Chem 1141
Fall 2012
Exam 4A

Name: KEY

Please write your full name, and which exam version (4A) you have on the scantron sheet.

Multiple Choice. [4 points each.] Record your answers to the multiple choice questions on the scantron sheet.

Q1. What is the effective nuclear charge felt by the valence electrons in an oxygen atom?

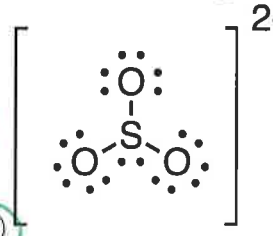
a) 1+ b) 2+ c) 4+ **d) 6+** e) 8+

Q2. Which is the correct electron configuration of Cu^+?

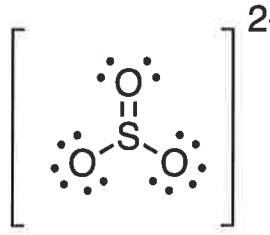
a) [Ar] $4s^1$ b) [Ar] c) [Ar] $4s^1 3d^9$ d) [Ar] $4s^2 3d^8$ **e) [Ar] $3d^{10}$**

Q3. Which of the following is a valid Lewis structure for the sulfite ion, SO_3^{2-}?

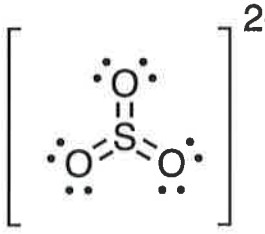
a)



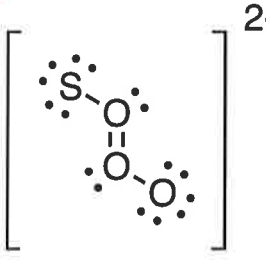
b)



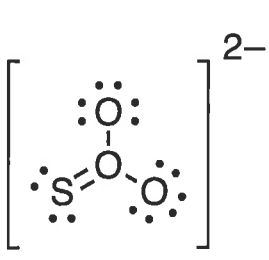
c)



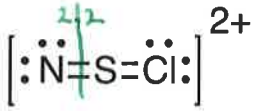
d)



e)

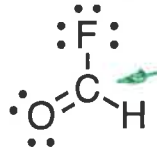


Q4. What is the formal charge on the nitrogen atom in the following structure:



a) 2+ b) 1+ c) 0 **d) 1–** e) 2–

Q5. What is the hybridization of the carbon atom in the following molecule:



3 repulsions ⇒ trigonal planar (120°) geom req'd
⇒ need 3 orbitals @ 120°
⇒ need 3 sp^2 hybrids!

a) sp b) sp^2 c) sp^3 d) sp^3d e) sp^3d^2

Q6. How many sigma and pi bonds are there in the previously drawn molecule?

a) 4 sigma, 0 pi b) 3 sigma, 1 pi c) 2 sigma, 2 pi
d) 1 sigma, 3 pi e) 0 sigma, 4 pi

1st bond between atoms = σ
additional bonds are π.

Q7. Which of the following is isoelectronic to Cs^+?

a) Ba^{2+} b) I^+ c) H^+ d) Rb^+ e) Te^{4+}

Cs^+ : [Xe]
Ba^{2+} : [Xe]

Q8. Breaking bonds releases energy, and making bonds requires energy.

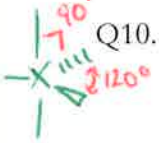
a) TRUE b) FALSE

Q9. Order the following atoms according to atomic radius:

a) Li < B < Ga b) Li < Ga < B c) Ga < Li < B
d) Ga < B < Li e) B < Li < Ga

B, Li ~ same period
But, valence e⁻s in B experience larger Z_{eff}
⇒ r ↓
(more p⁺ "hugging" e⁻s in)

Ga: 2 extra shells of e⁻s ⇒ larger than B, Li



Q10. What bond angles are present in a molecule with trigonal bipyramidal geometry?

a) 90° and 109.5° b) 109.5° and 120° c) 90° and 120°
d) 60° and 90° e) 109.5° and 180°

Q11. Give the number of protons (p), neutrons (n), and electrons (e) in one ion of $^{25}_{12}Mg^{2+}$

a) 12p, 25n, 10e b) 25p, 13n, 15e c) 13p, 12n, 11e
d) 12p, 13n, 14e e) 12p, 13n, 10e

Q12. Which is the correct formula for iron(III) nitride?

a) FeN_3 b) $Fe(NO_3)_3$ c) FeN d) $Fe(NO_2)_3$ e) $Fe_2(NO_3)_3$

Fe^{3+} N^{3-}

Q13. Which substance is **oxidized** in the following chemical equation?

