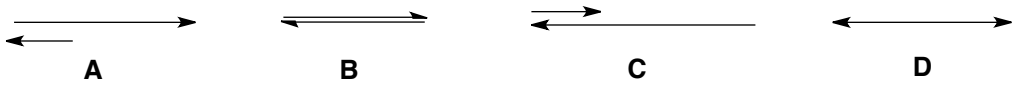
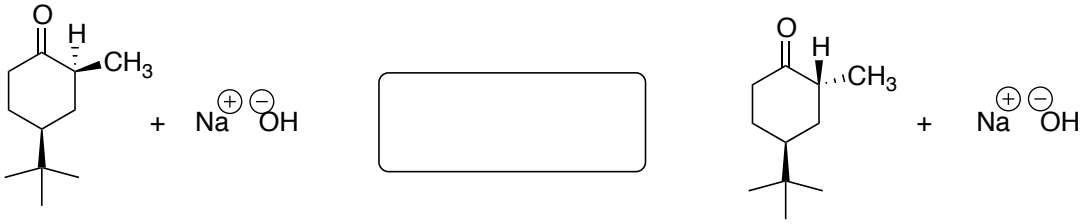
Section 1: Multiple choice. (42 marks) Questions 1-25 must be answered on the MC Answer form by shading the appropriate circle with pencil. Remark responses will be used to calculate your grade. Please indicate your answers on this examination paper in the event your Scantron is lost.

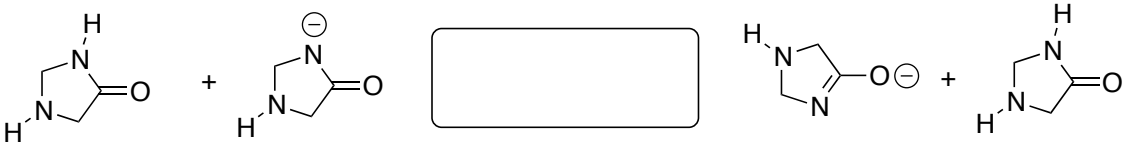
Note that ***more than one letter*** could be entered as an answer to a multiple choice question. Questions are not equally weighted in marks; it is ***not 1 mark per answer***.

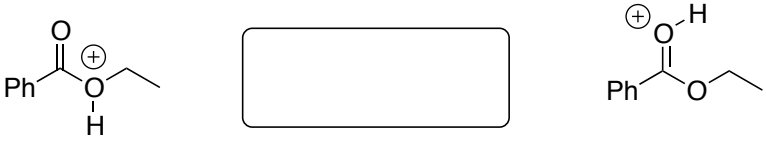
• For questions 1)-6), select the letter (**A**, **B**, **C**, **D**) that corresponds to the arrows that *best* describes the relationship between the 'reactants' and 'products' (9 marks). Be sure to fill in your Scantron!

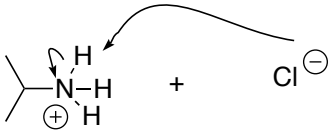


1) 

2) 

3) 

4) 

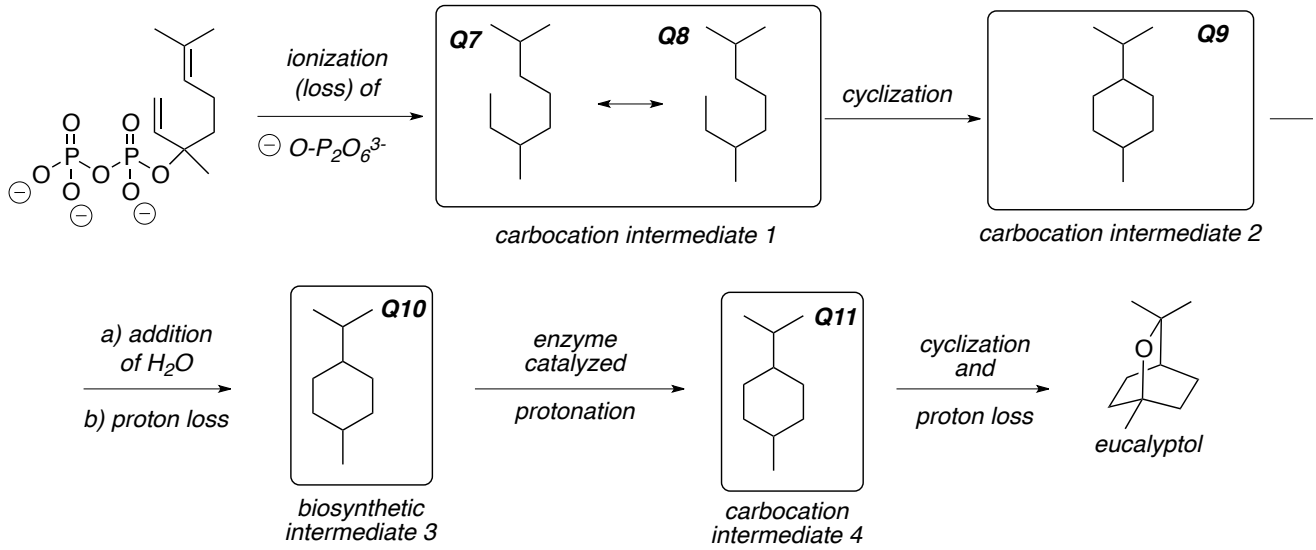
5) 

