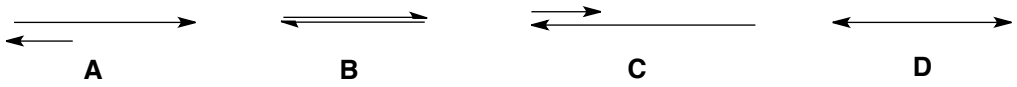
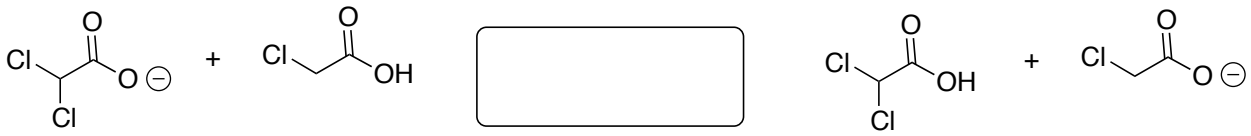
Poll question: ***How much time did you spend studying for this exam over the past week? Round to the nearest hour and enter the number in the*** **"EXAM NUMBER" section of the Scantron form. Example: 7 hours studying, enter "007" or 14 hours studying, enter "014"**

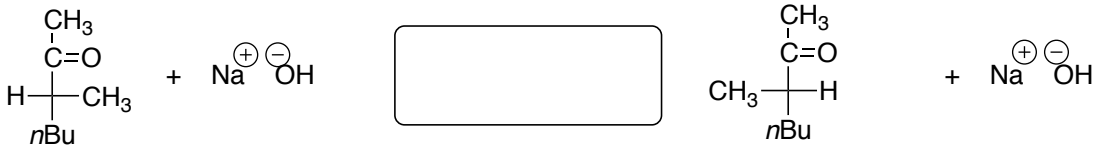
Section 1: Multiple choice. (43 marks) Questions 1-29 must be answered on the Scantron form by shading the appropriate circle with pencil. Scantron responses will be used to calculate your grade. Please indicate your answers on this examination paper in the event your Scantron is lost.

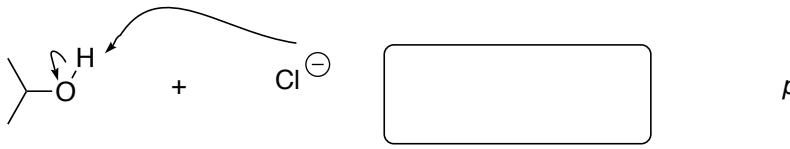
Note that ***more than one letter*** could be entered as an answer to a multiple choice question. Questions are not equally weighted in marks; it is ***not 1 mark per answer***.

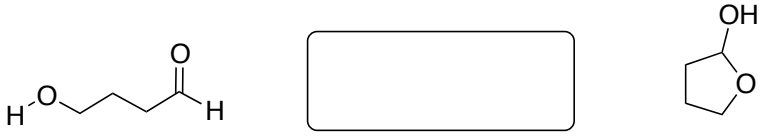
• For questions 1)-6), select the letter (**A**, **B**, **C**, **D**) that corresponds to the arrows that *best* describes the relationship between the 'reactants' and 'products'. Be sure to fill in your Scantron!

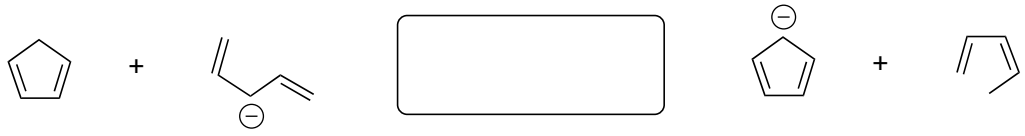


1) 

2) 

3) 

4) 

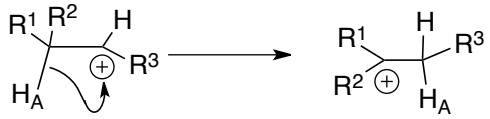
5) 

6) 

