

**City College, Chemistry Department
Chemistry 10301, sections T and T2, Prof. T. Lazaridis
Final exam, Dec 22, 2005**

Name (last name first): _____

I.D. Number: _____

Workshop leader: _____

Note: There are 17 questions in this exam. Fill in your answer in the blank space provided immediately following each question. 1/2 point will be subtracted every time you report a numerical result with an incorrect number of significant figures.

A Data Sheet with useful information is at the end.

1. (4) Write the names of the elements below next to their atomic symbols:

Ti **Titanium**

Mg **Magnesium**

Al **Aluminum**

Kr **Krypton**

2. (4) Write the molecular formula next to the names of the following compounds:

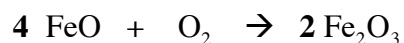
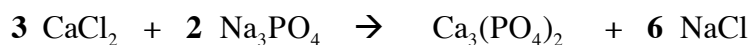
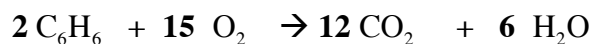
Magnesium Sulfate **MgSO₄**

Sodium Carbonate **Na₂CO₃**

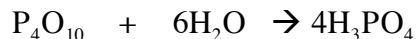
Barium Hydroxide **Ba(OH)₂**

Potassium Nitrate **KNO₃**

3. (8) Balance the following chemical equations:



4. (8) How many grams of phosphoric acid will form when 30.0 g of P_4O_{10} is mixed with 75.0 g of water? The reaction is



Molar masses:

$$P_4O_{10} : 4 \times 30.97 + 10 \times 16.00 = 283.88 \text{ g/mol}$$

$$H_2O : 2 \times 1.008 + 16.00 = 18.02 \text{ g/mol}$$

$$H_3PO_4 : 30.97 + 4 \times 16.00 + 3 \times 1.008 = 97.99 \text{ g/mol}$$

$$P_4O_{10} : 30.0 / 283.88 = 0.106 \text{ mol}$$

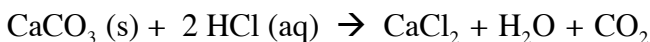
$$H_2O : 75.0 / 18.02 = 4.16 \text{ mol}$$

$4.16 / 0.106 = 39.24 \gg 6$ therefore P_4O_{10} is limiting

0.106 moles P_4O_{10} will give $4 \times 0.106 = 0.424 \text{ mol } H_3PO_4$

$$\times 97.99 \text{ g/mol} = 41.5 \text{ g } H_3PO_4$$

5. (5) It was found that 35.45 mL of a HCl solution was needed to dissolve 1.110 g of pure $CaCO_3$. What was the molarity of the HCl solution? The reaction is:



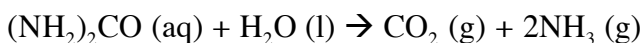
$$\text{Molar mass of } CaCO_3 : 40.08 + 12.01 + 3 \times 16.00 = 100.09 \text{ g/mol}$$

$$1.110 / 100.09 = 0.01109 \text{ mol } CaCO_3$$

From the stoichiometry, this requires $2 \times 0.01109 = 0.02218 \text{ mol HCl}$

$$\text{Molarity} = 0.02218 \text{ mol} / 35.45 \times 10^{-3} \text{ L} = 0.6257 \text{ M}$$

6. The enzyme-catalyzed reaction of urea with water is represented by the equation:



a) (3) How many mL of NH_3 , measured at 37°C and 755 torr, will be produced when 5.00 g of urea reacts with excess water?

Molar mass of urea: $2 \times 14.01 + 4 \times 1.008 + 12.01 + 16.00 = 60.06 \text{ g/mol}$

$$5.00 / 60.06 = 0.08325 \text{ mol urea}$$

This amount will produce $2 \times 0.0833 = 0.166 \text{ mol NH}_3$

$$\begin{aligned} \text{Ideal gas eq: } V &= nRT/P = 0.166 \text{ mol} \times 62.364 (\text{L torr/mol K}) (37 + 273.15 \text{ K}) / 755 \text{ torr} = \\ &= 4.26 \text{ L} = 4260 \text{ mL} \end{aligned}$$

b) (3) What will be the total volume, in mL, of gaseous products produced during the reaction of part (a)?