products of proton transfer

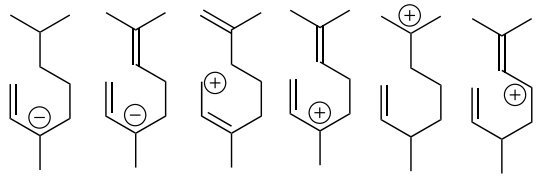
6) 

questions 7 to 11. (9 marks) A sequence outlining the biosynthesis of eucalyptol, a terpene that makes up around 90% of natural eucalyptus oil, , is given below. A blank practice version of this question has been provided on page 11. You are strongly recommended to work on this page before you select your answers. Page 11w will not be marked.

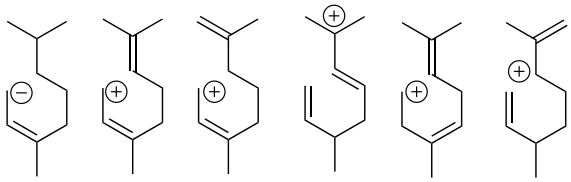
For each question, select the letter that represents the completed structure through the addition of necessary features (formal charges, π bonds, functional groups).



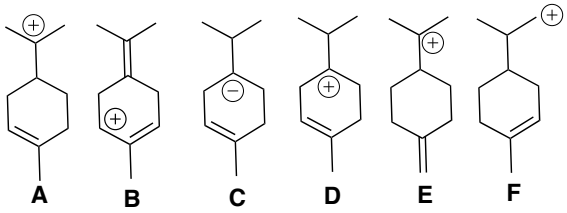
question 7:



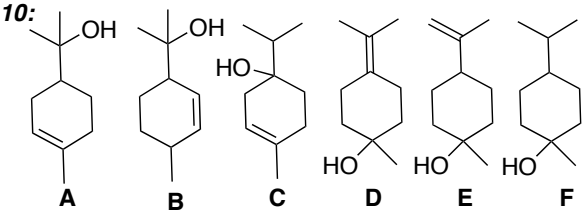
question 8:



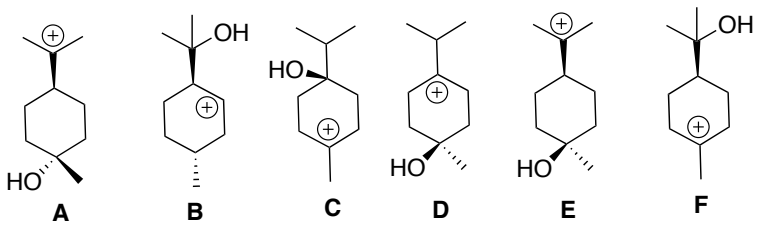
question 9:



question 10:

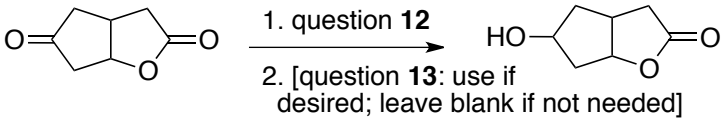


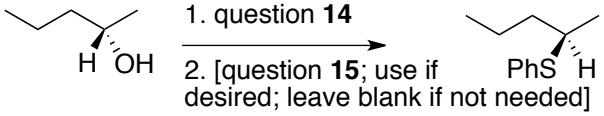
question 11:

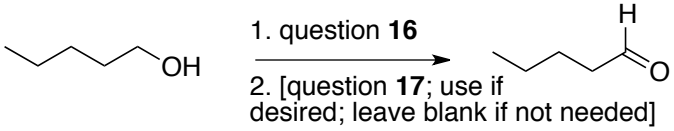


For questions 12 to 17, select the reagents and reaction conditions that could best carry out the indicated transformations (7 marks):

A	**B**	**C**	**D**	**E**
PBr_3 *solvent* *then workup*	CrO_3, pyridine-HCl, *solvent* *then* *workup*	a) $LiAlH_4$ b) H_3O^+ *workup*	a) H_2SO_4 (cat.) *solvent* b) NaSPh, *solvent* *then* *workup*	a) $NaBH_4$ MeOH b) *workup*
F	**G**	**H**	**I**	**J**
NaSPh, *solvent* *then* *workup*	pyridine, *p*-toluenesulfonyl chloride *then* *workup*	H_2, Pd/C *then* *workup*	CrO_3, H_2SO_4, H_2O *then* *workup*	a) NaH b) PhS-Cl c) *workup*







Questions 18-21. (10 marks) Four reactions (**A**-**D**) and a statement (**E**) are given. For each statement 18-21, select the reactions **A**-**D** for which those statements would be TRUE. More than one answer may apply, and note that points for incorrect selections will be deducted from points for correct answers.
A: 1-bromobutane + potassium ethanoate reacts to give an organic product.
B: 2-methyl-2-propanol + concentrated sulfuric acid reacts to give an organic product.
C: 2-bromobutane + potassium tert-butoxide reacts to give an organic product.
D: 3-methyl-3-bromopentane + ethanol reacts to give an organic product.
E: This statement is FALSE for all of the reactions described in **A** to **D**.

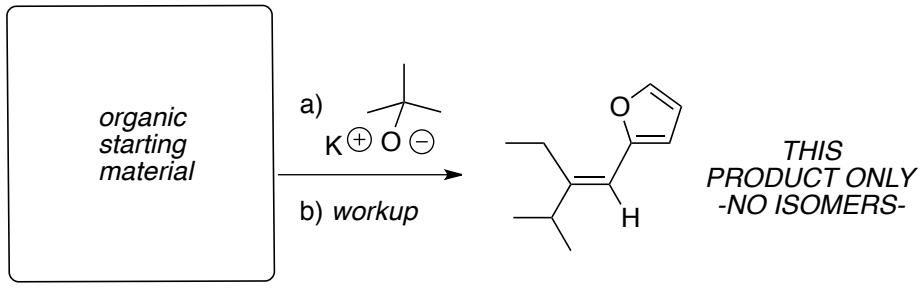
18) The reaction follows a second-order rate equation.

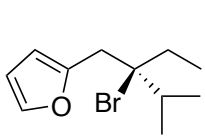
19) Adding n-hexane as a cosolvent results in an increased reaction rate.

20) The reaction mechanism involves carbocation intermediates.

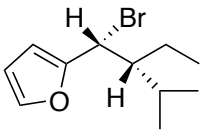
21) The rate-determining step in the reaction mechanism involves the simultaneous breaking and formation of covalent bonds.

22) (3 marks) Identify the structure of the alkyl bromide that would generate the indicated alkene only—no stereoisomers or constitutional isomers would be formed.

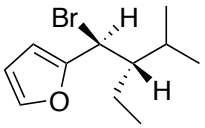




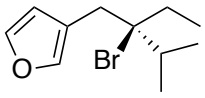
A



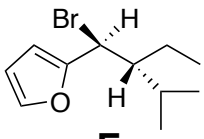
B



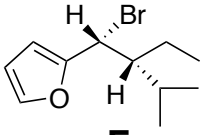
C



D



E



F

Questions 23 to 25 (4 marks). For the following, indicate whether the statements are either:

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

23) An alkyne functional group is at the same oxidation state as a ketone functional group.

24) A reaction involving achiral starting materials always produces racemic products.

25) A nitrogen atom within an aromatic ring always contains an unbonded pair of electrons in a p-orbital.