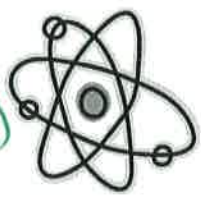
$$\overset{(0)}{PbO_2} + \overset{(0)}{Pb} + 2H_2SO_4 \longrightarrow \overset{(+2)}{2PbSO_4} + 2H_2O$$

a) PbO_2 b) Pb c) H_2SO_4 d) $PbSO_4$ e) H_2O

if ox# ↑, substance = oxidized.

Pb ~ elements = 0 (all elements have ox# = 0)

$PbSO_4$ = Pb^{2+} SO_4^{2-} (monatomic ions: ox# = charge)
↑(+2)



Short Response.

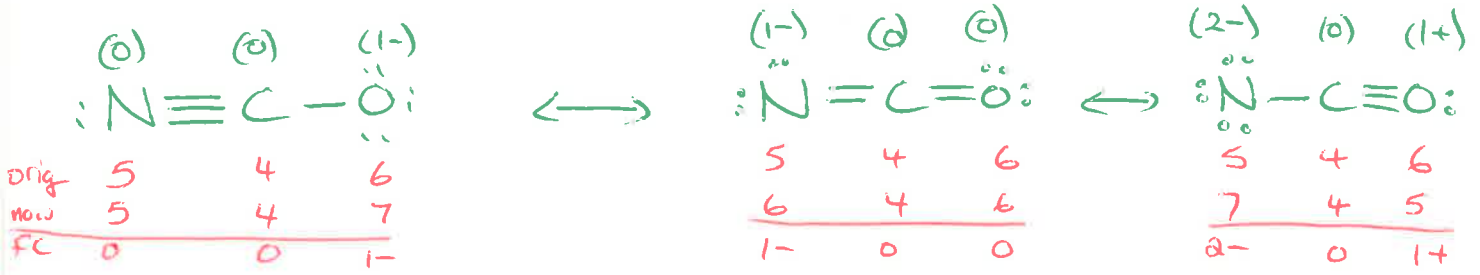
Show all work to receive credit. You must use the factor-label (conversion-factor) method for all conversions. Be sure to show all units and write your answers using the correct number of significant figures or decimal places.

Q14. [8 pts.] *Explain* the trend in atomic radius moving (i) across and (ii) down the periodic table.

(i) $r \downarrow$ since $Z_{eff} \uparrow$ across a period (more p^+ in nucleus, but same # core e⁻s shielding ⇒ valence e⁻s are attracted more strongly!)

(ii) $r \uparrow$ since $Z_{eff} \approx$ same, and # e^- shells increases ⇒ atom gets larger!

Q15. [10 pts.] Write out three possible resonance structures for the NCO^- anion. (C = central atom.) Calculate the formal charges on each atom, and explain which resonance structure(s) would be the most favored.



orig	5	4	6
now	5	4	7
FC	0	0	1-

	5	4	6
	6	4	6
	1-	0	0

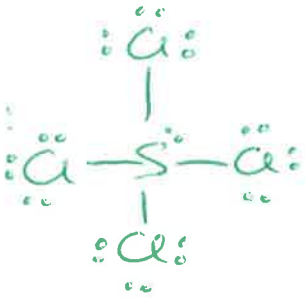
	5	4	6
	7	4	5
	2-	0	1+

lowest set of FC = more favored!

