US 110 Exam 3
Name Key
By submitting this exam, I affirm that I have neither given nor received unauthorized aid.

Useful Information: $q = m \times S \times \Delta T$, $\Delta E = q + w$, $w = -P\Delta V$, 1 Latm = 101 J, Bond Order = $\frac{\#bonding - \#antibonding}{2}$, U = $\frac{k|Z_1 Z_2|}{d}$, $\Delta E = \Delta H + w$, C_f = $E_{valence}$-(#bonds+$E_{nonbonding}$)

(1)(4points) Many power plants burn methane (natural gas) to generate electricity. The reaction for the combustion of methane is shown below. A small house needs 2.8 x 10^5 kJ of electricity a day. How much methane (in moles) must be burned to generate 2.8 x 10^5 kJ?

$CH_4(g) + 3O_2 \rightarrow CO_2(g) + 2H_2O(g)$ $\Delta H° = -802$ kJ/mole

2.8×10^5 kJ needed, 802 kJ/mole produced by the reaction

$\frac{2.8 \times 10^5 kJ}{802 kJ/mole} = 349$ moles of CH_4.

(2)(6 points) To 100.0 mL of water was added 0.250 moles (20.0 g) of NH_4NO_3. The initial temperature of the water was 20.0 °C. The final temperature of the water was 22 °C. Assume that the specific heat for the final solution is $4.18 \frac{J}{g \cdot °C}$ and the density of water is 1.00 g/mL.

$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$

What is the ΔH for the reaction and is the reaction endothermic or exothermic?

$q = m \times S \times \Delta T$ 100.0mL $H_2O \times \frac{1000g}{mL} = 1000g\ H_2O$

$q = (120.0g)(4.18 \frac{J}{g°C})(-12.4°C)$ $\Delta T = T_{fin} - T_{initial} = (22 - 20.1°C) = -12.4°C$

$q = -6420$ J from the water

$\therefore q = 6420$ J into the system $\Delta H = \frac{6420J}{0.250 moles} = 2.57 \times 10^4 \frac{J}{mole}$

$\therefore 25.7 \frac{kJ}{mole}$

(3)(2 points) Place the following in the order of increasing ionization energy:
Cs, As, Ca, S, He

Cs < Ca < As < S < He

(4)(2 points) Place the following in the order of increasing size:
P, Cl, As^{3-}, Se^{2-}

Cl < P < Se^{2-} < As^{3-}

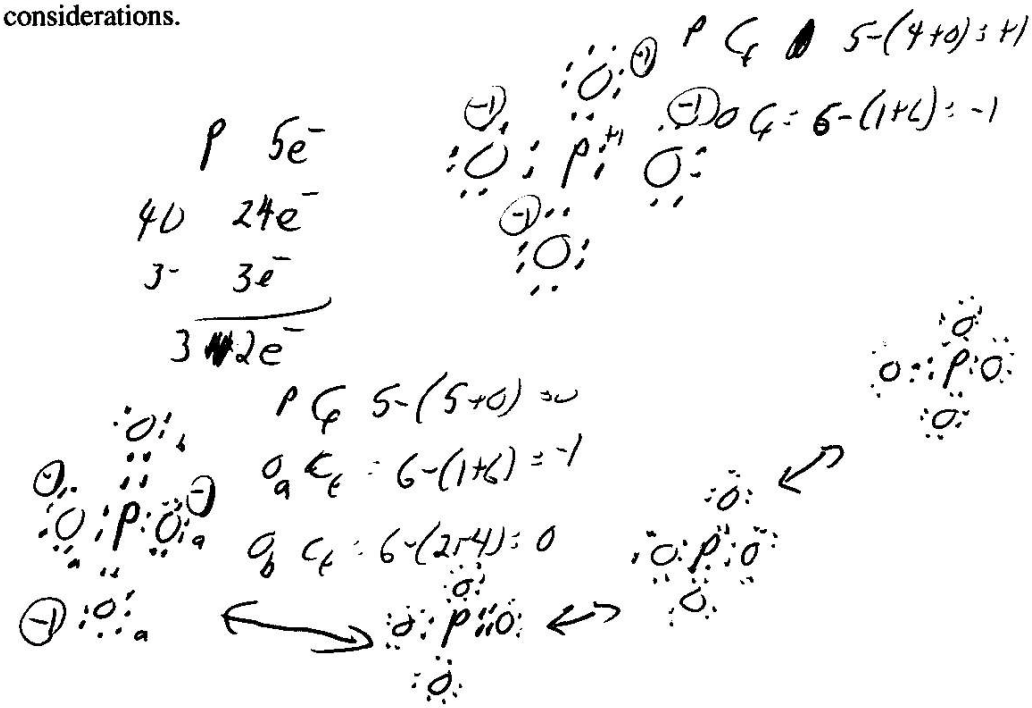
(5)(2 points) Which third row element should have the highest 4rth ionization energy?

