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(Please Print)

Chem 103 - Section 1
Sample Final Examination

This test consists of eleven (11) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

A separate copy of the periodic table will be provided with this test. Any necessary constants will be given along with the question to which they pertain.

DO NOT WRITE BELOW THIS LINE

DISCLAIMER

This is a copy of a typical final exam in Chem 103. Your test will be different. This test is being posted to give you a sense of the format, style, scope, and level of a typical test on this material. This test may have questions on topics that will not be covered on the test you take. Moreover, your test may have questions on topics that are not covered on this test. Posting this test in no way limits the format, style, scope, or level of the test that you will take. **Do not limit your preparation to the material on this sample test.**

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1. (90 points; 3 points each) Circle the correct answer to each of the following. In cases where numerical answers are required, select the answer closest to the one you calculate, making allowance for differences in rounding, etc.

a. Law of Constant Composition (also called Law of Definite Proportions)

Davy Dalton Lavoisier (Proust) Bohr

b. Wave equation for freely moving electrons and other particles

(deBroglie) Einstein Schrödinger Bohr Balmer

c. Calculated the charge to mass ratio for the electron

Rutherford (Thomson) Planck Wein Bohr

d. The I.U.P.A.C. name for $Fe_2(SO_4)_3$

diferric trisulfate iron(II) sulfate (iron(III) sulfate) ferric sulfate iron(II) sulfite

e. In water, this compound is properly called hydrosulfuric acid

H_2SO_4 H_2SO_3 (H_2S) S_8 SO_3

f. If the isotope of nickel ($Z = 28$) whose mass number (A) is 58 forms a Ni^{2+} ion, the ion has the following composition of protons (p), neutrons (n), and electrons (e):

$28p$, $58n$, $26e$ $28p$, $58n$, $30e$ $28p$, $30n$, $28e$

($28p$, $30n$, $26e$) $28p$, $30n$, $30e$

g. Is a strong electrolyte in water

(Hg_2Cl_2) CH_3CO_2H SiO_2 HNO_2 $C_{12}H_{22}O_{11}$

h. What is the energy in Joules of a photon whose wavelength is 525 nm? ($h = 6.64 \times 10^{-34}$ J·s; $c = 3.00 \times 10^{8}$ m·s^{-1})

(3.79×10^{-19} J) 1.99×10^{-25} J 1.26×10^{-27} J 3.79×10^{-28} J 1.05×10^{-31} J

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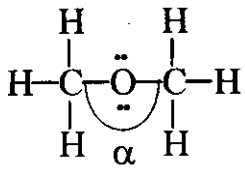
i. Complete and balance the following skeletal equation with *lowest whole number coefficients*:

$$C_6H_5CO_2H(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

The coefficient for $O_2(g)$ is

17 (15) 30 34 7

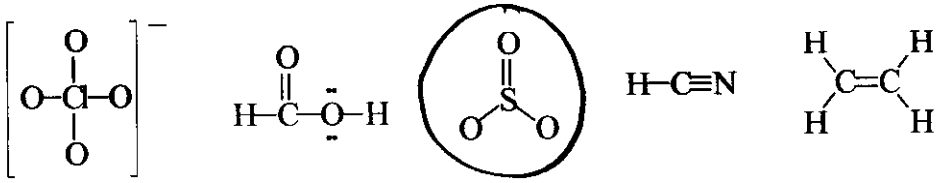
j. Consider the following Lewis model.



Which of the following best describes the size of the angle marked α?

~90° (~109.5°) ~120° ~180° exactly 180°

k. Which molecule or ion among the following has a *delocalized* π system (only central atom electrons shown)?



l. Judging from trends in electronegativity, which one of the following bonds is *most* polar

(Sn-Cl) C-N N-N S-O S-Br

m. Consider :N≡N:, diatomic nitrogen. In terms of valence bond theory, the nitrogen-nitrogen bond could be described as

σ only π only σ + π (σ + π + π) ionic

n. Among the following, the species that has a positive value of electron affinity, *A*, for acquiring one additional electron

Cl O C N (I^-)

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o. Among the following, which result definitely has two significant figures?