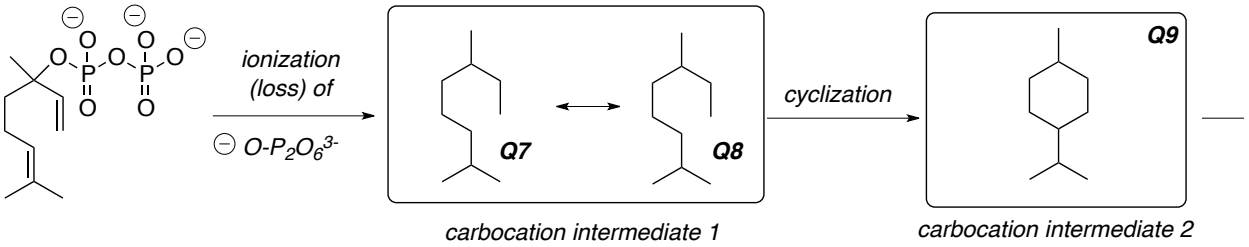
questions 7 to 12. (9 marks) A sequence outlining the biosynthesis of sabinene, a terpene partially responsible for the "spiciness" of black pepper and nutmeg, is given below. A blank practice version of this question has been provided on page 9. You are strongly recommended to work on this page before you select your answers. Page 9 will not be marked.

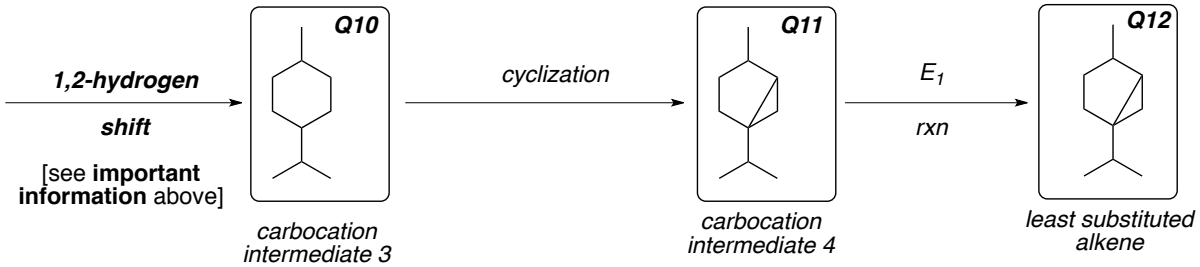
Important information: a reaction that occurs in biosynthesis is a **1,2 hydrogen shift** that moves a carbocation from one carbon to an adjacent carbon. This type of reaction occurs in this biosynthesis.

a 1,2-hydrogen shift:

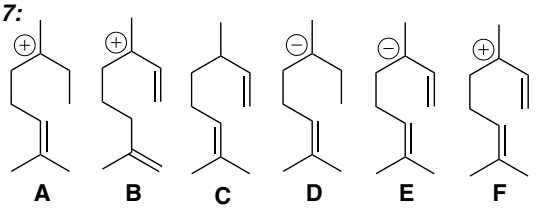


For each question, select the letter that represents the completed structure through the addition of necessary features (formal charges, π bonds).

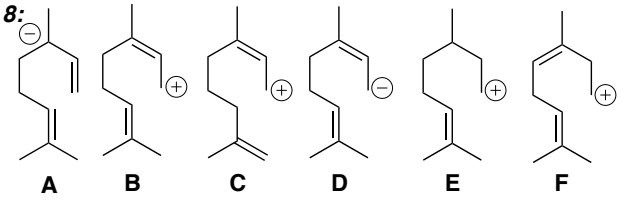




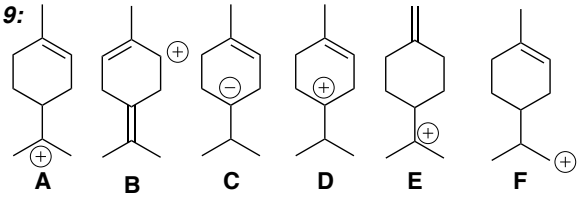
question 7:



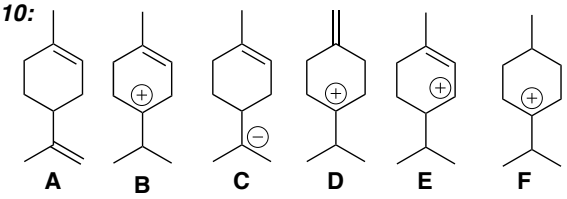
question 8:



