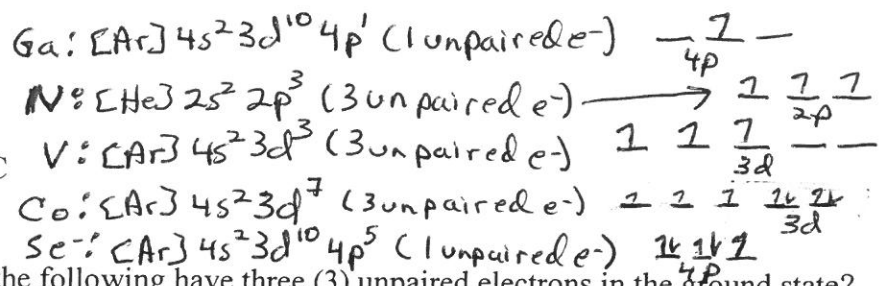


Form
A/B
C/D

CHEMISTRY 102B/C
Hour Exam I



Detailed
HE I
Solutions
Fall 2016

1/19
12/25

1. How many of the following have three (3) unpaired electrons in the ground state?



- a. 1 b. 2 c. 3 d. 4 e. 5 (all)

2/20
13/26

2. How many of the following five statements (I-V) about hydrogen is/are true?

- (T) I \rightarrow follows trend $\xrightarrow{IE \uparrow}$ trend! H has a smaller ionization energy than He.
 F II. H⁻ has a smaller size than H. H⁻, with more electrons, will be bigger.
 F III. H bonds with phosphorus to form a polar covalent bond. P-H bond is nonpolar since P and H have equal electronegativity.
 F IV. H is considered to be a metal. H reacts with nonmetals to form covalent bonds, so H is a nonmetal.
(T) V H does not have a second ionization energy. H only has 1 electron, so can't have an IE₂.

- a. 1 b. 2 c. 3 d. 4

e. 5 [All of these statements (I-V) are true.]

3/21
14/27

3. The isotope of an unknown element, X, has a mass number of 79. The most stable ion of the isotope has 36 electrons which forms a binary compound with sodium having a formula of Na₂X. Which of the following statements (a-d) is/are true?

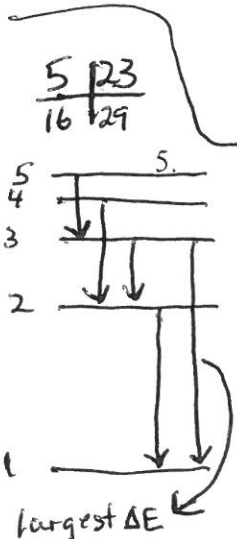
- Na_2X is formed from Na^+ and X^{2-} ions.
 X^{2-} has 36 e⁻, so X has 34 protons and $X = Se$.
(T) a The binary compound formed between X and fluorine will be a covalent compound. Se-F compound covalent since 2 nonmetals.
 F b. The isotope of X contains 38 protons.
 F c. The isotope of X contains 41 neutrons. $45 \quad 79 - 34 = 45$ neutrons
 F d. The identity of X is strontium, Sr. Se
 e. All of the above statements (a-d) are true.

When two non metals form bond, bonding is covalent and compound will be covalent.

4/22
15/28

4. A certain transition metal ion (Mⁿ⁺) forms a compound with sulfur (M_xS_y). The molar mass of the compound is 298.4 g/mol. If the charge on the transition metal ion is +3, what is the identity of the transition metal, M? Formula: $M^{3+} + S^{2-} \Rightarrow M_2S_3$

- a. Ti b. Mo c. Ir d. Ru e. Cf
 $298.4 \text{ g/mol} = 2(\text{molar mass } M) + 3(32.07)$ molar atomic mass $M = 101.1 \text{ g/mol}$
 From periodic table, $M = Ru$



Which of the following electronic transitions for a one electron atom or ion corresponds to an emission of electromagnetic radiation having the shortest wavelength?
 For an emission, go from higher n value to lower n value.

