

Form
A/B
C/D

Detailed Key Exam 1

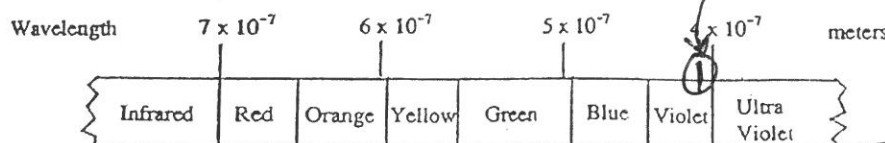
CHEMISTRY 102
Hour Exam I

$$\Delta E = -R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = -2.178 \times 10^{-18} \text{ J} \left(\frac{1}{2^2} - \frac{1}{6^2} \right) = -4.84 \times 10^{-19} \text{ J}$$

Spring 2023
Page 1

$$E_{\text{photon}} = |\Delta E| = 4.84 \times 10^{-19} \text{ J} = \frac{hc}{\lambda}$$

1. Use the figure below to answer the next question:



$$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s} (2.998 \times 10^8 \text{ m/s})}{4.84 \times 10^{-19} \text{ J}} = 4.10 \times 10^{-7} \text{ m} = \text{Violet light}$$

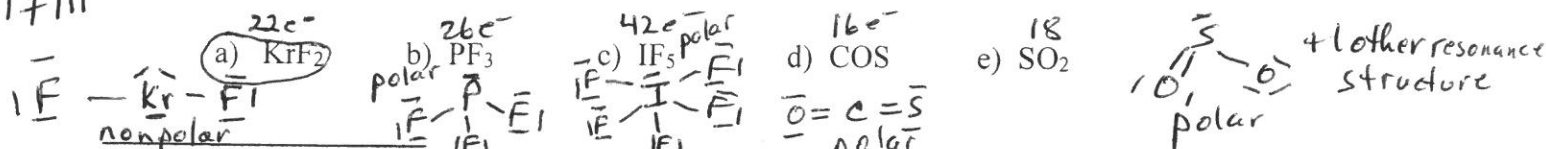
For hydrogen, the light emitted for the $n = 6$ to $n = 2$ electronic transition is in the visible region of the electromagnetic radiation spectrum (see spectrum above). What is the color of visible light emitted for the $n = 6$ to $n = 2$ electronic transition?

- a) red b) orange c) green d) blue e) violet

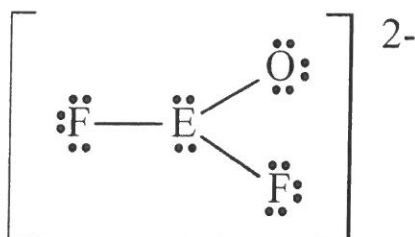
Water will dissolve other polar solutes. A nonpolar compound will be least soluble in water.

2. Which of the following compounds will be least soluble in water? Hint: Water is a polar solvent and "like dissolves like".

2/26
17/11



E in the Lewis structure below is a general symbol for some element. Consider this Lewis structure for the next two questions.



EF_2O^{2-} is the formula and this ion has 28 valence electrons.

$$28 = x + 2(7) + 6 + 2$$

$$x = 6 \text{ valence electrons}$$

E is a group 6 nonmetal. Since EF_2O^{2-} has more than 8 electrons around the central E atom, E must be a row 3 group 6 element or lower.

- Which of the following elements could be E?

S is the best choice.

- a) C b) Si c) Ne d) Kr e) S

EOF_2^{2-} will have a T-shaped molecular structure having 90° and 180° bond angles, since EF_2 exhibits trigonal bipyramidal geometry, E is dsp^3 hybridized.

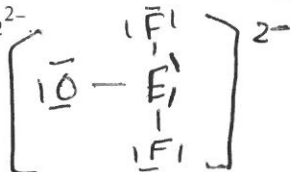
- Which of the following statements is false concerning the EOF_2^{2-} ion?

