

Name: KEY

Chemistry 111
Test 3
November 24, 2004

Instructions before starting the test:

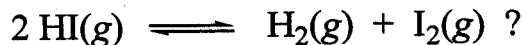
1. Your exam booklet should have **six** pages total, with questions on pages 2-5 and a periodic table on p. 6. Check to see you have six pages now. If you do not, ask for another copy of the exam.
2. Write your name in the space above and on the backs of pages 2-5.
3. You may use one side of an 8.5" by 11" sheet of paper filled with reference information.
4. You may use programmable calculators, but chemical data should not be stored in them.
5. You may start work on this test at 8:00 a.m. You must turn in this test by 9:30 a.m. (The test should take you only 60 minutes.)

<u>Question (Possible Points)</u>	<u>Your Score</u>
Question 1 (20)	
Question 2 (16)	
Question 3 (8)	
Question 4 (12)	
Question 5 (15)	
Question 6 (29)	
Total (100)	

Average of First 3 Tests	
Estimated Grade	

1. (20 points total) Circle the best answer to each of the following five questions. Your answers need not be justified, and no partial credit will be awarded.

A. At equilibrium, a system contains 0.0763 M $\text{H}_2(\text{g})$, 0.0932 M $\text{I}_2(\text{g})$, and 0.577 M $\text{HI}(\text{g})$. What is the value of K for the reaction



(a) 0.00534

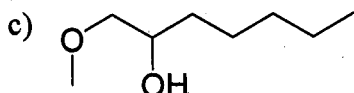
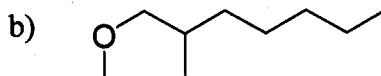
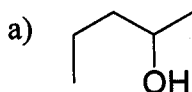
(b) 0.0123

(c) 0.0214

(d) 46.8

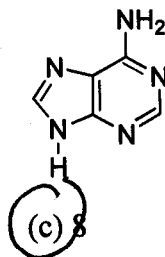
(e) 187

B. Which of the following molecules is not optically active?



e) Molecules a, b, c, and d are all optically active

C. How many sp^2 -hybridized atoms are in the molecule adenine (shown below)?



(a) 0

(b) 4

(c) 8

(d) 9

(e) 10

D. Aqueous solutions of $\text{K}_3[\text{Fe}(\text{CN})_6]$ are red. What color of light do these solutions most strongly absorb?

(a) yellow

(b) green

(c) orange

(d) red

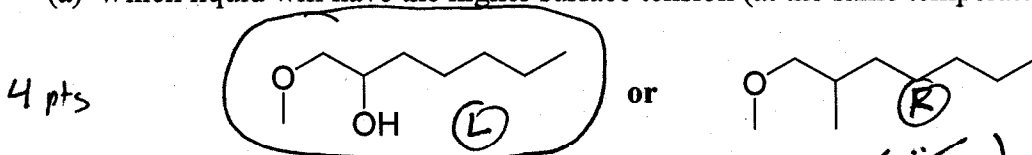
(e) violet

E. Which of the following species can function as a hydrogen bond donor?

(a) H_2S (b) LiH (c) $\text{N}(\text{CH}_3)_3$ (d) BeH_2 (e) NH_4^+

2. (16 points total) For each of the following comparisons, circle your choice and justify it below. Your justifications may be aided by drawing structures of the molecules you are discussing.

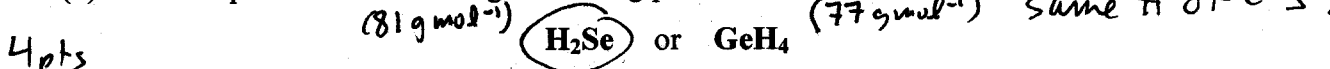
(a) Which liquid will have the higher surface tension (at the same temperature)?



4 pts Has ^{an} H-bond donors (OH) and acceptor (\ddot{O}). This H-bonding holds the molecule together more strongly, which means it requires more energy to pull them apart.