The number of moles of products now is 3 instead of 2 per mol urea.

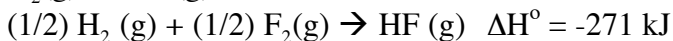
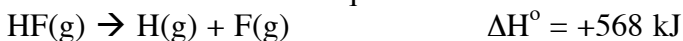
So, just multiply the previous result by 3/2:

$$4260 \times 3/2 = 6390 \text{ mL}$$

7. (7) Use Hess's law to calculate the standard enthalpy for the reaction



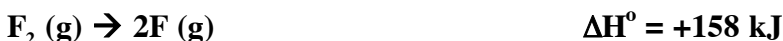
from the thermochemical equations:



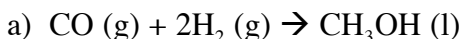
Multiply the first and third by 2 and flip the second:



— **Add these up**

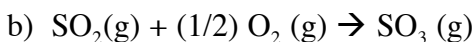


8. (6) Use enthalpy of formation data to compute standard enthalpy changes for the following reactions at 25 °C. State whether the reactions are endothermic or exothermic.



From the datasheet:

-238.7 – (-110.5) = -128.2 kJ/mol exothermic



-395.7 – (-296.8) = -98.9 kJ/mol exothermic

9. (3) Calculate and compare the de Broglie wavelengths of an electron, a proton, and a 0.40 Kg ball each traveling at 50 m/sec.

$\lambda = h / mv$ **Get h and the masses of electron, proton from datasheet**

1J = 1N X 1m = 1 Kg m²/s²

Ball: $6.626 \times 10^{-34} \text{ Js} / (0.40 \text{ Kg } 50 \text{ m/s}) = 3.3 \times 10^{-35} \text{ m}$

Proton: $6.626 \times 10^{-34} \text{ Js} / (1.67262 \times 10^{-27} \text{ Kg } 50 \text{ m/s}) = 7.9 \times 10^{-9} \text{ m}$

Electron: $6.626 \times 10^{-34} \text{ Js} / (9.10939 \times 10^{-31} \text{ Kg } 50 \text{ m/s}) = 1.5 \times 10^{-5} \text{ m}$

The lighter the particle, the smaller the de Broglie wavelength

10. (5) What is the wavelength of a photon emitted when a hydrogen atom falls from the n=3 state to the ground state? What type of electromagnetic radiation does this correspond to?

$\Delta E = -2.179 \times 10^{-18} (1/1^2 - 1/3^2) = 1.937 \times 10^{-18} \text{ J}$

$\Delta E = hv = h c / \lambda \Rightarrow \lambda = h c / \Delta E = 6.626 \times 10^{-34} \text{ Js } 2.9979 \times 10^8 \text{ m/s} / 1.937 \times 10^{-18} \text{ J} =$

$= 1.02 \times 10^{-7} \text{ m} = 102 \text{ nm}$

Ultraviolet

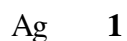
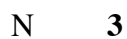
11. (4) Write an abbreviated (noble gas core) electron configuration for the following:



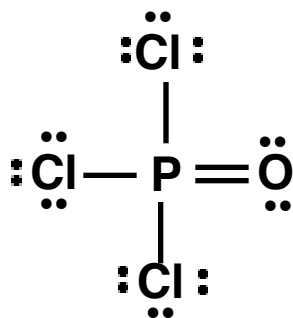
12. (2) Rank the atoms O, B, In in terms of electronegativity.



13. (4) How many unpaired electrons does each of the following atoms have?



14. (a) (5) Write down the best Lewis structure for phosphorus oxychloride (POCl₃) (i.e., the one with the lowest formal charges).