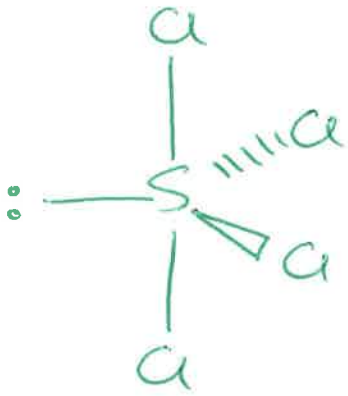
(1st resonance structure is BEST since -ve FC is on most electronegative element.)

Q16. [12 pts.] Is SCl_4 polar or non-polar? As part of your answer, you should include a valid Lewis structure, a sketch of the molecular geometry. Be sure to **explain** your answer in detail.

Lewis:

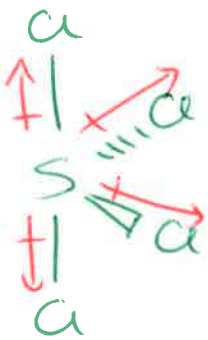


VSEPR



lp on equatorial pos^n has 2 lp-bp @ 90°
lp on axial pos^n has 3!!! lp-bp rep @ 90°

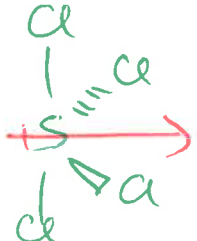
Bond dipoles:



Overall μ

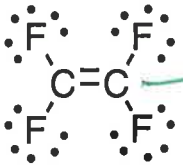
axial bond μ's cancel ($\uparrow\downarrow$)

equatorial bond μ's reinforce: ($\nearrow\searrow = \rightarrow$)



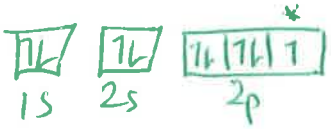
$\mu_{molecule} \neq 0 \Rightarrow$ POLAR

Q17. [10 pts.] Give a valence bond description of the bonding in tetrachloroethylene:

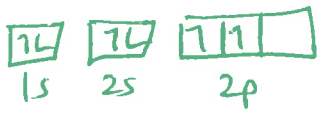


sp^2 (3 reps)

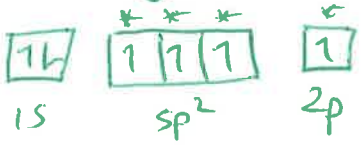
F: $1s^2 2s^2 2p^5$



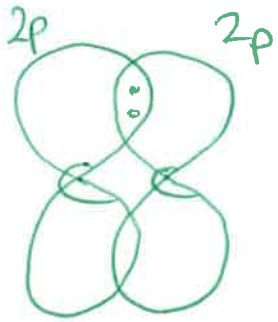
C: $1s^2 2s^2 2p^2$



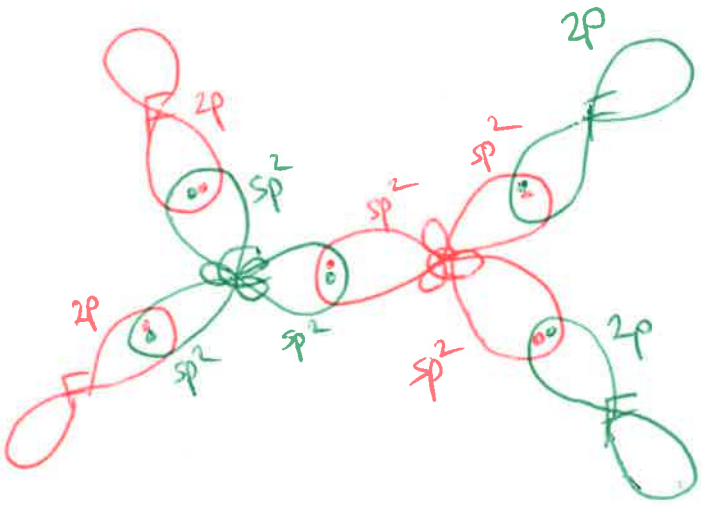
1. promote
2. sp^2 hybridize



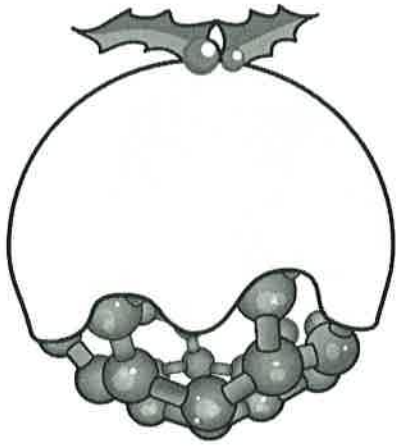
π-bond ($\perp$ to σ)



