General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Autumn 2022

December 1, 2022

Exam # 4A

Name Key

Please print 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 scantron sheet in pencil!)

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

Section #:

- ❒ 1. (Mon Lab, 10:10 AM – 1:00 PM)
- ❒ 2. (Wed Lab, 10:10 AM – 1:00 PM)

Fleeman

- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM)
- ❒ 4. (Thu Lab, 11:00 AM – 1:50 PM)

Napper

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	**/ 3**
TOTAL:	_____	**/ 100**

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

Q1. Which of the following statements is false?

A) a covalent bond is formed through the sharing of electrons between atoms

B) it is not possible for two atoms to share more than two electrons

C) single bonds are longer than double bonds

D) a pair of electrons not shared is referred to as a "lone pair"

Q2. Identify the inner-transition metal element.

A) Os

B) S

C) Na

D) Fm

Q3. For a particular element, identify the species that has the **largest** radius.

A) anion

B) cation

C) neutral

D) radical

Q4. When filling subshells (degenerate orbitals), electrons fill the orbitals singly first, with parallel spins. This way of filling orbitals is known as:

A) the Pauli exclusion principle

B) the Aufbau principle

C) Hund's rule

D) electron configuration

Q5. In what period and group of the periodic table would you find the element with the electron configuration [Kr] $5s^2\ 4d^{10}\ 5p^2$?

A) period 4, group 4A (group 14)

B) period 5, group 4A (group 14)

C) period 4, group 5A (group 15)

D) period 5, group 5A (group 15)

Q6. Which of the following is not isoelectronic with the others: Br^-, Rb^+, Se^{2-}, Sr^{2+}, Te^{2-}

A) Br^-

B) Rb^+

C) Se^{2-}

D) Sr^{2+}

E) Te^{2-}

Q7. Which choice lists two elements with ground-state electron configurations that are well known exceptions to the Aufbau principle?

A) Cs and Cl

B) Cu and Cr

C) Fe and Co

D) Cr and Co

Q8. Which of the following compounds does **not** obey the octet rule?

A) NCl_3

B) BCl_3

C) $CBrCl_3$

D) AsF_3

Q9. Which of the following species has the largest dipole moment (most polar)?

A) CH_3Br

B) CH_3Cl

C) CH_3I

D) CH_3F

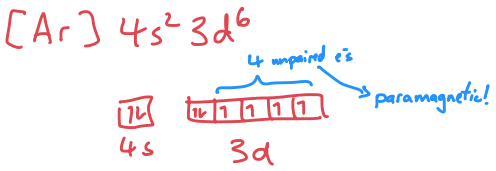
Q10. A ground-state atom of iron has _____ unpaired electrons and is _____.

A) 4, diamagnetic

B) 0, diamagnetic

C) 6, paramagnetic

D) 4, paramagnetic



Q11. The scientist generally credited with the first modern periodic table (in 1869) is:

A) Pauli

B) Avogadro

C) Mendeleyev

D) Schrödinger

Q12. The elements nitrogen, fluorine, and bromine when ordered in INCREASING atomic radius are:

A) N < F < Br

B) F < N < Br

C) Br < F < N

D) Br < N < F

Q13. The elements oxygen, fluorine, and iodine when ordered in INCREASING electronegativity are:

A) O < I < F

B) I < O < F

C) I < F < O

D) F <I < O

Q14. Breaking a covalent bond…

A) costs energy, $\Delta H > 0$

B) releases energy, $\Delta H < 0$

C) for non-polar bonds, $\Delta H > 0$; however polar bonds have $\Delta H < 0$

D) for polar bonds, $\Delta H > 0$; however non-polar bonds have $\Delta H < 0$

Q15. The chemical equation corresponding to the electron affinity of chlorine is:

A) $Cl_2(g) \longrightarrow 2Cl(g)$

B) $Cl^+(g) + e^- \longrightarrow Cl(g)$

C) $e^- + Cl(g) \longrightarrow Cl^-(g)$

D) $Cl(g) \longrightarrow Cl^+(g) + e^-$

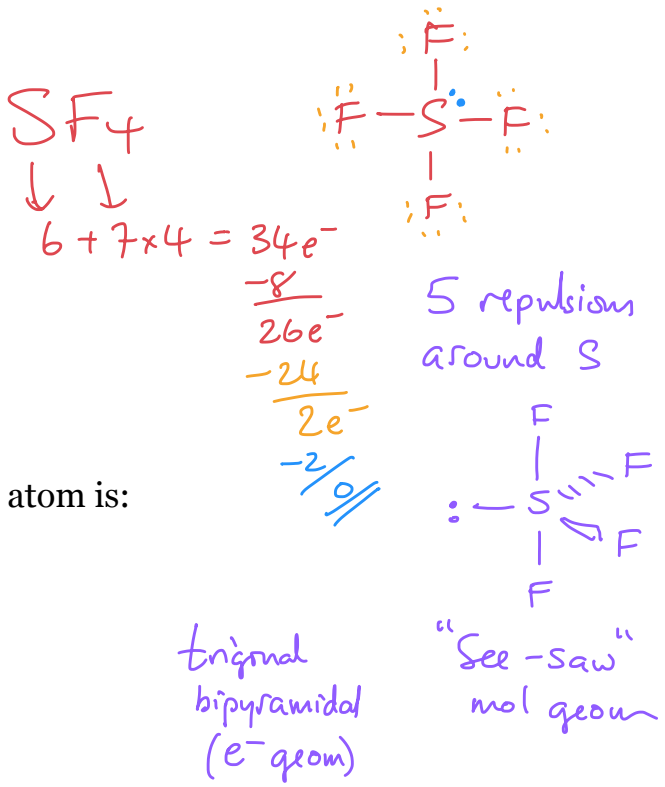
Q16. The molecular geometry of SF_4 is:

A) tetrahedral

B) trigonal bipyramidal

C) see-saw

D) square planar



Q17. The number of valence electrons in a bromine atom is:

A) 7

B) 8

C) 35

D) 80

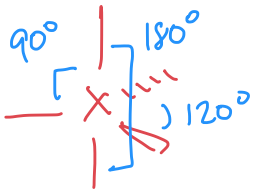
Q18. The bond angles in a trigonal bipyramidal geometry are:

A) 90°, 180°

B) 90°, 109.5°, 120°

C) 90°, 120°, 180°

D) 109.5°, 120°



Q19. Based on electronegativities, the compound most likely to be ionic is:

A) CsF

B) HF

C) CO

D) LiK

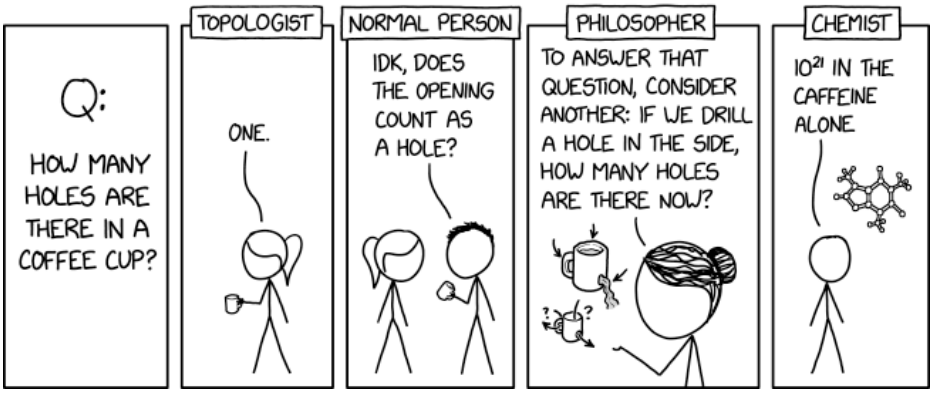
Q20. Which element would be expected to have the **highest** first ionization energy?