I will accept Al or Si

(6)(2 points) Place the following in the order of increasing electronegativity:
B, Ga, N, Ba, Cs

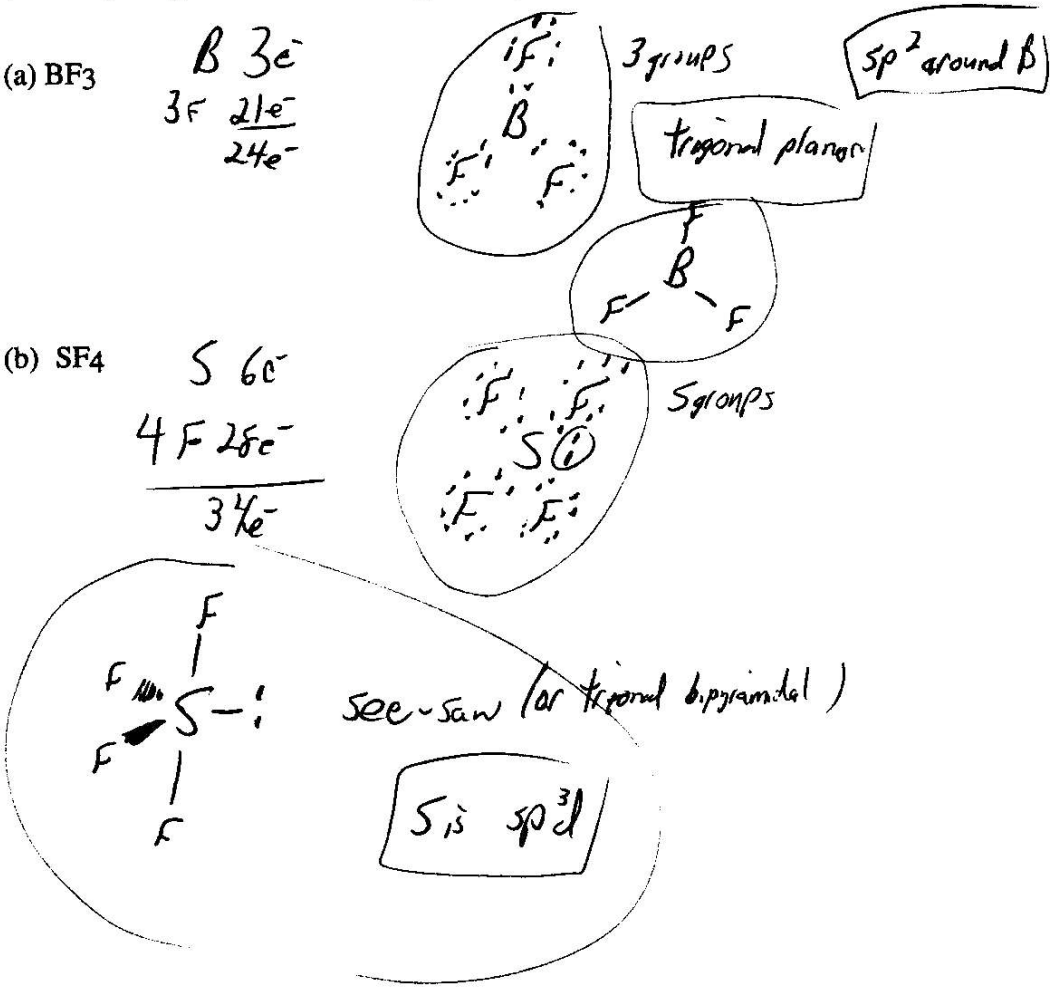
Cs < Ba < Ga < B < N

(7)(4 points) Draw the best Lewis dot structure(s) for PO_4^{3-}. Remember formal charge considerations.

