General Chemistry 1 – Practice Exam (Adapted from in-person Midterm 2021)

Instructions :

This is a **CLOSED BOOK** exam. All answers must be written within the exam booklet. If you have any issues with an exam question, write them on top of page 1 (this page).

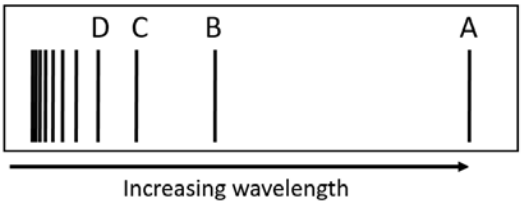
NO EXTRA BOOKLETS AND NO CRIB SHEETS are permitted.

Use of **translation-only** dictionaries, and only **non-programmable** calculators is permitted.

Use of Molecular Modeling kits is allowed. This booklet has **12 total pages (6 double-sided – PRINTED ON BOTH SIDES)** including the cover page.

- Please write legibly and dark enough for a scanner to read.
- **Answer ONLY on the sheets that have a QR code**.
- **Do not write on the QR codes** at the top of the page.
- **Do not write beyond the margins and the diagonal line in the top corners**.
- If you need extra paper to complete a question, use the extra workspace with the QR-code at the end of this booklet. Indicate in the appropriate question that the marker should look at Page # for the full answer.

Question 1 (8 points)



The figure given represents a part of a calculated *emission* spectrum of a one-electron ion in the gas phase (Assume Bohr's model can apply). Each line represents the wavelength of a photon resulting from the transition from an initial state to a final state of n = 5. The four longest wavelengths (A, B, C, and D) are denoted in the figure.

a. What transition corresponds to line D? Give $n_{initial}$ and n_{final} **2 points**

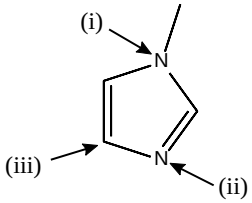
(i) $n_{initial}$	(ii) n_{final}

b. Among the lines A, B, C, and D, circle the correct choice reflecting which corresponds to a photon of (i) lowest and (ii) highest frequency? **2 points**

(i) Lowest:	A	B	C	D	(ii) Highest:	A	B	C	D

c. If line C is at a wavelength of 415.5 nm, which ion does this calculated emission spectrum correspond to? Show your work **4 points**

Question 2 (12 points)



For the molecule and indicated atoms (denoted with an arrow, (i) to (iii)) answer the following questions. Consider the structure as given (no need to consider resonance structures). All atoms have formal charge of 0 (lone pairs are not shown). (Use valence bond theory and hybridization to describe the bonding.)

a. How many **total** sp^2-s sigma bonds are in the given molecule **(1 point)**

b. **1.** Describe the orbitals involved in all bonds formed by N (i). Designate sigma/pi bonds. **(2 points)**

2. What is the electron **and** molecular geometry at N (i)? **(2 points)**

3. Circle the one value that best describes the C-N-C bond angle at N(i)). **(0.5 point)**

>90° to <109.5° 109.5° >109.5° to <120° 120° >120° to <180

c. **1.** Describe the orbitals involved in all bonds formed by N (ii). Designate sigma/pi bonds. **(2 points)**

2. What is the molecular geometry at N (ii). **(1 point)**

3. Circle the one value that best describes the C-N-C bond angle at N (ii). **(0.5 point)**

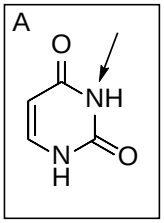
>90° to <109.5° 109.5° >109.5° to <120° 120°

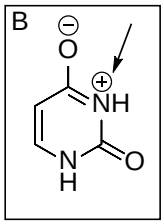
4. Consider x as the bond axis, how many p_x-p_x and p_y-p_y pi bonds does (ii) have? **(1 points)**

p_x-p_x pi bonds = p_y-p_y pi bonds =

d. What is the electron **and** molecular geometry at (iii) **(2 points)**

Question 3 (8 points)





