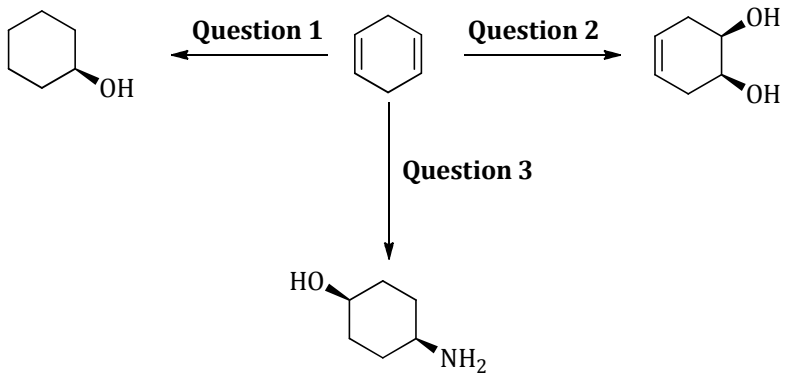
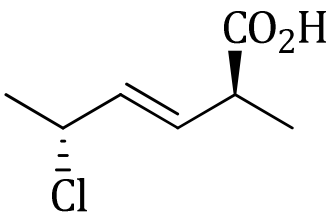
Part 1: Multiple Choice - Note that ***more than one letter could*** be entered as an answer to a multiple choice question. In the case of a discrepancy between your examination paper and your Scantron, the Scantron shall be graded as the intended answer. (This is how it will read on the exam, take note of the rules!!)

For **questions 1 - 3**, classify each transformation as a formal:

A Reduction **B** Oxidation **C** Neither

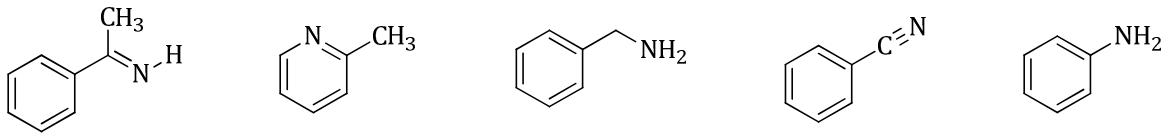


Question 4. What are the stereochemical designations in the systematic (IUPAC) name of the following structure?



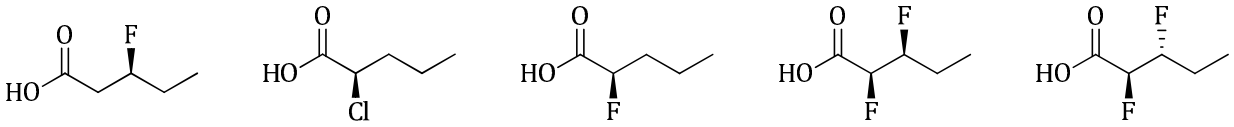
A) 2R, 5R, E
B) 2S, 5R, E
C) 2S, 5S, E
D) 2S, 5R, Z
E) 2R, 5R, Z

Question 5. Which of the compound(s) (**A** – **E**) below contains the most basic nitrogen atom?



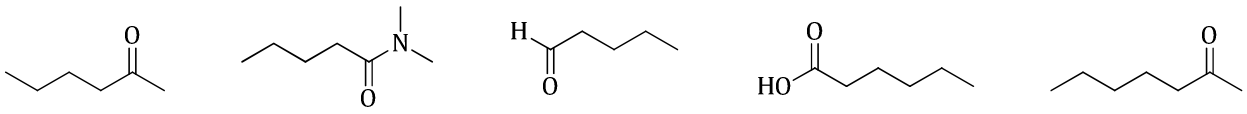
A **B** **C** **D** **E**

Question 6. Which of the following compound(s) (**A** – **E**) is/are the most acidic?



A **B** **C** **D** **E**

Question 7. Which of the following structure(s) (**A** - **E**) represents the line-bond structure of 2-heptanone?

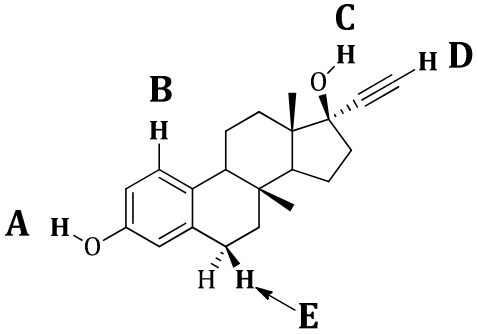


A **B** **C** **D** **E**

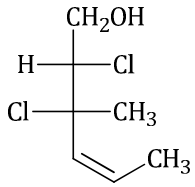
Question 8. What is the *predominant* intermolecular force in a solution of 2-propanol and cyclopentanol?

A) Dispersion Forces
B) Dipole-Dipole Interactions
C) Ion-Dipole Interactions
D) London Forces
E) Hydrophobic Interactions
F) Hydrogen bonding

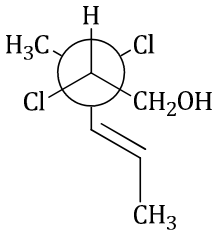
Question 9. Which hydrogen(s) labelled (**A** – **E**) is/are the most acidic?