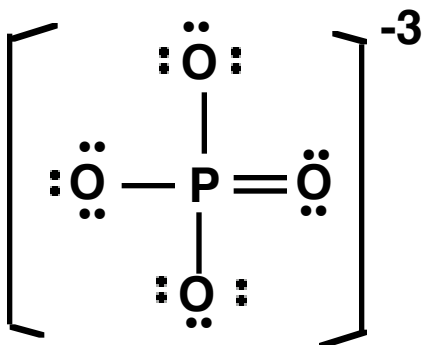
Expanded octet, zero formal charges

(b) (3) What is the molecular geometry of this compound?

Tetrahedral

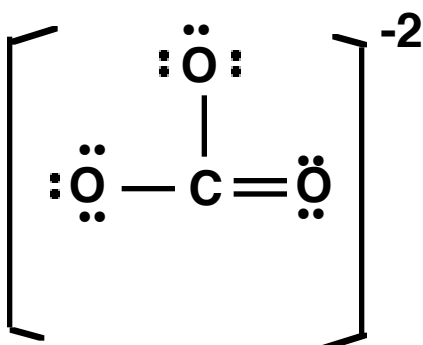
15. (12) Use Lewis structures and the VSEPR method to predict the molecular geometry and the bond angles of the following ions:

a) PO_4^{3-}



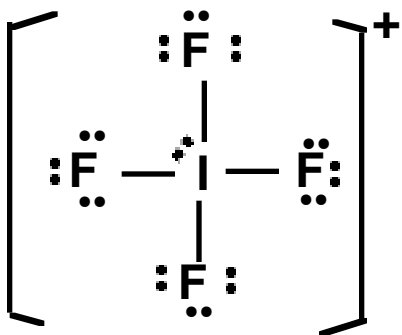
Tetrahedral, AX_4 , Angle= 109.5

b) CO_3^{2-}



Trigonal planar, AX_3 , Angle =120

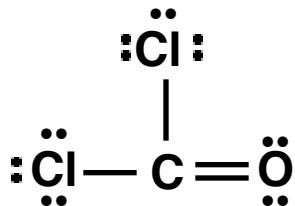
c) IF_4^+



**Trigonal Bipyramidal, AX_4E , Molecular geometry: Seesaw,
Angles: ~180, 120, 90 (lone pair repulsion)**

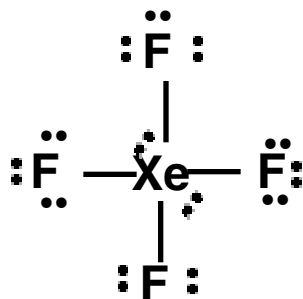
16. (9) Draw Lewis structures and give the molecular geometry and type of hybridization around each central atom:

a) COCl_2



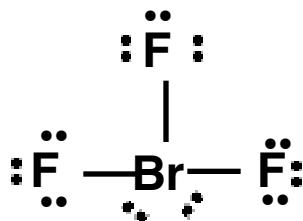
AX_3 , Trigonal planar, sp^2

b) XeF_4



Octahedral, AX_4E_2 , molecular geometry: square planar, hybridization: sp^3d^2

c) BrF_3



Trigonal Bipyramidal, AX_3E_2 , molecular geometry: T-shape, hybridization: sp^3d

+6

17. (5) Give the oxidation number of S in each of the following molecules and ions:

- | | |
|--------------------------------|----|
| a) H_2SO_4 | +6 |
| b) S_8 | 0 |
| c) H_2S | -2 |
| d) $\text{S}_2\text{O}_3^{2-}$ | +2 |
| e) S_4N_4 | +3 |

DATA SHEET

Speed of light : 2.9979×10^8 m/s

Planck's constant : 6.626×10^{-34} Js

$E_n = -2.179 \times 10^{-18}$ J/n²

Mass of a proton: 1.67262×10^{-24} g

Mass of an electron: 9.10939×10^{-28} g

R= 0.082058 L atm / (mol K) = 62.364 L torr / (mol K) = 8.3145 J / (mol K)

Substance ΔH_f° , kJ/mol

CO(g) -110.5

CO₂ (g) -393.5

CH₄ (g) -74.81

CH₃OH (l) -238.7

SO₂ (g) -296.8

SO₃ (g) -395.7