PRACTICE EXAM #3

Chem1A, General Chemistry I

1.) Consider the following formation of carbon tetrachloride (CCl_4) gas, from methane (CH_4) and chlorine gas (Cl_2). (35 pts)

$$CH_4\ (g) + 4\ Cl_2\ (g) \rightarrow CCl_4\ (g) + 4\ HCl\ (g) \qquad \Delta H_{rxn} = -397.3\ kJ/mol$$

Substance	ΔH_f (kJ/mol)
CH_4 (g)	-74.81
Cl_2 (g)	0
HCl (g)	-92.31

a.) Calculate the standard enthalpy of formation (ΔH_f) for CCl_4 (g) in kJ/mol using the above standard heats of formation.

Use $\Delta H_{rxn} = \sum m\ (\Delta H_f^o \text{ products}) - \sum n\ (\Delta H_f^o \text{ reactants})$

-397.3 kJ/mol = [(4)(-92.31 kJ/mol) + (1)(x)] – [(1)(-74.81 kJ/mol) + (4)(0)]

-397.3 kJ/mol = [-369.24 kJ/mol + x] – [-74.81 kJ/mol]

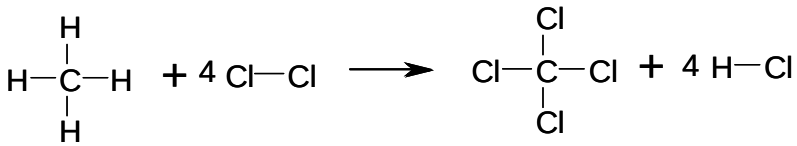
-472.11 kJ/mol = - 369.24 kJ/mol + x

-102.87 = x → **$\Delta H_f^o(CCl_4(g))$: -102.9 kJ/mol**

b.) Calculate the bond energy (ΔH) for a single C-Cl bond in gas phase.

Bond Type	H–C	Cl–Cl	H–Cl
Bond Energy (kJ/mol)	414	243	431

Draw the Lewis structures for the compounds in the reaction.



Use ΔH_{rxn} = [bonds broken] – [bonds formed]

-397.3 kJ/mol = [(4)(414 kJ/mol) + (4)(243 kJ/mol)] - [(4)(Cl-Cl) + (4)(431 kJ/mol)]

-397.3 kJ/mol = [(1656 kJ/mol) + (972 kJ/mol)] - [(4)(x) + (1724 kJ/mol)]

-397.3 kJ/mol = [2628 kJ/mol] - [4x + 1724 kJ/mol]

-1301.3 kJ/mol = - 4x

x = 325.325 → **325 kJ/mol**

2.) Write any possible quantum number set for the following electrons described.

a.) An electron in a first energy level s-orbital, spin up. **[1, 0, 0, + ½]**

b.) An electron in a third energy level d-orbital, spin down. **[3, 2, ±2, - ½]**

c.) Any electron in a fifth energy level f-orbital of any spin. **[5, 3, ±3, ± ½]**

3.) The threshold frequency for indium (In) is $9.96 \times 10^{14}\ s^{-1}$.

a.) Calculate the energy of this frequency, in J.

Use $E = h\nu$, where $h = 6.626 \times 10^{-34}$ J·s and $\nu = 9.96 \times 10^{14}\ s^{-1}$

$E = (6.626 \times 10^{-34}\ J{\cdot}s)(9.96 \times 10^{14}\ s^{-1}) = 6.5\underline{9}9 \times 10^{-19} \rightarrow$ **6.60×10^{-19} J**

b.) What is the minimum wavelength of light required to eject an electron from In, in nm?

Use $c = \lambda \cdot \nu$, or $\lambda = c/\nu$, where $c = 2.998 \times 10^{8}$ m/s, and $\nu = 9.96 \times 10^{14}\ s^{-1}$.