σ-bonds:



5 σ bonds



309 K

Q18. [8 pts.] 82.0 mL of 1.44 M $H_2SO_4(aq)$ is added to 1.09 g of $LiHCO_3(s)$. What volume of gas is produced at a temperature of 36 °C and a pressure of 0.979 atm?

$H_2SO_4(aq) + 2LiHCO_3(s) \longrightarrow Li_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)\uparrow$

(XS) $82.0\,mL \left| \frac{1\,L}{1000\,mL} \right| \frac{1.44\,mol\,H_2SO_4}{1\,L} \left| \frac{2\,mol\,CO_2(g)}{1\,mol\,H_2SO_4} \right. = 0.23616\,mol\,CO_2(g)$

(LR) $1.09\,g\,LiHCO_3 \left| \frac{1\,mol\,LiHCO_3}{67.96\,g\,LiHCO_3} \right| \frac{2\,mol\,CO_2}{2\,mol\,LiHCO_3} = 0.016039\,mol\,CO_2(g)$ *

$pV = nRT \Rightarrow V = \frac{nRT}{P} = \frac{0.016039\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 309\,K}{0.979\,atm}$

$= \boxed{0.415\,L}$ (3sf)

BONUS Question

Write the name and formula of eight polyatomic ions:

	FORMULA	NAME
i)	NH_4^+	ammonium
ii)	OH^-	hydroxide
iii)	NO_3^-	nitrate
iv)	NO_2^-	nitrite
v)	CN^-	cyanide
vi)	HCO_3^-	bicarbonate
vii)	$C_2H_3O_2^-$	acetate
viii)	CO_3^{2-}	carbonate
	SO_4^{2-}	sulfate
	SO_3^{2-}	sulfite
	PO_4^{3-}	phosphate

Useful Information:

$pV=nRT$ 1 atm = 760 mmHg = 101325 Pa $R = 0.08206 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$

$M_1V_1 = M_2V_2$ N_A = 6.022 x 10^{23}

Periodic Table

1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.01	2 IIA																2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.1	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac^** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)							

*	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
^	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

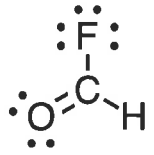
Chem 1141
Fall 2012
Exam 4B

Name: KEY

Please write your full name, and which exam version (4B) you have on the scantron sheet.

Multiple Choice. [4 points each.] Record your answers to the multiple choice questions on the scantron sheet.

Q1. What is the hybridization of the carbon atom in the following molecule:



a) sp b) sp^2 c) sp^3 d) sp^3d e) sp^3d^2

See exam 4A for details!

Q2. How many sigma and pi bonds are there in the previously drawn molecule?

a) 4 sigma, 0 pi b) 3 sigma, 1 pi c) 2 sigma, 2 pi
d) 1 sigma, 3 pi e) 0 sigma, 4 pi

Q3. Which of the following is isoelectronic to Cs^+?

a) Ba^{2+} b) I^+ c) H^+ d) Rb^+ e) Te^{4+}

Q4. Breaking bonds releases energy, and making bonds requires energy.

a) TRUE b) FALSE

Q5. What is the effective nuclear charge felt by the valence electrons in an oxygen atom?

a) 1+ b) 2+ c) 4+ d) 6+ e) 8+

Q6. Which is the correct electron configuration of Cu^+?

a) [Ar] $4s^1$ b) [Ar] c) [Ar] $4s^13d^9$ d) [Ar] $4s^23d^8$ e) [Ar] $3d^{10}$

Q7. Give the number of protons (p), neutrons (n), and electrons (e) in one ion of $^{25}_{12}Mg^{2+}$