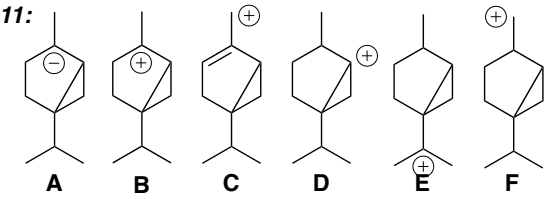
question 9:



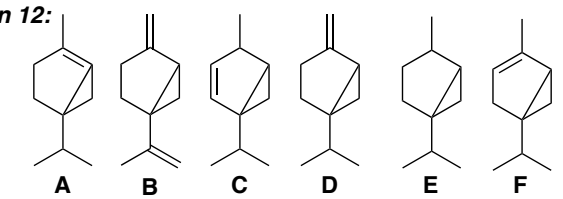
question 10:



question 11:

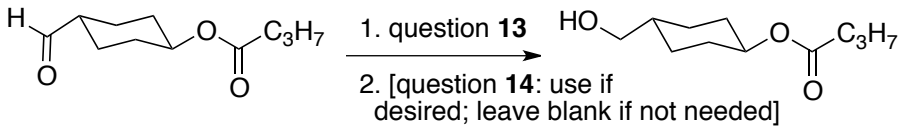


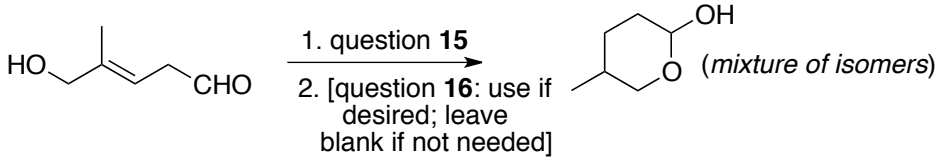
question 12:

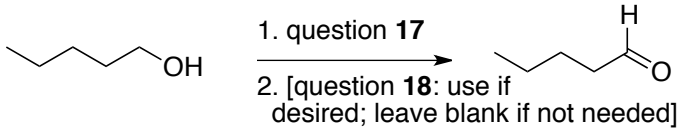


For questions 13 to 18, select the reagents and reaction conditions that could best carry out the indicated transformations:

A	**B**	**C**	**D**	**E**
PBr_3 *solvent* *then workup*	CrO_3, pyridine-HCl, *solvent* *then* *workup*	a) $LiAlH_4$ b) H_3O^+ *workup*	H_2SO_4 (cat.) *solvent* *then* *workup*	a) $NaBH_4$ MeOH b) *workup*
F	**G**	**H**	**I**	**J**
CO_2H_2, H_2SO_4 H_2O *then* *workup*	a) $LiN(i\text{-}C_3H_7)_2$ *solvent* b) *workup*	H_2, Pd/C *then* *workup*	a) NaH MeOH b) *workup*	CrO_3, H_2SO_4, H_2O *then* *workup*





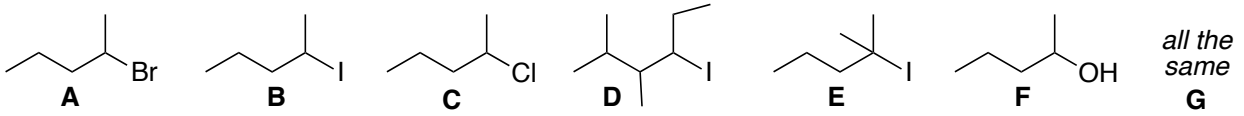


Questions 19 and 20. The reactions described are carried out under otherwise identical conditions.

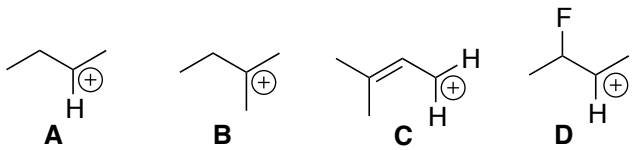
19) Identify the molecular species that would react with 1-chlorobutane at the *highest* rate:

(A) $HOCH_2CH_3$ [solvent] (B) $NaOCH_2CH_3$ [1 mol/L] (C) NaO_2CCH_3 [1 mol/L]
(D) $NaOCH_2CH_3$ [2 mol/L] (E) HO_2CCH_3 [1.5 mol/L] (F) all the same

