar covalent bond, but partial negative end is around the more electronegative Cl.

(F) e) The H-Cl bond is an example of a polar covalent bond where the valence electrons in the polar bond are found nearer (on the average) to the hydrogen atom.

Vitamin B₆ is an organic compound whose deficiency in the human body can cause apathy, irritability, and an increase susceptibility to infections. Below is an incomplete Lewis structure for vitamin B₆. Using the guidelines covered in class regarding Lewis structures for organic compounds, complete the Lewis structure and answer the next two questions. Ignore any possible resonance structures.



Sp² hybrids have 120° bond angles (trigonal planar geometry).

Organic Rules!
C: 4 bonds + 0 lone pairs
N: 3 " + 1 " "
O: 2 " + 2 " "

The circle atoms have trigonal planar geometry, so they

12. How many of the C and N atoms are sp² hybridized? *are sp² hybridized. There are 7 total. The other two*

- a) 1 b) 3 c) 4 d) 6 (e) 7

Carbons have 109° bond angles (tetrahedral geometry), so they are both sp³ hybridized

13. What are the approximate bond angles about the oxygen atom labeled 1 and the carbon atom labeled 2, respectively?

O₁ has tetrahedral geometry so ~109° bond angle.

- a) 120°; 90° b) 109°; 120° c) 180°; 120° d) 180°; 180° e) 109°; 90°

C₂ has trigonal planar geometry, so 120° bond angles.

Ionization energy generally increases left to right across the periodic table. But notice a decrease in IE between X and Y.

14. The properties of 4 consecutive elements in the periodic table (abbreviated Q, X, Y and Z) are listed below where IE = ionization energy and EN = electronegativity.

The exceptions to the general IE trend are

	Q	X	Y	Z
IE (kJ/mol)	786	1012	999	1256
Radius (pm)	118	110	103	100
EN	1.8	2.1	2.5	3.0

between Groups 2A and 3A and between Groups 5A and 6A.

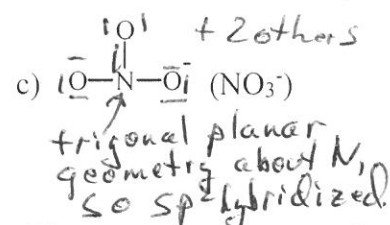
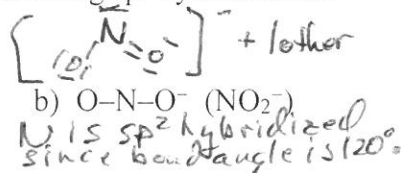
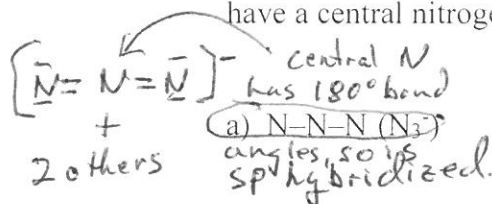
Which of the following sets of elements best fits the properties of Q, X, Y, and Z (in this order) if the elements are from row three of the periodic table?

So X = Mg and Y = Al or X = P and Y = S. Only

- a) Mg, Al, Si, P b) Al, Si, P, S c) Si, P, S, Cl d) P, S, Cl, Ar

X = P and Y = S is listed as an answer. The four consecutive elements are Si = Q, P = X, S = Y, and Cl = Z.

15. Nitrogen is/are the central atom(s) in each of the following compounds or ions (the correct skeletal structures are given below). The central nitrogen atoms in the compounds are all sp^2 hybridized with one exception. Which compound or ion does not have a central nitrogen atom exhibiting sp^2 hybridization?



16. Which of the following statements is false?

T a) An atom is mostly empty space.

T b) Glucose, $C_6H_{12}O_6$, is an example of a covalent compound. - contains only nonmetals

T c) Metals generally form stable cations in ionic compounds. metals lose electrons when forming ionic compds.

T d) When a metal forms a compound with a nonmetal, an ionic compound generally results.