- a. $n=5 \rightarrow n=3$ b. $n=4 \rightarrow n=2$ c. $n=3 \rightarrow n=2$
 As diagram to left illustrates, as n increases, the energy levels get closer together ($E_n = -R_H/n^2$). The shortest λ emission has the largest Energy ($E = hc/\lambda$). The $n=3 \rightarrow n=1$ is largest energy transition, which will release the shortest wavelength EMR.
(e) $n=3 \rightarrow n=1$

6/8
20/22

6. How many of the following are **correct** ground state electron configurations for the elements listed?

Correct C: $[\text{He}]2s^22p^2$ Correct Cl: $[\text{Ne}]3s^23p^5$ NO Sc: $[\text{Ar}]4s^03d^3$ Correct Cu: $[\text{Ar}]4s^13d^{10}$ Correct Element #115: $[\text{Rn}]7s^25f^{14}6d^{10}7p^3$

Element 115 is in group 5A (under Bi).

a. 1

b. 2

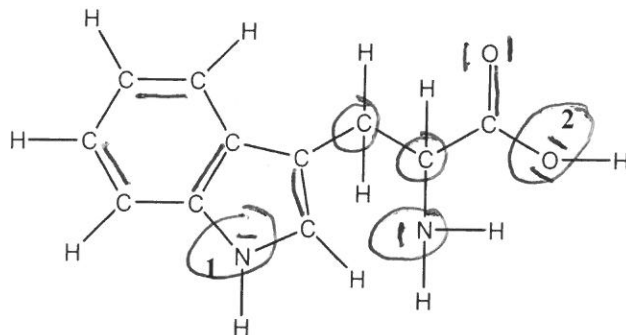
c. 3

d. 4

e. 5 (All are correct ground state electron configurations.)

Tryptophan is the organic molecule largely responsible for the sleepy feeling you get after eating turkey. The skeletal structure of tryptophan is shown below. Complete a Lewis structure and answer the next two questions.

Follow "Organic Rules" to complete Lewis structure.



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

7/9
21/23

7. How many atoms in tryptophan are sp^3 hybridized?

a. 2

b. 3

c. 4

d. 5

e. 6

The circled atoms have tetrahedral geometry (109° bond angles), so they are all sp^3 hybridized.

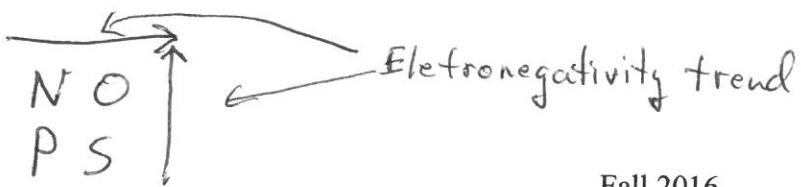
8/10
22/24

8. What are the approximate bond angles around the nitrogen atom labeled 1 and the oxygen atom labeled 2, respectively?

a. $109^\circ; 109^\circ$ b. $120^\circ; 109^\circ$ c. $120^\circ; 120^\circ$ d. $109^\circ; 180^\circ$ e. $90^\circ; 120^\circ$

N₁ has tetrahedral geometry (109° b.a.)
O₂ has tetrahedral geometry (109° b.a.)

Form
A/B
C/D



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9/24
6/16

9. Which of the following bonds is expected to be the most polar covalent bond?
The most polar bond has the largest difference in electronegativity.
a. O-N b. S-N c. P-N **d. P-O**
This will be between P+O.

