General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Fall 2018

December 6, 2018

Exam # 4A

Name KEY

Please write your full name, and the exam version (4A) that you have on the scantron sheet !
(Bubble in the best answer choice for each question on the green & white scantron sheet in pencil !)

Please ☑ check the box next to your correct section number.

Section #:

- ❒ 1. (Monday Lab, 10:00 AM – 12:53 PM) – Dr. Wendi Fleeman
- ❒ 2. (Wednesday Lab, 10:00 AM – 12:53 PM)
- ❒ 3. (Monday Lab, 2:00 PM – 4:53 PM) – Dr. Andy Napper
- ❒ 4. (Wednesday Lab, 2:00 PM – 4:53 PM)
- ❒ 6. (Tuesday Lab, 12:30 PM – 3:23 PM) – Dr. Daniel Finnen

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	
TOTAL:	_____	**/ 100**

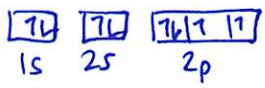
Each problem in this section (multiple choice) is worth 2.5 points !

Q1. What type of **orbital** is shown below?

A) s
B) p
C) d
D) f

Q2. Which of the following atoms will be **paramagnetic**?

A) He $1s^2$
B) Mg $1s^2 2s^2 2p^6 3s^2$
C) O $1s^2 2s^2 2p^4$
D) Zn $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$



Q3. What period three element has the following ionization energies (all in kJ/mol)?

$IE_1 = 1012$, $IE_2 = 1900$, $IE_3 = 2910$, $IE_4 = 4960$, $IE_5 = 6270$, $IE_6 = 22{,}200$

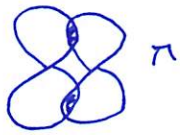
A) Cl
B) P
C) S
D) Si

Q4. The chemical equation corresponding to the electron affinity for nitrogen is:

A) $N_2(g) + 6e^- \rightarrow 2N^{3-}(g)$
B) $N(g) \rightarrow N^+(g) + e^-$
C) $N(g) \rightarrow N^-(g) + e^-$
D) $e^- + N(g) \rightarrow N^-(g)$

Q5. What type of bond is best shown by the overlap below?

σ : head-on overlap : 

π : side-on overlap : 

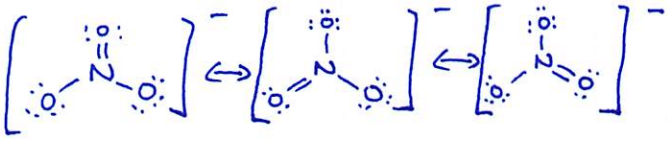
A) sp^3

B) sigma

C) pi

D) delta

Q6. The reason that all the nitrogen-oxygen bonds in the nitrate ion are the same length is best explained in terms of nitrate having:

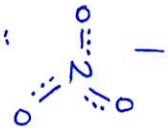


A) more than one resonance structure

B) the lowest set of formal charges possible

C) the most electronegative element on the outside of the ion

D) an expanded octet

hybrid:  — all bonds ≈ 1⅓

Q7. Arrange the following atoms in terms of **increasing** Z_{eff} (effective nuclear charge, lowest < highest) for their valence electrons:

$Z_{eff} = Z - S$

└ screening constant ≈ # core e⁻s.

across a period, S is ≈ same → Z_{eff} ↑ as Z ↑

A) Na < Si < Cl

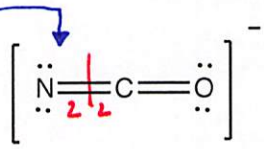
B) Kr < Pb < K

C) F < N < Al

D) C < Si < Al

Q8. What is the formal charge on the **nitrogen atom** in the cyanate ion shown below?

ORIG: 5
NOW: 6
FC: 1−



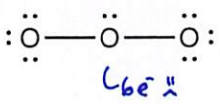
A) −2

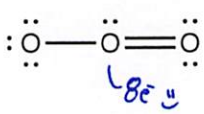
B) −1

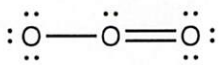
C) 0

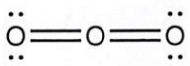
D) +1

Q9. The most correct Lewis structure for the ozone (O_3) molecule is:

A)  18e⁻ ✓ └ 6×3 = 18 e⁻

B)  18e⁻ ✓ octets ✓

C)  20e⁻ ✗

D)  16e⁻ ✗

Q10. Which of the following bonds would be the **least polar**?

