Section 1: Multiple choice. Questions 1-25 must be answered on the Remark Multiple Choice answer form by shading the appropriate circle with **pencil or pen**. Remark responses will be used to calculate your grade. Please indicate your answers on this examination paper in the event your Remark form is lost. Questions are not equally weighted in marks; it is ***not 1 mark per answer***.

Questions 1 to 5. Select the letter (**A, B, C, D**) that corresponds to the arrows that *best* describes the relationship between the structures on the left and right sides of the chemical equations shown below.

1) 

2) 

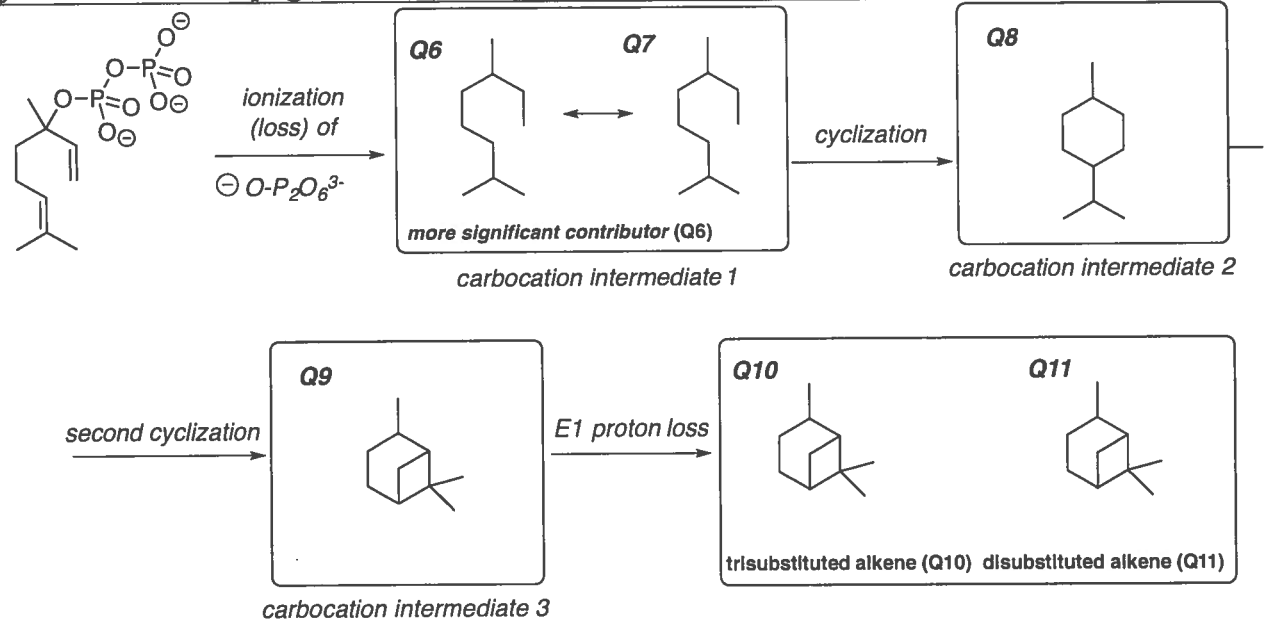
3) 

4) $H_3C{-}C{\equiv}C{-}H + \overset{\ominus}{O}H$ ⟶ $H_3C{-}C{\equiv}C^{\ominus} + H_2O$

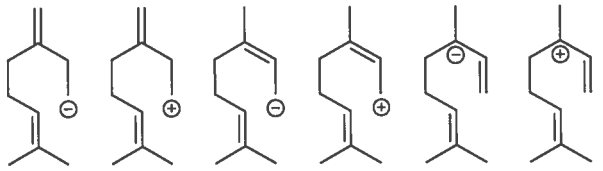
5) 

Questions 6 to 11. The biosynthesis of two pinenes, α-pinene and β-pinene, is shown below. For each question, select the letter that represents the completed structure in the boxes through the addition of necessary features (formal charges, π bonds, functional groups).

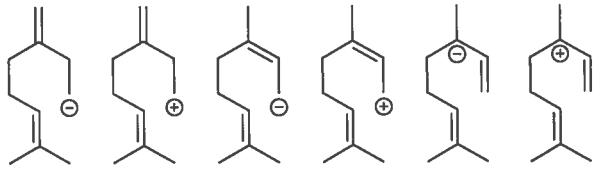
A *blank practice version* of this question has been provided on page 9. We strongly recommend you work on this page before you select your answers. Page 9 will not be marked!



