

1/10
18/23

1. Which of the following statements is **false** concerning the Bohr model of the atom?

- T a) The Bohr model correctly predicts the energies of photons emitted by excited hydrogen atoms.
(F) b) The Bohr model correctly predicts the wavelengths of visible light emitted by excited neon (Ne) atoms. *Bohr model doesn't work for substances having more than 1 electron. Neon has 10 electrons.*
T c) The symbol n in the Bohr model represents allowed circular orbits in which an electron can be located.
T d) The simple, well-defined circular orbits for an electron in the Bohr model are not allowed by the Heisenberg uncertainty principle.
T e) As an electron in the Bohr model absorbs a photon of electromagnetic radiation, the electron moves farther away from the nucleus.

2/11
19/24

2. Which of the following statements is **false**? *TiO₂ is composed of Ti⁴⁺ and O²⁻ ions. Ti⁴⁺ is isoelectronic with Argon; Ti⁴⁺ has the Ar electron configuration.*

- T a) The metal ion in TiO₂ has a noble gas electron configuration.
T b) A bond between two identical nonmetals will be a pure (nonpolar) covalent bond.
T c) An S-O bond is an example of a polar covalent bond. *2 different non-metals*
(F) d) Ca(NO₃)₂ is an example of a compound that contains only ionic bonds. *Bonding within NO₃⁻ is covalent.*
T e) The partial negative end of the bond dipole in the Se-Cl bond should be around the Cl atom. *Se-Cl. Cl is more electronegative than Se, so Cl is the partial negative end.*

3/12
20/25

3. How many of the following are **correct** ground state electron configurations for the element or ion listed? Bi is element #83.

NO C: $1s^2 2s^2 2p^2$ $1s^2 2s^2 2p^2$
NO Mg: $[Ar] 4s^2$ $[Ne] 3s^2$
NO Si²⁺: $[Ne] 2s^2 2p^4$ $[Ne] 3s^2 3p^4$
NO Bi: $[Xe] 6s^2 5f^{14} 6d^{10} 6p^3$ $[Xe] 6s^2 4f^{14} 5d^{10} 6p^3$

- (a) 0 (None are correct.) b) 1 c) 2 d) 3 e) 4 (All are correct.)

4/13
21/26

4. Apply the hybrid orbital theory to the bonding in a nitrogen molecule (N₂) and complete the following sentence. The nitrogen-nitrogen bonding in N₂ is best described as: *about it, so each*

- a) one σ bond due to overlap of an sp^2 hybrid orbital from each nitrogen and one π bond from overlap of unhybridized 2p atomic orbitals.
b) one σ bond due to overlap of an sp^2 hybrid orbital from each nitrogen and two π bonds from overlap of unhybridized 2p atomic orbitals.
(c) one σ bond due to overlap of an sp hybrid orbital from each nitrogen and two π bonds from overlap of unhybridized 2p atomic orbitals. *linear geometry and 2 sp hybrid*
d) one σ bond due to overlap of an sp hybrid orbital from each nitrogen and one π bond from overlap of unhybridized 2p atomic orbitals.

The triple bond contains 1 σ bond and 2 π bonds. The sp hybrid s from each N overlap to form the σ bond while the 2 unhybridized p atomic orbitals on each N overlap to form the 2 π bonds.

Form

A/B
C/DCHEMISTRY 102
Hour Exam I

Fall 2019

Page 2

5/27
14/11

5. The successive ionization energies for an unknown element are:

$$IE_1 = 896 \text{ kJ/mol}$$

$$IE_2 = 1,752 \text{ kJ/mol}$$

$$IE_3 = 14,807 \text{ kJ/mol}$$

$$IE_4 = 17,948 \text{ kJ/mol}$$

Huge jump between IE_2 and IE_3 .

This indicates that the element has

2 valence electrons. Note that

valence electrons are much easier

to remove than inner core

electrons. So this element is an

alkaline earth metal (all have

2 valence electrons).

In which group in the periodic table does this element belong?

- a) alkali metal group
 b) alkaline earth metal group
 c) boron group
 d) nitrogen group
 e) oxygen group

6/28
15/12

6. How many of the following five terms (I-V) did Dalton
- not**
- discuss in his atomic theory? Dalton only proposed the idea of a generic atom. He had no idea what made up the atom.

