General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Fall 2019

December 5, 2019

Exam # 4 A

Name _____

Please write your full name, and the exam version (4 A) 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, 11:10 AM – 1:55 PM)
- ❒ 2. (Wednesday Lab, 11:10 AM – 1:55 PM) — **Fleeman**
- ❒ 3. (Monday Lab, 2:30 PM – 5:20 PM)
- ❒ 4. (Wednesday Lab, 2:30 PM – 5:20 PM) — **Napper**
- ❒ 5. (Thursday Lab, 12:30 PM – 3:20 PM)
- ❒ 6. (Tuesday Lab, 12:30 PM – 3:20 PM) — **Finnen**

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	**/ 5**
TOTAL:	_____	**/ 100**

You are only allowed to use a TI30–XIIS or equivalent non–programmable calculator on this exam !
(This means no cell phones, no smart phones, no smart watches, no iPads, or any other such devices will be allowed !)

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

Q1. Who is credited with the invention of the periodic table in the late 1860s, whereby the elements were ordered by atomic mass?

A) Pauli

B) Schrodinger

C) Moseley

D) Mendeleyeev

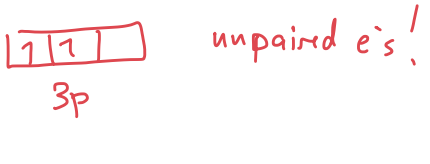
Q2. Which of the following atoms will be **paramagnetic** in their ground state?

A) helium

B) beryllium

C) neon

D) silicon



Q3. The chemical equation corresponding to the first ionization energy of carbon is:

A) $C(g) \longrightarrow C^{+}(g) + e^{-}$

B) $C(g) + e^{-} \longrightarrow C^{-}(g)$

C) $C^{+}(g) \longrightarrow C^{2+}(g) + e^{-}$

D) $C^{2+}(g) + e^{-} \longrightarrow C^{+}(g)$

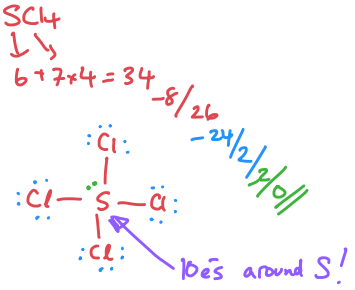
Q4. Which compound below has an expanded octet:

A) $BeCl_2$

B) CCl_4

C) SCl_4

D) $SiCl_4$



Q5. The bond angle in a tetrahedral molecule is

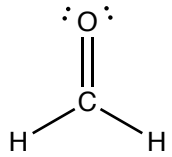
A) 90°

B) 109.5°

C) 120°

D) 180°

Q6. How many sigma and pi bonds are there in the following molecule:



A) 4 sigma, 0 pi

B) 3 sigma, 1 pi

C) 2 sigma, 2 pi

D) 1 sigma, 3 pi

Q7. What is the correct name of the compound, Cr_2O_3

A) chromium oxide

B) dichromium trioxide

C) chromium(II) oxide

D) chromium(III) oxide

Cr^{3+} O^{2-}

Cr_2O_3

Q8. How many **atoms** are there in 16.04 g of CH_4?

A) 6.022×10^{23}

B) 1.204×10^{23}

C) 3.011×10^{24}

D) 4.306×10^{22}

$16.04\text{g } CH_4 \times \frac{1\text{ mol } CH_4}{16.04\text{g } CH_4} \times \frac{6.022\times10^{23}\ CH_4}{1\text{ mol } CH_4} \times \frac{5\text{ atoms}}{1\ CH_4} = 3.011\times10^{24}\text{ atoms}$

Q9. A hydrocarbon contains 81.71 % carbon and 18.29 % hydrogen by mass. Its empirical formula is:

A) CH_2

B) CH_3

C) C_2H_9

D) C_3H_8

100g

$81.71\text{g C} \times \frac{1\text{ mol C}}{12.01\text{g C}} = 6.803\text{ mol C}$

$18.29\text{g H} \times \frac{1\text{ mol H}}{1.008\text{g H}} = 18.14\text{ mol H}$

÷ 6.803 mol

1.000 C

2.667 H (2 2/3)

C_3H_8 ← 3C : 8H ← ×3

Q10. Which quantum number determines the **shape** of an orbital?

A) n

B) l

C) m_l

D) m_s

Q11. Hot tea is a solution containing caffeine, water, and various polyphenols that are present in a consistent composition throughout. It can best be described as being a(n):

A) heterogeneous mixture

B) compound

C) homogeneous mixture

D) extensive solution

Q12. Which of the following atoms or ions would have the **smallest** radius?