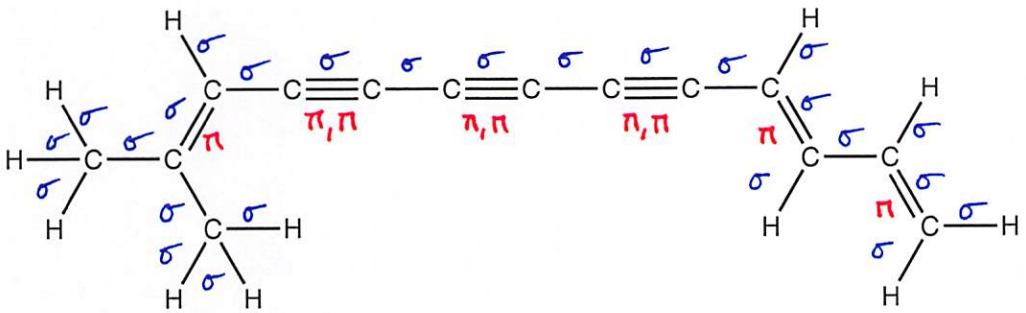
A) H—F $\Delta E_N = |2.1 - 4.0| = 1.9$ └ smallest ΔE_N

B) O—H $\Delta E_N = |3.5 - 2.1| = 1.4$

C) N—H $\Delta E_N = |3.0 - 2.1| = 0.9$

D) C—H 2.5 2.1 $\Delta E_N = 0.4$ ✱

Q11. The compound shown below is found in safflowers and serves as the chemical defense against nematodes (roundworms).



The total number of pi (π) bonds in this compound is:

A) 3

B) 6

C) 9

D) 15

1st bond between atoms: sigma (σ)

2nd/3rd bond(s) "——": π (pi)

Q12. Each of the following sets of quantum numbers is supposed to specify an orbital. Choose the one set of quantum numbers that **does NOT contain an error**.

A) $n = 2, l = 2, m_l = -1$ ✗

B) $n = 2, l = 2, m_l = -3$ ✗

C) $n = 3, l = 2, m_l = -3$ ✗

✓ D) $n = 4, l = 3, m_l = +2$

n: 1, 2, 3, ...
l: 0, ..., $n-1$
m_l: $-l$, ..., 0, ..., $+l$
m_s: $\pm 1/2$

Q13. Give the complete electron configuration for Mn: $_{18}Ar$, $_{25}Mn$ → [Ar] $4s^2 3d^5$

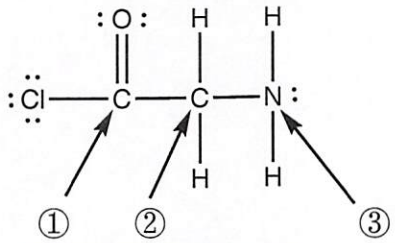
A) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4d^5$

B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^6$

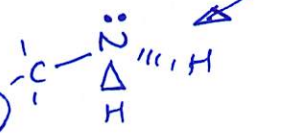
C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4p^5$

D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$ = [Ar]

Q14. Consider the molecule below. Determine the **molecular geometry** at each of the three labelled atoms.



1: 3 rep : trig planar
2: 4 rep : tetrahedral
3: 4 rep : e^- geom = tetrahedral
mol. geom = trigonal pyramidal



A) 1 = trigonal planar, 2 = tetrahedral, 3 = trigonal pyramidal

B) 1 = tetrahedral, 2 = tetrahedral, 3 = tetrahedral

C) 1 = trigonal planar, 2 = tetrahedral, 3 = tetrahedral

D) 1 = tetrahedral, 2 = tetrahedral, 3 = trigonal planar

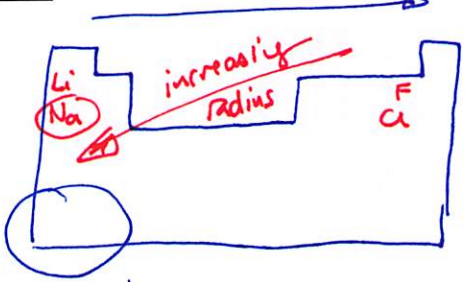
Q15. Of the following, which atom has the **largest** atomic radius? radius↓ (Z_{eff}↑)