I. isotopes II. ions III. protons IV. electrons V. neutrons

So none of these terms were discussed in Dalton's Atomic theory.

a) 1

b) 2

c) 3

d) 4

- e) 5; Dalton did
- not**
- discuss any of these terms in his atomic theory.

By subtraction/addition rule, the numerator is known to the tenths place (a 3 sig fig number).

Consider the calculation:

$$\frac{39.0630 - (4.7) + 2.7392}{7.084 \times 3.1978} = \frac{37.1022}{7.084 \times 3.1978} = 1.64$$

3 sig fig. answer by multiplication/division rule.

Which of the following is the answer to this calculation to the correct number of significant figures?

a) 1.6378

b) 1.638

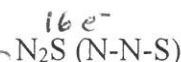
c) 1.64

d) 1.6

e) 2

only N_2S and TeS_3 have multiple bonds that can be placed in multiple locations (only N_2S and TeS_3 exhibit resonance).8/30
17/14

8. How many of the following four compounds exhibit resonance?



yes



no



yes



no resonance

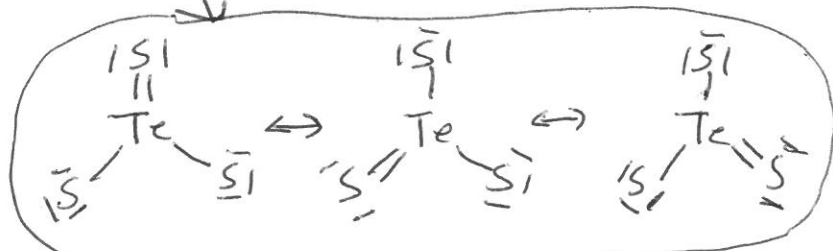
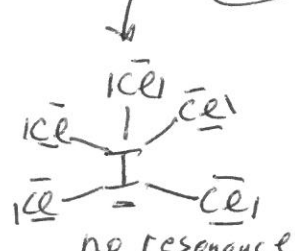
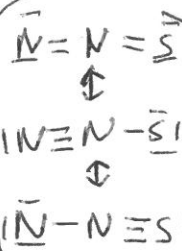
a) 0 (none)

b) 1

c) 2

d) 3

e) 4 (All exhibit resonance.)



Form

A/B

C/D

CHEMISTRY 102
Hour Exam I SF_4 , 34e⁻The S-F individual
bond dipoles do
not all cancel each
other out, so SF_4
is a polar molecule.

Fall 2019

Page 3

9/19

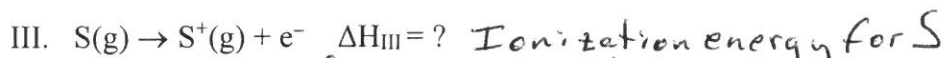
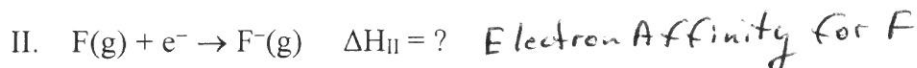
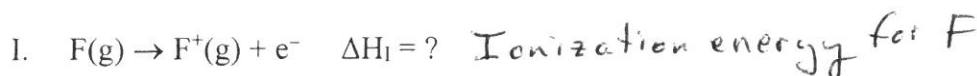
5/19

9. Draw the Lewis structure for SF_4 . Which of the following statements concerning SF_4 isfalse? Central S atom exhibits trigonal bipyramidal geometry which dictates sp^3 hybrids.

- T a) The hybridization of sulfur in SF_4 is sp^3 .
 F b) The molecular shape of SF_4 is square pyramid. shape = see-saw
 T c) The smallest bond angle in SF_4 is approximately 90° .
 T d) SF_4 is polar.
 T e) It is impossible to satisfy the octet rule for all atoms in SF_4 .

10/20
6/20

10. Consider the following three reactions:

From IE trend, F has a larger ionization energy than S.
Which of the following statements (a-c) concerning these reactions is/are true?So $\Delta H_I > \Delta H_{III}$.

