Chemistry 351
Exam #1
October 10, 2018

Name: _____

Student Number: _____

Section Number: _____

TA: _____

INSTRUCTIONS:

This examination consists of 27 questions on 10 pages. Please make certain that your examination is complete.

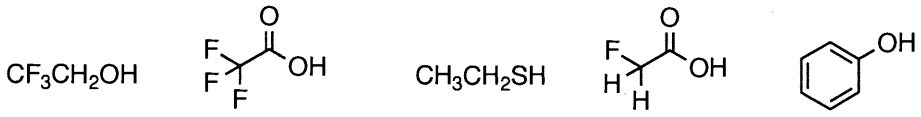
Write your name, student number, and section number **on both the examination and answer sheet. Be certain to bubble in your PID digits on the answer sheet. The absence of any of these identification items will result in the deduction of 2 points from your score.**

Questions 1-21 are each worth 3 points. Point totals for Questions 22-27 are indicated on the exam.

Write your answers to Questions 1- 21 on the enclosed answer sheet. **Write your answer to Questions 22-27 in the space provided on this examination.**

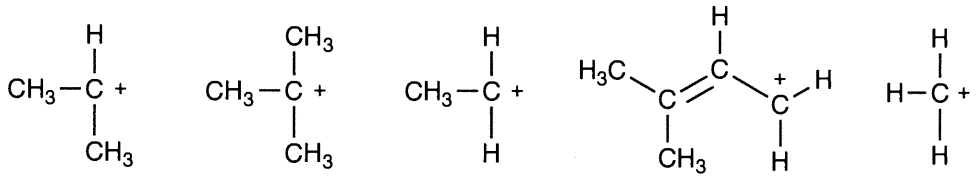
When you complete the examination, insert your answer sheet into your examination and then hand both in on the bench in front of the lecture hall in the spot indicated by your section number.

1. Identify the molecule that is the most acidic Brønsted-Lowry acid.



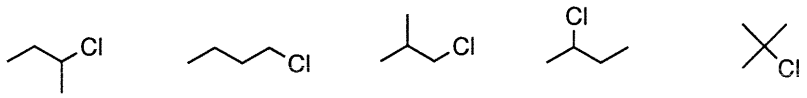
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

2. From the carbocations listed below, identify the **two most stable** carbocations.



(a) 1,2 (b) 1,3 (c) 1,4 (d) 1,5 (e) 2,3 (f) 2,4 (g) 2,5 (h) 3,4 (i) 3,5 (j) 4,5

Questions 3 and Question 4 are to be answered from the following possibilities



3. Which molecule do you predict will have the highest boiling point?

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

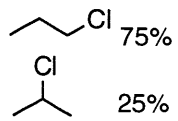
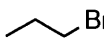
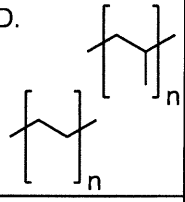
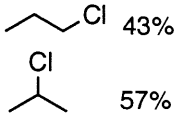
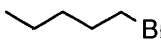
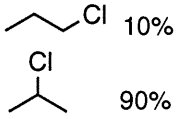
4. Identify the structure of 2-chloro-2-methylpropane.

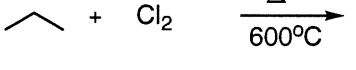
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

5. What molecule constitutes 76% of the composition of Marcellus shale gas?

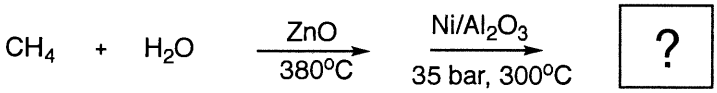
(a) N_2 (b) *n*-butane (c) CO_2 (d) propane (e) isobutane (f) ethane
(g) isopentane (h) pentane (i) methane

Questions 6-10 are to be answered from the following possibilities:

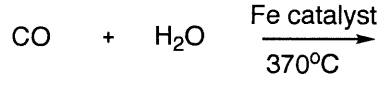
A. 	B. 	C. $CO + 3\ H_2$	D. 	E. 
F. 	G. $CO_2 + H_2$	H. 	I. CH_3OH	J. No Reaction

6. 