10/25
7/17

10. Each molecule of cortisone contains 21 atoms of carbon (plus other atoms). The mass percentage of carbon in cortisone is 69.98%. What is the molar mass of cortisone?
In 100.00g compd: 69.98g C $\left(\frac{1 \text{ mol C}}{12.01 \text{ g}}\right) \left(\frac{1 \text{ mol cortisone}}{21 \text{ mol C}}\right) = 0.2775 \text{ mol cortisone}$
a. 176.5 g/mol b. 252.2 g/mol c. 287.6 g/mol
d. 312.8 g/mol **e. 360.4 g/mol** molar mass = $\frac{100.00 \text{ g}}{0.2775 \text{ mol}} = 360.4 \text{ g/mol}$

11/26
8/18

11. Which of the following is named **incorrectly**?
- a. H₂SO₄ sulfuric acid ok
 - b. Ca₃P₂** tricalcium diphosphide NO; calcium phosphide correct for this ionic compound.
 - c. NH₄ClO₃ ammonium chlorate ok
 - d. Cu(C₂H₃O₂)₂ copper(II) acetate ok
 - e. P₄O₆ tetraphosphorus hexoxide ok

12/27
9/19

12. Which of the following molecules exhibits delocalized π bonding?
Only SeS₂ exhibits resonance, so only SeS₂ has delocalized π bonding.
- H — Be — H $\text{F} - \text{Kr} - \text{F}$
- a. BeH₂, 4e⁻ **b. SeS₂, 18e⁻** c. KrF₂, 22e⁻ d. SCl₂, 20e⁻ e. H₂O, 8e⁻

13/28
10/20

13. How many of the following five molecules have a linear shape?
Note: these are the same molecules used in the previous question.
See above for Lewis structures. BeH₂ has linear shape, as does KrF₂. SeS₂ has bent shape (120° bond angle), SCl₂ and H₂O also have bent shape, but 109° bond angle.
- a. 1** **b. 2** c. 3 d. 4 e. 5 (all)

14/29
11/21

14. Rank the following ions from smallest radius to largest radius?
Ca²⁺ and S²⁻ are isoelectronic (18e⁻). Ca²⁺, with more protons, will be smaller than S²⁻. As³⁻ is isoelectronic with Ca²⁺ and S²⁻. From radius trend, Se²⁻ is bigger than S²⁻. So As³⁻ is bigger than S²⁻. Order = Ca²⁺ < S²⁻ < As³⁻
- a. Ca²⁺ < S²⁻ < As³⁻** b. S²⁻ < As³⁻ < Ca²⁺ c. S²⁻ < Ca²⁺ < As³⁻
- d. Ca²⁺ < As³⁻ < S²⁻ e. As³⁻ < S²⁻ < Ca²⁺
- Smallest largest

15/4
23/12

15. How many of the following four calculations (I-IV) give an answer with 3 significant figures?

yes (I) $10.01 + 2.3 + 0.01 = 12.32 = 12.3$

yes (II) $27.0 \times 0.0300 = 0.810$ $3sf \times 3sf = 3sf$ sig fig answer
← difference known to tenths place

NO III. $16 \times (30 + 100 - 6) = 16 \times 124 = 1984$
← at most, 2 sig fig answer

IV. $\frac{49.1 - 40.0}{805} = \frac{9.1}{805}$ $\frac{2sf}{3sf} \Rightarrow$ gives 2 sig fig answer

- a. 0 (none) b. 1 c. 2 d. 3 e. 4 (all)



16/5
24/13

16. Consider the combustion of $C_{12}H_{22}O_{11}$, an organic compound. What is the sum of the coefficients of all the reactants and products in the best balanced equation?

O_2 is other reactant; CO_2 and H_2O are the products.
a. 22 b. 36 c. 42 d. 56 e. 70

$$1 + 12 + 12 + 11 = 36$$

17/6
25/14

17. Which of the following statements is false?

T a. The three $5p$ atomic orbitals all have the same energy but have different orientations about the x, y, and z axes. $5p_x, 5p_y, \text{ and } 5p_z$ orbitals have same energy, different orientations.

T b. $2d$ atomic orbitals do not exist in the quantum mechanical model of the atom.