- F a) ΔH for reaction I is equal to the first electron affinity for fluorine.
 F b) ΔH for reaction II is equal to the first ionization energy for fluorine.
 F c) ΔH for reaction III is larger (more positive) than ΔH for reaction I ($\Delta H_{III} > \Delta H_I$).
 d) All of the above statements (a-c) are true.
 e) None of the above statements (a-c) are true.

$$\text{molar mass} = \frac{\text{mass}}{\text{moles}} = \frac{100.0 \text{ g NaClO}_x}{0.9395 \text{ moles NaClO}_x}$$

11/21
7/2111. A compound has a formula of $NaClO_x$ where x is some whole number. A 100.00 g sample of this compound contains 21.6 g of sodium. Which of the following is the formula of this compound?

$$\text{mol NaClO}_x = 21.6 \text{ g Na} \left(\frac{1 \text{ mol Na}}{22.99 \text{ g Na}} \right) \left(\frac{1 \text{ mol NaClO}_x}{1 \text{ mol Na}} \right) = 0.9395 \text{ mol NaClO}_x$$

a) $NaClO$ b) $NaClO_2$ c) $NaClO_3$ d) $NaClO_4$ e) $NaClO_6$

$$\text{molar mass} = \frac{100.0 \text{ g}}{0.9395 \text{ mol}} = 106.4 \text{ g/mol}$$

$$\text{mass O}_x \text{ in } 1 \text{ mol compd} = 106.4 - 22.99 - 35.45 = 48.0 \text{ g}$$

12/22
8/2212. Which of the following statements is false?

Brass and air are homogeneous mixtures.

- T a) A homogeneous mixture can be a solid mixture or a gaseous mixture.
 T b) It is not possible for five measurements of the same object to be described as accurate but imprecise. If all are accurate, then all measurements must be close to each other which makes them precise.
 T c) An atom is mostly empty space.
 F d) One would expect the undiscovered element 122 to be an alkaline earth metal.
 T e) A compound is a substance with constant composition that can be broken down into elements by chemical processes.

48.0 g O is 3 mol of O (O has molar mass = 16.0 g/mol)
 Formula = $NaClO_3$

Element 120 would be an alkaline earth metal, 119 would be an alkali metal and 118 is a noble gas (just count over from element 112 in periodic table).

The trends are for comparing neutral charged atoms like in groups II and III. From trend, group II is in order of largest IE to smallest, while group III is in correct order of smallest to largest IE.

Consider the following four groups (I-IV) of atoms/ions for the next two questions:

no I. N^+, N, N^-

no II. Al, Ca, Rb

yes III. Sn, Se, Ar

no IV. Na^+, F^-, O^{2-}

Applying the radii trend to groups II and III, Rb is largest in group II and Sn is largest in group III.

For group I, all have 7 protons. N^+ has fewest electrons (6e-) so it is smallest in size and has largest IE. N^- with the most electrons (8e-) is largest in size and has the smallest ionization energy.

So group I is in order from largest IE to smallest IE.

13. How many of the four groups (I-IV) is/are in order of increasing ionization energy (smallest to largest I.E.)? Group IV is isoelectronic (10e-). Na^+ with the most protons (11) is smallest in size and has largest IE. O^{2-} with the fewest protons (8) is largest in size and has the smallest ionization energy. Group IV is in order from largest IE to smallest IE.

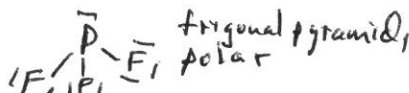
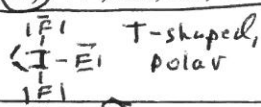
a) 0 (none) b) 1 c) 2 d) 3 e) 4 (All of the groups are in order of increasing ionization energy.)

14. In each group (I-IV), which atom/ion has the largest radius? The largest species in each group is circled.

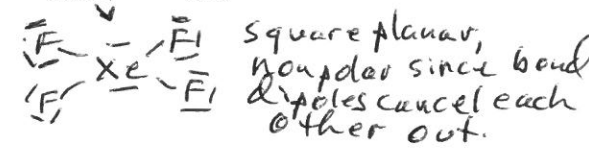
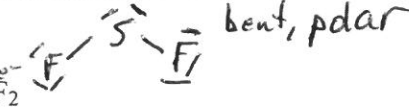
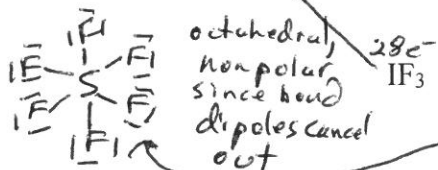
a) N^+, Al, Ar, Na^+ b) N^+, Rb, Ar, Na^+ c) N^-, Al, Ar, O^{2-}

d) N^-, Rb, Sn, O^{2-}

e) N^-, Rb, Sn, Na^+



Draw Lewis structures for the following five molecules then answer the next two questions.