T a) The predicted VSEPR shape of EOF_2^{2-} is T-shaped.

F b) The predicted VSEPR bond angles about the central E atom are 120°, 90° and 180°.

T c) The predicted hybridization of the central E atom is dsp^3 .

T d) It is impossible to draw a Lewis structure for EOF_2^{2-} which satisfies the octet rule for all atoms in EOF_2^{2-} .



Central E atom has 10 electrons around it.

3/27
18/12

4/28
19/13

All measured quantities have uncertainty associated with them.

5. Measured quantities, such as length, mass, or volume, can best be described as:

- a) sometimes certain b) always certain
c) always uncertain d) sometimes uncertain

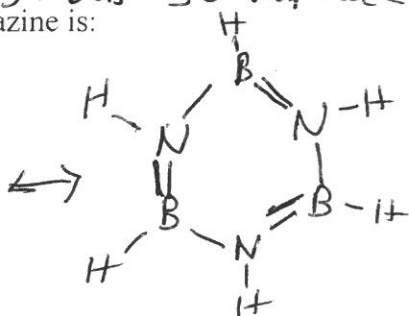
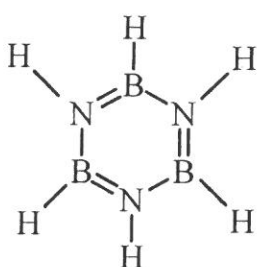
HClO_4 = perchloric acid: $1.008 + 35.45 + 4(16.00) = 100.46 \text{ g/mol}$

6. Calculate the number of oxygen atoms in 2.0 g of perchloric acid.

a) 4.8×10^{22} O atoms b) 6.0×10^{23} O atoms c) 1.7×10^{21} O atoms
d) 3.4×10^{21} O atoms e) 1.2×10^{22} O atoms

$$2.0 \text{ g HClO}_4 \left(\frac{1 \text{ mol HClO}_4}{100.46 \text{ g}} \right) \left(\frac{4 \text{ mol O}}{1 \text{ mol HClO}_4} \right) \left(\frac{6.022 \times 10^{23} \text{ O atoms}}{1 \text{ mol O}} \right) = 4.8 \times 10^{22} \text{ O atoms}$$

$\text{B}_3\text{N}_3\text{H}_6$: $3(3) + 3(5) + 6(1) = 30$ valence electrons
A Lewis structure for borazine is:



Bond angles are 120° (trigonal planar geometry). Each B and N are sp^2 hybridized. Each B and N atom has an unhybridized p atomic orbital pointing out and into the plane of the paper. These unhybridized p atomic orbitals all overlap to give delocalized π electrons above and below the ring of molecules.

Which of the following statements is false concerning borazine?

- T a) Each sigma bond between boron and nitrogen is formed from overlap of a sp^2 hybrid orbital from boron with a sp^2 hybrid orbital from nitrogen.
T b) Another resonance Lewis structure can be drawn for borazine. *see above*
F c) Each boron atom and nitrogen atom in borazine has two unhybridized 2p atomic orbitals. *sp^2 hybridization has 1 unhybridized p atomic orbital.*
T d) The π electrons in borazine are delocalized above and below the entire ring surface.
T e) All boron-nitrogen bond lengths are equivalent in borazine. *when resonance structures can be drawn, bond lengths are equivalent*

8. How many of the following five processes (I-V) are examples of chemical change?

Formulas change in a chemical change. In a physical change, the state of the substance changes, not the formula.