A) N

B) Li

C) K

D) Not possible to determine



Each problem in this section is worth 10 points. ***All work must be shown to receive credit!***

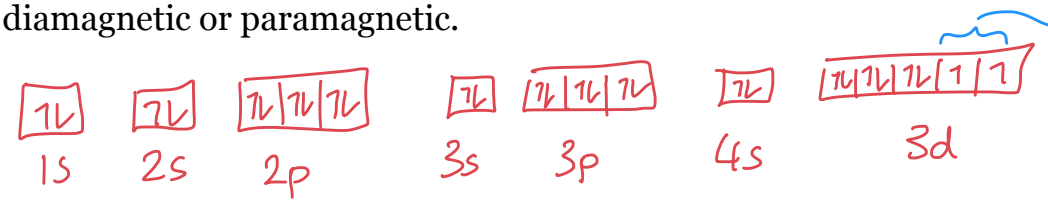
Use the factor–label (conversion–factor) method for all conversions. Include units where applicable.

Rounded all numeric answers to the correct number of significant figures.

Q21. (A) Write out the full electron configuration of $_{28}Ni$.

$1s^2\ 2s^2 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^8$

(B) Draw the orbital diagram for $_{28}Ni$. Using your diagram, explain whether Ni is diamagnetic or paramagnetic.



→ Paramagnetic!

(C) Nickel (Ni) can form a 2+ ion. Write out its electron configuration using an appropriate noble gas core.

loses 2 e⁻s from valence shell (4s) → [Ar] $3d^8$

(D) How would you expect the size of Ni^{2+} to compare with Ni? Briefly explain your reasoning.

Ni^{2+} would be smaller. It has lost $2e^-$, so e^- cloud is smaller. 2 more p^+ than e^-s!
(smaller radius)

(E) Nitrogen (N) has an extremely large sixth ionization energy (I_6), compared to its fifth ionization energy. Why is this? Write out the chemical equation (reaction) that corresponds to I_6 as part of your answer.

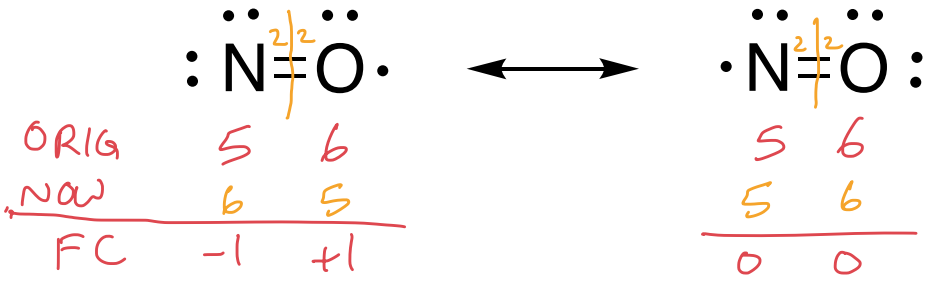
chem. eq: $N^{5+}(g) \longrightarrow N^{6+}(g) + e^-$

$_7N$: $1s^2\ 2s^2\ 2p^3$ — 5 valence e⁻s

I_6 removes an e^- from CORE
- req's much more e^- since e⁻s are closer to (+) nucleus!

Q22. The nitric oxide molecule, NO, has an odd number of electrons. Its structure can be represented via a resonance hybrid:

Structure (1) *Structure (2)*



	N	O	N	O
ORIG	5	6	5	6
NOW	6	5	5	6
FC	−1	+1	0	0

FC
bonding e's are shared equally between atoms!

(A) Being sure to clearly show your work, calculate formal charges for the following atoms:

N: ___−1___ *Structure (1)* N: ___∅___ *Structure (2)*

O: ___+1___ *Structure (1)* O: ___∅___ *Structure (2)*

(B) On the basis of formal charges, which resonance structure is preferred? Explain.

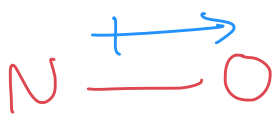
Structure (2) ... lowest set of #'s ($\sum |FC|$)

abs. value of FC's

(C) Is the N–O bond polar in nitric oxide?
- If so, sketch out the direction of the dipole moment.
- If not, explain why it is non-polar.