15. How many of these molecules are polar?

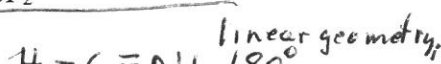
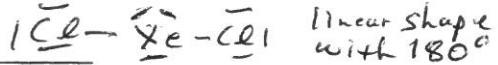
a) 1 b) 2 c) 3 d) 4 e) 5 (All are polar.)

IF_3, PF_3 and SF_2 are all polar. In all of these molecules, the bond dipoles don't cancel each other out, so they are polar.

16. Which molecule has a trigonal pyramidal shape?

PF_3 has trigonal pyramidal shape.

a) IF_3 b) SF_6 c) PF_3 d) XeF_4 e) SF_2



17. Which of the following molecules or ions has the smallest bond angle?

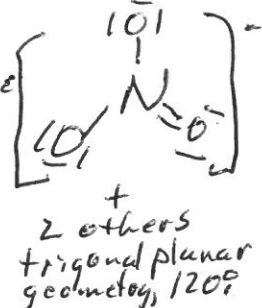
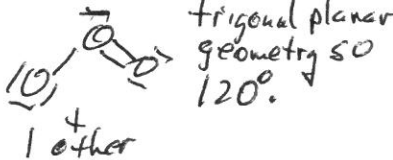
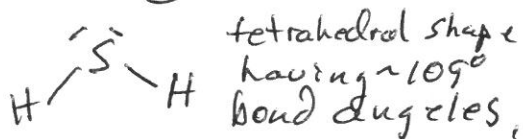
a) $H_2S, 8e^-$ ~109°

b) $XeCl_2, 22e^-$ 180°

c) $O_3, 18e^-$ ~120°

d) $HCN, 10e^-$ 180°

e) NO_3^- 120°, 24e-



Exam I
 $1 \text{ mol NH}_4\text{MnO}_4 \left(\frac{2 \text{ mol ions}}{1 \text{ mol NH}_4\text{NO}_3} \right) \left(\frac{6.022 \times 10^{23} \text{ ions}}{1 \text{ mol ions}} \right) = 1.2 \times 10^{24} \text{ ions}$

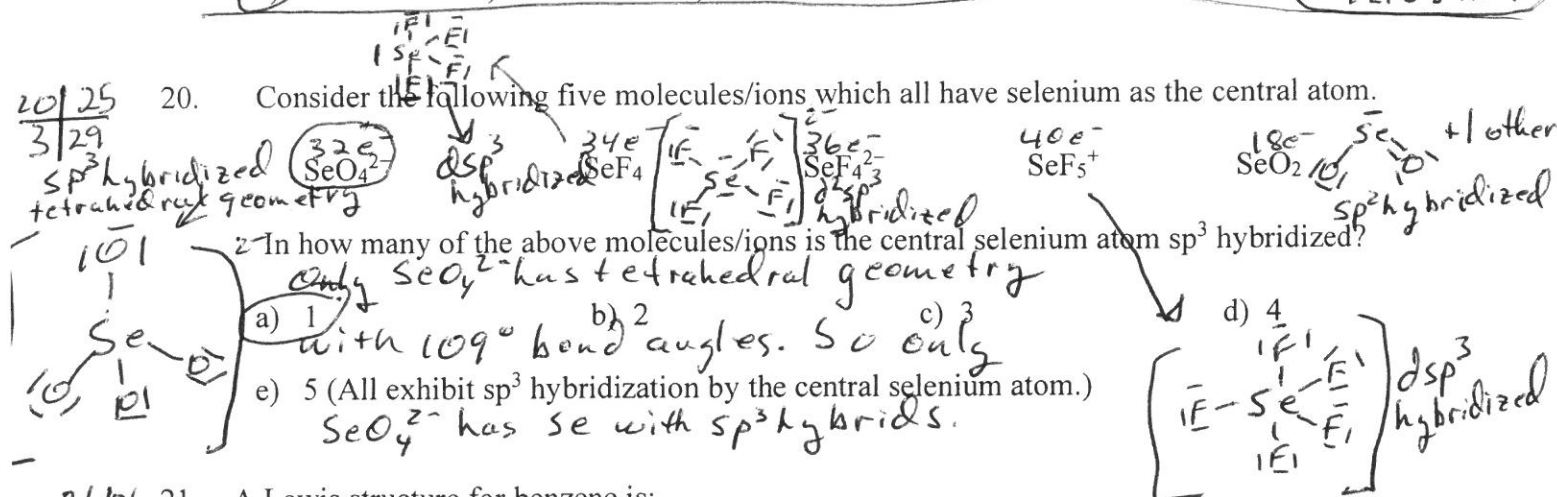
- a) 1.8×10^{24} ions b) 6 ions c) 6.0×10^{23} ions