20) Identify the molecular species that would react with sodium cyanide (NaCN) at the *highest* rate:

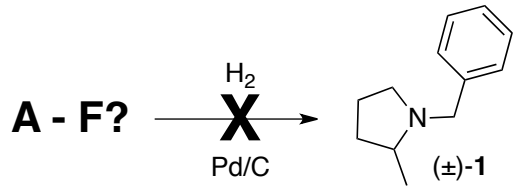


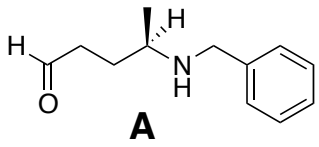
Questions 21 to 24. Consider the following cations for these questions.



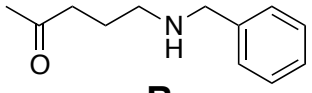
21) identify the least stable carbocation
22) identify the second least stable carbocation
23) identify the second most stable carbocation
24) identify the most stable carbocation

25) Which of the following answer sets, when subjected to hydrogen over palladium on carbon, will **not** generate racemic amine **1**?

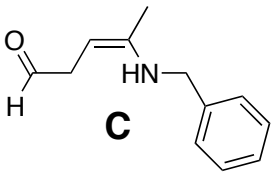




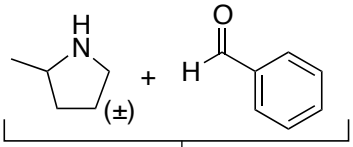
A



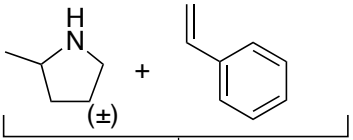
B



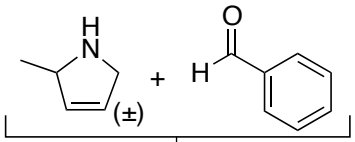
C



D

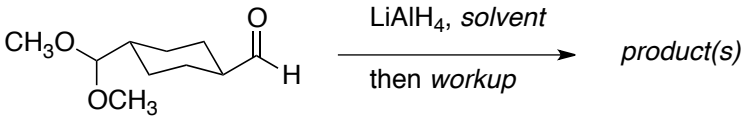


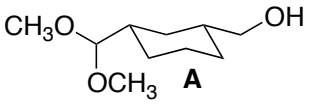
E



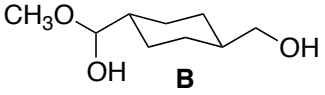
F

Question 26. Identify the product(s) for the following reaction:

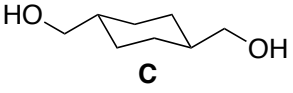




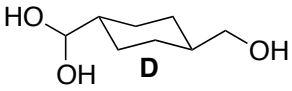
A



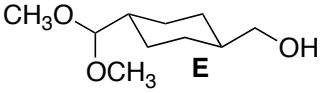
B



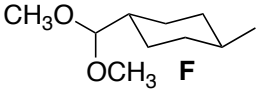
C



D



E



F

Questions 27 to 29. For the following, indicate whether the statements are either:

(**A**) TRUE or (**B**) FALSE.

27) Carbanions localized in a sp orbital are more stable compared to carbanions localized in a sp^3 orbital.

28) There is a larger amount of a major resonance contributor in solution compared to a minor resonance contributor.

29) Unimolecular substitution reactions of chiral alkyl halides will lead to the formation of a mixture of racemic products.

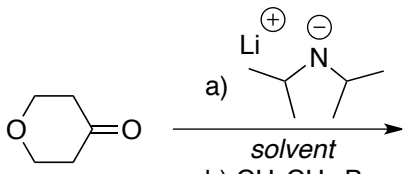
******END OF SCANTRON QUESTIONS******

Section 2. Short answer questions. Please write your answers in the designated space. Please note that in some cases it is better for you to work out your answer on practice paper and copy a neat version to the examination paper.

*****Messy and/or incoherent answers that are difficult to read or interpret may receive reduced or zero credit.*****

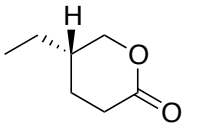
2-1) (14 marks) Provide the requested information. Draw all stereoisomers that are formed.