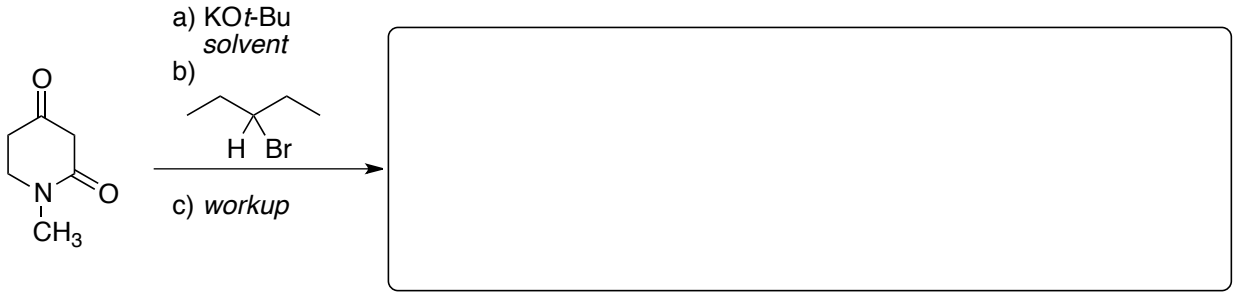
******END OF MULTIPLE CHOICE QUESTIONS******

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.*****

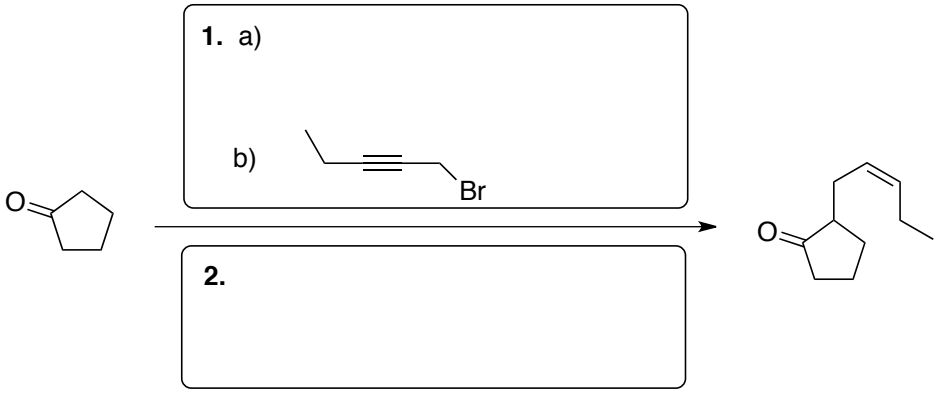
2-1) (10 marks) Provide the requested information. Draw all stereoisomers that are formed. Do not draw the same stereoisomer twice.

(a)



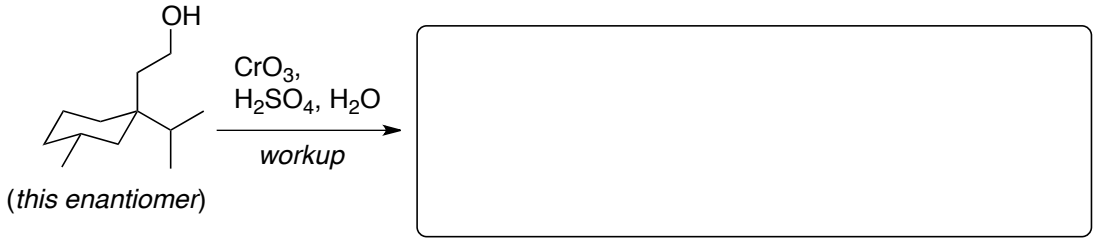
product(s) of this transformation

(b)



reagants to carry out these transformations

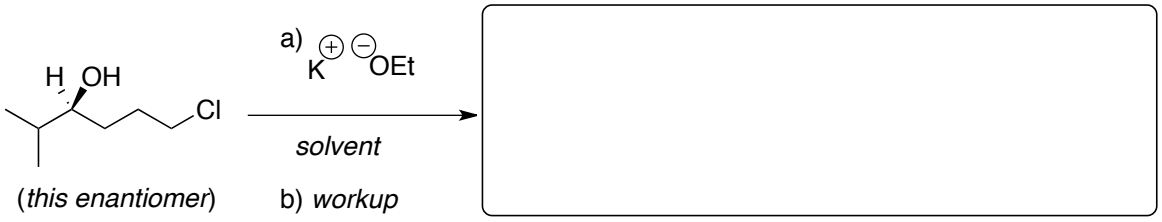
(c)