One of the research projects in Prof. McKeague's lab focuses on understanding how small molecules may bind to nucleic acids (DNA/RNA) and develop small molecules for therapeutic purposes. A and B represent the structures of a nucleotide (building block of nucleic acids). Note: Lone pairs of electrons are not shown.

i. What is the relationship between A and B? **(1 point)**

ii. What is the hybridization on the N (indicated with an arrow) in A? What is the hybridization of the N (indicated with an arrow) in structure B? **(2 points)**

Hybridization of indicated N in A:

Hybridization of indicated N in B:

iii. What are the intermolecular forces present between different molecules of A? **(3 points)**

iv. Between structures A and B, how many electrons are delocalized? **(2 points)**

Question 4 (12 points)

a. (6 points) Arrange the following (molecules 1, 2, and 3). Briefly explain your answer in the space provided

i. In increasing order of boiling point

1. 2-methylpentane 2. 2,2-dimethylbutane 3. Heptane

Increasing Order (lowest to highest): Explanation:

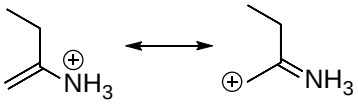
ii. In increasing order of bond angles

1. H_2S 2. XeF_2 3. $[SbF_6]^-$

Increasing Order (smallest to largest): Explanation:

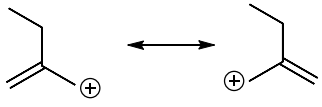
b. (6 points) True or False

Pair 1



Pair 1 is a pair of resonance structures. True or False (Circle one) Briefly explain your choice in the space below