A) K

B) K^+

C) Na

D) Na^+

Q13. Which diatomic molecule would contain the **shortest** covalent bond?

A) Br_2

B) Cl_2

C) O_2

D) N_2

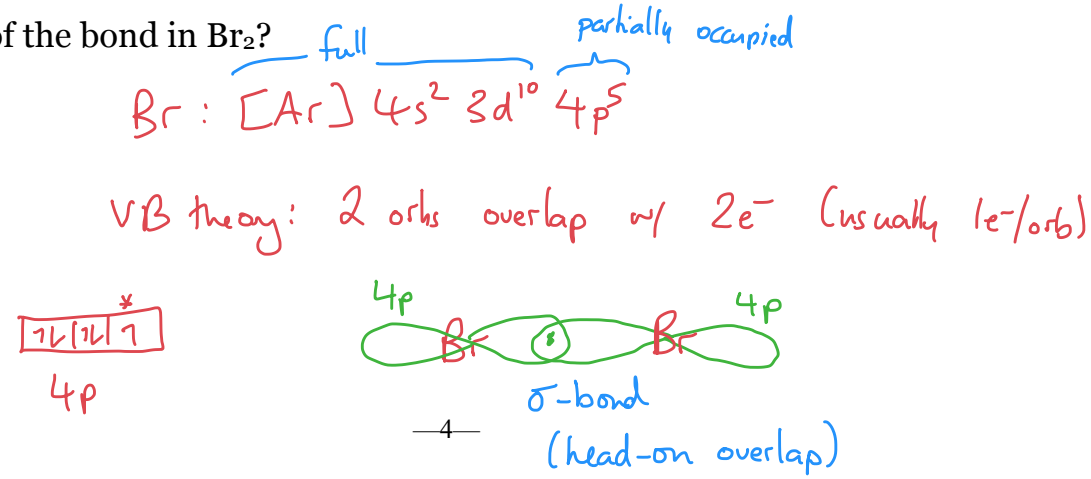
Q14. According to valence bond theory, which orbitals on bromine atoms overlap in the formation of the bond in Br_2?

A) 4s

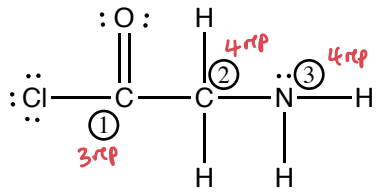
B) 4p

C) 4d

D) 4f



Q15. Consider the molecule below. Determine the hybridization at each of the three labeled atoms.



A) 1 = sp^2, 2 = sp^3, 3 = sp^3

B) 1 = sp^2, 2 = sp^3, 3 = sp^2

C) 1 = sp^3, 2 = sp^3, 3 = sp^3

D) 1 = sp^3, 2 = sp^3, 3 = sp^2

#rep	geom	angles	hybrids
2	linear	180°	sp
3	trig.-planar	120°	sp^2
4	tetrahedral	109.5°	sp^3
5	trigonal bipyramidal	90°, 120°, 180°	sp^3d
6	octahedral	90°, 180°	sp^3d^2

Q16. Choose the ground state electron configuration for Cr^{3+}

A) [Ar] $3d^3$

B) [Ar] $4s^1\ 3d^2$

C) [Ar] $4s^2 3d^6$

D) [Ar] $4s^2 3d^1$

Cr [Ar] $4s^1\ 3d^5$ (Anf Bau exception)

Cr^{3+} [Ar] $3d^3$ (remove 4s before 3d)

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

Q17. Give the molecular geometry and the number of *electron groups* (#repulsions) for BrF_5.

A) seesaw, 5 electron groups

B) square pyramidal, 6 electron groups

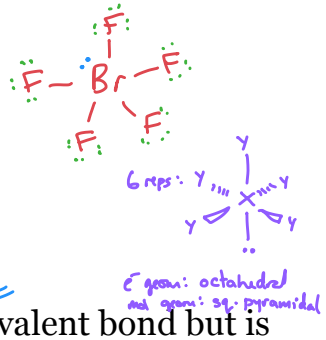
C) t-shaped, 5 electron groups

D) octahedral, 6 electron groups

BrF_5

7 + 7×5 = 42 e⁻

−10
32
−30
2
2
0



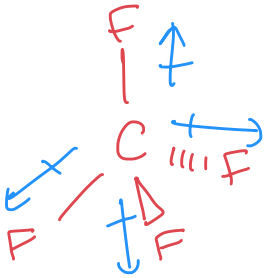
Q18. Choose the compound below that contains at least one polar covalent bond but is nonpolar.