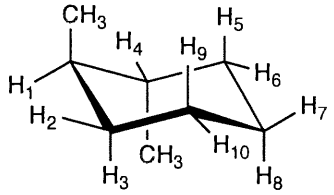
7. 

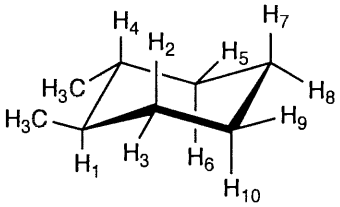
8. 

9. 

10. 

Questions 11 and 12 refer to the following conformers of *trans*-1,2-dimethylcyclohexane:





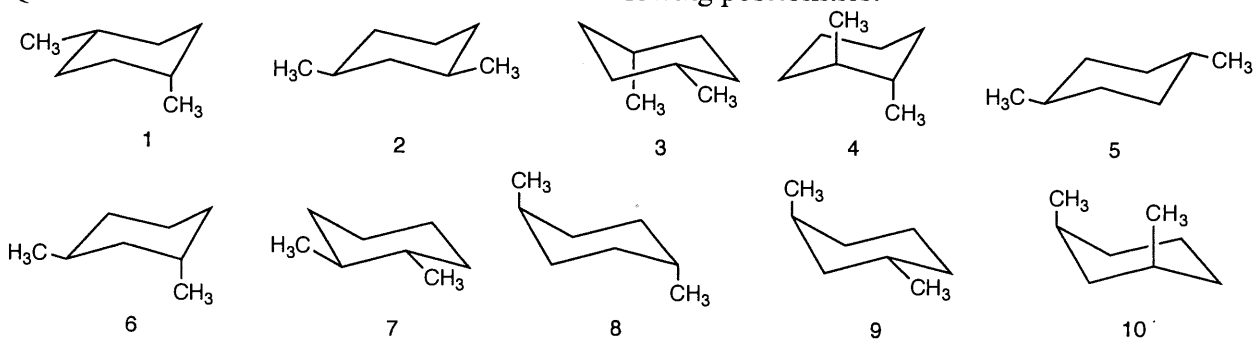
11. Identify all of the equatorial hydrogen atoms in the MOST stable conformer of *trans*-1,2-dimethylcyclohexane:

(a) H_5, H_9 (b) H_3, H_5, H_8, H_9 (c) $H_1, H_2, H_4, H_6, H_7, H_{10}$
(d) H_2, H_4, H_7 (e) H_3, H_8 (f) H_1, H_6, H_{10}

12. Identify all hydrogen atoms having destabilizing 1,3-diaxial steric interactions in the LEAST stable conformer of *trans*-1,2-dimethylcyclohexane:

(a) H_5, H_9 (b) H_3, H_5, H_8, H_9 (c) $H_1, H_2, H_4, H_6, H_7, H_{10}$
(d) H_2, H_4, H_7 (e) H_3, H_8 (f) H_1, H_6, H_{10}

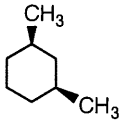
Questions 13-15 are to be answered from the following possibilities:



13. Identify the LEAST stable conformer of *cis*-1,3-dimethylcyclohexane:

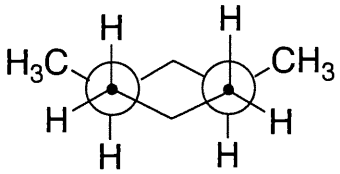
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