(a)



product(s) of this transformation

(b)

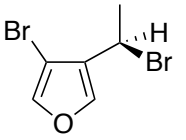


(*this enantiomer*)

$LiAlH_4$
solvent
then
workup

product(s) of this transformation

(c)

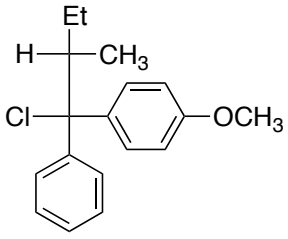


(*this enantiomer*)

a) HS H
K-O*t*-Bu,
solvent
b) *workup*

product(s) of this transformation

(d)

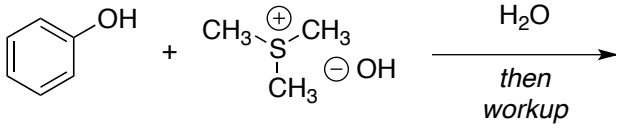


(*this enantiomer*)

a) NaOEt
solvent
b) *workup*

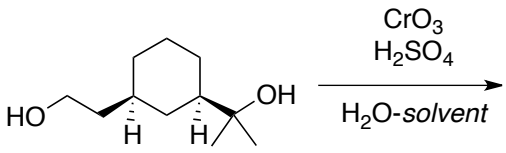
product(s) of this transformation

(e)



product(s) of this transformation

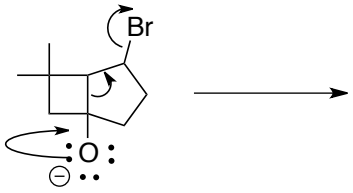
(f)



product(s) of this transformation

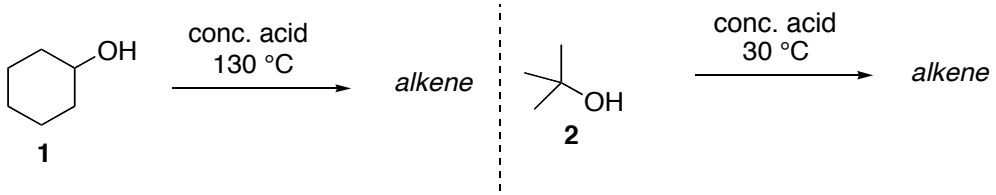
You are given the curved arrow description of the reaction:

(g)

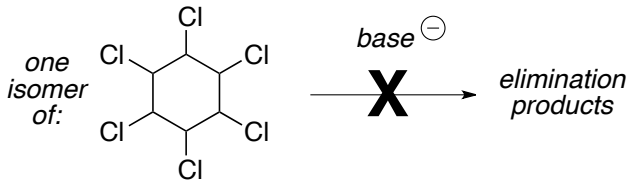


product of this transformation

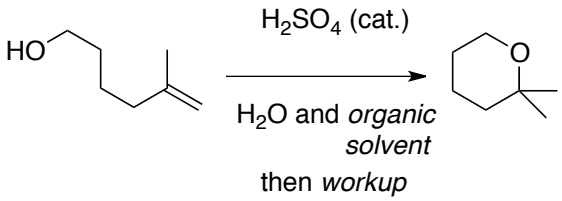
2-2) (4 marks) The dehydration of alcohol **1** to its corresponding alkene occurs only above 130 °C, while the same reaction of alcohol **2** occurs rapidly at 30 °C. Using structural formulas accompanied by *brief comments*, provide an explanation for this phenomenon.



2-3) (4 marks) One stereoisomer of 1,2,3,4,5,6-hexachlorocyclohexane does not react with potassium *tert*-butoxide to produce elimination products. Provide the structure of the unreactive stereoisomer and provide brief comments to explain why this is so.



2-4) (6 marks). Using arrows that represent electron-movement, provide a mechanism for the following reaction. Transition states do not have to be drawn. Marks will be removed for: incorrect arrows, incorrect intermediates, breaking the octet rule, incorrect acid-base reactions.



End of Exam Questions

You can use this page for rough work. Work on this page will not be graded.

Periodic Table of the Elements

1 H																1 H	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

This is the rough workspace for questions Q7-Q12. Work on this page will not be graded.