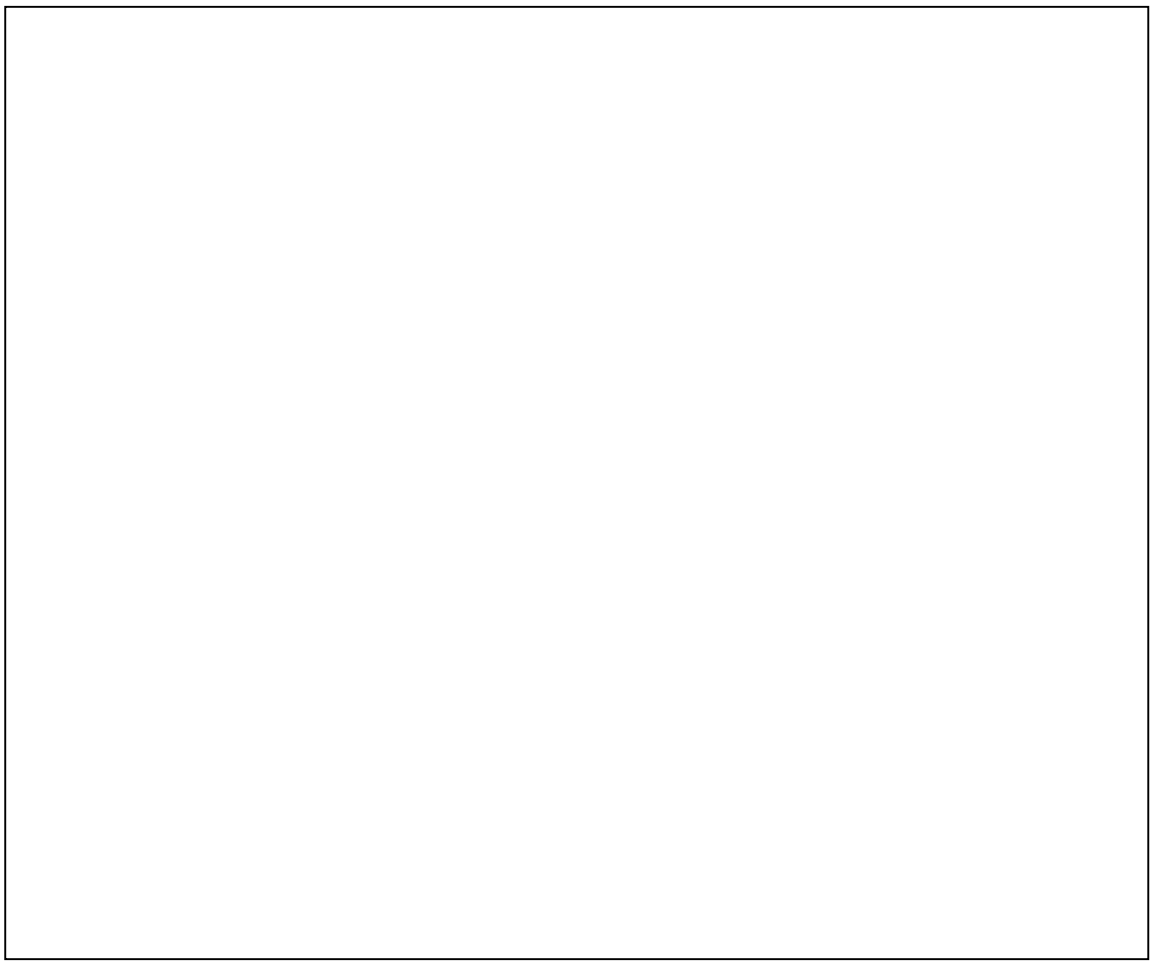
Pair 2



Pair 2 is a pair of resonance structures. True or False (Circle one) Briefly explain your choice in the space below

Question 5 (7 points)

Draw the complete MO diagram (valence orbitals only) for the molecule CN. Make sure to label atomic and molecular orbitals. Label the energy axis. What is the bond order?

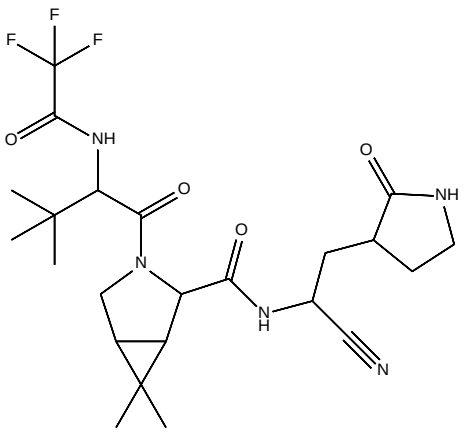


Question 6 (10 points)

a. Draw the following molecules as skeletal structures. **(8 points)**

meta-dichlorobenzene	4-methylnon-6-en-2-yne
4-bromopent-2-ene	1-ethyl-4,5-dimethylcyclohex-1-ene

b. How many units of unsaturation are there in Paxlovid, the new Pfizer drug for COVID-19 shown below? **(2 points)**

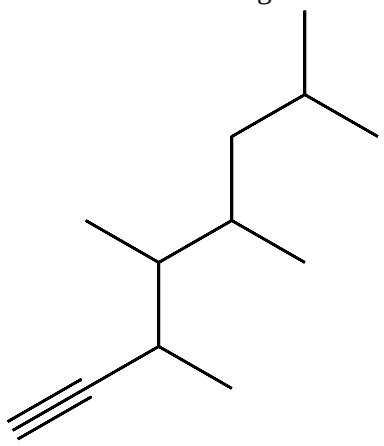


Question 7 (10 points)

a. For the following hydrocarbons, determine the degree of unsaturation (show your work) and draw one possible structure using skeletal structures **(6 points)**.

i. C_7H_{12}
ii. C_8H_{12}

b. Consider the following molecule.