14. Identify the dimethylcyclohexanes corresponding to the following dash wedge structure:



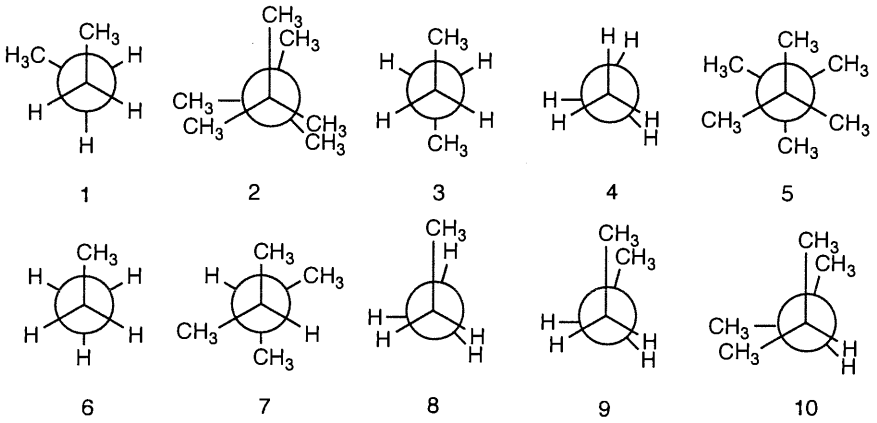
(a) 1,8 (b) 4,7 (c) 6,9 (d) 9,10 (e) 5,8
(f) 1,3 (g) 3,8 (h) 2,6 (i) 2,10 (j) 6,10

15. Identify the conformer corresponding to the following Newman projection formula:



(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

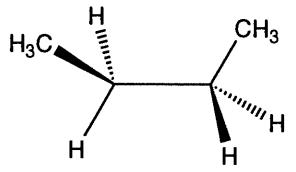
Question 16 and Question 17 refer to the following Newman projection formulas:



16. Which Newman projection formula corresponds to the most stable conformer of *n*-butane?

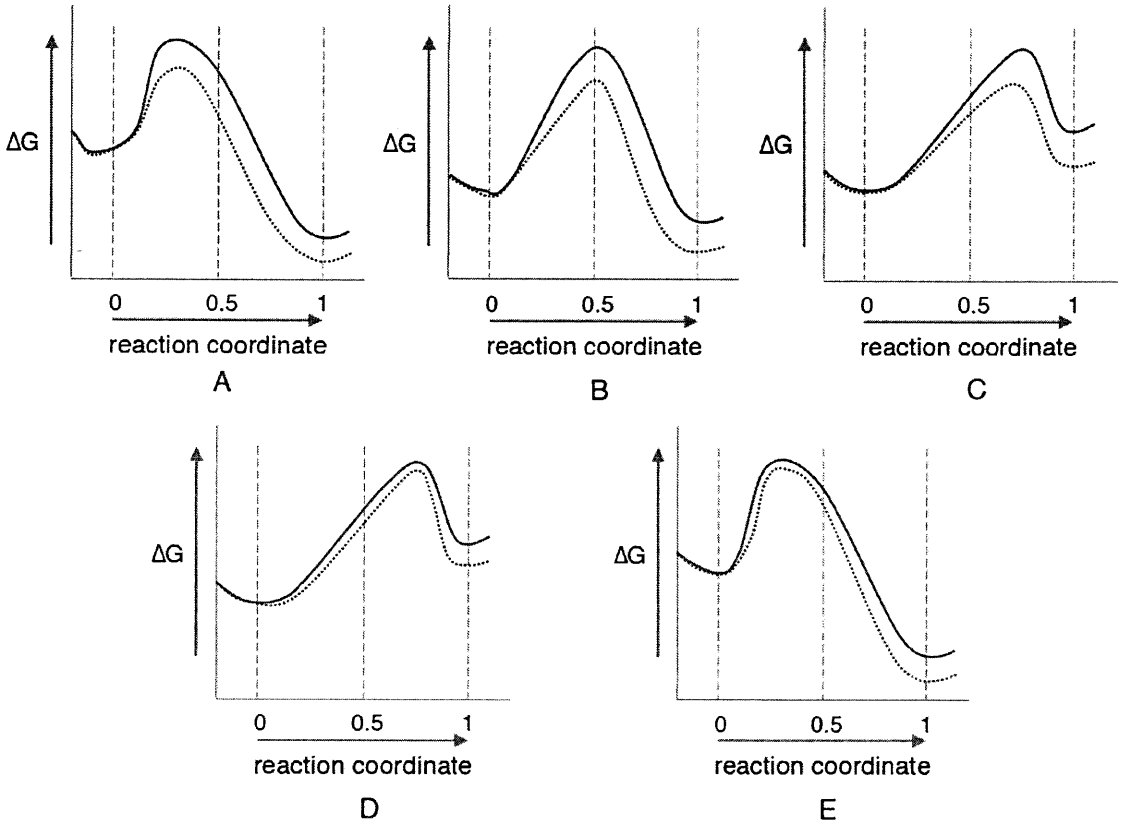
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