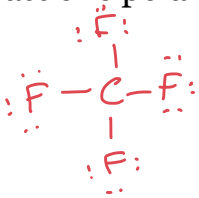
A) CF_4

B) HCN

C) $SeBr_4$

D) ICl_3





⟷ = bond-dipoles

bonds are polar, but overall dipole = 0 since bond dipoles all cancel out! (opposing dirns)

Q19. Identify the correct Lewis structure for MgO

A) :Mg≡≡≡O:

B) Mg—O

C) Mg^{2+} $[:\ddot{O}:]^{2-}$

D) Mg :O:

Q20. What is the best explanation for the fact that both bonds in ozone, O_3, have exactly the same strength?

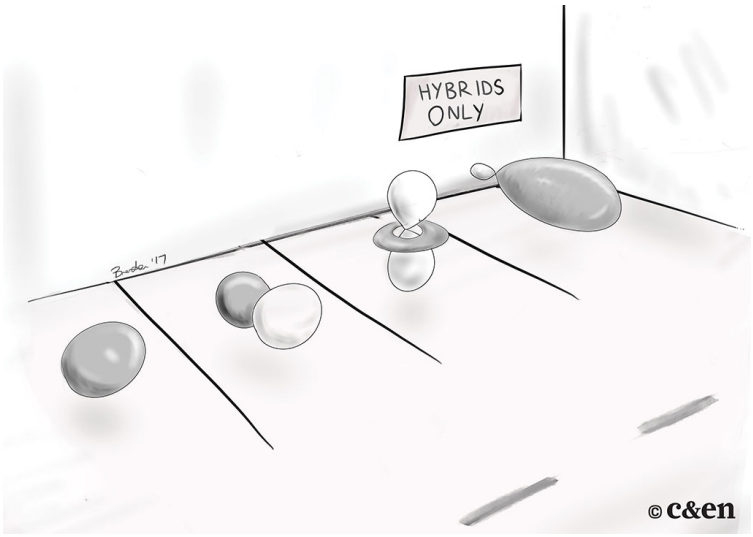
:O—O=O:

A) The central atom is sp^3 hybridized

B) Both outer atoms have complete octets

C) Ozone has resonance structures

D) Ozone is a stable form of the element, oxygen



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 !

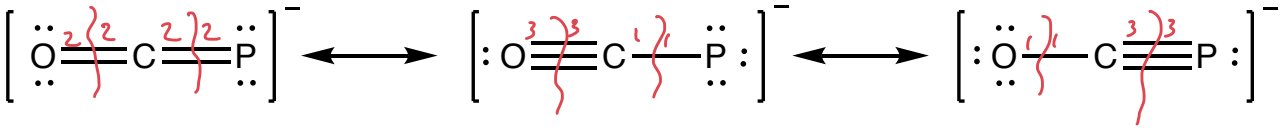
Q21. Place the correct number next to the letter that best matches.
(use each number only once)

2 A.	Increases across the periods from left to right	1. Beryllium
4 B.	States that electrons enter unoccupied orbitals in a subshell with parallel spins before pairing up	2. First ionization energy
6 C.	An element that is capable of expanding its octet	3. Auf Bau
1 D.	An element that is frequently electron deficient	4. Hund's rule
10 E.	Decreases across the periods from left to right	5. Shielding
3 F.	States that electrons tend to enter lower energy subshells first before entering higher energy subshells	6. Sulfur
5 G.	The effect by which core electrons tend to reduce the effective nuclear charge felt by valence electrons	7. Pauli principle
7 H.	States that electrons must have a unique set of quantum numbers in an atom	8. Core
8 I.	The 2s electrons in a magnesium atom	9. Valence
9 J.	The 2p electrons in a nitrogen atom	10. Atomic radii

Q22. The polyatomic ion, OCP^- has several resonance structures that contribute to its electronic description. Three possible resonance structures are drawn below.

i) Determine the formal charge for each atom in the structures: *(be sure to show your work)*

FC: atoms share e's in bond.



O 0 **C** 0 **P** −1

O +1 **C** 0 **P** −2

O −1 **C** 0 **P** 0

	O	C	P
ORIG	6	4	5
NOW	6	4	6
FC	0	0	−1

	O	C	P
	6	4	5
	5	4	7
	+1	0	−2

	O	C	P
	6	4	5
	7	4	5
	−1	0	0

ii) **Explain** which structure (left, middle, right) likely contributes the most to our electronic description of the ion?