- d) 1.2×10^{24} ions e) 3.6×10^{24} ions

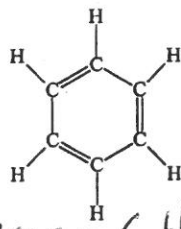
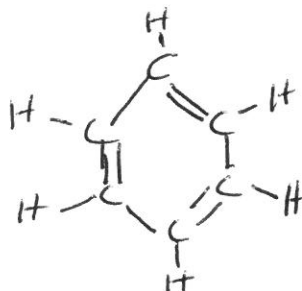
$$\Delta E = -R_H \left(\frac{1}{n_2^2} - \frac{1}{n_1^2} \right), \Delta E = -2.178 \times 10^{-18} \text{ J} \left(\frac{1}{8^2} - \frac{1}{1^2} \right) = 2.144 \times 10^{-18} \text{ J} = E_{\text{photon}}$$

- atom from the $n = 1$ to the $n = 8$ energy level?
- $E_{\text{photon}} = \frac{hc}{\lambda}$, $\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} (2.998 \times 10^8 \text{ m/s})}{2.144 \times 10^{-18} \text{ J}} = 9.265 \times 10^{-8} \text{ m}$
- (a) 92.65 nm b) 104.2 nm c) 729.7 nm d) 1261 nm e) 5837 nm $= 92.65 \text{ nm}$

20. Consider the following five molecules/ions, which all have selenium as the central atom.



21. A Lewis structure for benzene is:



$\begin{array}{c} \text{H} & & \text{H} \\ & \backslash & / \\ & \text{C} \\ & / \\ \text{H} & & \end{array}$
 Benzene = C_6H_6 2 resonance structures are possible.

Which of the following statements concerning benzene is **false**?

- Which of the following statements concerning benzene is false?
- T a) All six C-C bonds are equal in length and strength. The actual bond is an average of the 2 resonance structures (about a 1.5 bond).
 F b) Another equivalent (resonant) Lewis structure can be drawn for benzene.
 T c) As predicted from the Lewis structure(s), three of the six carbon-carbon bonds are shorter than the other three C-C bonds. *With resonance, all six C-C bonds are equal in length and strength.*
 T d) The carbon-carbon sigma bonds are formed from overlap of sp^2 hybrid orbitals from each carbon. *Each C exhibits trigonal planar geometry, so sp^2 hybridized. Hybrids form the sigma bonds.*
 T e) The electrons in the π bonds can be thought of as delocalized above and below the entire ring surface. *Explains why all C-C bonds are equal.*
 T e) Each carbon in benzene has one unhybridized p atomic orbital. *with sp^2 hybridization, each carbon has 1 unhybridized p atomic orbital. Each carbon has an unhybridized p atomic orbital perpendicular to the plane of the molecule. All six of the unhybridized p orbitals ~~can~~ overlap to form a delocalized ^{the} π bonding system. The six π electrons are delocalized above/below ring surface.*

Form
A/B
C/D

CHEMISTRY 102
Hour Exam I

Atomic masses in periodic table are all average masses of the various isotopes that make up the element. No one isotope has the average mass, but a large sample of the element behaves as if each atom has the average mass.

Fall 2019
Page 6

22/14
9/1

22. Bromine consists of two isotopes and the average mass of a bromine atom is 79.90 amu. Assuming you were able to pick up only one bromine atom, what are the chances that you would pick a bromine atom having a mass of 79.90 amu?

a) 0% b) 35% c) 50% d) 65% e) 100%

23/15
10/2

23. Consider the following ground state electron configuration:

V: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$ → so not V

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^5$

Cr: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ ← exception to know

Which of the atoms or ions below has this ground state electron configuration?