17. Which Newman projection formula corresponds to the following dash-wedge structure:

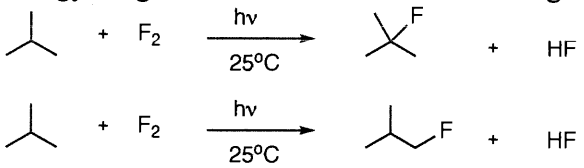


(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

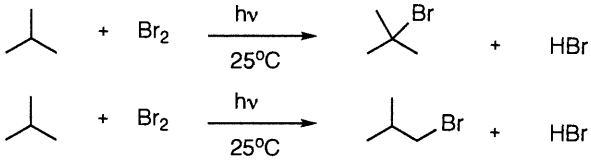
Questions 18 and 19 are to be answered from the following potential energy diagram possibilities:



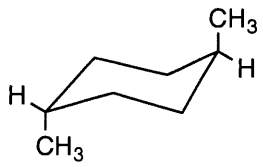
18. Identify the potential energy diagram that describes the following two reactions:



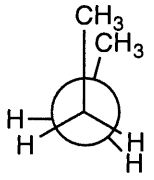
19. Identify the potential energy diagram that describes the following two reactions:



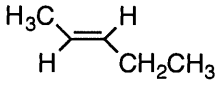
Question 20 and Question 21 refer to the following molecules:



1

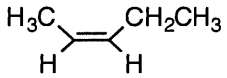


2



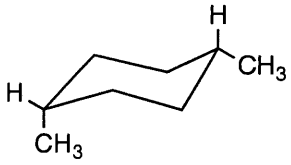
3

4

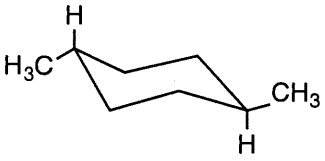


5

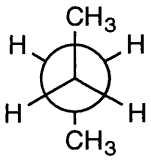
6



7



8



9

20. Identify the *trans* substituted molecule or molecules containing only sp^2-hybridized carbon atoms.

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 3,6

21. Identify pairs of molecules having the same molecular formula and the same boiling point:

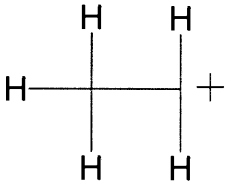
(a) 1 and 7 (b) 7 and 8 (c) 1 and 8, 2 and 9 (d) 3 and 5
(e) 4 and 6 (f) 1 and 7, 7 and 8, 4 and 6, 3 and 5

22. (3 points total)

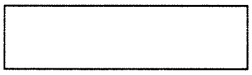
a. (1 pt) In the labeled box, provide the structure of ethyl carbocation Resonance Hybrid B that shows the hyperconjugative stabilization of ethyl carbocation Resonance Hybrid A.

b. (1 pt) Draw one arrow that shows the flow of electrons during hyperconjugative stabilization of ethyl carbocation Resonance Hybrid A leading to ethyl carbocation Resonance Hybrid B.

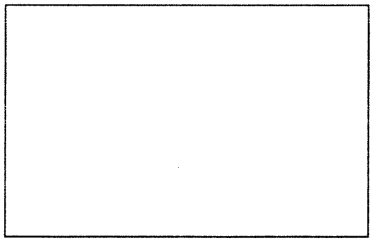
c. (1 pt) In the labeled box provided below, draw the correct arrow or arrows that shows the correct relationship between ethyl carbocation Resonance Hybrid A and ethyl carbocation Resonance Hybrid B.



ethyl carbocation
Resonance Hybrid A



arrows or arrow

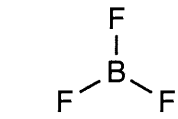


ethyl carbocation
Resonance Hybrid B

23. (5 points total)

a. (1 pt) Provide in the labeled box below, the structure of the Product Complex formed upon reaction of boron trifluoride and dimethyl ether.