F c. The lanthanide series elements have ground state electrons in the $5f$ atomic orbitals.

T d. For an atom, there is only one ground state electron configuration. ground state = lowest energy

T e. For neutral atoms, the $6p$ atomic orbitals should be higher in energy than the $4f$ atomic orbitals. From periodic table, this is true (4f orbitals fill before 6p).

→ The actinide series starts filling the $5f$ atomic orbitals.

18/7
26/15

18. How many of the following four statements (I-IV) is/are true?

T I. As successive electrons are removed from an atom, size decreases. As electrons removed, have fewer electrons held by the nucleus, nucleus will hold these fewer electrons more strongly resulting in size decrease.

T II. As successive electrons are removed from an atom, ionization energy increases.

T III. For an isoelectronic series, the species with the most negative charge has the smallest ionization energy. Most negative ion has fewest protons holding same

T IV. In general, the atomic radius of neutral atoms decreases when going left to right across a row in the periodic table. \leftarrow radius trend \downarrow number of electrons.

- a. 0 (None are true.) b. 1 c. 2 d. 3

(e) 4 [All four statements (I-IV) are true.]

metals lose electrons when forming ionic compounds.

19/11
1/7

19. Which of the following statements is **false**?

- F**a. In general, transition metals ^{lose} gain electrons to form stable ions when in ionic compounds.
- T**b. Noble gases are found on the right side of the periodic table.
- T**c. Alkaline earth metals form stable +2 ions in compounds.
- T**d. In general, the halogens are nonmetals.
- T**e. In general, when a metal reacts with a nonmetal, an ionic compound is produced.

20/12
2/8

20. The -3 charged ion of an element has an excited state electron configuration of $1s^2 2s^1 2p^3 3s^1 3p^2 4s^1 3d^1$. Which of the following is the identity of the ion?

- a. B^{3-} (8e) **b. O^{3-}** (11e) c. Na^{3-} (14e) d. Sc^{3-} (24e) e. Si^{3-} (14+3=17e)

Only O^{3-} has 11 electrons, so this is the only possible correct answer.

21/13
3/9

21. For a hydrogen atom, how many of the following five electronic transitions are **exothermic**? Exothermic \Rightarrow energy is a product (energy is released) and ΔE is negative.

- n=6 to n=1** (emission) n=2 to n=3 n=3 to n=5 **n=4 to n=2** (emission) **n=126 to n=61** (emission)

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

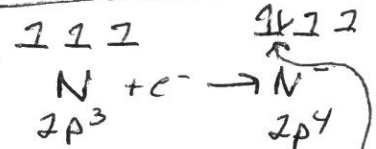
All emissions release energy (are exothermic). Emissions occur when go from higher Energy level to lower level.

22/14
4/10

22. Which of the answers best completes the following statement?

$N + e \rightarrow N^-$ $\Delta H =$ Electron Affinity

The electron affinity of nitrogen is positive (endothermic) because:



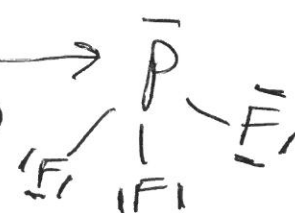
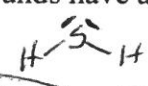
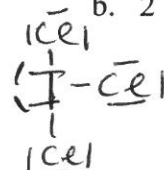
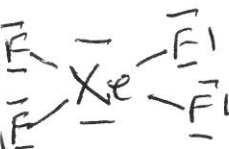
- F**a. electron affinities are always positive.
- F**b. an electron added to nitrogen will have to go into a p-orbital and adding an electron to a p-orbital is always unfavorable overall.
- F**c. only elements with more than 10 protons have negative electron affinities.
- F**d. the ionization energy of nitrogen is negative (exothermic).
- e.** an electron added to nitrogen must occupy a 2p orbital that already contains one electron; this gives rise to extra electron repulsions.