- 4 (R) can H-bond better
- 4 (L) being an alcohol weakens intermol forces
- 3 (L) has higher surface tension due to mass only
- 4 (R) forms fewer H-bonds
- 1 (R) has dipole-dipole
- 4 begs question, or random reason

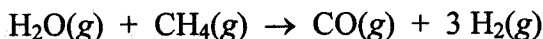
(b) Which liquid will have the higher boiling point?



4 pts $\text{H}-\overset{\text{Se}}{\underset{\text{H}}{\text{H}}}-\text{H}$ is polar \Rightarrow dipole-dipole + dispersion.
 $\text{H}-\overset{\text{Ge}}{\underset{\text{H}}{\text{H}}}-\text{H}$ is non-polar \Rightarrow dispersion only

- (-4) H_2Se can H-bond (or GeH_4)
- (-3) ΔX of H-Se vs. H-Ge
- (-3) mass/dispersion only
- (-4) GeH_4 weighs more
- (-4) GeH_4 is smaller
- (-2) GeH_4 has more bonds ($\therefore T_b(\text{GeH}_4)$ greater)
- (-2) Ge atom is bigger than Se
- (-4) GeH_4 ionic
- (-4) lone pair creates more E^-

3. (8 points) The endothermic "water gas" reaction



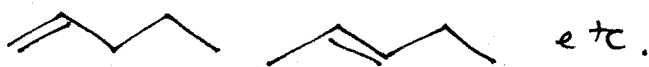
is commonly used in chemical plants to generate hydrogen gas. State and briefly explain two ways one can increase the yield of hydrogen gas in this reaction besides increasing the number of moles of $\text{H}_2\text{O}(g)$ or $\text{CH}_4(g)$.

- (1) \downarrow system P (more moles of gas on right)
- (2) \uparrow system V (ditto)
- (3) Remove CO and H_2 (more right to restore product concentrations)
- (4) $\uparrow T$ (forward rxn is endothermic)

2 per means, 2 per explanation

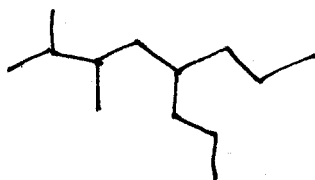
→ main chain must be skeletal, or -2 per structure.
 4. Draw skeletal structures for the following: Writing out substituents is OK

(a) (8 points) Two monounsaturated C₅ compounds:



-4 per wrong structure

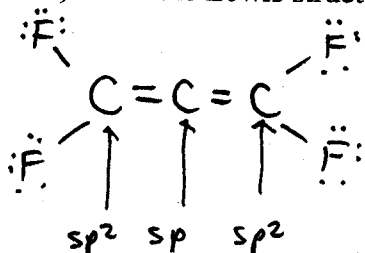
(b) (4 points) The molecule 2,3-dimethyl-5-propyloctane:



-4 wrong structure

5. Tetrafluoroallene has the molecular formula F₂CCCF₂.

(a) (4 points) Draw the Lewis structure of tetrafluoroallene.



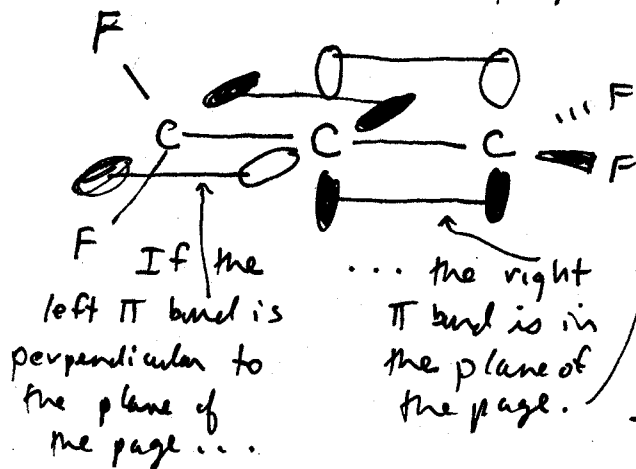
-4 wrong structure

(b) (3 points) For your Lewis structure above, label the hybridizations of all carbon atoms.

(You need not justify your answers.) 1 pt per hybridization (correctly labeled)

(c) (8 points) Using your answers to part (b), explain why the three-dimensional structure of tetrafluoroallene is non-planar.