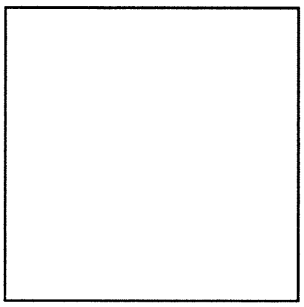
b. (1 pt) Insert a single arrow to show the flow of electrons during reaction of boron trifluoride with dimethyl ether.



boron trifluoride

CH_3OCH_3

dimethyl ether



Product Complex

c. (2 pts) Provide in the labeled boxes below, the structures of Product A and Product B formed upon reaction of sodamide with 1-propyne.

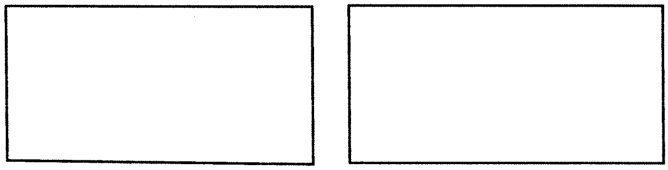
d. (1 pt) Insert two arrows that show the flow of electrons during the reaction of sodamide with 1-propyne.

$Na^+ \ ^-NH_2$

sodamide

$H-C\equiv C-CH_3$

1-propyne



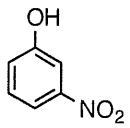
Product A Product B

24. (5 points total)

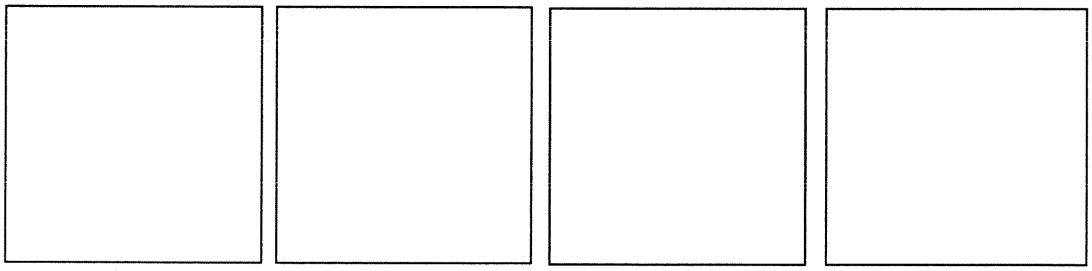
a. (1 pt) In the labeled box below, provide the structure of the conjugate base of 3-nitrophenol

b. (3 pts) In the labeled boxes below, provide the structures of Resonance Hybrid A, Resonance Hybrid B, and Resonance Hybrid C that show delocalization of charge onto ring carbon atoms.

c. (1 pt) Insert two arrows in the box labeled "3-nitrophenol Conjugate Base" that show the movement of electrons onto a ring carbon atom.

