Chemistry 1A, Fall 2002

Midterm Exam II, Version A
October 15, 2002

(90 min, closed book)

Name:_____ **TA:**_____

SID:_____ **Section:**_____

Please read this first: Write your name and that of your TA on all 10 pages; On the **Scantron™**, bubble in Form A.

Test-taking Strategy

This test consists of two parts: multiple choice (**answers to be circled and entered on the Scantron™ sheet**) and short answer. In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Then, go back and spend more time on the questions you find more challenging.
- Budget your time carefully -- don't spend too much time on one problem.

- Show all work for which you want credit and don't forget to include units.

Page	Score
MC	
9	
10	
11	
Total	

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Potentially Useful Information

$PV = nRT$

$MM = mRT / (PV)$

$T(K) = T(C) + 273.15$

$R = 0.0821\ L \cdot atm / (mol \cdot K)$

$A = elC$

$P_a = X_a * P_{tot}$

$P = F/A$

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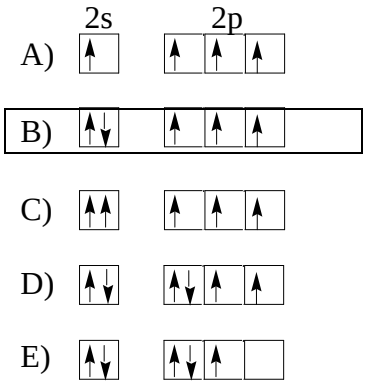
Part I Multiple Choice (4 pts each, 108 pts total) Bubble in the correct answer on your Scantron™ form AND circle your answer on the exam. There is only one correct answer for each question, so you should circle and fill in one and only one answer for each question. There is no penalty for an incorrect response.

1.) Which of the following is the most likely valence electron configuration of an oxygen atom after it has been ionized to O^+?



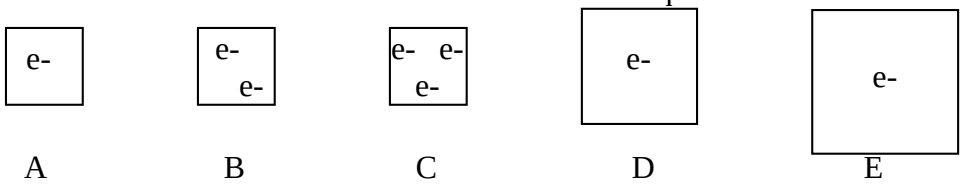
2.) Which of the following has the highest ionization energy?

A) F B) Na^+ C) Na D) Xe E) Li

3.) Which of the following has the largest radius?

A) F B) F^- C) Be D) Na^+ E) Li correct, but F- accepted also

Use the pictures below of electrons confined to boxes to answer the following two questions. Fill in the letter of the box which answers each question.



4.) Which box contains the electron with the highest ionization energy? E

5.) Which box contains the electron with the lowest kinetic energy? E

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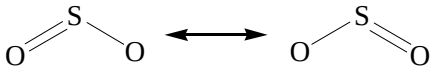
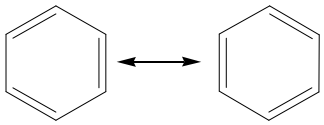
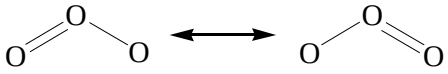
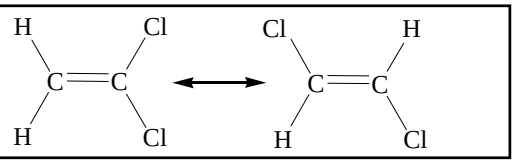
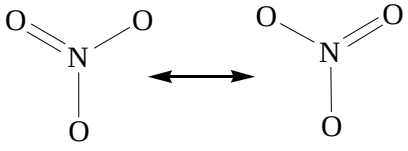
6.) Which of the following is not a resonance pair?

A) 

B) 

C) 

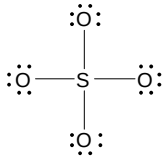
D) 

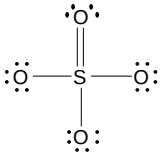
E) 

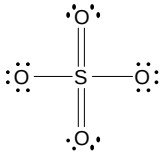
7.) Which of the following statements about ionic solids is FALSE?

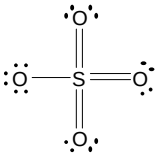
A) Coulombic attractions account for many of their properties.
B) They are typically brittle.
C) They generally have high melting points.
D) Smaller ions result in weaker interactions.
E) Ions generally pack in regular crystalline structures.

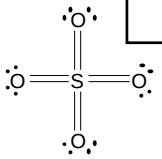
8.) Which of the following representations is correct for the sulfate ion (SO_4^{2-})?

A) 

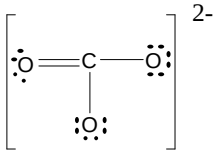
B) 

C) 

D) 

E) 

9.) What is the bond order of the C-O bond in the carbonate ion shown below?