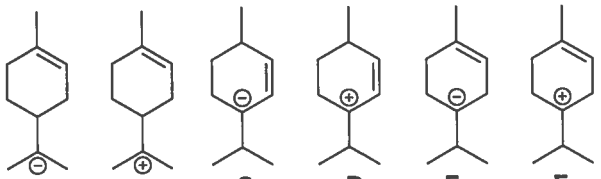
question 6:



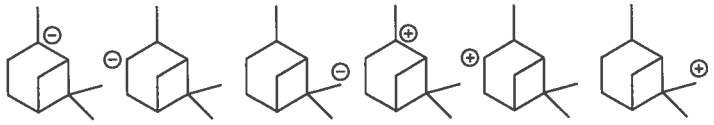
question 7:



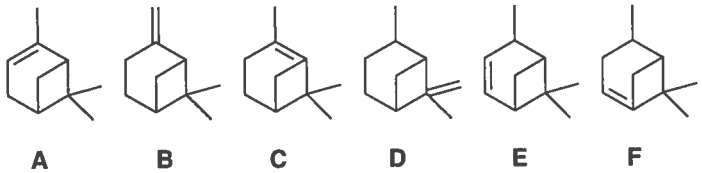
question 8:



question 9:



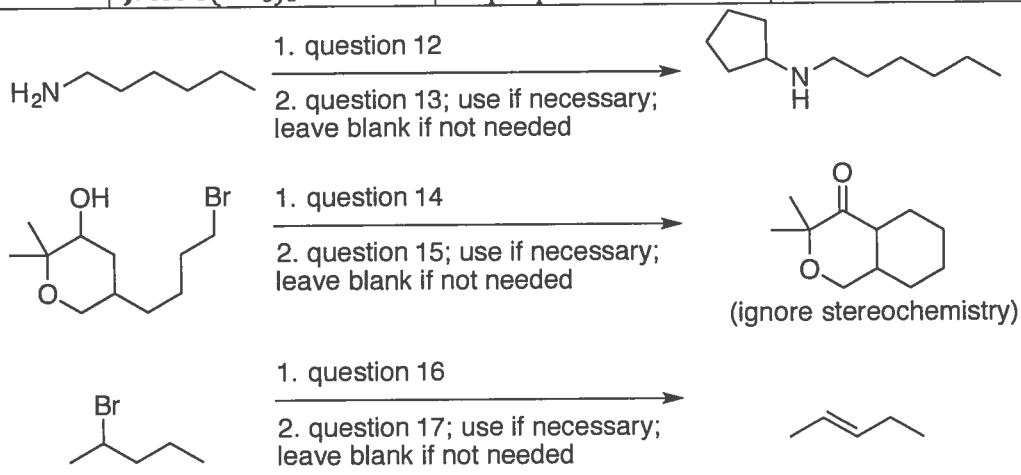
questions 10 and 11:



For questions 12 to 17, select the reagents and reaction conditions that could best carry out the indicated transformations. **You may need to include more than one letter in the same step.**

Options (you can assume all necessary solvents are included and *workup* steps performed)

A: H_2, Lindlar's cat.	**F**: $NaOCH_3$	**K**: CrO_3, H_2SO_4, H_2O	**P**: cyclopentanone
B: H_2, Pd/C	**G**: H_2SO_4 conc., *heat*	**L**: CrO_3, pyridine, HCl	**Q**: *p*-toluenesulfonylchloride
C: $NaBH_4$, EtOH	**H**: PBr_3	**M**: LDA	**R**: H_2SO_4 (cat.) pH = 5
D: $LiAlH_4$	**I**: $NaNH_2$	**N**: ammonia (NH_3)	**S**: NaOH
E: Li, NH_3	**J**: $KOC(CH_3)_3$	**O**: propanone	**T**: CH_3Br



Questions 18 to 21. For the following, indicate whether the statements are either True (T) or False (F).

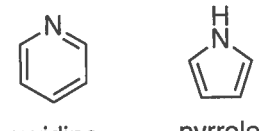
18) SAM is a biological reducing agent.

19) Hydroxide ion is the strongest base that can be formed in water.

20) Pyridine is a stronger base than pyrrole (see structures below).

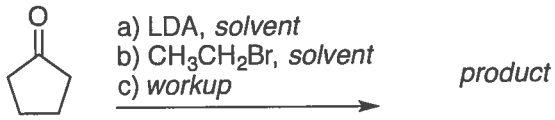
21) This reaction will give a single stereoisomer as product (see reaction below).