Right. (1) Lowest sum of |FC|
(2) −1 FC is on most electronegative atom (O vs. P)

Q23. Write out **full** electron configurations for the following atoms/ions:

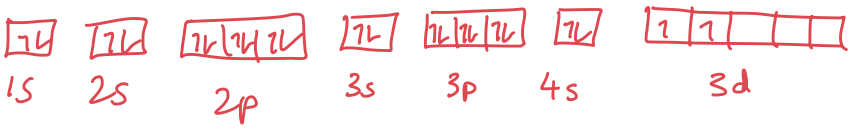
i) Ti $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

ii) Cu $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ (Aufbau exception!)

iii) Ni^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$ (remove from 4s (valence) before 3d (core))

Write out the orbital diagram for:

iv) Ti



Is Ti diamagnetic or paramagnetic? Explain!

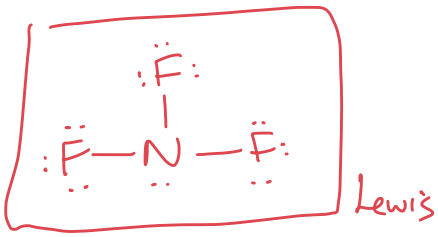
Paramagnetic, due to it having two(2) unpaired e⁻s in 3d subshell.

Q24. Predict the molecular geometry and polarity of NF_3. Your answer should include:

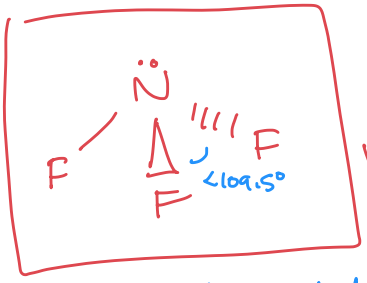
- ❑ A valid Lewis structure
- ❑ The total number of valence electrons
- ❑ A sketch of the geometry using line/dash/wedge notation
- ❑ The value of the bond angle(s) written out
- ❑ The name of both the **molecular** and **electron** geometry
- ❑ A clear explanation of why NF_3 is polar or non-polar

NF_3

$5 + 7 + 3 = \boxed{26\ e^-}$



Lewis



VSEPR

e^- geom: tetrahedral

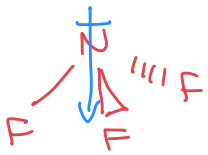
mol. geom: trigonal pyramidal

$\overrightarrow{N-F}$ bond is polar

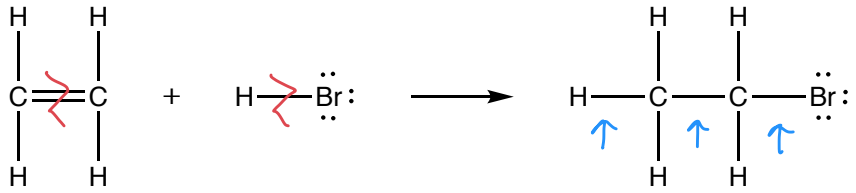
bond dipoles do not cancel

→ NF_3 is Polar!

overall dipole:



Q25. (i) Using the table of bond dissociation energies below, estimate ΔH for the following gas-phase chemical equation:



break (+)

make (−)

Bond	Bond enthalpy (kJ/mol)
C–C	348
C=C	614
C–H	413
H–Br	366
C–Br	276

$\Delta H^\circ_{rxn} \approx [1 \times C{=}C + 1 \times H{-}Br] - [1 \times C{-}H + 1 \times C{-}C + 1 \times C{-}Br]$

$\approx [1 \times 614\ \frac{kJ}{mol} + 1 \times 366\ \frac{kJ}{mol}] - [1 \times 413\ \frac{kJ}{mol} + 1 \times 348\ \frac{kJ}{mol} + 1 \times 276\ \frac{kJ}{mol}]$

$\approx -57\ kJ/mol$

(ii) What is the molecular geometry about each carbon atom in the **reactant** molecule, C_2H_4?

trigonal planar, 120° (3 reps)

(iii) According to valence bond theory, the C–H bond in the **reactant** molecule, C_2H_4 forms from the overlap between which two orbitals?

___1s___ on Hydrogen, with ___sp^2___ on Carbon

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 (4A, 4B, 4C, or 4D) 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

Thank-you from the Chemistry Professors and Good Luck!

Useful information:

$N_A = 6.022 \times 10^{23}\ mol^{-1}$

Periodic Table of the Elements

IA 1	IIA 2	3	4	5	6	7	8	9	10	11	12	IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	VIIIA 18
1 **H** 1.008																	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											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]