(*this enantiomer*)

product(s) of this transformation

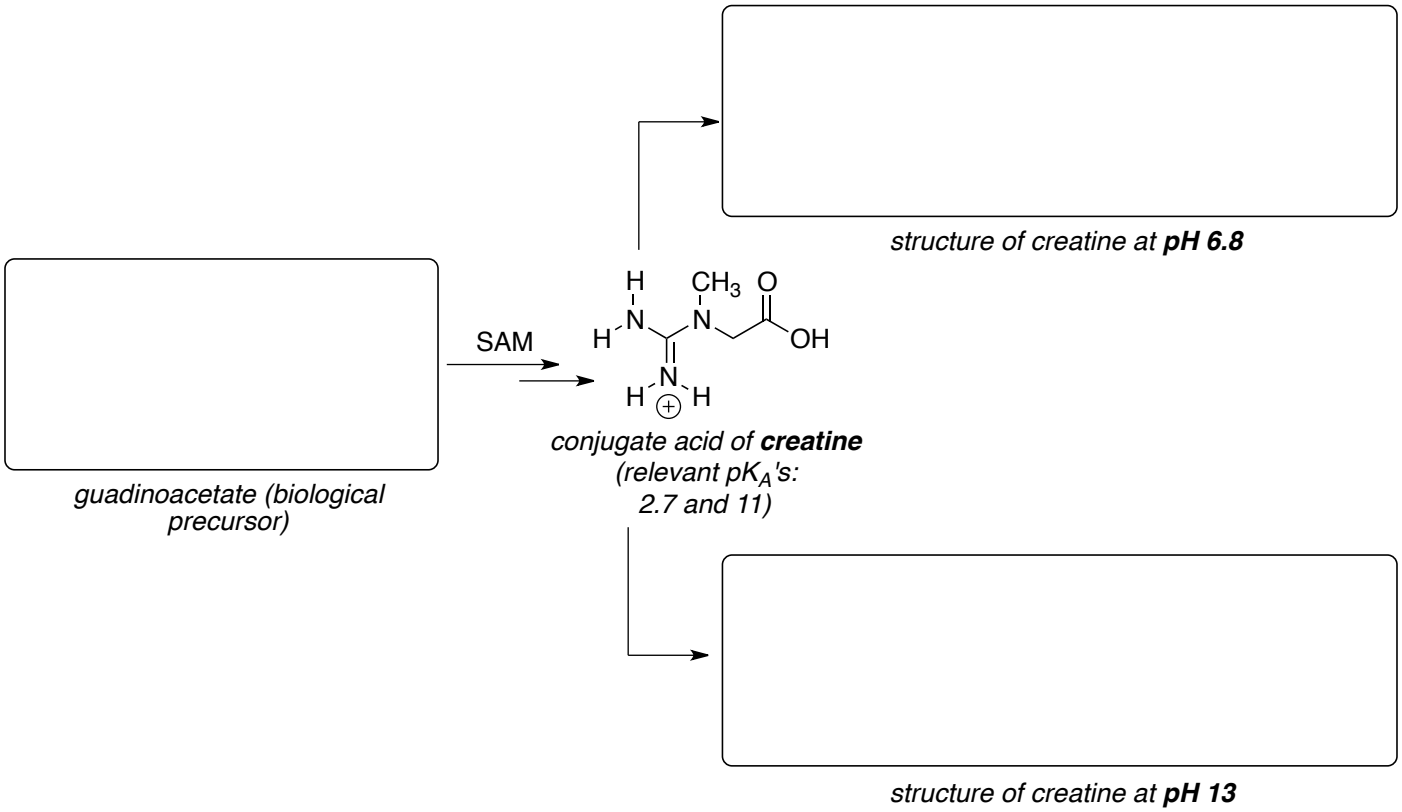
(d)



(*this enantiomer*)

product(s) of this transformation

2-2) (6 marks) Creatine is a non-essential amino acid derivative that is often used as a supplement for athletes to increase muscle mass. Given the information below, provide the requested structures.