$\lambda = \frac{2.998 \times 10^{8}\ m/s}{9.96 \times 10^{14}\ s^{-1}} = 3.0\underline{1}0 \times 10^{-7}\ m \times \frac{1\ nm}{10^{-9}\ m} = 3.0\underline{1}0 \times 10^{2} \rightarrow$ **3.01×10^{2} or 301 nm**

c.) How many electrons would be ejected by 2.50 mJ of light with a wavelength of 2.15×10^{-12} m?

Convert 2.15×10^{-12} m to J/photon, so 1 photon = 1 e^- ejected

$E = \frac{(6.626\times10^{-34}\ J{*}s)(3.00\times10^{8}\frac{m}{s})}{2.15\times10^{-12}\ m} = 9.2\underline{4}5 \times 10^{-14}$ J/photon

$2.50\ mJ \times \frac{10^{-3}\ J}{1\ mJ} \times \frac{1\ photon}{9.245\times10^{-14}\ J} \times \frac{1\ e^-}{1\ photon} = 2.7\underline{0}3 \times 10^{10} \rightarrow$ **$2.70 \times 10^{10}\ e^-$**

4.) An electron in a hydrogen atom travels from n = 5 to n = 2. ($R_H = 1.097 \times 10^{7}\ m^{-1}$)

a.) Calculate the wavelength associated with this transition, in nm.

Use Rydberg's Equation: $1/\lambda = (R_H)[1/n_1^2 - 1/n_2^2]$ where $R_H = 1.097 \times 10^{7}\ m^{-1}$, $n_1 = 2$, and $n_2 = 2$.

$1/\lambda = (1.097 \times 10^{7}\ m^{-1})[(1/2^2) - (1/5^2)]$

$1/\lambda = (1.097 \times 10^{7}\ m^{-1})[(1/4) - (1/25)]$

$1/\lambda = (1.097 \times 10^{7}\ m^{-1})[0.21]$

$1/\lambda = 230\underline{3}700$ m-1

$\lambda = 4.34\underline{0}8 \times 10^{-7}\ m \times \frac{1\ nm}{10^{-9}\ m} = 4.34\underline{0}8 \times 10^{2} \rightarrow$ **4.341×10^{2} or 434.1 nm**

b.) Is this energy being **emitted** or **absorbed**? **Emitted (5 > 2, relaxing)**

4.) Write the electron configuration for the following elements. (14 pts)

a.) Br ___[Ar]$4s^2 3d^{10} 4p^5$___

b.) Pb ___[Xe]$6s^2 4f^{14} 5d^{10} 6p^2$___

c.) In ___[Kr]$5s^2 4d^{10} 5p^1$___

d.) Ba ___[Xe]$6s^2$___

e.) Which will have the **highest** electron affinity? ___Br (up and right)___

f.) Which one will have the **largest** atomic radius? ___Ba (down and left)___

g.) Which will have the **least** metallic character? ___Br (up and right)___

5.) Draw the **MOST PLAUSIBLE** Lewis structure for the following molecules, including all possible **resonance structures** as well as **formal charges**. (16 pts)

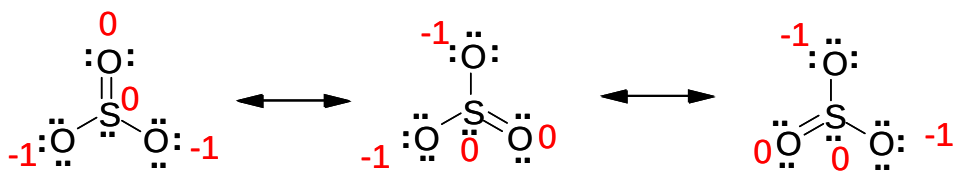
a.) SO_3^{-2}

Total: (1)(6 e^-) + (3)(6 e^-) + 2 e^- = 26 total e^-

3 bonds x (2 e^-) = 6 used e^-

20 needed e^-, so 26 total – 6 used – 20 needed = 0, structure is plausible.

S is period 3 and can have an expanded octet to minimize formal charges.



b.) O_3

Total: (3)(6 e^-) = 18 total e^-

2 bonds x (2 e^-) = 4 used e^-

16 needed e^-, so 18 total – 4 used – 16 needed = -2, need 1 multiple bond