Added electron most pair in a p orbital which already has an electron. Gives rise to electron repulsions.

23/15
5/11

23. How many of the following five compounds have a Lewis structure where the central atom has two (2) lone pairs?

- a. 1 **b. 2** c. 3 **d. 4** e. 5 (all)

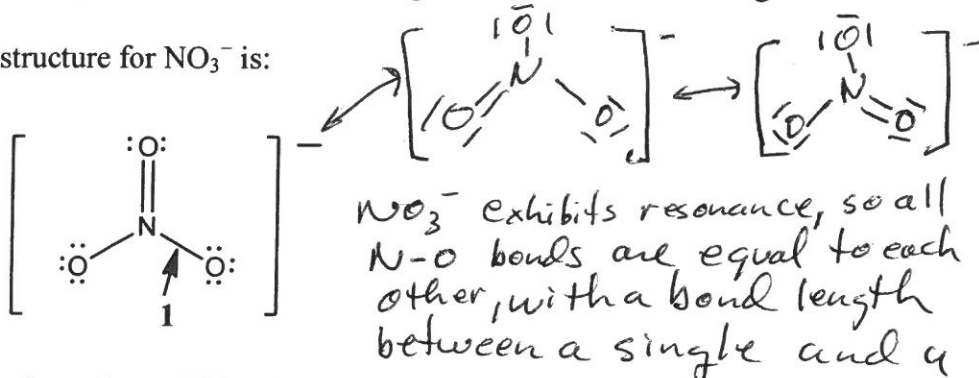


only PF_3 does not have 2 lone pairs on central atom.

- 24/1
27/4
24. Consider the following nitrogen-oxygen bond lengths which are all in some hypothetical unit.

N—O is 2.00 units long. N=O is 1.00 unit long. N≡O is 0.50 units long.

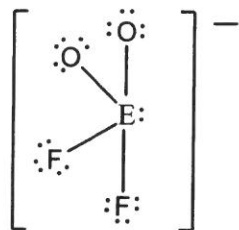
A possible Lewis structure for NO_3^- is:



- Which of the following values will be closest to the actual bond length for the bond labeled 1?
- a. 2.00 units **b. 1.67 units** c. 1.50 units d. 1.00 unit e. 0.75 units
- Handwritten note: NO3- exhibits resonance, so all N-O bonds are equal to each other, with a bond length between a single and a double bond. Since in all three resonance structures, any one bond is a single bond in two of the resonance structures and a double in just one of the structures, the bond length will be closer to a single bond in length. This makes 1.67 units the correct answer.*

25/2
28/5

25. In the Lewis structure below, E is a general symbol for some element.



Formula = EO_2F_2^-

Valence electrons in Lewis structure = 34

Let x = valence electrons of element E

$$34 = x + 2(6) + 2(7) + 1 = x + 27$$

$$x = 7 \text{ (halogens have 7 valence } e^-)$$

Element E is a halogen. Also notice the E has 10 electrons around it in the Lewis structure. Row 2 elements never

- a. S b. F c. P **d. Br** e. O
- Handwritten note: Row 2 elements never have more than 8 electrons around it, so can't be F. Any row 3 halogen or heavier is fine. Br is the only choice.*

- 26/3
29/6
26. Pure aluminum oxide, Al_2O_3 , occurs in nature as a mineral called corundum, which is noted for its hardness and resistance to attack by acids. Corundum's density is 3.97 g/mL. Calculate the number of atoms of aluminum in 15.00 mL of corundum.

