Chem 101 Test 2
ANSWER KEY
Versions A & B

Part I Multiple Choice Questions

Question #	Version A	Version B
1	A no mark	B no mark.
2	C	A
3	B	E
4	D	E
5	A	B
6	D	A
7	C	D
8	C	C
9	C	A
10	C	E
11	B	C
12	B	D
13	C	D

There were supposed to have been 13 graded questions instead of only 12. So we added 1 mark to everyone's raw score out of 12 (a free mark). Essentially everyone was assumed to have got the missing 14th question right.

ANSWER KEY

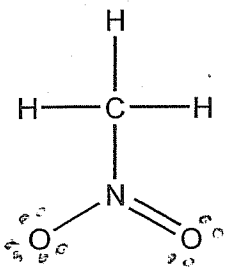
PART II – Written Answers to Questions. [Total Marks = 24]

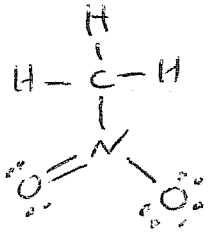
Write your answers directly on this test paper. **Show all your work.** This helps us to award part marks instead of zero where appropriate. Hand in the entire test paper at the end of the test period.

1. **[3 Marks]** (a) Complete the following Lewis structure of nitromethane by filling in the appropriate number of pairs of non-bonding electrons on the appropriate atoms. Then draw a second different Lewis structure for this molecule that obeys the octet rule. Then use these structures and the DATA sheet to estimate the length of the nitrogen-to-oxygen bond in nitromethane.

[2.5]

There are 24 valence electrons





From Data Sheet N–O 136 pm
N=O 122 pm

Average = $\frac{136+122}{2}$ = 129 pm
= 1.29 Å

[0.5] (b) Nitromethane has a boiling point of 103°C. What kind of intermolecular forces contribute most to giving this small molecule such a high boiling point? Circle ONE.

Ionic Ion-Dipole (Dipole-Dipole) Hydrogen Bonding London Dispersion

2. **[4 MARKS]**

The reaction of hydrogen peroxide (H_2O_2) with carbon monoxide (CO) to form hydrogen (H_2) and carbon dioxide (CO_2) is shown below. The bond dissociation energy (D) of the carbon-to-oxygen bond in CO is 1072 kJ mol^{-1}. Using data from the data sheet calculate an approximate enthalpy of reaction ($\Delta H_{reaction}$) for this process.

Data Sheet Gives D_{H-O} = 467 kJ mol^{-1}, D_{O-O} = 146, D_{H-H} = 432, $D_{C=O}$ = 800 kJ/mol

$$H{-}O{-}O{-}H\ (g) + 2\ CO\ (g) \longrightarrow H_2(g) + 2\ CO_2\ (g)$$

Bonds Broken

2 mol O–H = 2 × 467 = 934 kJ mol^{-1}
1 mol O–O = 1 × 146 = 146 " "
2 mol CO = 2 × 1072 = 2144 " "
Total 3224 kJ mol^{-1}

Bonds Formed

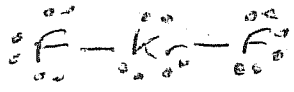
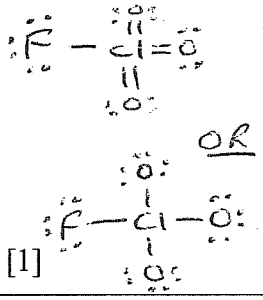
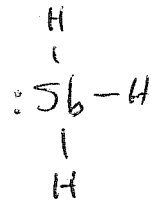
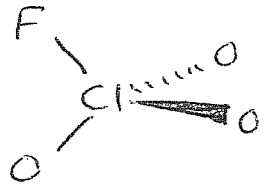
1 mol H–H = 1 × 432 = 432
4 mol C=O = 4 × 800 = 3200
Total = 3632 kJ mol^{-1}

But this energy change is negative because energy is given off.

Approximate ΔH_{rxn} = 3224 + (−3632) = −408 kJ mol^{-1}

3. [9 Marks] ANSWER KEY

Complete the following table by filling in the appropriate information or drawing in each empty cell:

Molecular formula	KrF_2 22 e⁻	$ClFO_3$ (Cl is central atom) 32e⁻	SbH_3 8 e⁻
Lewis structure	 [1]	 OR [1]	 [1]
Electron domain shape (central atom)	trigonal bipyramid [0.5]	tetrahedral [0.5]	tetrahedral
Hybridization of central atom	sp^3d	sp^3 [0.5]	sp^3 [0.5]
Molecular shape **(sketch, but do not sketch orbitals)**	F—Kr—F	 [1]	 [1]
Name of molecular shape.	linear	tetrahedron [0.5]	trigonal pyramid [0.5]
Is the molecule polar? (yes/no)	no	yes [0.5]	yes [0.5]