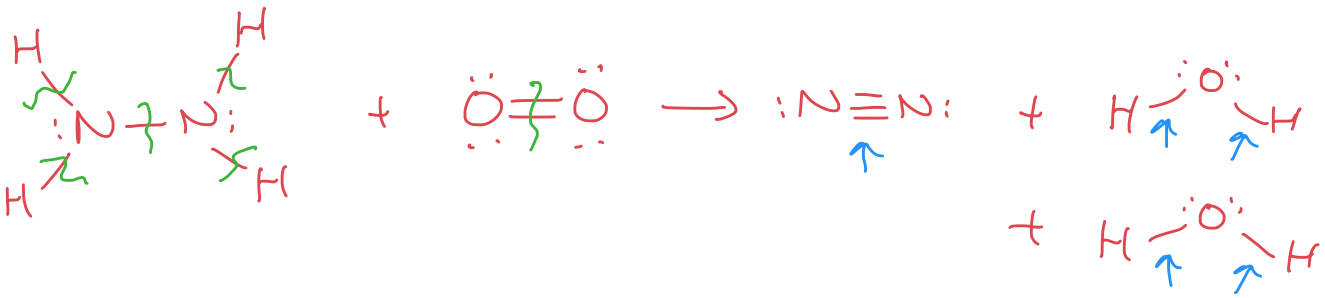
Yes, it is polar.

O is more E_N than N



Q23. Use bond energies to calculate ΔH_{rxn} for the chemical reaction given below. Be sure to show Lewis structures for all reactants and products as part of your answer. Show your work clearly.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$$



Break (+): 4 x N-H, 1 x N-N, 1 x O=O

Make (−): 4 x O-H, 1 x N≡N

$$\Delta H^\circ_{rxn} \approx \left[4 \times 393\ \tfrac{kJ}{mol} + 1 \times 193\ \tfrac{kJ}{mol} + 1 \times 499\ kJ/mol\right] - \left[4 \times 460\ \tfrac{kJ}{mol} + 1 \times 946\ \tfrac{kJ}{mol}\right]$$

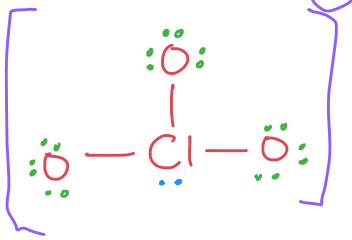
$$= -522\ kJ/mol$$

Bond	Bond Enthalpy (kJ/mol)	Bond	Bond Enthalpy (kJ/mol)
H—H	436	C—C	347
N—F	272	C═C	620
N—N	193	C≡C	812
N═N	418	O—O	142
N≡N	946	O═O	499
C—H	414	F—F	157
O—H	460	N—H	393

Q24. Draw a correct Lewis structure for the following species. Be sure to include the total number of valence electrons in your answer.
Note: if resonance structures are possible, you do not need to show more than one of them!

A) ClO_3^- **Total valence electrons:** 26

7+3×6+1=26
−6
20
−18
2
−2
0



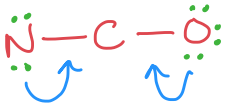
B) IF_3 **Total valence electrons:** 28

7+7+3=28
−6
22
−18
4
−4
0

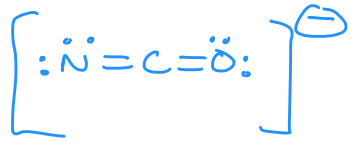
C) NCO^- **Total valence electrons:** 16

(structure is linear with C in the center)

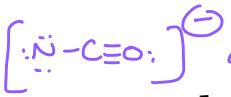
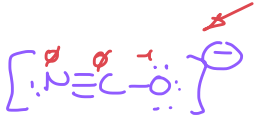
5+4+6+1=16
−4
12
−12
0



share 2 lp w/ C

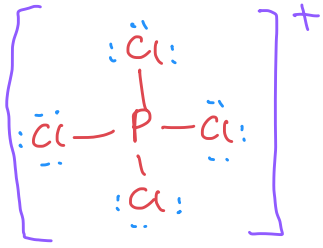


"best" on basis of FC's

note: 2 other possibilities are:  and 

D) PCl_4^+ **Total valence electrons:** 32

5+7+4−1=32
−8
24
−24
0

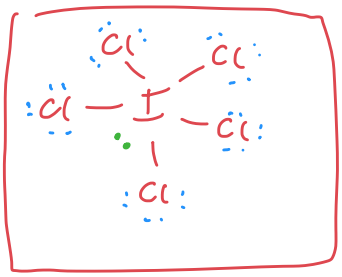


Q25. Predict the molecular geometry and polarity of ICl_5.
Include the following information in your answer.