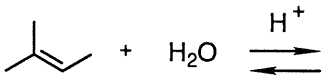


3-nitrophenol



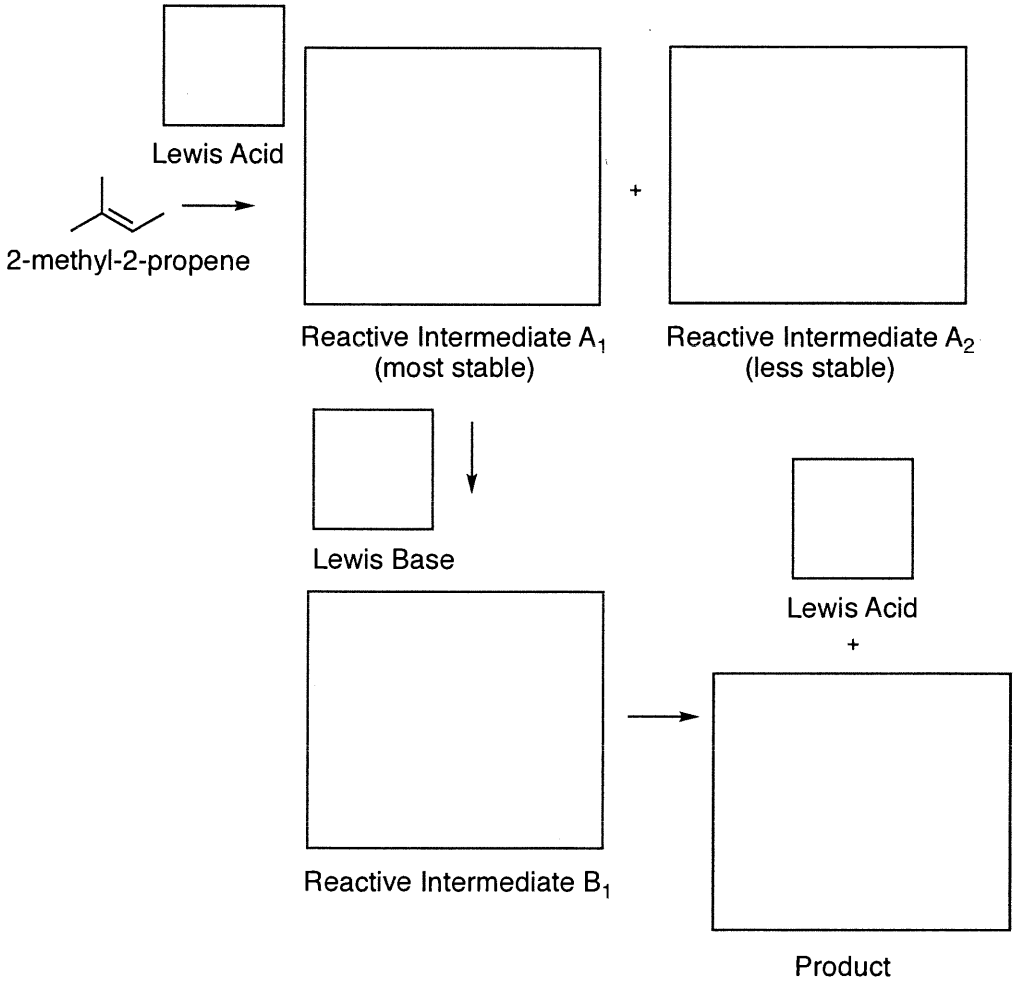
3-nitrophenol Conjugate Base | Resonance Hybrid A | Resonance Hybrid B | Resonance Hybrid C

25. (9 points total) For the acid-catalyzed reaction of 2-methyl-2-propene with water:



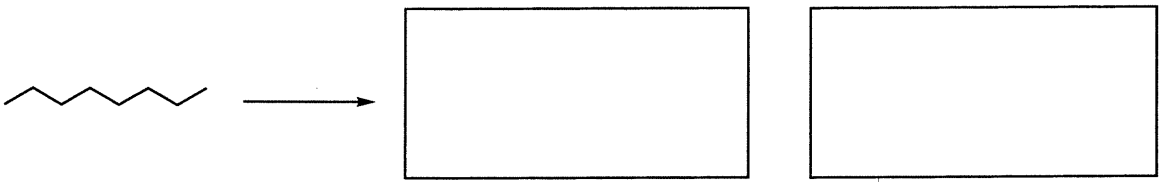
2-methyl-2-propene

a. (2 pts) In the three labeled boxes below, provide the Lewis Acid and Lewis Base structures.
b. (1 pt) Draw one arrow that shows the flow of electrons during attack of the Lewis Acid on 2-methyl-2-propene.
c. (1 pt) In the box labeled Reactive Intermediate A_1, provide the structure of **the most stable** reactive intermediate resulting from attack of the Lewis Acid on 2-methyl-2-propene.
d. (1pt) In the box labeled Reactive Intermediate A_2, provide the structure of **the less stable** reactive intermediate resulting from attack of the Lewis Acid on 2-methyl-2-propene.
e. (1 pt) Draw one arrow that shows the flow of electrons during attack of the Lewis Base on the **most stable** Reactive Intermediate A_1.
f. (1 pt) In the box labeled Reactive Intermediate B_1, provide the structure of Reactive Intermediate B_1 resulting from attack of the Lewis Base on the **most stable** Intermediate A_1.
g. (1 pt) In the box labeled Reactive Intermediate B_1, insert one arrow that shows the flow of electrons when Reactive Intermediate B_1 collapses.
h. (1 pt) In the boxes labeled Product, provide the structure of the Product resulting from collapse of Reactive Intermediate B_1.



26. (5 pts) In the thermal cracking of *n*-octane to form *n*-pentane and propene:

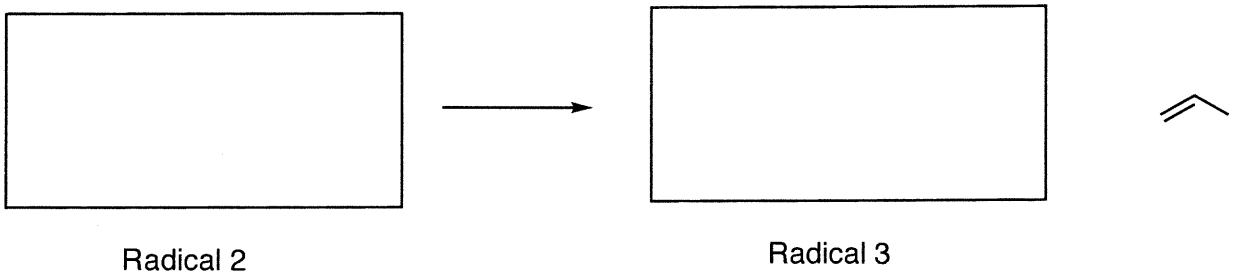
a. (1 pt) Insert two arrows in the structure of *n*-octane provided below showing the flow of electrons during conversion of *n*-octane to **Radical** 1 (leads to pentane) and **Radical 2** (leads to propene).



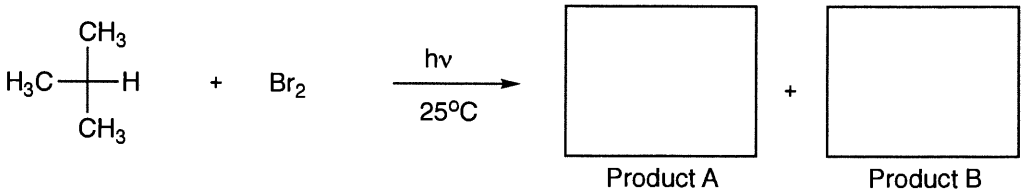
b. (2 pts) Provide the structures of the two radical intermediates that are formed in the labelled boxes provided above. **Radical 1** ultimately leads to formation of *n*-pentane. **Radical 2** ultimately leads to formation of propene.

c. (1 pt) Insert three arrows in **Radical 2** redrawn in the box provided below that show the flow of electrons during the chain propagation step leading from **Radical 2** to propene.

d. (1 pt) In the labelled box below, provide the structure of **Radical 3** that is formed in the chain propagation step leading to propene.



27. (10 pts total) For the following light-induced reaction of isobutane with bromine:



Product A Product B

a (2 pts) In the labeled boxes above, provide the structure of the Products A and B that are formed in 99% yield.

b. (2 pts) Provide a detailed mechanism in the space provided below showing all arrows, reactants and radicals for the **chain initiation step**.

c. (4 pts) Provide a detailed mechanism in the space provided below showing all arrows, reactants, radicals and products for the **two chain propagation steps** leading to the Products A and B that are formed in 99% yield.

d. (2 pts) Provide a detailed mechanism in the space provided below showing all arrows, reactants, radicals, and product for the **chain termination step** leading to 2,2,3,3-tetramethylbutane.