In version B these two columns are switched

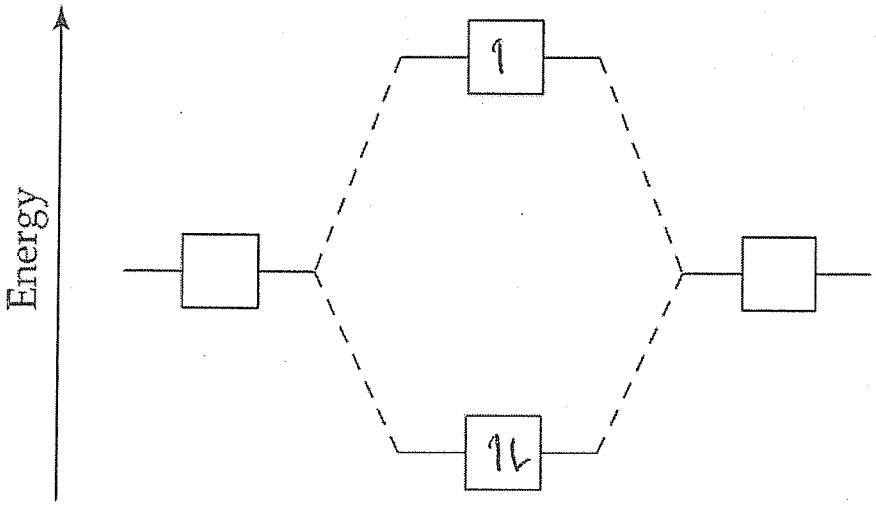
ANSWER KEY

4. [2 MARKS] Consider the following molecular orbital energy diagram, which applies to diatomic species that use only 1s orbitals.

a) Using arrows to represent electrons (↑↓), use this diagram to represent the electron configuration of the He_2^+ ion.

b) Calculate the bond order in this ion.

He_2^+ has 3 e^-



He_2^+

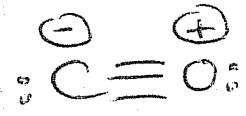
$$\text{Bond Order} = \frac{(\#\text{ bonding } e^-) - (\#\text{ antibonding } e^-)}{2}$$

$$= \frac{2-1}{2} = 0.5$$

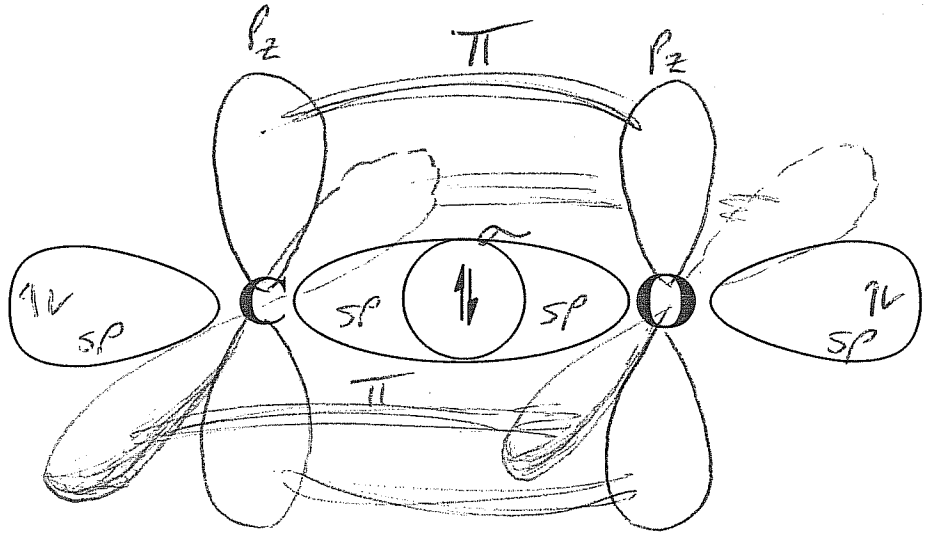
5. **[6 MARKS]** ANSWER KEY

Consider the carbon monoxide molecule CO.

[2] (a) Draw one Lewis structure for CO that obeys the octet rule. Show any non-zero formal charges on the C and O atoms. [2MARK]



[4] (b) Based on the structure in part (a) above, **complete the sketch below**. That is, ensure that the completed drawing includes all the atomic orbitals used to form ALL sigma (σ) bonds and pi (π) bonds in this molecule, as well as any orbitals containing lone pairs of electrons. Show clearly how the orbitals overlap to form bonds. **Label all the orbitals, including all the ones already shown (what type of hybrid orbital). Label <u>all</u> bonds as sigma (σ) or pi (π). [4 MARKS]**



Labeling of orbitals in the template [1]

Sketch of one pi-bond [1]

Sketch of other pi-bond [1]

Labeling of one σ and two π bonds [1]

Compare Figure 4.24 p134 in custom Text.

END