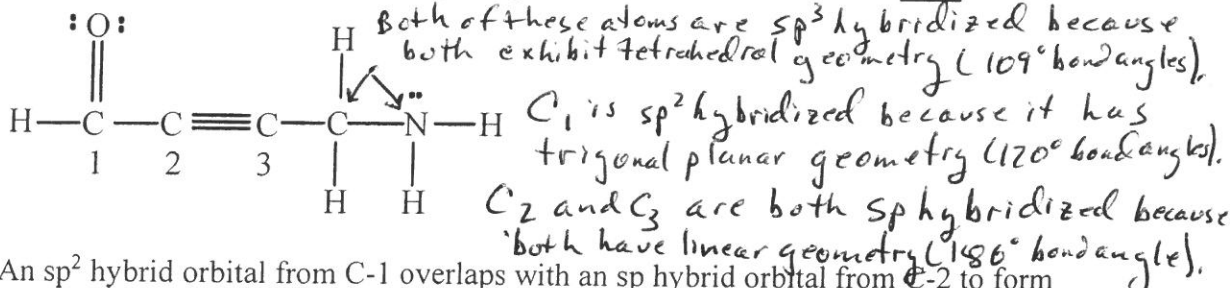
- physical I. $\text{H}_2\text{O(l)} \rightarrow \text{H}_2\text{O(g)}$
physical II. $\text{I}_2\text{(s)} \rightarrow \text{I}_2\text{(g)}$
Chemical III. $\text{CH}_4\text{(g)} + 2 \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + 2 \text{H}_2\text{O(l)}$
physical IV. $\text{C}_6\text{H}_{12}\text{O}_6\text{(s)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6\text{(aq)}$
Chemical V. $2 \text{H}_2\text{O}_2\text{(aq)} \rightarrow 2 \text{H}_2\text{O(l)} + \text{O}_2\text{(g)}$

- a) 1 b) 2 c) 3 d) 4
e) 5 (All are examples of chemical change.)

single bond = σ
 double bond = $1\sigma + 1\pi$
 triple bond = $1\sigma + 2\pi$

9/17
20/6

Which of the following statements regarding the Lewis structure below is false?



- T a) An sp^2 hybrid orbital from C-1 overlaps with an sp hybrid orbital from C-2 to form the sigma bond between C-1 and C-2. Hybrids form the sigma bonds.
 T b) This molecule has three π bonds.
 T c) Two of the atoms in this compound are sp^3 hybridized.
 F d) The π bonds between C-2 and C-3 are formed from overlap of sp hybrid orbitals. *He unhybridized p atomic orbitals*
 T e) There are 10 sigma bonds in this molecule. *Unhybridized p atomic orbitals always form π bonds.*

10/18
21/7

Which of the following statements is false concerning ionization energy (IE)?

- From IE trend, 1st IE of Ne will be greater than IE for F. Therefore, 2nd IE must be larger than IE for F since 2nd IE greater than 1st IE for any element.
 T a) The second ionization energy of Ne is greater than the first ionization energy of K.
 F b) For an isoelectronic series, the species with the most protons should have the smallest ionization energy. *Species with most protons has largest IE (smallest size).*
 T c) As the size of an atom increases, ionization energy generally decreases. *trends are opposite.*
 T d) As the electronegativity of an atom increases, ionization energy generally increases. *trends are the same.*
 T e) The third ionization energy for magnesium corresponds to the enthalpy change for the reaction: $\text{Mg}^{2+}(\text{g}) \rightarrow \text{Mg}^{3+}(\text{g}) + e^-$ $\Delta H = \text{IE}_3$.

corresponds to third electron removed from Mg.

11/19
22/8

11. How many of the following are correct ground state electron configurations for the element or ion listed? Note: Element #118 is not yet discovered and Zr is element #40.

noble gas under Rn $\rightarrow$ element #118:

Zr:
 S^{2-} :
 Ge:

$[\text{Rn}] 7s^2 5f^{14} 6d^{10} 7p^6$
 $[\text{Kr}] 5s^2 4d^2$
 $[\text{Ne}] 3s^2 3p^6$
 $[\text{Ar}] 4s^2 3d^{10} 4p^2$

All are correct
 All follow what
 is predicted from
 periodic table.

a) 0 (None are correct.)

b) 1

c) 2

d) 3

e) 4 (All are correct.)