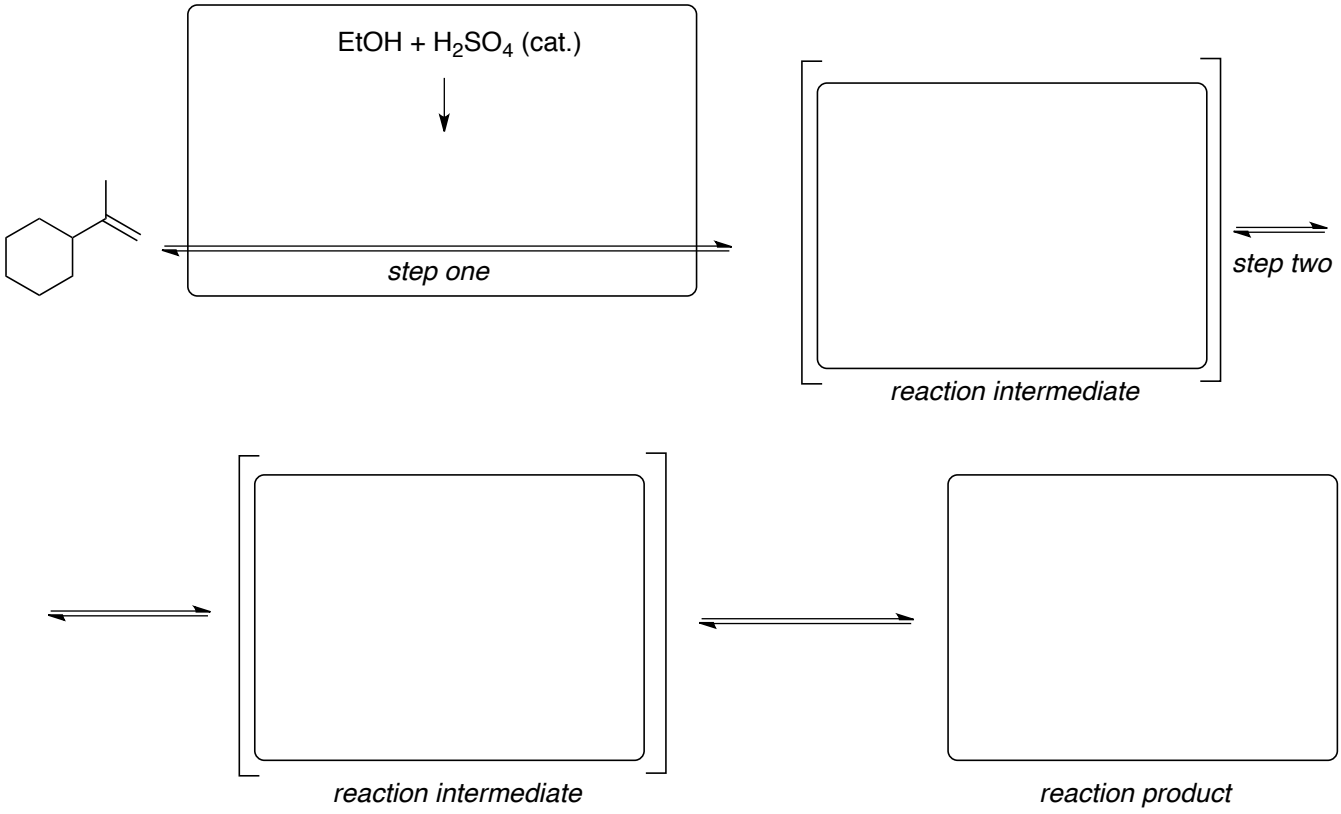
*structure of creatine at **pH 6.8***

guadinoacetate (biological precursor)

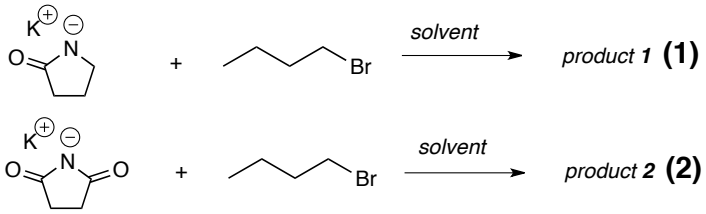
*conjugate acid of **creatine** (relevant pK_A's: 2.7 and 11)*

*structure of creatine at **pH 13***

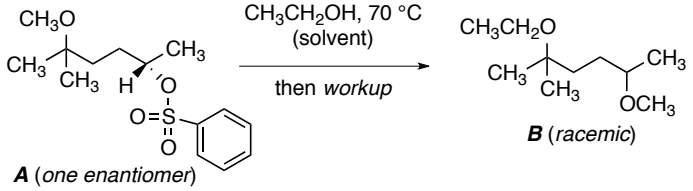
2-3) (9 marks) (a) Place structures of reaction intermediates and products within boxes and (b) draw mechanistic arrows to indicate how the reaction progresses from box to box.



2-4) (4 marks) Two reactions are shown below. Clearly identify the reaction that occurs at a faster rate, and justify your decision using pictures accompanied with brief comments.



2-5) (4 marks). Heating one enantiomer of compound ***A*** to 70 °C in the absence of acid catalyst (pH 7) generates racemic compound ***B***. 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.



A (*one enantiomer*) ***B*** (*racemic*)

End of Exam Questions