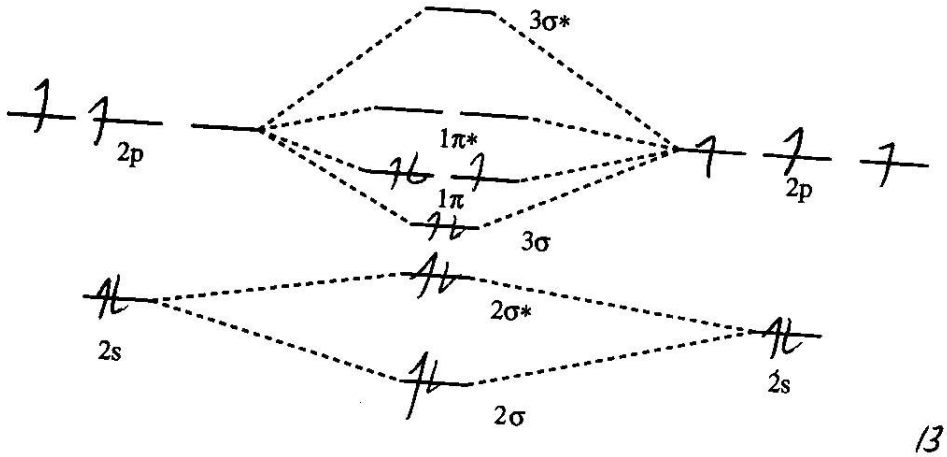


(8)(8 points) Draw the Lewis dot structures for the following species. Draw the 3D stucture (VSPER) and give the name of the geometry. Then, list the hybridization of the central atom.

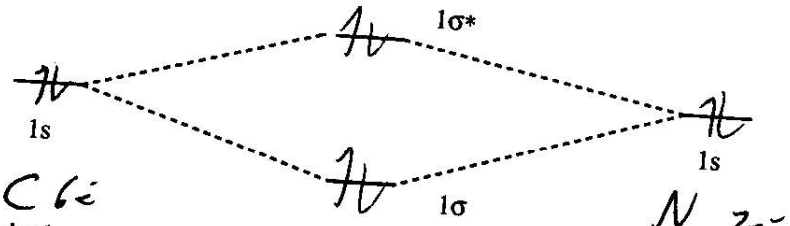
(a) BF_3



(9)(6 points)



13 total e⁻



C 6e⁻ N 7e⁻

(a) What is the ground state electron configuation of CN?

$1\sigma^2 1\sigma^{*2} 2\sigma^2 2\sigma^{*2} 3\sigma^2 1\pi^3$

(b) What is the bond order of CN?

$\frac{9-4}{2} = \frac{5}{2}$

(c) What should have a shortest bond distance, CN^+, CN or CN^-?