(1) ☐ A valid Lewis structure
(2) ☐ A sketch of the geometry of the molecule using line/dash/wedge notation
(3) ☐ The value of the bond angle(s) written out
(4) ☐ The name of the molecular geometry
(5) ☐ A clear explanation of why the molecule ICl_5 is polar or nonpolar

(1) ICl_5

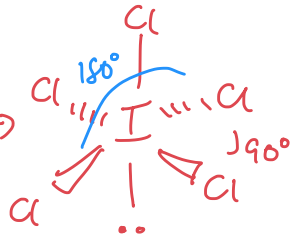
7 + 7 + 5 = 42
− 10
32
− 30
2
− 2
0



Lewis

(2)

6 reps →

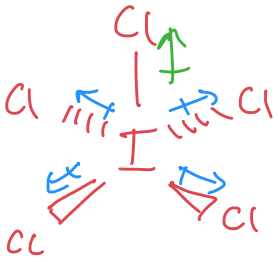


(3) 90°/180°

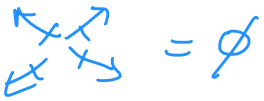
(4) e^- geom = octahedral

Mol geom = Square pyramidal

(5) Polar, since I–Cl bonds are polar and in geom, not all bond dipoles cancel → POLAR!



blue bond dipoles cancel!

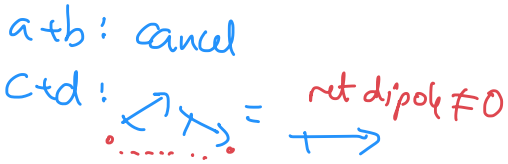


green dipoles doesn't cancel → molecule has non-zero dipole → POLAR

3 Point Bonus Question

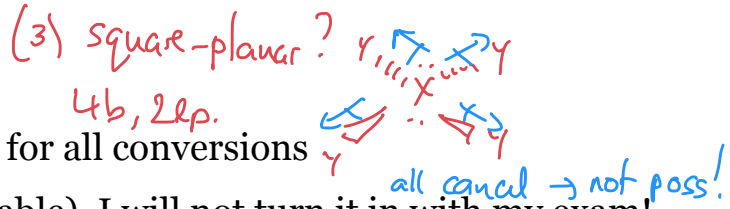
A molecule with the formula XY_4 is found to be <u>polar</u>. If atoms "X" and "Y" have different electronegativities, what <u>must</u> its molecular geometry be?

Exam checklist:



(Check the boxes to certify the following:)

- ❒ My full name is written legibly on the front page
- ❒ My correct lab section has been indicated on the front page
- ❒ My full name is written legibly on the scantron sheet
- ❒ My exam version (A, B, C, or D) is written on the scantron sheet
- ❒ I have shown work for all problems (where appropriate), paying attention to
  - Significant figures / decimal places
  - Units
- ❒ I have used the conversion-factor method for all conversions
- ❒ If I have torn off the back page (periodic table), I will not turn it in with my exam!



Thank you from the Chemistry Professors and Good Luck!

Partial List of Solubility Rules

TABLE 4.2 Solubility Rules for Common Ionic Compounds in Water at 25°C

Soluble Compounds	Exceptions
Halides (Cl^-, Br^-, I^-)	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Compounds	**Exceptions**
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), and sulfides (S^{2-})	Compounds containing alkali metal ions and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metal ions and the Ba^{2+} ion

Useful information:

$c = \nu\lambda$ $\quad E = h\nu$ $\quad c = 3.00 \times 10^8$ m/s $\quad h = 6.626 \times 10^{-34}$ J·s

$E_n = -R_H\left(\frac{1}{n^2}\right)$ $\quad R_H = 2.18 \times 10^{-18}$ J $\quad \lambda = \frac{h}{mu}$

Bond	Bond Enthalpy (kJ/mol)	Bond	Bond Enthalpy (kJ/mol)
H—H	436	C—C	347
N—F	272	C═C	620
N—N	193	C≡C	812
N═N	418	O—O	142
N≡N	946	O═O	499
C—H	414	F—F	157
O—H	460	N—H	393

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]