Q20

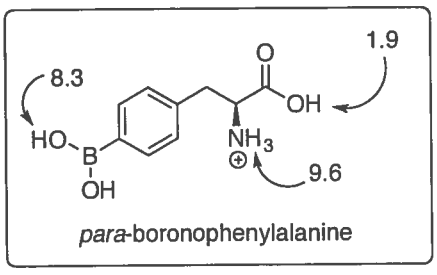


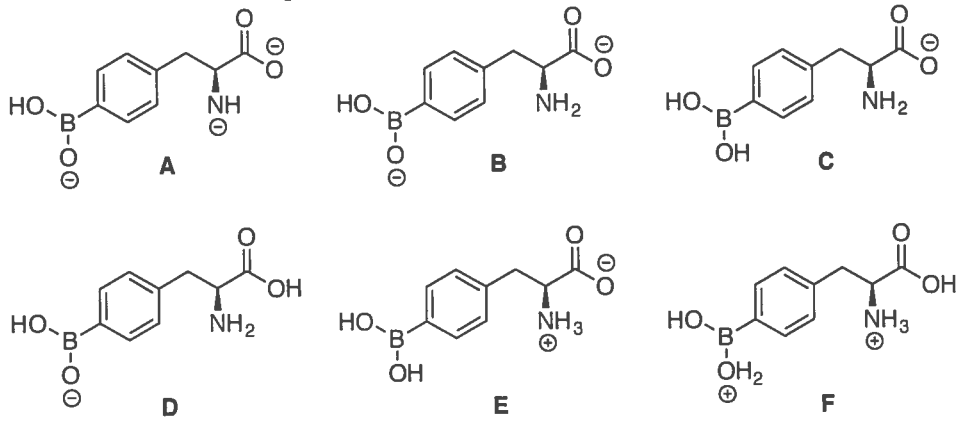
pyridine pyrrole

Q21



22) The non-standard amino acid *para*-boronophenylalanine is shown below. The pK_a values have been labelled. Select the dominant form of this amino acid at pH 5.



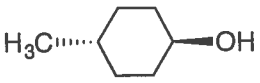


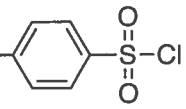
Section 2. Short answer questions. Please write your answers in the designated space. Please note that in some cases it is better for you to work out your answer on practice paper and copy a neat version to the examination paper.

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

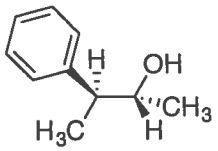
2-1) (10 marks) Draw the final product(s) of the following transformations. Draw all stereoisomers that are formed. Do not draw the same stereoisomer twice.

(a)



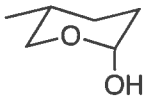
1. H_3C–  –Cl
pyridine, *solvent*
2. CH_3SNa, *solvent*
3. *workup*

(b)



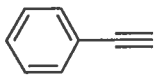
1. PBr_3, *solvent*
2. KOtBu, *solvent*
3. *workup*

(c)



CH_3OH (solvent),
HCl (cat.)
then workup

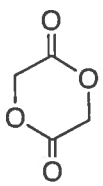
(d)



1. $LiN(i\text{-}C_3H_7)_2$, *solvent*
2. 

, *solvent*
3. H_2, Pd-$BaSO_4$, $Pb(OAc)_2$, quinoline
4. *workup*

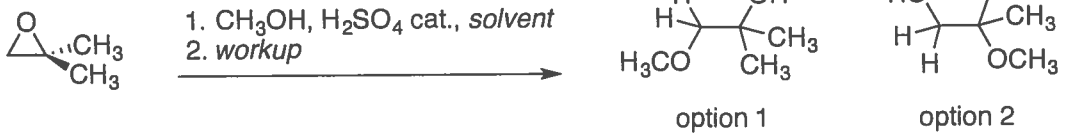
(e)



1. $LiAlH_4$
2. H_3O^+ (work-up)

2-2) (4 marks) Adding a few drops of H_2SO_4 to a mixture of methanol and ethanal (acetaldehyde) speeds up the reaction to form the hemiacetal intermediate approximately 100,000 fold. Using chemical structures and mechanistic arrows, plus some text, explain this observation.

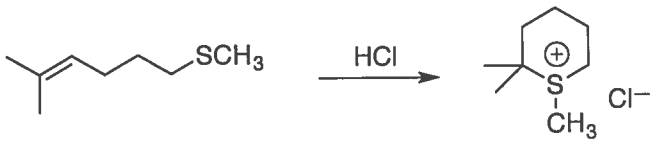
2-3 (4 marks). Circle the major product of the reaction below (option 1 or option 2). Using chemical structures and mechanistic arrows, plus some text, explain your choice.



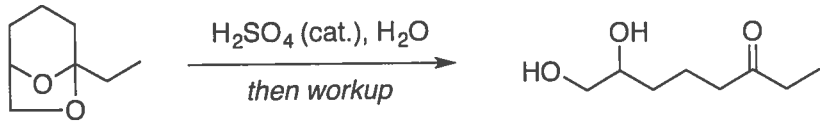
option 1 option 2

2-4) (8 marks). Using arrows that represent electron-movement, provide a mechanism for the two reactions below. Do not show transition states. Marks will be removed for: incorrect arrows, incorrect intermediates, inappropriate octet rule violations, incorrect acid-base reactions. ***Ignore sterochemistry.***

a)



b)



End of Exam Questions