F e) CaF_2 contains an alkali metal and a halogen.
Ca is an alkaline earth metal.

17. A 50.00 g sample of a solid is placed into a graduated cylinder and then the cylinder is filled to the 100.00 mL mark with Code Red Mountain Dew (density = 1.040 g/mL). The mass of Code Red and solid together is 146.40 g. Assuming the solid is insoluble in the Code Red, calculate the density of the solid.

mass of code red = $146.40g - 50.00g = 96.40g$
volume of code red = $96.40g \left(\frac{1mL}{1.040g} \right) = 92.69mL$

volume of solid = $100.00mL - 92.69mL = 7.31mL$

density of solid = $\frac{50.00g}{7.31mL} = 6.84g/mL$

18. Into a flask, a student adds 2.2 g of table salt (pure NaCl) to 152.0 g of pure water, forming a salt water solution. All of the NaCl dissolves. She then heats the solution to boiling and boils off all the water, leaving only pure NaCl in the flask. Which of the following statements (a-d) is true concerning this experiment?

- (T) a) The boiling process is an example of a physical change.
 F b) The salt water solution is an example of a ~~heterogeneous~~ ^{homogeneous} mixture.
 F c) NaCl and water are each examples of ~~elements~~ ^{compounds}.
 F d) NaCl and water are each examples of ionic compounds.
 H₂O is a covalent compound.

19. How many sulfur atoms are present in a 38 g-sample of aluminum sulfide? ^{Al³⁺ and S²⁻ are the ions.}

- a) 3.0×10^{21} S atoms b) 1.5×10^{23} S atoms c) 3.0×10^{23} S atoms

(d) 4.6×10^{23} S atoms e) 6.0×10^{23} S atoms

$$38 \text{ g Al}_2\text{S}_3 \left(\frac{1 \text{ mol Al}_2\text{S}_3}{150.17 \text{ g}} \right) \left(\frac{2 \text{ mol Al}}{1 \text{ mol Al}_2\text{S}_3} \right) \left(\frac{6.022 \times 10^{23} \text{ S atoms}}{\text{mol Al}} \right) = 4.6 \times 10^{23} \text{ S atoms}$$

20. How many significant figures should the answer to the following problem have?

Math tells us to
 Apply subtraction
 rule first, then
 apply mult/division
 rule.

$$\frac{(0.002 + 101.23)(3.24 + 2.221)}{6.24 - 5.841} = \frac{101.232 (5.461)}{0.399} \Rightarrow \text{answer will have 2 sig figs since denominator answer only known to 2 sig figs.}$$

- a) one b) two c) three d) four e) five
- For subtraction rule, fewest decimal places determines sig figs. $6.24 - 5.841 = 0.399$ ← only known to 2nd decimal place (2 sf).

21. Sarin is a nerve agent whose chemical formula has two oxygen atoms per molecule. If 50.0 g of sarin contains 11.4 g of oxygen, what is the molar mass of sarin?

$$\text{moles Sarin} = 11.4 \text{ g O} \left(\frac{1 \text{ mol O}}{16.00 \text{ g}} \right) \left(\frac{1 \text{ mol Sarin}}{2 \text{ mol O}} \right) = 0.35625 \text{ mol Sarin}$$

- a) 281 g/mol b) 561 g/mol c) 1120 g/mol

d) 70.2 g/mol (e) 140. g/mol

$$\text{molar mass Sarin} = \frac{50.0 \text{ g Sarin}}{0.35625 \text{ mol Sarin}} = 140.4 = 140. \text{ g/mol}$$

22. Place the following ions in order of increasing size (smallest to largest)

Sr²⁺, Rb⁺, I⁻, Br⁻

- a) Br⁻ < I⁻ < Sr²⁺ < Rb⁺
 (b) Sr²⁺ < Rb⁺ < Br⁻ < I⁻
 c) Br⁻ < I⁻ < Rb⁺ < Sr²⁺
 d) Sr²⁺ < Rb⁺ < I⁻ < Br⁻
 e) Rb⁺ < Sr²⁺ < I⁻ < Br⁻

Sr²⁺, Rb⁺, Br⁻ are all iso electronic (36e⁻).
 Sr²⁺ has the most protons in the nucleus, so it is smallest. Br⁻ has fewest protons in nucleus, so it is largest of the three iso electronic species.
 Since I⁻ is larger than Br⁻ (by size trend), then I⁻ will be larger than Br⁻.

