1. (30 points) KBr is 78% ionic. Use Coulomb's law to estimate the energy required to dissociate KBr (which has a bond length of 2.82 Angstroms) into K^+ and Br^-. Note that 78% ionicity implies that only 0.74e of charge is transferred from K to Br.

$(K^{+\delta}\ Br^{-\delta} = -0.78e) \longrightarrow K^+ + Br^-$

$R = 2.82\,\text{Å}$

$$\Delta E = 0 - \left(\frac{Q_1 = +\delta\ Q_2 = -\delta}{4\pi\epsilon_0 R}\right) = -\frac{(+0.78e)(-0.78e)}{4\pi\epsilon_0 (2.82\times10^{-10}\,m)}$$

$$= +\frac{(0.78)^2(1.6\times10^{-19})^2\ C^2}{4\pi(8.85\times10^{-12})\ C^2\ (2.82\times10^{-10})\ J\,m}$$

$$= 5.0\times10^{-19}\ J$$

2. (30 points) Ammonia and oxygen react to give nitrous oxide and water according to the (unbalanced!) reaction

$$NH_3 + O_2 \rightarrow NO + H_2O.$$

If we start with 6.8 g of NH_3 and 6.8 g of O_2, how much of each reactant and product is present after the reaction has gone to completion?

$$NH_3 + \frac{5}{4}O_2 \longrightarrow NO + \frac{3}{2}H_2O$$

(or $4\,NH_3 + 5\,O_2 \longrightarrow 4\,NO + 6\,H_2O$

$\frac{6.8\ g\ NH_3}{17\ g\ NH_3/mole\ NH_3} = 0.40$ moles NH_3

Need $\frac{5}{4}(0.40)$ moles O_2 = 0.50 moles O_2

i.e., $(0.50\ moles\ O_2)\left(\frac{32\ g\ O_2}{mole\ O_2}\right) = 16\ g\ O_2$

But only have 6.8 g of O_2

Thus **no O_2 remains**

$\frac{6.8\ g\ O_2}{32\ g\ O_2/mole\ O_2} = 0.21$ moles of O_2 react

$\therefore \frac{4}{5}(0.21)$ moles NH_3 = 0.17 moles NH_3 react

$= (0.17\ moles\ NH_3)\left(\frac{17\ g\ NH_3}{mole\ NH_3}\right) = 2.9\ g\ NH_3$

So $(6.8 - 2.9)\ g\ NH_3$ = **3.9 g NH_3 remain**

0.17 moles NO $= (0.17\ moles\ NO)\left(\frac{30\ g\ NO}{mole\ NO}\right)$ = **5.1 g NO produced**

$\frac{3}{2}(0.17\ moles\ H_2O) = 10.26\ moles\ H_2O\left(\frac{18\ g\ H_2O}{mole\ H_2O}\right)$ = **4.6 g H_2O produced**

3. (20 points) Use the VSEPR model to compare the angle between CH bonds in the methyl anion CH_3^- with the angle between CH's in methane, CH_4.

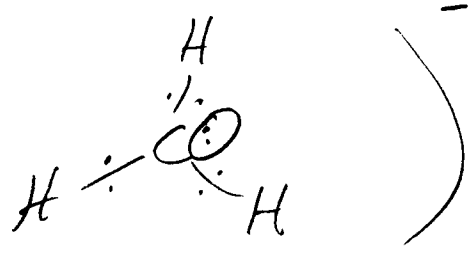
10 PTS

CH_3^-

$N_1 = 4 + 3\times1 + 1 = 8$

$N_2 = 8 + 3\times2 = 14$

$N_2 - N_1 = 6$

(5) 

$SN = 3 + 1 = 4$

1 lone pair $\Rightarrow$ CH $\measuredangle$'s smaller than (5) tetrahedral

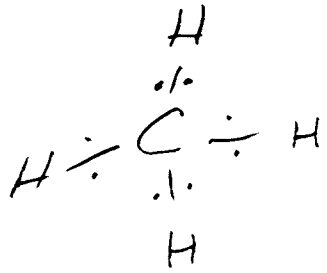
10 PTS

CH_4

$N_1 = 4 + 4\times1 = 8$

$N_2 = 8 + 4\times2 = 16$

$N_2 - N_1 = 8$

(5) 

$SN = 4 + 0$

(5) CH $\measuredangle$'s tetrahedral

4. (20 points) What is the ionization energy (IE) of the negative ion Br^-?

(5) $Br^- \longrightarrow Br + e^-$ $\quad \Delta E \equiv IE(Br^-)$

(5) $Br + e^- \longrightarrow Br^-$ $\quad \Delta E'$

$\Delta E' \equiv -EA(Br)$

$\Delta E' = -\Delta E$

$-EA(Br) = -IE(Br^-)$

10 $\therefore \quad IE(Br^-) = EA(Br)$

$= 325 \frac{kJ}{mole}$

IF ONLY THIS +5PTS