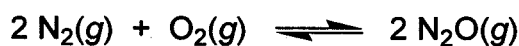
Each sp² C forms one π bond to the central sp C. This central C has 2 perpendicular unhybridized p AO's:



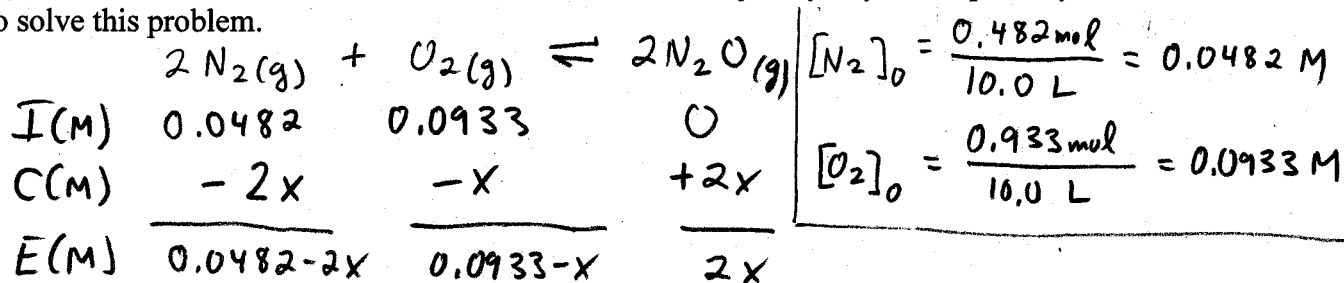
But this means that the left F's are in the plane of the page and the right F's are out of the plane of the page. ∴ the actual molecule is non-planar.

- 1 minor error
- 5 VSEPR argument unhelpful
- 4 no explanation why π bonds are ⊥ to each other
- 8 completely irrelevant argument
- 6 some orbital language in argument (e.g. just mentioning π bonds) (often begging question)

6. (29 points) The molecule N_2O , commonly called nitrous oxide, is used by atmospheric chemists to monitor air circulation. Under extreme conditions, the principal components of air can react to form N_2O :



At 800 K, the equilibrium constant for this reaction is $K = 2.1 \times 10^{-26}$. Say that 0.482 mol of N_2 and 0.933 mol of O_2 are injected into a container with a volume of 10.0 L. Predict the equilibrium concentration of N_2O at 800 K. You should justify any assumptions you make to solve this problem.



$$K = \frac{[N_2O]^2}{[N_2]^2 [O_2]} = \frac{(2x)^2}{(0.0482 - 2x)^2 (0.0933 - x)} = 2.1 \times 10^{-26}$$

Both initial concs are $> 10^4 K$, so let's cancel all terms in x in denominator:

$$K = \frac{4x^2}{(0.0482)^2 (0.0933)} = 2.1 \times 10^{-26}$$

$$x = \sqrt{\frac{(0.0482)^2 (0.0933) (2.1 \times 10^{-26})}{4}}$$

$$x = 1.067 \times 10^{-15} \text{ M}$$

$$\text{so } [N_2O] = 2x = 2(1.067 \times 10^{-15} \text{ M}) = \boxed{2.134 \times 10^{-15} \text{ M}}$$

Another way to justify canceling x in the denominator is...

$$\rightarrow \% \text{ loss } N_2 = \frac{2x}{[N_2]_0} \times 100\% = \frac{2.134 \times 10^{-15} \text{ M}}{0.0482 \text{ M}} \times 100\% = 4.4 \times 10^{-12}\% < 5\% !$$

(or check % loss of O_2) (or plug x back into K)

- 1 units or sig figs
- 4 missing or incorrect final answer
- (+5) same effort
- 6 erroneous assumption
- 6 unjustified assumption
- 6 doubled $[N_2]_0$
- 4 partially justified assumption
- 4 wrong coefficient
- 6 didn't square N_2 or N_2O concentrations
- 6 no assumption re: x

Possibly Useful Information

1 H 1.0079																2 He 4.0026	
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 †Ac 227.03															

* 58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
† 90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	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)	103 Lr (260)