Putting all this together gives the ordering:
 Sr²⁺ < Rb⁺ < Br⁻ < I⁻
 smallest largest

$$\lambda = \frac{c}{\nu} = \frac{2.998 \times 10^8 \text{ m/s}}{580 \times 10^3 \text{ s}^{-1}} = 516.9 \text{ m}$$

23. To be effective, a radio antenna must have a height of at least one-half the wavelength of the radio frequency being transmitted. Considering this, what is the minimum height you would expect for a WILL antenna if the station broadcasts at a frequency of 580. kHz?

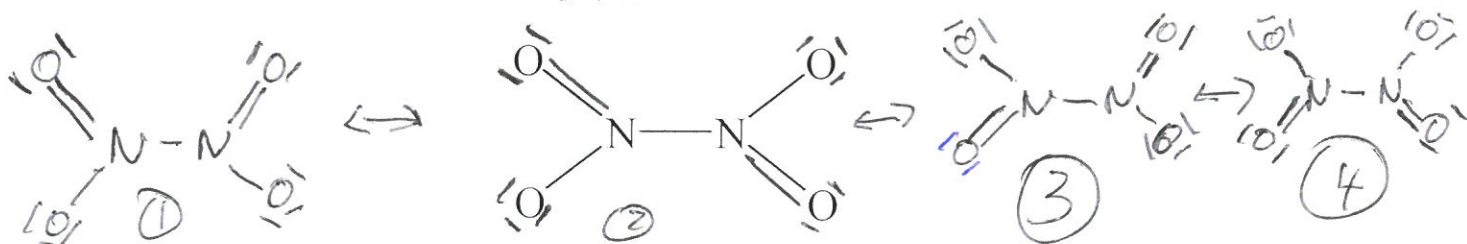
(1000 Hz = 1 kHz)

Antenna height = $\frac{1}{2}(\lambda) = \frac{1}{2}(516.9) = 258 \text{ m}$

a) 258 meters b) 0.258 meters c) 103 meters
d) 0.103 meters e) 5.17×10^8 meters

$$2(5) + 4(6) = 34 \text{ valence electrons}$$

24. The skeletal structure of N_2O_4 is:



How many different resonance structures that obey the octet rule can be drawn for N_2O_4 ?
There are 4 total resonance structures for N_2O_4 .

- a) 2 b) 4 c) 5 d) 6 e) 8

25. The periodic table can be used to predict properties of elements. Which of the following statements is **false** concerning the elements 116-120?

T a) Element 116 is expected to have two unpaired electrons in the ground state.

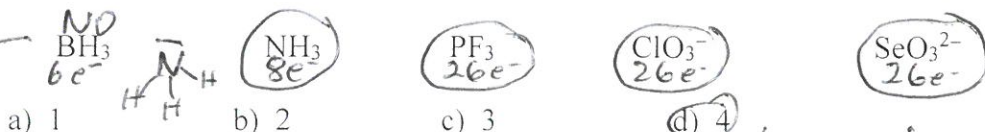
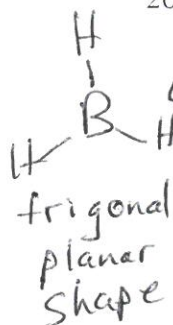
T b) Element 117 is expected to have seven valence electrons.

F c) The ground state electron configuration for element 118 is expected to be $[\text{Rn}]8s^2 6f^{14} 7d^{10} 8p^6$. 118: $[\text{Rn}]7s^2 5f^{14} 6d^{10} 7p^6$ is correct.