Handwritten note: Molar mass $\text{Al}_2\text{O}_3 = 2(26.98) + 3(16.00) = 101.96 \text{ g/mol}$

- a. **7.03×10^{23} atoms Al** b. 6.40×10^{22} atoms Al c. 3.52×10^{21} atoms Al

- d. 1.16×10^{23} atoms Al e. 3.52×10^{23} atoms Al

$$\frac{15.00 \text{ mL}}{\text{mL}} \times \frac{3.97 \text{ g Al}_2\text{O}_3}{1 \text{ mL}} \times \frac{1 \text{ mol Al}_2\text{O}_3}{101.96 \text{ g}} \times \frac{2 \text{ mol Al}}{1 \text{ mol Al}_2\text{O}_3} = 6.022 \times 10^{23} \text{ atoms Al} = 7.03 \times 10^{23} \text{ atoms Al}$$

Form
A/B
C/D

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Because molecule obeys octet rule and has 180° bond angles, XY_2 has linear geometry. Linear geometry dictates sp hybridization, having 2 unhybridized p atomic orbitals. Each of these unhybridized p orbitals go to form a different π bond.

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27. The central atom in a molecule of the type XY_2 obeys the octet rule. Experiments show that the bond angle about the central atom X is 180° . How many π bonds does X form to the other atoms (Y) in this molecule?

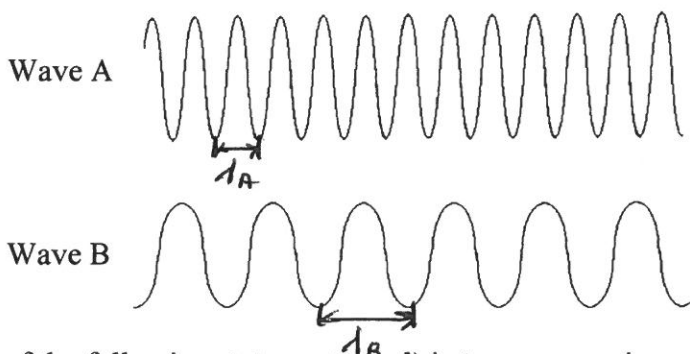
- a. 0 (X forms no π bonds.)
b. 1 π bond
c. 2 π bonds
d. 3 π bonds

So XY_2 has 2 π bonds formed from the two unhybridized p atomic orbitals about the central atom. Examples are $H-C\equiv N$ and $\underline{O}=C=\underline{O}$. Note that each has 2 π bonds.

28/17
18/2

28. Consider the figure below illustrating two different types of electromagnetic radiation.

$\lambda\nu = c$, $E = h\nu = hc/\lambda$; ν and λ are inversely proportional; photon energy E and λ are also inversely proportional.



and λ are also inversely proportional.

$\lambda_A < \lambda_B$, so
 $\nu_A > \nu_B$ and
 $E_A > E_B$.

Which of the following statements (a-d) is true concerning wave A and wave B?

- F a. Wave A has a faster velocity than wave B. - both travel at c
F b. The wavelength of wave A is longer than the wavelength of wave B. shorter
F c. The photon energy associated with wave A is smaller than the photon energy associated with wave B. larger
F d. The frequency of wave A is lower than the frequency of wave B. higher
e. None of these statements (a-d) are true.

29/18
19/3

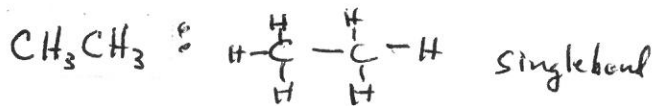
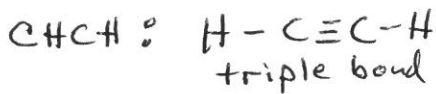
29. Which of the following is true?

Atom has tiny dense nucleus with electrons at relatively huge distances away from nucleus.

- F a. All particles in the nucleus of an atom are charged. neutrons are neutral
F b. The atom is best described as a uniform sphere of matter in which electrons are embedded.
F c. The mass of the nucleus is only a very small fraction of the mass of the entire atom.
T d. The volume of the nucleus is only a very small fraction of the volume of the entire atom.
F e. The number of neutrons in a neutral atom must equal the number of electrons.

