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

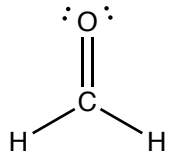
A) 90°

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

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}

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

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 **<u>smallest</u>** radius?

A) K

B) K^+

C) Na

D) Na^+

Q13. Which diatomic molecule would contain the **<u>shortest</u>** 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?

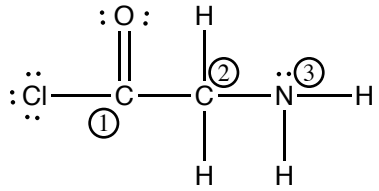
A) 4s

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

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] $4s^2 3d^1$

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

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

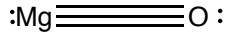
A) CF_4

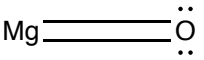
B) HCN

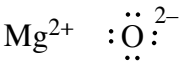
C) $SeBr_4$

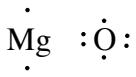
D) ICl_3

Q19. Identify the correct Lewis structure for MgO

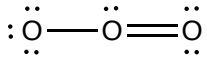
A) 

B) 

C) 

D) 

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

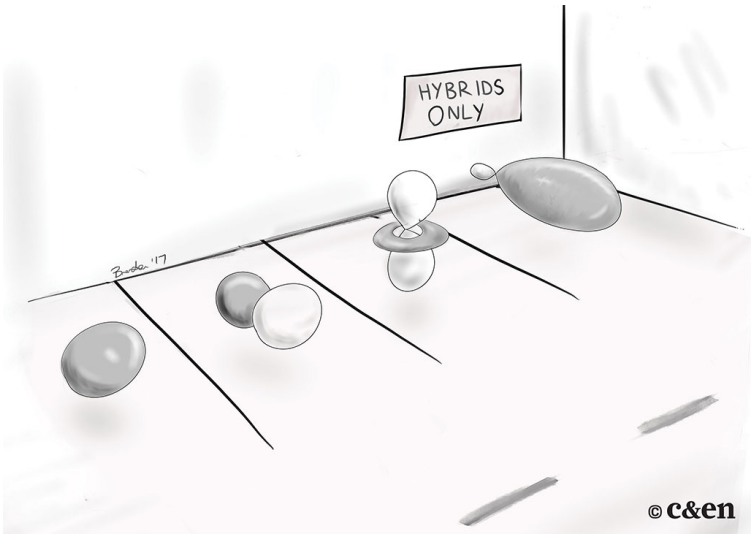


A) The central atom is sp^3 hybridized

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 !

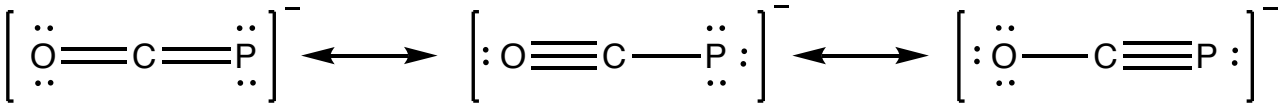
All numeric answers must be rounded to the correct number of significant figures !

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

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



O ___ **O** ___ **O** ___

C ___ **C** ___ **C** ___

P ___ **P** ___ **P** ___

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

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

i) Ti

ii) Cu

iii) Ni^{2+}

Write out the orbital diagram for:

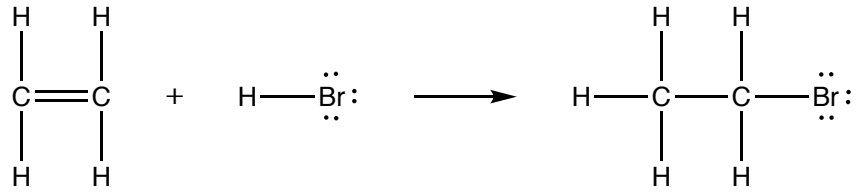
iv) Ti

Is Ti diamagnetic or paramagnetic? Explain!