12/20
23/9

12. Which of the following statements is true?

- F a) Rutherford's metal foil experiment proved the ~~existence of electrons~~. *nuclear model for atom*
 F b) Dalton's atomic theory said that each element is made up of ~~neutrons~~. *atoms*
 F c) Most of an atom's volume is occupied by its nucleus. *nucleus is tiny and dense*
 F d) Most of an atom's mass comes from its ~~electrons~~. *nucleus*
 T e) It is possible for an isotope of carbon and an isotope of nitrogen to have the same mass number.

$^{14}_7\text{N}$ and $^{14}_6\text{C}$ both have same mass number.

Form
A/B
C/D

CHEMISTRY 102
Hour Exam I

From Heisenberg's Uncertainty principle, we cannot know the exact position of an electron in an atom. So the simple circular orbits and a specific distance from the nucleus is not allowed.

Spring 2023
Page 4

13/11
5/19

13. Which aspect of the Bohr model is not allowed by Heisenberg's uncertainty principle?

- a) discrete atomic energy levels
- ☒ b) simple circular orbits
- c) deBroglie wavelengths
- d) atomic orbitals

radius trend ↓

Trend only works for neutral atoms. For the neutral atoms, the correct order is $FLBr < Ca < Sr$.

14/12
6/20

14. Which of the following correctly orders the radius of the atoms/ions listed from smallest to largest radius? F^+ has 1 fewer electron than F . F^+ will be smaller than F . Rb^- and Sr both have 38 electrons. Rb^- with fewer protons in the nucleus will be larger than Sr .

- a) $F < F^+ < Ca < Br < Rb^- < Sr$
- b) $F < F^+ < Ca < Sr < Rb^- < Br$
- c) $F^+ < F < Br < Ca < Rb^- < Sr$
- ☒ d) $F^+ < F < Br < Ca < Sr < Rb^-$
- e) $F^+ < F < Ca < Sr < Br < Rb^-$

Putting all this together: $F^+ < F < Br < Ca < Sr < Rb^-$.

15/13
7/21

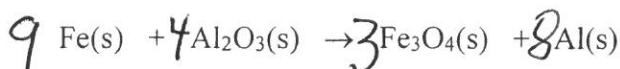
15. Which of the following statements is false concerning bonding?

- ☒ a) In a C-O bond, electron density on average is greater near the O atom.
- ☒ b) A C-O bond is an example of a polar covalent bond.
- ☒ c) The bond in NaBr is formed by sharing electrons. NaBr bond is ionic (metal + nonmetal).
- ☒ d) Elements with extremely different electronegativity values tend to form ionic bonds with each other.
- ☒ e) An N-H bond is more polar than a P-H bond.

H and P have identical electronegativities. H-P bond is nonpolar. It has EN value between C and B. N-H bond is a polar bond.

16/14
8/22

16. Consider the following unbalanced reaction (it is called the thermite reaction):



In the best-balanced equation, what is the sum of the coefficients for the reactants and the products?

$$9 + 4 + 3 + 8 = 24$$

- ☒ a) 24
- b) 6
- c) 8
- d) 9
- e) 13

17/15
9/23

17. Which of the following is named incorrectly?

- ☒ a) $\text{Cr}_2(\text{SO}_3)_3$ chromium(III) sulfite
- ☒ b) $\text{NaC}_2\text{H}_3\text{O}_2$ sodium acetate
- ☒ c) KNO_2 potassium nitride
- ☒ d) $\text{Ca}(\text{OH})_2$ calcium hydroxide
- ☒ e) NiCO_3 nickel(II) carbonate

Nitride = N^{3-} ; NO_2^- = nitrite

Cu^+ : $[\text{Ar}] 4s^0 3d^{10}$ (0 unpaired e-)
 Ni^{2+} : $[\text{Ar}] 4s^0 3d^8$ 2 unpaired electrons
 Zn^{2+} : $[\text{Ar}] 4s^0 3d^{10}$ (all filled, 0 unpaired electrons)
 Cr^{2+} : $[\text{Ar}] 4s^0 3d^4$ 4 unpaired electrons

18/16
10/24

18. Consider the transition metal ions Cu^+ , Ni^{2+} , Zn^{2+} , Cr^{2+} , and Ti^{2+} . How many of these five transition metal ions has/have two (2) unpaired electrons in the ground state?