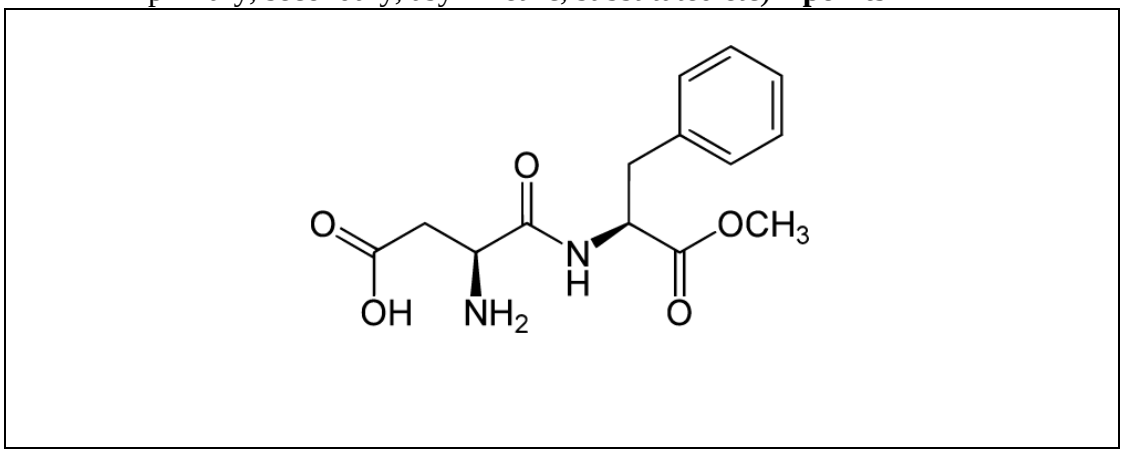
i. Circle all the tertiary carbons in the structure provided. **(1 point)**

ii. Provide the molecular formula of this molecule. **(1 point)**

iii. Provide the systematic (IUPAC) name **(2 point)**

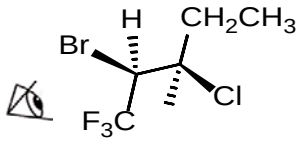
Question 8 (7 points)

a. Regarding the molecule aspartame below, circle and identify all the functional groups present (what we learned in class). Be sure to provide the details about the functional groups (e.g., primary, secondary, asymmetric, substituted etc) **4 points**



a) How many units of unsaturation are there in the aspartame molecular above? **1 point**

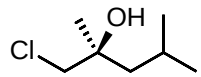
b) Draw the Newman projection of the following molecule from the perspective indicated **2 points**



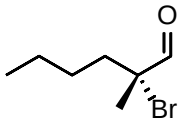
Question 9. 10 points

a) Give each molecule the appropriate stereochemical assignment (R vs S). Show the priority. **3 points**

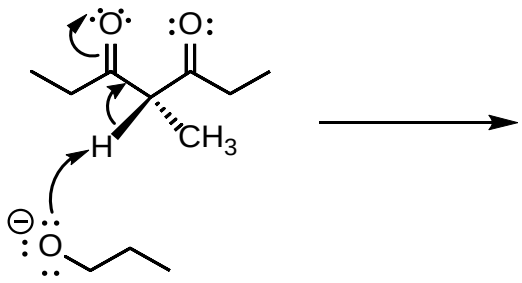
i.



ii.

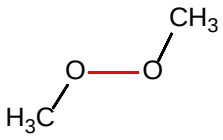


b) Draw the **product(s)** of this arrow pushing. Use skeletal structures. Be sure to include any charges and lone pairs in the product(s). **4 points**

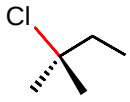


c) Break the red bond of the following molecules as indicated, showing the correct arrows to represent the movement of electrons. Show the cleaved products with the appropriate electrons or charge. **3 points**

i. homolytic

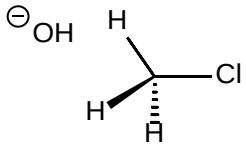


ii. heterolytic



Question 10 (7 points)

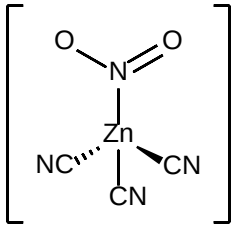
a) Provide the detailed mechanism of the SN2 reaction of methylchloride with the hydroxyl shown below. Include any transition states or intermediates of the reaction. Use arrows to indicate the flow of electrons and indicate any charge. **4 points**



b) Assume that the SN2 reaction above is exothermic, draw the associated reaction energy diagram for this reaction. Include all the necessary labels. (**3 points)**

Question 11 (9 points)

Fill out the table by providing the following information for the two coordination complexes. **8 points**

	diamminedichloroplatinum(II)	Na_2 
Oxidation state		
Coordination number		
Shape		
Draw isomers indicated	The pair of possible geometric isomers	A linkage isomer of the above complex

b) Provide the IUPAC name for this coordination complex: $[Cr(en)_2Cl_2]Cl$ **(1 points).**