7.51 + 5.6 (98.3 – 96.37) 54.6/6.00 12.5 × 4 500/25

p. The following indicate transitions between two *n* states of the hydrogen atom. Which one would result in emission of visible light?

2→1 4→5 (3→2) 4→3 1→∞

q. Of the following, the electromagnetic radiation with the highest energy is

infrared visible radio ultraviolet (gamma rays)

r. Among the following, the only one with a fully filled 4*f* subshell

$_{40}Zr$ $_{54}Xe$ $_{57}La$ ($_{72}Hf$) $_{50}Sn$

s. How many milliliters of 0.100 M NaOH(*aq*) are required for complete neutralization of 25.0 mL of 0.120M H_2SO_4, a diprotic acid?

3.00 mL 30.0 mL 6.00 mL (60.0 mL) 15.0 mL

t. The specific heat of copper is 0.385 J/°C·g. How much heat is liberated when a 1.94-g block of copper is cooled from 35.0 °C to 20.0 °C?

29.1 J (11.2 J) 5.78 J 2.98 J 0.747 J

u. Which of the following ions does not have a noble gas configuration?

$_{13}Al^{3+}$ $_{53}I^{-}$ $_{34}Se^{2-}$ $_{38}Sr^{2+}$ ($_{31}Ga^{3+}$)

v. If treated with HCl(*aq*), which one of the following solutions would give no metathetical reaction?

$(NH_4)_2CO_3(aq)$ $PbNO_3$ (*aq*) KOH(*aq*) ($NaNO_3(aq)$) $Na_2SO_3(aq)$

w. Which one of the following solutions contains the highest concentration of nitrate ion?

0.10 M $Al(NO_3)_3$ 0.25 M KNO_3 0.12 M $Ca(NO_3)_2$

(0.12 M NH_4NO_3 + 0.12 M $Pb(NO_3)_2$) 0.050 M $Fe(NO_3)_3$ + 0.12 M $NaNO_3$

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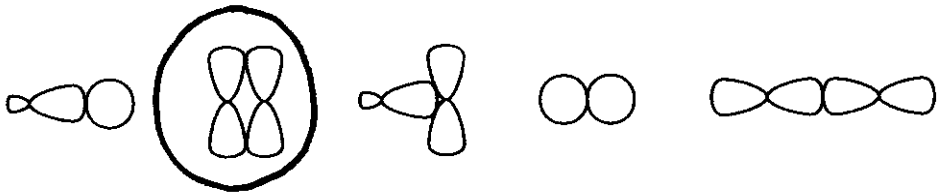
x. $2Na(s) + 3N_2(g) \rightarrow 2NaN_3(s)$ is an example of which one of the following types of reaction?

metathesis (combination) decomposition combustion double displacement

y. Which one of the following would best be described as ionic?

(LiF(*s*)) HF(*g*) CO(*g*) $I_2(s)$ $SiO_2(s)$

z. Which of the following sketches of orbitals on two adjacent atoms represents formation of a π bond?



aa. The quantum number most closely identified with the *orientation* of an orbital is

n *l* (m_l) m_s *k*

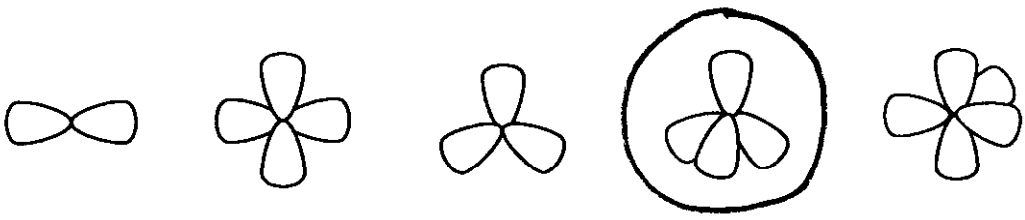
bb. Of the following, the one that probably has the lowest lattice energy is

LiCl Al_2O_3 MgF_2 (RbI) CaO

cc. Which of the following is largest?