- ☒ a) 1
- ☒ b) 2
- c) 3
- d) 4
- e) 5 (All have 2 unpaired electrons.)

Ni^{2+} and Ti^{2+} both have 2 unpaired electrons. Note that all of these ions are exceptions to know. Transition metal cations all lose the s electrons before losing d electrons.

Form

Volume = $32.37 - 30.07 = 2.30 \text{ mL}$ ← This result is known to 2 decimal places by subtraction rule.

A/B CHEMISTRY 102
C/D Hour Exam I

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{1.0107 \times 10^{-2} \text{ kg} \left(\frac{1000 \text{ g}}{1 \text{ kg}} \right)}{2.30 \text{ mL}}$$

Spring 2023
Page 5

$$\text{density} = 4.39 \text{ g/mL}$$

19. A piece of metal has a mass of $1.0107 \times 10^{-2} \text{ kg}$. When it was placed into a 100-mL graduated cylinder containing 30.07 mL of water, the volume of water increased to 32.37 mL. What is the density of the metal (in g/mL) to the correct number of significant figures?

The final result is known to 3 sig figs. The division is

- a) $4.4 \times 10^{-3} \text{ g/mL}$ b) $4.394 \times 10^{-3} \text{ g/mL}$ c) 4.4 g/mL

a 5 sig fig number by a 3 sig fig number. The result will have

- d) 4.39 g/mL e) 4.394 g/mL

3 sig figs by the division rule.

20. Experiments show that an unknown element, X, has one unpaired electron in the ground state and has an exothermic electron affinity. Its most stable ion exhibited in ionic compounds is known to be isoelectronic with argon. Which of the following elements

could be X? Cl , Na , and Ga all have 1 unpaired electron (Ca has 0 unpaired electrons and S has 2 unpaired electrons). Cl forms Cl^- when in ionic compound; Cl^- is isoelectronic with Ar . Na^+ and Ga^{3+} are not isoelectronic with Ar .

- a) Cl b) Na c) Ca d) S e) Ga

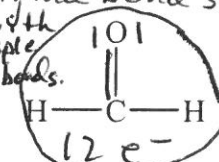
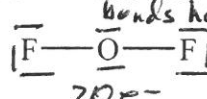
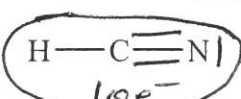
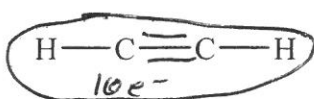
21. Which of the following does not correctly describe 16.0 grams of methane, CH_4 ?
molar mass $\text{CH}_4 = 12.0 + 4(1.0) = 16.0 \text{ g/mol} = 1 \text{ mol CH}_4 = 6.022 \times 10^{23} \text{ molecules CH}_4$

- a) One (1.00) mole of methane.
b) The amount of methane that contains 12.0 g of carbon.
c) The amount of methane that contains 4.0 g hydrogen.
d) The amount that contains 6.02×10^{23} molecules of methane.
e) The amount that contains $4.0 \times (6.02 \times 10^{23})$ atoms of hydrogen.

$$\text{atoms H} = \frac{16.0 \text{ g CH}_4}{16.0 \text{ g}} \times \frac{1 \text{ mol CH}_4}{1 \text{ mol CH}_4} \times \frac{4 \text{ mol H}}{1 \text{ mol CH}_4} \times \frac{6.02 \times 10^{23} \text{ atoms H}}{1 \text{ mol H}} = 4(6.02 \times 10^{23}) \text{ atoms H}$$

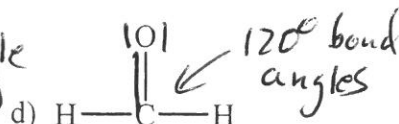
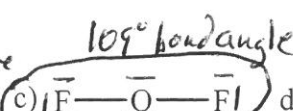
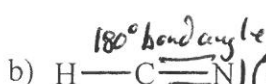
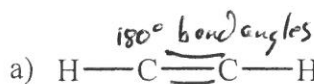
22. In some bonds, the atoms can rotate freely without breaking the bond between the atoms; while in other bonds, the atoms cannot rotate freely unless the bond is broken. How many of the following four molecules has/have at least one bond where the atoms cannot freely rotate unless a bond is broken?