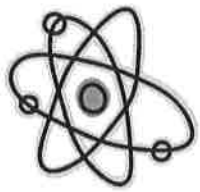
a) 12p, 25n, 10e b) 25p, 13n, 15e c) 13p, 12n, 11e
d) 12p, 13n, 14e e) 12p, 13n, 10e

Q8. Which is the correct formula for iron(III) nitride?

a) FeN_3 b) $Fe(NO_3)_3$ c) FeN d) $Fe(NO_2)_3$ e) $Fe_2(NO_3)_3$

Q9. What bond angles are present in a molecule with trigonal bipyramidal geometry?

a) 90° and 109.5° b) 109.5° and 120° c) 90° and 120°
d) 60° and 90° e) 109.5° and 180°

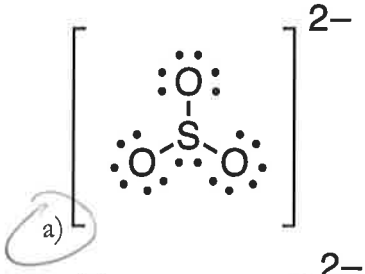


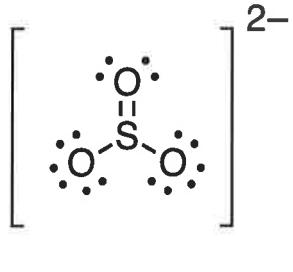
Q10. Which substance is **oxidized** in the following chemical equation?

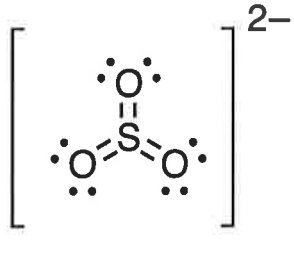
$$PbO_2 + Pb + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O$$

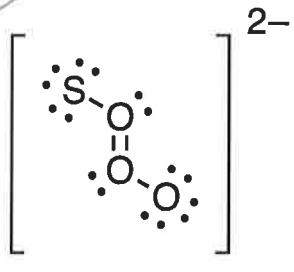
a) PbO_2 b) Pb c) H_2SO_4 d) $PbSO_4$ e) H_2O

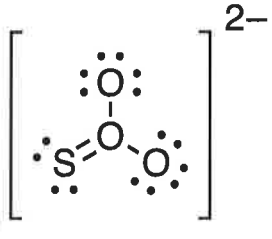
Q11. Which of the following is a valid Lewis structure for the sulfite ion, SO_3^{2-}?

a) 

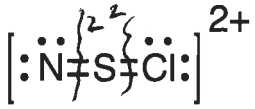
b) 

c) 

d) 

e) 

Q12. What is the formal charge on the sulfur atom in the following structure:



S: 6 valence e's only
now: 4 valence e's
⇒ missing 2 e's
⇒ 2+ FC

a) 2+ b) 1+ c) 0 d) 1– e) 2–

Q13. Order the following atoms according to atomic radius:

a) Li < B < Ga b) Li < Ga < B c) Ga < Li < B
d) Ga < B < Li e) B < Li < Ga

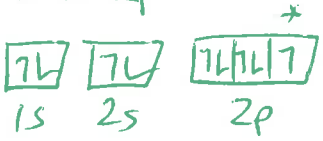
Short Response.

Show all work to receive credit. You must use the factor-label (conversion-factor) method for all conversions. Be sure to show all units and write your answers using the correct number of significant figures or decimal places.