CN^+ Bond order $= \frac{8-4}{2} = 2$

CN Bond order $= 2.5$

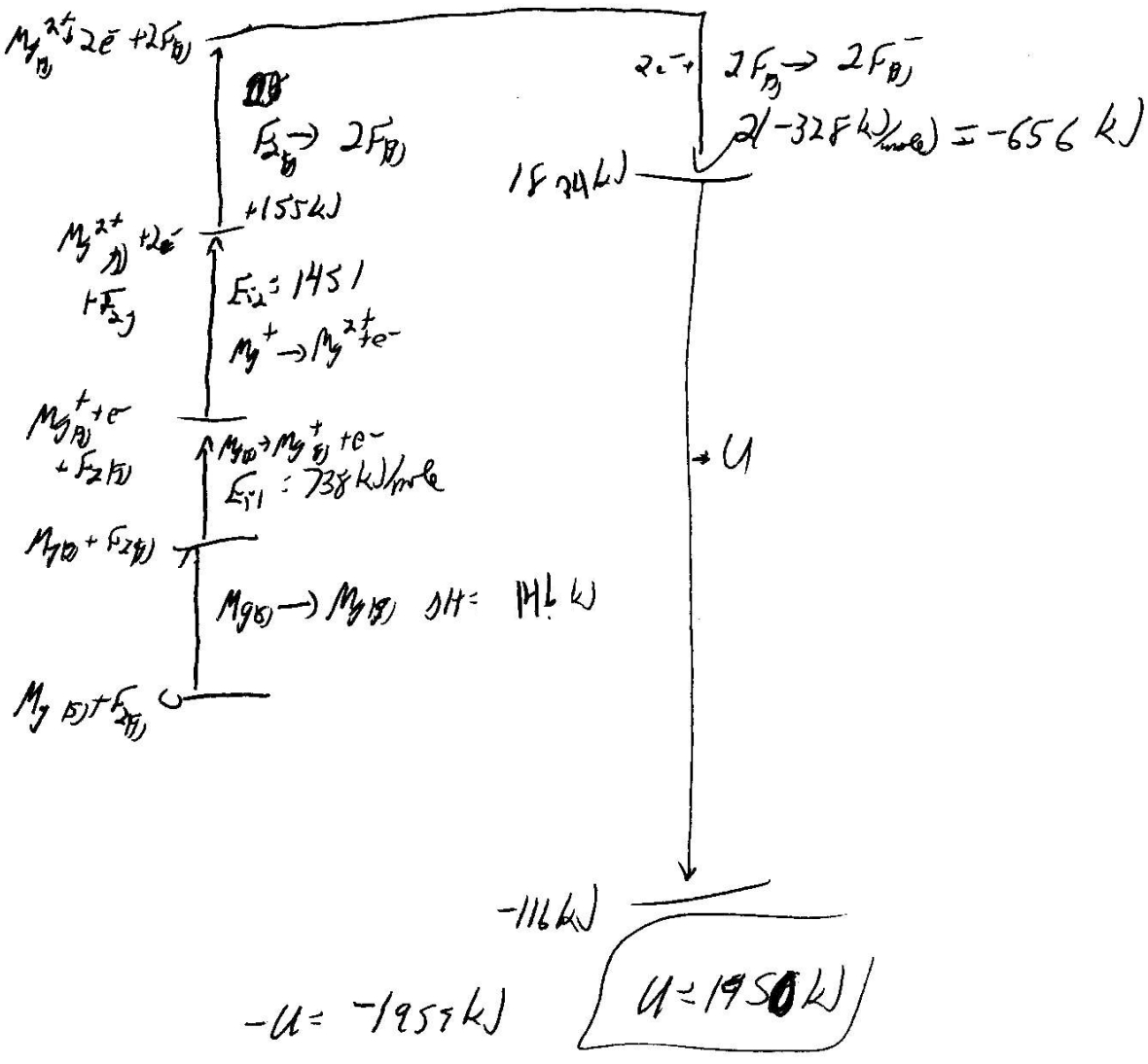
CN^- bond order $= \frac{10-4}{2} = 3$

$\therefore CN^-$ should have the shortest C-N distance

(10)(8 points) Create a Born-Haber cycle to find the U for the following reaction using the information below.

$Mg(s) + F_2(g) \text{ -----> } MgF_2(s)$ $\Delta H = -116$ kJ

F_2 bond dissociation energy = 155 kJ/mole
Mg $\Delta H_{sublimation}$ = 146 kJ/mole
Mg (g): E_{i1} = 738 kJ/mole, E_{i2} = 1451 kJ/mole
F(g) Electron Affinity = -328 kJ/mole



(11)(4 points) Arrange the following in order of increasing ionic bond strength.

$ZnCl_2$, Ca_3P_2, MgO, BaS, CsI

$U = \frac{k(z_1 z_2)}{d}$

	$(z_1 z_2)$
$ZnCl_2$	2
Ca_3P_2	6
MgO	4
BaS	4
CsI	1

$CsI < ZnCl_2 < BaS < MgO < Ca_3P_2$

(12)(4 points) Find ΔE for the following reaction assuming that when one mole of N_2 reacts with 3 moles of H_2 at 1 atmosphere of constant pressure, that the change in volume is -1.12 L.

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g) \quad \Delta H = -92.2 \text{ kJ}$$

$\Delta E = q + w$

$\Delta E = \Delta H + w$

$\Delta E = \Delta H - P\Delta V$

$P\Delta V = (1.00 \text{ atm})(-1.12 \text{ L}) = -1.12 \text{ L atm}$

$P\Delta V = -1.12 \text{ L atm} \times \frac{101 \text{ J}}{1 \text{ L atm}} = -113 \text{ J}$

$\Delta E = -92.2 \text{ kJ} - (-0.113 \text{ kJ}) = \boxed{-92.1 \text{ kJ}}$

Extra Credit:(4 points): In *Science and Modern Thought*, J. Arthur Thomson lists several limitations of science. What is one of them?

Science can discover what? & how? but not why? (There are others that are acceptable answers).