A) Li

B) F

C) Na

D) Cl

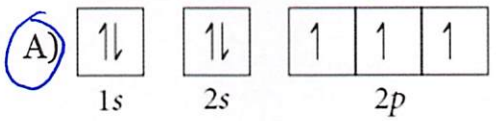


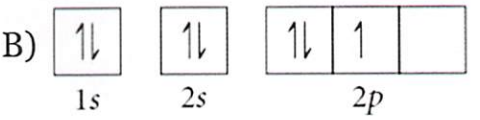
large atoms
Z_{eff}↓
#shells↑

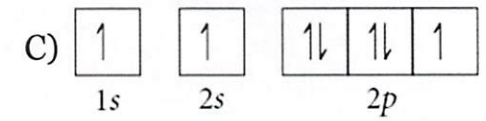
radius↑ (more e^- shells)

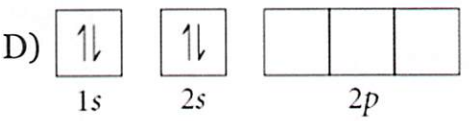
Hund's rule! Fill orbitals w/ same spin e⁻ before pairing up

Q16. Choose the orbital diagram that represents the ground state of N. $1s^2 2s^2 2p^3$

A) 

B) 

C) 

D) 

Q17. Place the following in order of **increasing radius** (smallest < largest).

A) $Sr^{2+} < Br^- < Se^{2-}$

B) $Br^- < Sr^{2+} < Se^{2-}$

C) $Se^{2-} < Br^- < Sr^{2+}$

D) $Sr^{2+} < Se^{2-} < Br^-$

For isoelectronic species:

anions > cations

- more e⁻s
- larger size

- fewer e⁻s
- smaller size

Q18. Place the following elements in order of **decreasing electronegativity**

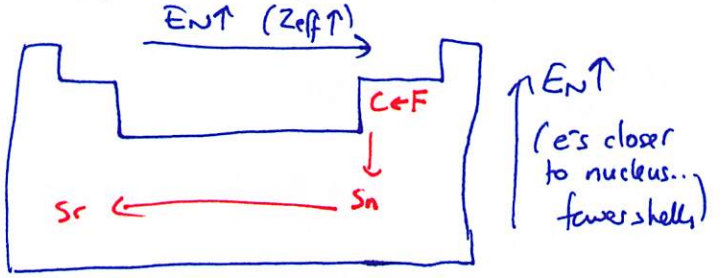
(largest > smallest): **Sr, C, F, Sn**

A) Sn > Sr > F > C

B) F > Sn > C > Sr

C) Sn > F > Sr > C

D) F > C > Sn > Sr



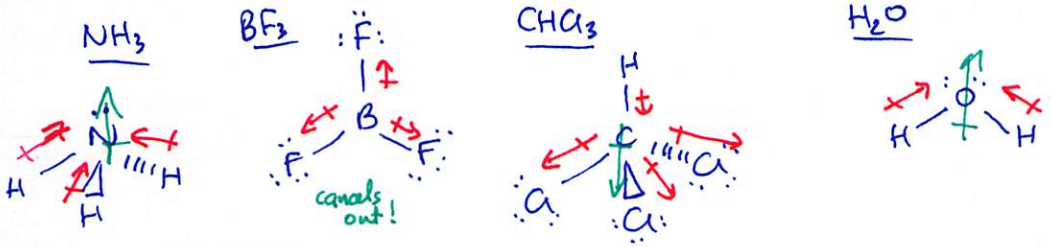
Q19. Identify the **least polar** (*most non-polar*) compound:

A) NH_3

B) BF_3

C) $CHCl_3$

D) H_2O



↔ = bond dipoles, ⟶ = overall dipole

Q20. Identify the compound with an atom that has an **incomplete octet**:

A) ICl_5

B) CO_2

C) CCl_4

D) $BeCl_2$

Be, B compounds often e⁻ deficient (Be: 4e⁻, B: 6e⁻)

Each problem in this section (short answer) is worth 10 points !

All work must be show in order to receive credit !

You must use the factor–label (conversion–factor) method for all conversions !

Be sure to include units where applicable !

All numeric answers must be rounded to the correct number of significant figures !