Single bonds are all sigma bonds where the atoms can rotate. π bonds cannot rotate. Compounds with double and triple bonds have π bonds.



- a) 0 (none) b) 1 c) 2 d) 3 e) 4 (All have at least one bond where the atoms cannot freely rotate.)
 C_2H_2 , HCN , and CH_2O all have π bonds which cannot rotate. F_2O contains only sigma bonds which can rotate.

23. Which of the following molecules have at least one bond angle which is approximately 109° as predicted by the VSEPR model? Hint: reference the Lewis structures you drew for the previous question.



- e) None of the above molecules (a-d) have at least one approximate 109° bond angle.

→ The O in F_2O has 4 sets of electrons about it, so this O exhibits tetrahedral geometry and 109° bond angle.

Form
A/B
C/D

CHEMISTRY 102
Hour Exam I

Spring 2023
Page 6

24. How many of the following molecules have a square planar shape?



a) 1
square planar

b) 2

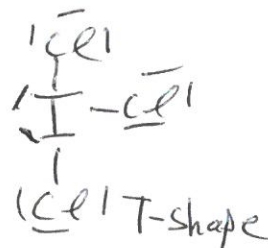
c) 3

d) 4

e) 5 (All have a square planar shape.)



IEI see-saw



ICl T-shape

25. Which ion, in each of the following three pairs of ions, has the largest ionization energy?

O^- , with fewer electrons,

O^- vs O^{2-}
has the larger IE.

a) O^{2-} ; Mg^+ ; O^{2-}

Mg^{2+} , with fewer e^- ,

Mg^+ vs Mg^{2+}
has the larger IE.

b) O^- ; Mg^+ ; O^{2-}

O^{2-} vs Mg^{2+}

c) O^- ; Mg^+ ; Mg^{2+}

Both have $10e^-$, Mg^{2+} with more protons, has the larger IE.

d) O^{2-} ; Mg^{2+} ; O^{2-}

e) O^- ; Mg^{2+} ; Mg^{2+}

M must form 2+ charged ions since S forms 2- charged ions.

26. The isotope of an unknown metal, M, has a mass number of 26. The most stable ion of the isotope forms a binary compound with sulfur having the formula MS . How many neutrons does M have?

a) 14

b) 26

c) 12

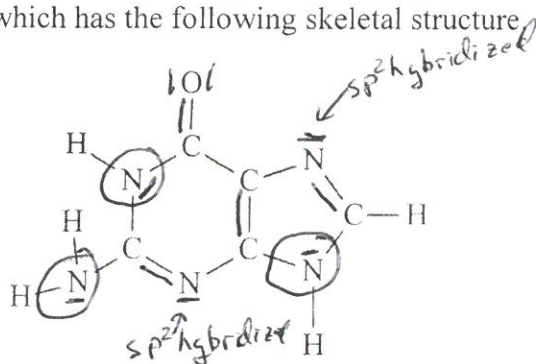
d) 10

e) 24

For light elements, the number of protons and neutrons are about equal. With a mass number of 26, guess that M has 13 protons. However, element 13 (Al) doesn't form 3+ ions. Assume element is

DNA molecules are complex organic compounds found in every living cell which act as the Mg which does information and control centers for the cell. Part of any DNA molecule is the organic compound Mg which does form 2+ ions.