O^{2-} (S^{2-}) Ar Na^+ Al^{3+}

dd. Which of the following sketches represents a set of sp^3 hybrids?



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2. (10 points; 5 points each) Use your knowledge of weak electrolytes, gas-forming reactions, and insoluble compounds to write balanced ***net** ionic equations* for each of the following, using lowest whole-number coefficients. Be sure to write any weak electrolytes or insoluble compounds in "molecular" form.

a. $(NH_4)_2SO_4(aq) + Ba(NO_3)_2(aq)$

$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

b. $Na_2CO_3(aq) + CH_3CO_2H(aq)$

$CO_3^{2-}(aq) + 2CH_3CO_2H(aq) \longrightarrow CO_2(g) + H_2O(l) + 2CH_3CO_2^-(aq)$

3. (8 points; 4 points each) Give the ***complete*** electronic configuration (using the usual spectroscopic notation; i.e., $1s^2 2s^2$ ...) for the following:

$_{34}Se^{2-}$ $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

$_{26}Fe^{2+}$ $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ $(4s^0)$

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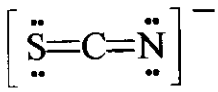
4. (12 points) The following is the principal resonance form of the thiocyanate ion:



Draw Lewis structures for the two lesser contributing resonance forms (6 points), assign formal charges for each form (3 points), and name the hybrid orbitals on the carbon atom in the space below (3 points).

The hybrid orbitals on the carbon atom are sp.

5. (12 points) A certain hydrocarbon with a molecular weight of 56.10 u consists of 85.63% C and 14.37 % H. What is its molecular formula? Show work to justify your answer.

Assume 100g:

$$\text{mol C} = (85.63\text{g C})\left(\frac{\text{mol C}}{12.01\text{g C}}\right) = 7.130\text{ mol C}$$

$$\text{mol H} = (14.37\text{g H})\left(\frac{\text{mol H}}{1.008\text{g H}}\right) = 14.26\text{ mol H}$$

CH_2 f.w. = 14.03

m.w./f.w. = 56.10/14.03 = 4 $\Rightarrow$ C_4H_8

OR Assume one mole compound = 56.10g:

$$\text{mol C} = (56.10\text{g comp})\left(\frac{0.8563\text{g C}}{\text{g comp}}\right)\left(\frac{\text{mol C}}{12.01\text{g C}}\right) = 4$$

$$\text{mol H} = (56.10\text{g comp})\left(\frac{0.1437\text{g H}}{\text{g comp}}\right)\left(\frac{\text{mol H}}{1.008\text{g H}}\right) = 8$$

C_4H_8

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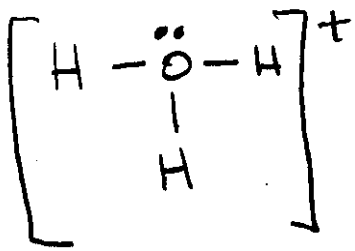
6. (36 points; 12 points each) For each of the following molecules or ions draw a Lewis dot diagram (5 points), draw *and* name the shape (3 + 2 points), and indicate whether the species is polar or nonpolar (2 points).

a. H_3O^+

[Lewis model]

3H3
O6
+-1
8



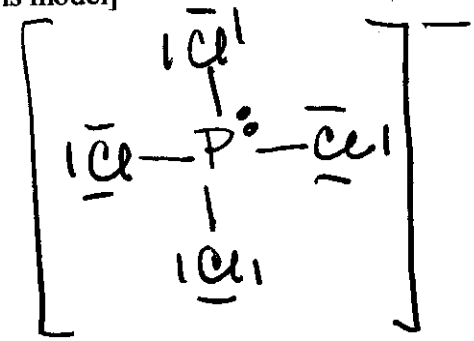
[Shape drawing]

trigonal pyramid (name of shape) | yes (polar?)