Q21. Write **full** electron-configurations for the following species:

A) F $1s^2 2s^2 2p^5$

B) V $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

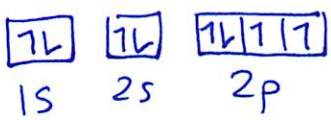
C) The zinc ion, Zn^{2+}

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ (remove 4s e⁻ before 3d)

4s: valence n=4; 3d: core n=3

Write the **<u>orbital diagram</u>** for oxygen, O

8 O $1s^2 2s^2 2p^4$

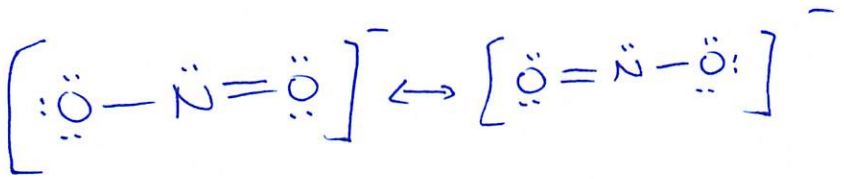


Q22. Write valid Lewis structures for the following species. Be sure to include the total number of valence electrons as part of your answer.

$5+6\times2+1=18$

A) NO_2^- **total #valence e⁻s:** 18

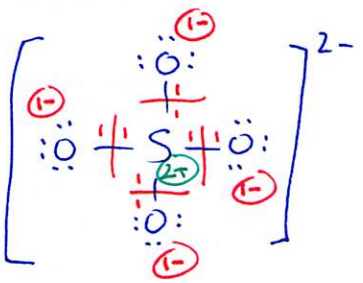
(also, show <u>all</u> resonance structures)



$6+6\times4+2=32$

B) SO_4^{2-} **total #valence e⁻s:** 32

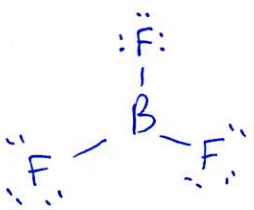
*(also, show formal charges for each atom, and **<u>explain</u>** how you calculated them)*



	atoms	
	O	S
orig:	6	6
now:	7	4
FC:	1−	2+

$3+7\times3=24$

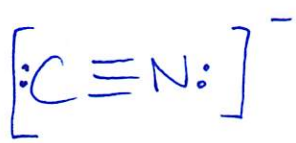
C) BF_3 **total #valence e⁻s:** 24



e⁻ deficient!
B only needs 6 e⁻

$4+5+1=10$

D) CN^- **total #valence e⁻s:** 10



Q23. Use bond energies to calculate ΔH^{o}_{rxn} for the chemical equation given below. Be sure to draw valid Lewis structures of all reactants and products as part of your answer. Clearly explain your calculation!

$$\mathbf{4H_2(g) + 2CO(g) \longrightarrow O_2(g) + 2CH_4(g)}$$

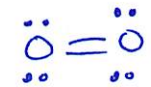
each structure represents 1 mol of substance!

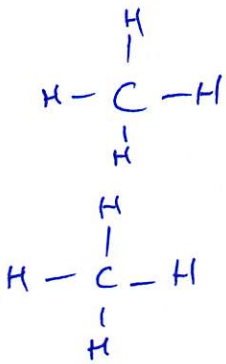
H–H :C≡O:

H–H :C≡O:

H–H

H–H





$\Delta H^{\circ} \approx \sum$ bonds broken $- \sum$ bonds made

$\approx [4 \times H\text{–}H + 2 \times C\equiv O] - [1 \times O=O + 8 \times C\text{–}H]$

$\approx \left[4\,mol \times 436.4\frac{kJ}{mol} + 2mol \times 1077\frac{kJ}{mol}\right] - \left[1mol \times 498.7\frac{kJ}{mol} + 8mol \times 414\frac{kJ}{mol}\right]$

$\approx +88.9\ kJ$

Q24. ***Fill in the blanks:***

(A) Four valid quantum numbers for an electron in a 3-p orbital are:

n = 3, l = 1, m_l = 0, and m_s = $-\frac{1}{2}$.

(B) Give the proper name for the following **rules/principles**:

- Electrons occupy lower-energy orbitals before filling up higher-energy ones: Auf bau principle. (Building-up principle)

- Electrons occupy different orbitals within a subshell with parallel spins, before pairing up in the same orbital: Hund's rule.