A) $^1/_2$ B) 1 C) $1\ ^1/_3$ D) $1\ ^1/_2$ E) 2

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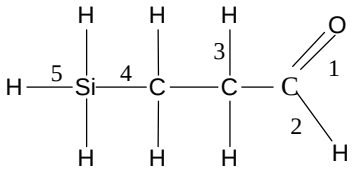
10.)Which of the numbered bonds in the picture below has the highest dipole moment?



A) 1 B) 2 C) 3 D) 4 E) 5

11.)Which of the following has the shortest bond distance?

A) HF B) HCl C) HBr D) HI E) HAt

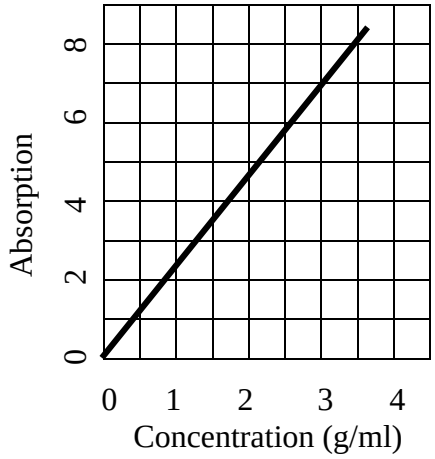
12.)Which of the following has the lowest bond dissociation energy?

A) HF B) HCl C) HBr D) HI E) HAt

13.)Which of the following carbon-carbon bonds has the shortest bond distance?

A) single B) double C) triple D) not enough information

14.)What is the extinction coefficient in units of $ml \cdot g^{-1} \cdot cm^{-1}$ of a sunscreen sample with the absorption plot shown below? A 0.5 cm cuvette was used.



A) 2.4 B) 3.0 C) 4.8 D) 6.2 E) 7.2

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15.)Why does the ionization energy of atoms increase as you sequentially remove electrons?

A) the electron experiences a higher effective nuclear charge
B) the remaining electrons are held more strongly
C) atomic radius is decreasing
D) all of the above
E) none of the above

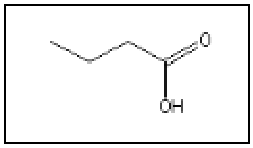
16.)Arrange Ar, S^{2-}, K^{+}, Ca^{2+}, Cl^{-} in order of increasing ionization energy.

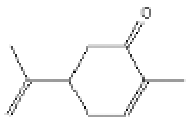
A) $Ar < S^{2-} < K^{+} < Ca^{2+} < Cl^{-}$
B) $K^{+} < Ca^{2+} < Cl^{-} < Ar < S^{2-}$
C) $Ca^{2+} < K^{+} < Ar < Cl^{-} < S^{2-}$
D) $Ar < S^{2-} < K^{+} < Ca^{2+} < Cl^{-}$
E) $S^{2-} < Cl^{-} < Ar < K^{+} < Ca^{2+}$

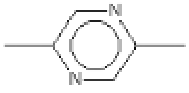
17.)In class you observed the reaction between boron trifluoride and ammonia to form BF_3NH_3. Why does this reaction occur?

A) boron completes its octet as a result of the reaction
B) nitrogen completes its octet as a result of the reaction
C) fluorine needs one electron to complete a shell
D) because light is released
E) because the product is a solid

18.)If butyric acid (shown below) smells sour, which one of the following compounds is also likely to smell sour?

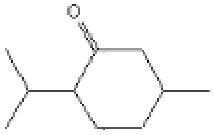


A) 

B) 

C) 

D) 

E) 

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19.)Which of the following molecules has the molecular structure most similar to CH_4?

A) SF_4
B) XeF_4
C) $SiCl_4$
D) NH_3
E) None of these

20.)What are the approximate HNH angles in NH_3?

A) 60
B) 90
C) 107
D) 109
E) 120

21.)Which of the following molecules is bent?

A) CO_2
B) H_2S
C) $BeCl_2$
D) N_2O
E) None of these

22.)Which of the following molecules has a central atom with sp^3 hybridization?

A) NH_3
B) XeF_4
C) $BeCl_2$
D) SF_4
E) SF_6

23.)A 0.67 g sample of a hydrocarbon is held in a 1 L balloon at 1 atm and a temperature of 300 K. What is the hydrocarbon?

A) CH_4
B) C_2H_4
C) C_2H_6
D) C_3H_8
E) C_3H_4

24.)Assuming the surface area of your body as seen from above is 150 square inches, what is the approximate difference between the weight of air you support (in pounds) at sea level (atmospheric pressure= 14.7 lbs/inch^2) and on Mt. Everest (atmospheric pressure=4.7 lbs/inch^2)?

A) 10
B) 100
C) 500
D) 1000
E) 1500

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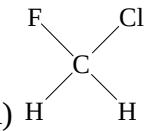
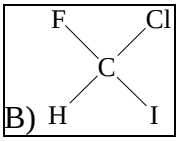
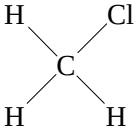
25.)A 250 mL rigid closed container containing air at 1atm and 27°C is heated until it explodes at 1227°C. What was the pressure inside the container just before it exploded?