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

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

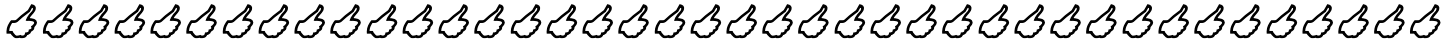


Bond	Bond enthalpy (kJ/mol)
C–C	348
C=C	614
C–H	413
H–Br	366
C–Br	276

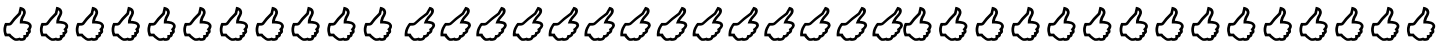
(ii) What is the molecular geometry about each carbon atom in the **reactant** molecule, C_2H_4?

(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?

_____ on Hydrogen, with _____ on Carbon



5 Point Bonus Question



The following page contains a General Education Program (GEP) assessment problem that is required from all students taking General Chemistry. Your answers are very important and will be used to make improvements to all of our science courses in the GEP. Please allow approximately 10–20 minutes at the end of today's exam to read the following passage and answer the associated questions.

In order for this assessment to be valid, ALL students are required to fully complete this exercise.

Thank-you!

Name: _____ Semester / Year: _____

Course (circle): CHEM 1121, 1141, 1142, NTSC 1110
Section #: _____

Please read the following narrative and answer the seven questions below to the best of your ability.

In the early 5th century BCE, the Greek philosophers Democritus and Leucippus documented the concept of the *atomos* (or atoms), indivisible building blocks of matter. Atoms, which combine to form molecules, are extremely small—being around a ten-billionth of a meter. In 1904, soon after the discovery of the electron, English physicist J. J. Thomson proposed a model of the atom using two basic principles known at the time: (1) the newly discovered electrons were negatively charged and (2) atoms were overall neutral.

Known as the "plum pudding model," Thompson's proposal needed to account for a source of positive charge to counter-balance the negative charge of the electrons. Among several possibilities, he settled on the idea that the electrons occupied regions of space within a uniform region of positive charge—like plums in a pudding!

Thompson's ideas, at the time, were not universally accepted. Ernest Rutherford, a New Zealand-born British physicist, spent time early in his career working on the concepts of radioactive half-life and the particles that are produced. One particle produced by radioactive decay, the alpha particle, is identical to the helium-4 nucleus. Rutherford and other scientists fired these positively charged alpha particles at a thin sheet of gold foil. This was later known as the "Rutherford gold foil experiment."

If Thompson's model were correct, the alpha particles when fired at an atom (in this case gold) would pass through largely unaffected with only slight deflections. When Rutherford performed the experiment, most alpha particles passed through with little deflection. However, some deflected at unexpectedly large angles. In fact, alpha particles were spotted deflecting in all directions, with some coming right back towards the source! Building on the ideas of Rutherford, Danish physicist Niels Bohr modified Rutherford's model by stating that electrons moved around the positive nucleus in fixed orbits and could not occupy areas in between. His notions helped explain the spectral emission lines of atoms. Rutherford's and Bohr's ideas helped set forth our understanding of a nuclear atom with vast amounts of empty space and a concentrated positive charge in the atom's center surrounded by electrons orbiting like planets around the sun.

Q1. The problem that these scientists are seeking to solve can best be summarized as:

Q2. Identify and describe whether a theory or a hypothesis is being evaluated and summarize it in your own words:

Q3. Identify and describe the prediction(s) that logically follows from the theory / hypothesis and describe any other factors that may alter the outcome:

Q4. Identify and describe data pertinent to evaluating the theory / hypothesis under study and corresponding prediction:

Q5. Describe the type of reasoning and methodology used to collect these data:

Q6. From this article, describe what you can conclude based on the findings and how robust those conclusions should be considered:

Q7. Based on the experimental design and data described, explain why and how strongly the conjecture represents sound science or pseudoscience:

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]