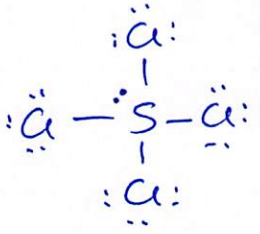
- Every electron in an atom must have a unique set of quantum numbers: Pauli exclusion principle.

(C) A fourth period element that is an exception to the usual rules of forming electron configurations is: Cr (or) Cu and has an abbreviated (noble-gas core) electron configuration of: $[Ar]4s^1 3d^5$ (OR) $[Ar]4s^1 3d^{10}$.

Q25. Predict the molecular geometry and polarity of SCl_4. Your answer should include:

- ❑ A valid Lewis structure
- ❑ The total number of valence electrons
- ❑ A sketch of the geometry using line/dash/wedge notation
- ❑ The value of the bond angle(s) written out
- ❑ The name of the molecular geometry
- ❑ A clear explanation of why SCl_4 is polar or non-polar

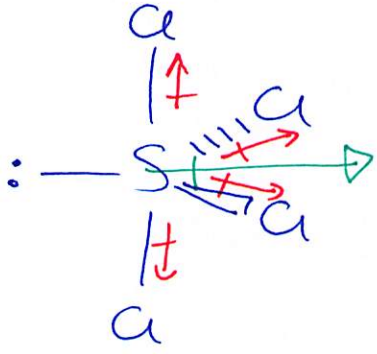
6 + 4×7 = 34e⁻



34 e⁻
− 8
26 e⁻
− 24
2 e⁻
− 2
0

↑ = bond dipoles.
Cl is more EN than S!
so, $Cl^{\delta-} - S^{\delta+}$

5 repulsions!
→ e⁻ geom is trigonal bipyramidal



overall dipole ≠ 0
⇒ POLAR

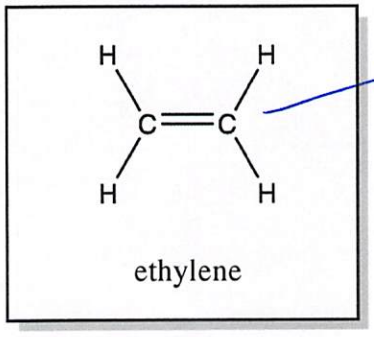
lp goes equatorial, not axial
(2 lp-bp @ 90°) (3 lp-bp @ 90°)

2 repulsions  vs. 3 repulsions 

mol. geom = See Saw (where atoms are!)

Bonus Question

What type of hybrid orbitals are used on the carbon atoms in ethylene, C_2H_4?



ethylene

3 rep → 120° (trigonal planar)
-so need to use sp^2 hybridization!

#rep	2	3	4	5	6	...
hybrids	sp	sp^2	sp^3	sp^3d	sp^3d^2	...

Type of hybrid orbital: sp^2

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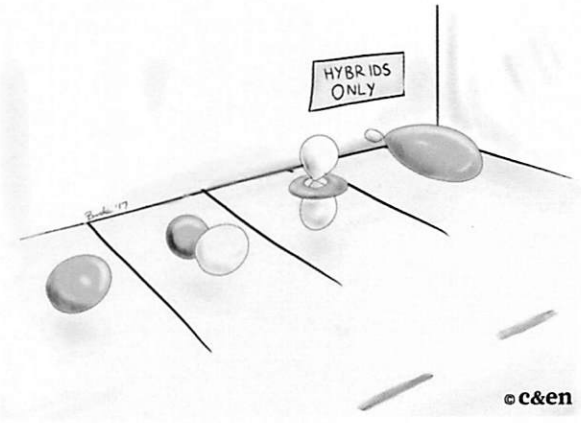
Useful Information:

Bond	Bond Enthalpy (kJ/mol)	Bond	Bond Enthalpy (kJ/mol)
H—H	436.4	C—H	414
H—O	460	C—C	347
C—O	351	C=C	620
C=O	745 (average)	C≡C	812
C=O	799 (in CO_2)	O—O	142
C≡O	1077	O=O	498.7

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	18
1 H 1.008	2											13	14	15	16	17	2 He 4.003
3 Li 6.941	4 Be 9.012											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	4	5	6	7	8	9	10	11	12	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 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 74.92160	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 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.60	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba* 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	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 209.0	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra** [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 La 138.9	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 162.50	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
**	89 Ac [227]	90 Th 232.0	91 Pa 231.0	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]



"Rats! I thought lanthanoids and actanoids were gonna be giant robots or something."