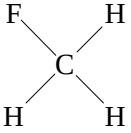
A) 1atm
B) 2 atm
C) 5 atm
D) 20 atm
E) 45 atm

26.)Which of the following molecules is chiral?

A) 

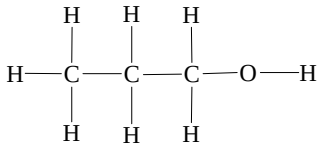
B) 

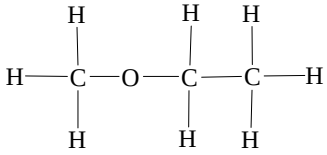
C) 

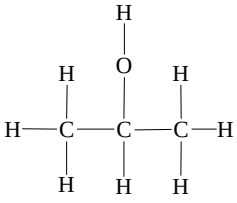
D) 

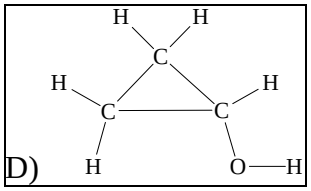
E) none of these

27.)Which of the following molecules is not a structural isomer of C_3H_8O?

A) 

B) 

C) 

D) 

E) all of these molecules are structural isomers of C_3H_8O

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Part 2: Short Answer Problems (42 pts total)
Instructions: Enter answers in the boxes where provided. Show all work for which you wish to receive credit.

1. (10 pts) In the space below, complete the MO energy level diagrams for N_2^+, N_2, and N_2^-; provide the bond order; circle P or D to indicate whether the species is paramagnetic or diamagnetic. 2 pts. for each MO, 1 for B.O, 1 for P/D

N_2^+	N_2	N_2^-
____ s^*_{2p}	____ s^*_{2p}	____ s^*_{2p}
____ ____ p^*_{2p}	____ ____ p^*_{2p}	_?_ ____ p^*_{2p}
_?_ s_{2p}	_??_ s_{2p}	_??_ s_{2p}
_??_ _??_ p_{2p}	_??_ _??_ p_{2p}	_??_ _??_ p_{2p}
_??_ s^*_{2s}	_??_ s^*_{2s}	_??_ s^*_{2s}
_??_ s_{2s}	_??_ s_{2s}	_??_ s_{2s}
5/2 bond order	3 bond order	5/2 bond order
P	D	P

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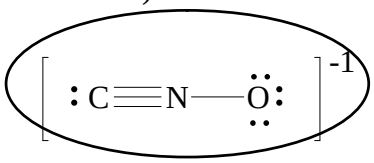
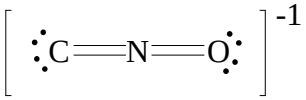
2. (12 points total) The cyanate anion has many possible structures.

a) For each of the structures below, write the formal charge for each atom in the boxes provided. Then circle the structure that is most stable. 1 point for each box, one bonus point for circling the correct structure

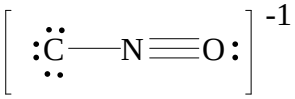
b)



-1	+1	-1
C	N	O



-2	+1	0
C	N	O



-3	+1	+1
C	N	O

b) (3 pts) For the structure on the right, what are the oxidation numbers for C, N, and O?

-2	+3	-2
C	N	O

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3. (18 points total) The reaction below is used in submarines and spacecraft to remove CO_2 (carbon dioxide) and add O_2 (oxygen) to the air.

$$4\ KO_{2(s)} + 2\ CO_{2(g)} \longrightarrow 2\ K_2CO_{3(s)} + 3\ O_{2(g)}$$

A rigid closed 1 liter container holds CO_2 at 1 atm and 300 K. Enough KO_2 is added to consume exactly half of the CO_2; the temperature in the container is constant.

a) (8 points) How many moles of each gas are present after the reaction with the KO_2 described above is complete? Show your work and write your final answers in the boxes provided.

initial moles of CO_2 PV=nRT solve for n

$$n = {(1atm)(1L)}\Big/{(0.0821Latm/molK)(300K)} = 0.0406molesCO_2$$

if half of the CO_2 is consumed, 0.0203 moles CO_2 are left over

$$\frac{0.0203\,\text{moles}\,CO_2}{} \times \frac{3molesO_2}{2molesCO_2} = 0.0305molesO_2$$

4 points | moles CO_2: 0.0203 | 4 points | moles O_2: 0.0305

b) (8 points) What are the partial pressures of each gas (CO_2 and O_2) in the container after the reaction with the KO_2 described above is complete? Show your work and write your final answers in the boxes provided.

Convert excess moles of gas to pressure

$$P = {nRT}\Big/{V}$$

$$P_{CO2} = {(0.0203moles)(0.0821Latm/molK)(300K)}\Big/{1L} = 0.5atm$$ 4 points

$$P_{CO2} = {(0.0305moles)(0.0821Latm/molK)(300K)}\Big/{1L} = 0.75atm$$ 4 points

c) (2 pts) What is the total pressure in the container after the reaction with the KO described above is complete? Show your work and write your final answer in the box provided.

$P_{total} = P_{CO2} + P_{O2}$ 2 points | total pressure: 1.25 atm