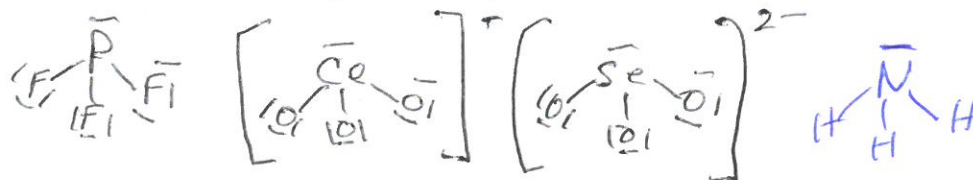
T d) Element 119 (abbreviated with X) is expected to react with sulfur to form an ionic compound having the formula X_2S . 119 is next alkali metal to be discovered. Alkali metals form +1 charged ion. Since S forms 2- ions, X_2S is correct.

e) Element 120 is expected to form stable +2 charged cations when it forms ionic compounds. 120 will be the next alkaline earth metal to be discovered. These form +2 charged ions in ionic compounds.

26. How many of the following five compounds have a trigonal pyramid shape?



- a) 1 b) 2 c) 3 d) 4 e) 5 (All have a trigonal pyramid shape.)
- $\text{NH}_3, \text{PF}_3, \text{ClO}_3^-, \text{and } \text{SeO}_3^{2-}$ all have a trigonal pyramid shape.



27. Which of the following (a-d) is/are the **correct** ground state electron configuration(s) for the elements/ions listed? Cd is element #48 and Te is element #52.

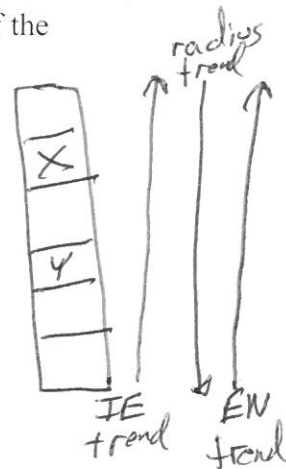
- a) Cr: $[Ar]4s^2 3d^4$
b) Cu: $[Ar]4s^2 3d^9$
c) Cd^{2+} : $[Kr]5s^2 4d^8$
d) Te^{2-} : $[Kr]5s^2 4d^{10} 5p^6$ **correct**
e) All of the above (a-d) are correct ground state electron configurations.

28. Two different compounds have the formula SF_4Cl_2 (where S is the central atom). Which of the following statements concerning the two SF_4Cl_2 compounds is **false**?

- a) Both compounds of SF_4Cl_2 are polar. **False**
b) The central atom in both compounds of SF_4Cl_2 exhibit d^2sp^3 hybridization.
c) Both compounds of SF_4Cl_2 exhibit some 90° bond angles.
d) Both compounds of SF_4Cl_2 have an octahedral shape.
e) Both compounds of SF_4Cl_2 are exceptions to the octet rule for at least one of the atoms in the formula.

29. Unknown elements X and Y are in the same family (group) in the periodic table. Element Y has more protons in the nucleus as compared to element X. Which of the following statements concerning elements X and Y is most likely **false**?

- a) Elements X and Y should have the same number of valence electrons. **True**
b) Element Y should have a larger atomic number than element X. **True**
c) Element X should have a larger electronegativity value than element Y. **True**
d) Element X should have a smaller radius than element Y. **True**
e) Element Y should have a larger ionization energy than element X. **False**



30. Which of the following statements about Dalton's Atomic Theory is **false**?

- a) It defined atoms and compounds. **True**
b) It proposed that a specific compound has the same type of atoms but may have different relative numbers of atoms. **False**
c) It proposed that the smallest indivisible particle of an element is an atom. **True**
d) It provided the rationale for balancing chemical equations. **True**
e) It needed to be modified when the existence of isotopes was discovered. **True**