Q14. [10 pts.] Give a valence bond description of the bonding in 1,2-difluoroacetylene:

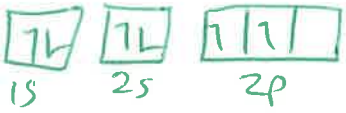
sp (2 repulsions)

F: $1s^2 2s^2 2p^5$

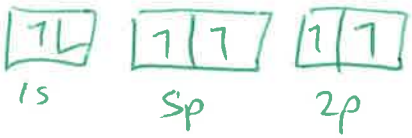


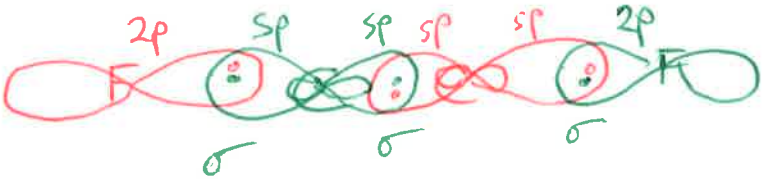
σ-framework

C: $1s^2 2s^2 2p^2$

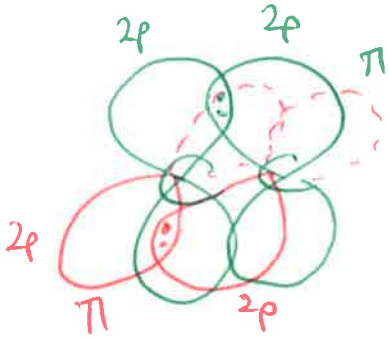


1. promote
2. hybridize





π-framework 1 to σ

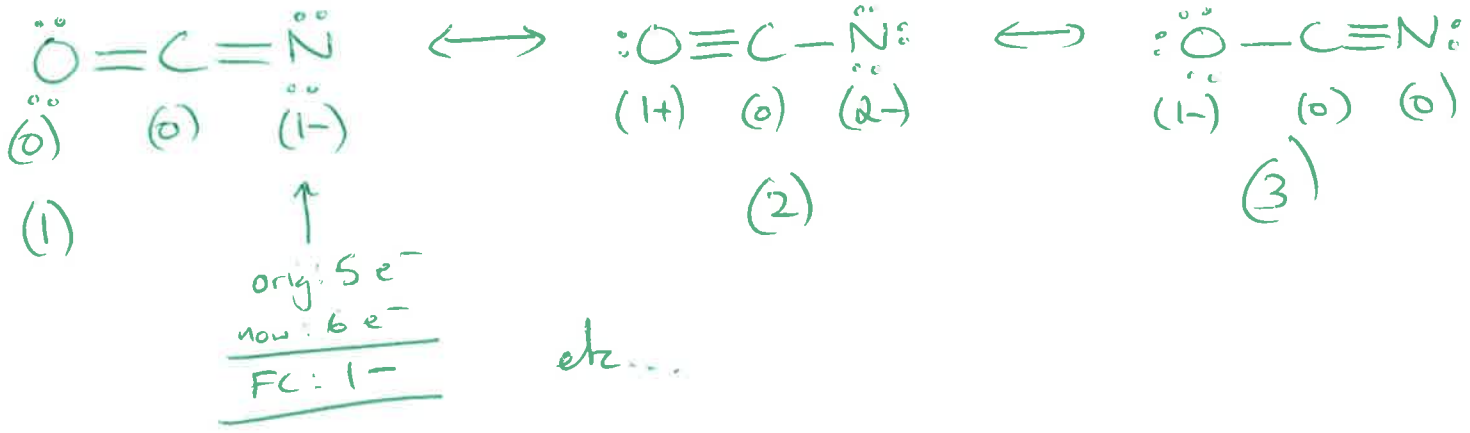


Q15. [8 pts.] *Explain* the trend in first ionization energy moving (i) across and (ii) down the periodic table.

(i) IE↑ across period since Z_{eff}↑

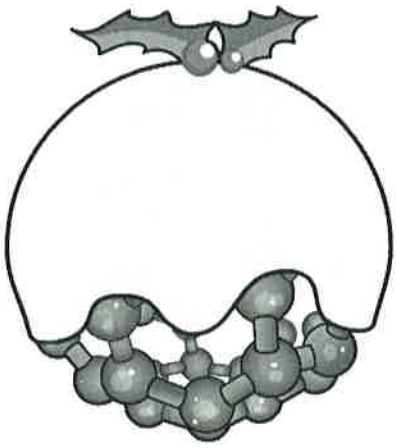
(ii) IE↓ down group since valence e^- is in a larger shell w/ same Z_{eff}.
(further away e^- is from nucleus, lower the attraction is!)