#neutrons = $26 - 12 = 14$



Organic Rules

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

Using the guidelines outlined in class for organic compounds, complete a Lewis structure for guanine and answer the following two questions.

the circled atoms have tetrahedral geometry, so they are sp^3 hybridized.

27. How many C and N atoms are sp^3 hybridized?

a) 1

b) 2

c) 3

d) 4

e) 5

Two of the N atoms are sp^2 hybridized and all of the C atoms are sp^2 hybridized since they have trigonal planar geometry.

28. How many double bonds are in the completed Lewis structure?

a) 1

b) 2

c) 3

d) 4

e) 5

There are 4 double bonds in the Lewis structure.

E_{photon} = energy difference between 2p and 2s orbital

$$E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s} (2.998 \times 10^8 \text{ m/s})}{670.8 \text{ nm} (1 \times 10^9 \text{ nm})}$$

29. When an electron in a 2p orbital of a lithium atom makes a transition to the 2s orbital, a photon of wavelength 670.8 nm is emitted. The energy difference between the 2p and 2s orbitals in lithium is:

$$E = 2.961 \times 10^{-19} \text{ J}$$

- a) $2.96 \times 10^{-10} \text{ J}$ (b) $2.96 \times 10^{-19} \text{ J}$ c) $3.38 \times 10^{-18} \text{ J}$
d) $2.96 \times 10^{-17} \text{ J}$ e) $3.38 \times 10^{-20} \text{ J}$

$$\text{mass O in compound} = 100.00 - 68.42 \text{ g M} = 31.58 \text{ g O}$$

30. A metal M forms an oxide having the formula M_2O_3 . If 100.00 g of M_2O_3 contains 68.42 g of M, what is the atomic mass of the metal, M?

$$\text{mol M} = 31.58 \text{ g O} \left(\frac{1 \text{ mole O}}{16.00 \text{ g}} \right) \left(\frac{2 \text{ mole M}}{3 \text{ mole O}} \right) = 1.3158 \text{ mol M}$$

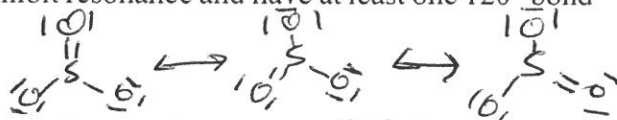
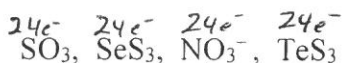
- a) 26.98 amu b) 44.96 amu c) 52.00 amu d) 69.72 amu e) 102.9 amu

$$\text{molar mass M} = \frac{68.42 \text{ g M}}{1.3158 \text{ mol M}} = 52.00 \text{ g/mol}; \text{ atomic mass} = 52.00 \text{ amu}$$

31. Which of the following statements is false?

- T a) The three 6p atomic orbitals have the same energy but they differ in their orientation about the x, y and z axes.
T b) 3f atomic orbitals do not exist in the quantum mechanical model of the atom. *- 4f orbitals are the first ones to exist.*
T c) For neutral charged atoms, the 8s atomic orbital should be lower in energy than the 7d atomic orbitals. *From periodic table*
F d) An excited state electron configuration for an atom represents a higher energy electron configuration as compared to the ground state electron configuration. *ground state = lowest energy configuration*

32. How many of the following compounds/ions exhibit resonance and have at least one 120° bond angle as predicted by the VSEPR model?



All of these have similar Lewis structures to SO_3 . All have

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

- 24 valence electrons with a central atom surrounded by 3 atoms. All exhibit trigonal planar geometry and 120° bond angles and exhibit resonance.

33. If the frequency of electromagnetic radiation is decreased by a factor of one-half, which of the following statements is false? *As ν halves, λ will double and E_{photon} will halve.*

- T a) The number of cycles passing a given point per unit time halves. *this is frequency definition.*
F b) The velocity of the radiation halves. *- speed is constant (c).*
T c) The wavelength of electromagnetic radiation is doubled.
F d) The photon energy of the electromagnetic radiation is halved.

34. My answers for this 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