- Cr⁺: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^5$ ← another exception to know
a) V⁻ (24e⁻) b) V (23e⁻) c) Mn (transition metals lose s electrons before they lose the d electrons).
So Cr⁺ is the correct answer, (23e⁻)
d) Mn⁺ (24e⁻) e) Cr⁺ (23e⁻)

24/16
11/3

24. Which of the following statements is false?

- Group 5A: $ns^2 np^3$ = valence shell 1 1 1 ← all have three unpaired electrons
np
T a) Elements in group 5A of the periodic table have a total of 3 unpaired electrons in the ground state. I: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$ 6+6+5 = 23 p electrons for I
+ b) Iodine has a total of 23 electrons in various p orbitals in the ground state.
T c) Element 114 should have a total of 4 valence electrons in the ground state. ← under Pb, so Group 4A
F d) The periodic table predicts that iridium (element #77) should have a total of 7 unpaired electrons in various d orbitals (in the ground state). ← element with 4 valence e⁻
T e) Mercury (element #80) has a total of 14 electrons in various f orbitals (in the ground state). Hg: $[Xe] 6s^2 4f^{14} 5d^{10}$; Hg has 14 electrons in f orbitals.
← Ir: $[Xe] 6s^2 4f^{14} 5d^7$ 1 1 1 1 1 ← Ir has 3 unpaired electrons. 5d

25/17
12/4

25. A microwave oven emits 1.0×10^{28} photons of wavelength 4.0 cm each minute of operation. If a cup of coffee requires 77,000 J to bring it to boiling, how many seconds are required by this microwave oven to boil the coffee? Assume all the microwave energy is absorbed by the coffee.
- $E = \frac{hc}{\lambda}$ $E = \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s} (2.998 \times 10^8 \text{ m/s})}{4.0 \times 10^{-2} \text{ m}} = 4.966 \times 10^{-24} \text{ J}$ ← energy of 1 photon
- a) 13 seconds b) 35 seconds c) 52 seconds

- d) 70 seconds e) 93 seconds

$77,000 \text{ J} \left(\frac{1 \text{ photon}}{4.966 \times 10^{-24} \text{ J}} \right) \left(\frac{60 \text{ s}}{1.0 \times 10^{28} \text{ photons}} \right) = 93 \text{ s}$

26/18
13/5

26. A certain metal ion (M^{n+}) forms an ionic compound with phosphorus. The molar mass of the compound is 238.0 g/mol. If the charge on the metal ion is +2, which of the following is the identity of the metal, M? M^{2+} with P^{3-} gives M_3P_2 formula.

Let x = molar mass of M

- a) Pb b) U c) Pm d) Ge e) Ni

$238.0 = 3x + 2(30.97), x = 58.69 \text{ g/mol}$

From periodic table, the metal is Ni.

Form

A/B
C/DCHEMISTRY 102
Hour Exam I

Fall 2019

Page 7

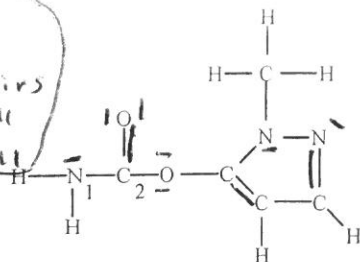
Isolan, an organic compound used as an insecticide, has the following skeletal structure. Complete a Lewis structure and answer the following two questions.

Organic "rules"

C: 4 bonds + 0 lone pairs

N: 3 " + 1 " "

O: 2 " + 2 " "



N₁ has tetrahedral geometry
so 109° bond angles.

C₂ has trigonal planar geometry
so 120° bond angles.

- 27/16 27. How many π bonds are in the complete Lewis structure?
22/15 There are 3 double bonds in Lewis structure. Each double bond consists of 1 σ and 1 π bond. So 3 total π bonds.
a) 0 b) 1 c) 2 d) 3 e) 4
- 28/17 28. What are the approximate bond angles about the nitrogen atom labeled 1 and the carbon atom labeled 2, respectively?
13/16 a) 90°; 180° b) 120°; 120° c) 120°; 180° d) 109°; 90° e) 109°; 120°

- 29/8 29. How many of the following formula/name combinations is/are correct?
24/17
- | | | |
|------------------------------------|-----------------------|---|
| Al ₂ S ₃ | dialuminum trisulfate | ionic compound; aluminum sulfide is correct. |
| CuCO ₃ | copper(I) carbonate | ionic compound; CO ₃ ²⁻ has 2- charge. copper(II) carbonate is correct. |
| Fe(ClO ₄) ₂ | iron(IV) chlorate | ClO ₄ ⁻ has 1- charge. iron(II) perchlorate is correct. |
| CsBr | bromium ceside | ionic; cesium bromide is correct. |
- yes S₂F₄ disulfur tetrafluoride ← correct for this covalent compound.
- a) 1 b) 2 c) 3 d) 4 e) 5 (All are correct.)