Q16. [10 pts.] Write out three possible resonance structures for the OCN^- anion. (C = central atom.) Calculate the formal charges on each atom, and explain which resonance structure(s) would be the most favored.



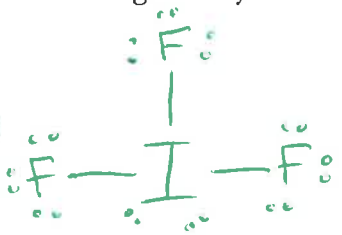
Best lewis structures are (1) + (3)
- lowest set of FCs.

(3) is actually better than (1) since -ve charge is on more electronegative atom.)

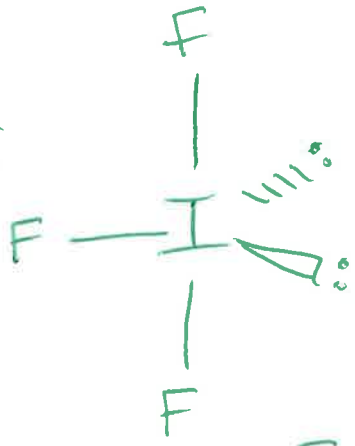


Q17. [12 pts.] Is IF_3 polar or non-polar? As part of your answer, you should include a valid Lewis structure, a sketch of the molecular geometry. Be sure to **explain** your answer in detail.

Lewis:

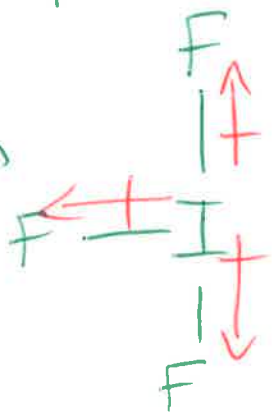


VSEPR

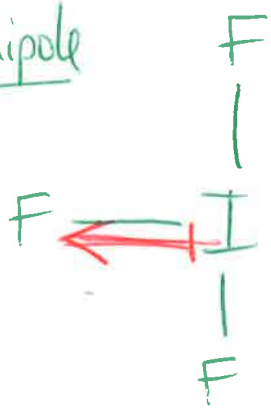


(fewer lp-bp or lp-lp repulsions @90° if lp's are equatorial)

Bond dipoles



molecular dipole



⇒ since $\mu_{molecule} \neq 0$

POLAR

305K

Q18. [8 pts.] 82.0 mL of 1.44 M $H_2SO_4(aq)$ is added to 2.09 g of $KHCO_3(s)$. What volume of gas is produced at a temperature of 32 °C and a pressure of 0.924 atm?

$H_2SO_4(aq) + 2KHCO_3(s) \longrightarrow K_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)\uparrow$

(XS) $82.0\,mL \left|\frac{1\,L}{1000\,mL}\right| \frac{1.44\,mol\ H_2SO_4}{1\,L} \left|\frac{2\,mol\ CO_2(g)}{1\,mol\ H_2SO_4}\right| = 0.23616\,mol\ CO_2$

(LR) $2.09\,g\ KHCO_3 \left|\frac{1\,mol\ KHCO_3}{100.12\,g\ KHCO_3}\right| \frac{2\,mol\ CO_2(g)}{2\,mol\ KHCO_3} \Big| = 0.020875\,mol\ CO_2$ *

$pV = nRT \Rightarrow V = \frac{nRT}{P} = \frac{0.020875\,mol \times 0.08206\,\frac{atm \cdot L}{mol \cdot K} \times 305\,K}{0.924\,atm}$

$= \boxed{0.565\,L}$

BONUS Question

Write the name and formula of eight polyatomic ions:

	FORMULA	NAME
i)		
ii)	See exam 4A	
iii)		
iv)		
v)		
vi)		
vii)		
viii)		

Useful Information:

$pV=nRT$ 1 atm = 760 mmHg = 101325 Pa $R = 0.08206 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$

$M_1V_1 = M_2V_2$ $N_A = 6.022 \times 10^{23}$

Periodic Table

1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.01	2 IIA																2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.1	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac^** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)							

*	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
^	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)