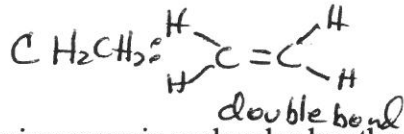
number protons = number electrons in neutral atom.

Form
A/B
C/D



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Apply "Organic Rules" to get Lewis structures.

30. Which of the following organic molecules has the carbon-carbon bond with the shortest bond length? For the skeletal structures, the two carbon atoms are bonded to each other with the other atoms bonded to the carbons. Note that the bond which is strongest will have the shortest bond length.

a. CHCH

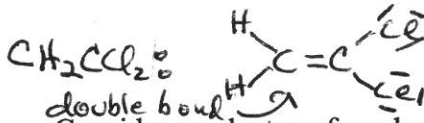
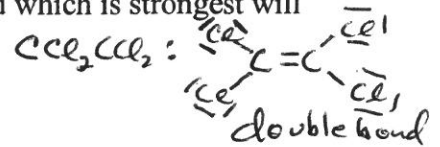
b. CH_2CH_2

c. CH_3CH_3

d. CCl_2CCl_2

e. CH_2CCl_2

The triple bond is strongest and it will have the shortest bond length. Only CHCH has a triple bond.



31. Consider an electron for a hydrogen atom that is in an excited state. The maximum wavelength of electromagnetic radiation that can completely remove (ionize) the electron from this H atom is 3283 nm. What is the initial excited state for the electron ($n = ?$)? $n_1 = n, n_2 = \infty$

a. $n = 2$

b. $n = 3$

c. $n = 4$

d. $n = 5$

e. $n = 6$

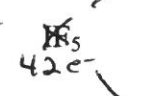
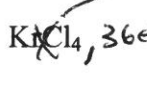
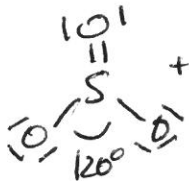
$\Delta E = -R_H \left(\frac{1}{n_2^2} - \frac{1}{n_1^2} \right) = -R_H \left(\frac{1}{\infty^2} - \frac{1}{n^2} \right) = R_H / n^2$

$E = |\Delta E| = hc/\lambda$

$E = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} (2.998 \times 10^8 \text{ m/s})}{3283 \times 10^{-9} \text{ m}} = 6.05 \times 10^{-20} \text{ J}$

$6.05 \times 10^{-20} = \frac{2.178 \times 10^{-18}}{n^2}$
solving, $n = 6$

32. How many of the following five compounds are predicted by VSEPR to have at least one bond angle that is 120° ?



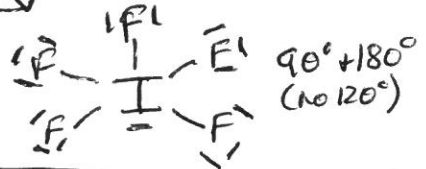
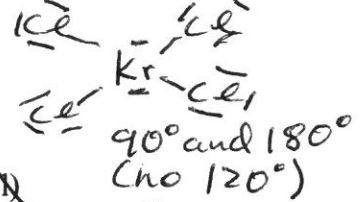
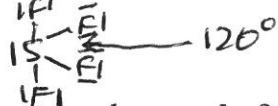
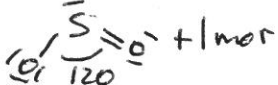
a. 1

b. 2

c. 3

d. 4

e. 5 (all)



33. How many of the following five compounds are polar?

Note: These are the same compounds used in the previous problem.

Bond dipoles are symmetrically arranged in SO_3 and KrCl_4 , so these compounds are nonpolar.

The bond dipoles are not symmetrically arranged in SO_2 , SF_4 , and IF_5 , these 3 compounds will be polar because the individual bond dipoles will not cancel.

a. 1

b. 2

c. 3

d. 4

e. 5 (All are polar.)

34. My answers for the chemistry 102 exam should be graded with the answer sheet associated with:

a. Form A

b. Form B

c. Form C

d. Form D

e. Form E