- 30/9 30. How many neutrons and electrons are in ¹²⁷I⁻?
25/18 I is element 53 protons. # neutrons = 127 - 53 = 74 neutrons
- a) 128 neutrons and 53 electrons b) 74 neutrons and 54 electrons
- c) 127 neutrons and 54 electrons d) 127 neutrons and 52 electrons
- e) 74 neutrons and 52 electrons
- Because we have I⁻ ion, # electrons = 53 + 1 = 54 electrons

Form
A/B
C/D

CHEMISTRY 102
Hour Exam I

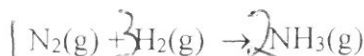
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is balanced reaction.
For 1 mol N_2 reacted, $\Delta H = -93 \text{ kJ}$ (from problem).
From balance reaction, 3 mol H_2 react with 1 mol N_2 . So 93 kJ of heat will be released for 3 mol H_2 reacted (or 2 mol NH_3 produced).

Fall 2019

Page 8

31/31
31/31

31. Consider the following unbalanced equation:



If 93 kJ of an energy are released for every 1 mole of nitrogen (N_2) reacted by the above reaction, what would be the enthalpy change for the reaction when 3 moles of hydrogen (H_2) are reacted?

$$\Delta H = -93 \text{ kJ}$$

- a) $\Delta H = 279 \text{ kJ}$ b) $\Delta H = -279 \text{ kJ}$ c) $\Delta H = 31 \text{ kJ}$
d) $\Delta H = -31 \text{ kJ}$ (e) $\Delta H = -93 \text{ kJ}$

32/32
32/32

32. Assume Illini rays were recently discovered as a new type of electromagnetic radiation and assume that they possess extremely long wavelengths ($\lambda = 100 \text{ km}$). Comparing Illini rays to microwaves ($\lambda = 1.0 \text{ cm}$), which of the following statements (a-c) is/are true?

- a) A photon of Illini rays is more energetic than a photon of microwaves.
(b) The frequency of microwaves is higher than the frequency of Illini rays.
c) Microwaves will have a faster velocity than Illini rays.
d) All of the above statements (a-c) are false.
e) All of the above statements (a-c) are true.

Since $\lambda_{\text{Illini}} > \lambda_{\text{micro}}$, $\nu_{\text{Illini}} < \nu_{\text{micro}}$ and $E_{\text{Illini}} < E_{\text{micro}}$.

33/33
33/33

33. An element in the ground state has one unpaired electron in the 5p atomic orbitals. The element reacts with chlorine to form a covalent compound. Which of the following is this element? In ($5p^1$) and I ($5p^5$) both have 1 unpaired electron.

- a) Tl b) At c) In (d) I e) Ga

Since we have a covalent compound, the other element bonded to Cl must be a nonmetal. This means I is the correct answer.

34/34
34/34

34. A 25.00 g sample of an unknown solid is placed in a graduated cylinder and then the cylinder is filled to the 50.0 mL mark with benzene. The mass of benzene and solid together is 58.80 g. Assuming that the solid is insoluble in benzene and the density of benzene is 0.880 g/cm^3 , what is the density of the unknown solid?

density = $\frac{\text{mass}}{\text{volume}}$; mass of solid = 25.00 g. Need volume of solid.

- (a) 2.16 g/cm^3 b) 0.651 g/cm^3 c) 4.25 g/cm^3 d) 1.18 g/cm^3 e) 3.68 g/cm^3

mass of benzene = $58.80 \text{ g} - 25.00 \text{ g} = 33.80 \text{ g}$ benzene
Volume of benzene = $33.80 \text{ g benzene} \left(\frac{1 \text{ cm}^3}{0.880 \text{ g}} \right) = 38.41 \text{ cm}^3$

35. 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

$$\text{Volume of solid} = 50.0 - 38.41 = 11.59 \text{ cm}^3$$

$$\text{density} = \frac{25.00 \text{ g}}{11.59 \text{ cm}^3} = 2.16 \text{ g/cm}^3$$