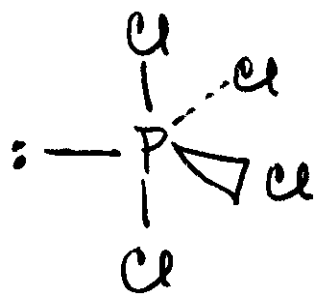
b. PCl_4^-

[Lewis model]

P 5
4Cl 28
- 1
34



[Shape drawing]



irregular tetrahedron ("see-saw") (name of shape) | yes (polar?)

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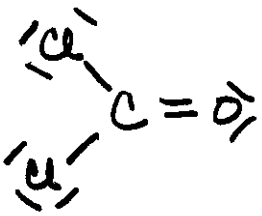
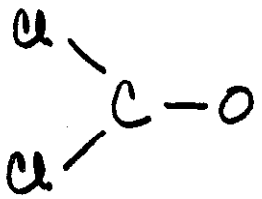
c. Cl_2CO

[Lewis model]

2 Cl 14
C 4
O 6
24



[Shape drawing]



trigonal planar
(name of shape)

yes
(polar?)

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7. (16 points) Calculate the standard enthalpy of formation of $Ca(OH)_2(s)$, given the following data:

a $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ $\Delta H^\circ = -1271.0$ kJ

b $Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(l)$ $\Delta H^\circ = +64.9$ kJ

c $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H^\circ = -571.7$ kJ

Target reaction:

$$Ca(s) + H_2(g) + O_2(g) \longrightarrow Ca(OH)_2(s) \quad \Delta H_f^\circ = ?$$

$\frac{1}{2}$ a $Ca(s) + \frac{1}{2}O_2(g) \longrightarrow \cancel{CaO(s)}$ $\Delta H^\circ = (\frac{1}{2})(-1271.0) = -635.5$

$-$ b $\cancel{Ca(OH)_2(s)} + \cancel{H_2O(l)} \longrightarrow Ca(OH)_2(s)$ $\Delta H^\circ = -64.9$

$\frac{1}{2}$ c $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow \cancel{H_2O(l)}$ $\Delta H^\circ = (\frac{1}{2})(-571.7) = -285.85$

$Ca(s) + H_2(g) + O_2(g) \rightarrow Ca(OH)_2(s)$ $\Delta H^\circ = -986.25$ kJ

$= \boxed{-986.2 \text{ kJ}}$

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8. (16 points) Consider the following reaction

$$2H_3PO_4(aq) + 3Ca(OH)_2(s) \rightarrow Ca_3(PO_4)_2(s) + 6H_2O(l)$$

How many grams of $Ca_3(PO_4)_2(s)$ (f.w. = 310.18 u) should be produced when a 1.74-g sample of $Ca(OH)_2(s)$ (f.w. = 74.09 u) is treated with 64.0 mL of 0.250 M $H_3PO_4(aq)$ solution? Your work must show an explicit determination of the limiting reagent.

$$\text{mol } Ca(OH)_2 = (1.74\text{ g})\left(\frac{\text{mol}}{74.09\text{ g}}\right) = 0.02348\text{ mol} = 23.48\text{ millimol}$$

$23.48 / 3 = 7.828$ "sets"

$$\text{millimol } H_3PO_4 = (64.0\text{ mL})(0.250\text{ M}) = 16\text{ millimol}$$

$16 / 2 = 8$ "sets"

$\Rightarrow$ $Ca(OH)_2$ limits

$$\text{g } Ca_3(PO_4)_2 = (0.02348\text{ mol } Ca(OH)_2)\left(\frac{\text{mol } Ca_3(PO_4)_2}{3\text{ mol } Ca(OH)_2}\right) \times \left(\frac{310.18\text{ g } Ca(OH)_2}{\text{mol } Ca_3(PO_4)_2}\right) = \boxed{2.43\text{ g } Ca_3(PO_4)_2}$$

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