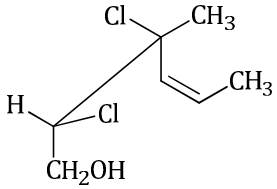
Consider the structures **1** – **3** below when answering **questions 10 – 12**.



1



2



3

10) What is the relationship between compounds **1** and **2**?

(A) Conformers **(B)** Constitutional Isomers **(C)** Diastereomers **(D)** Enantiomers **(E)** Identical

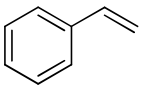
11) What is the relationship between compounds **1** and **3**?

(A) Conformers **(B)** Constitutional Isomers **(C)** Diastereomers **(D)** Enantiomers **(E)** Identical

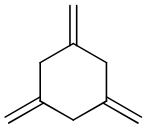
12) What is the relationship between compounds **2** and **3**?

(A) Conformers **(B)** Constitutional Isomers **(C)** Diastereomers **(D)** Enantiomers **(E)** Identical

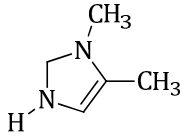
Question 13. Select the compound(s) (**A** – **E**) which have aromatic character.



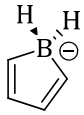
A



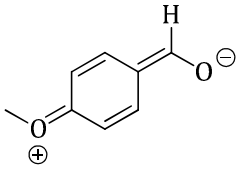
B



C

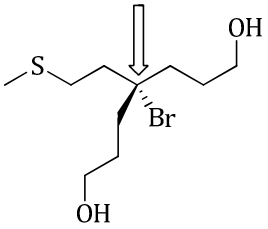


D



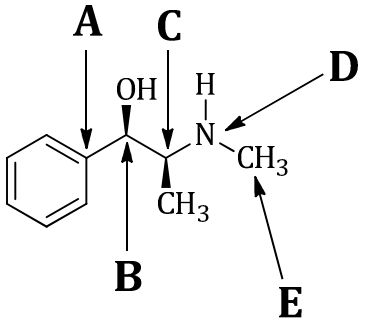
E

Question 14. Indicate the stereochemical designation for the indicated atom below.



(A) R **(B)** S **(C)** E **(D)** Z **(E)** Cis **(F)** Trans **(G)** meso **(H)** achiral

Ephedrine, shown below, is used as a decongestant in cold remedies. When answering **questions 15 – 20**, note that certain atoms have been labelled (**A** – **E**).



15) What is the name of the functional group into which carbon **B** is incorporated?

(A) 1° alcohol **(B)** Aldehyde **(C)** Ether **(D)** 2° alcohol **(E)** 2° Hemiacetal **(F)** 1° Imine

16) What is the hybridization of the carbon labeled **A**?

(A) sp **(B)** sp^2 **(C)** sp^3 **(D)** s **(E)**p **(F)** sp^3d

17) What is the hybridization of the nitrogen atom labeled **D**?

(A) sp **(B)** sp^2 **(C)** sp^3 **(D)** s **(E)**p **(F)** sp^3d

18) Which of the following applies to the stereochemistry of the carbon atom labeled **A**?

(A) R **(B)** S **(C)** Not stereogenic **(D)** E **(E)** Z **(F)** Cis

19) Which of the following applies to the stereochemistry of the carbon labeled **B**?

(A) R **(B)** S **(C)** Not stereogenic **(D)** E **(E)** Z **(F)** Trans

20) Which of the following applies to the stereochemistry labeled **C**?

(A) R **(B)** S **(C)** Not stereogenic **(D)** E **(E)** Z **(F)** alpha

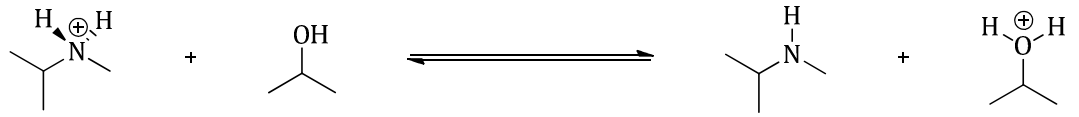
Question 21. Which of the following statements (**A** – **E**) is/are correct regarding a S_N1 mechanism?

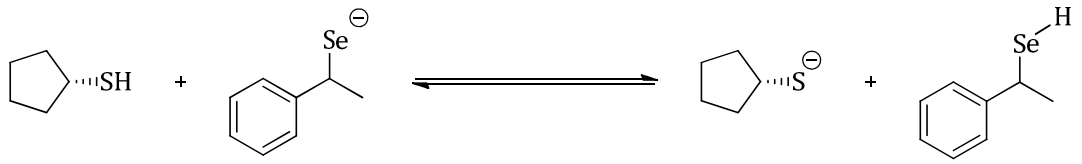
(A) S_N1 reactions involve carbocations
(B) Primary substrates react more rapidly compared with tertiary substrates
(C) Rate = k[substrate]
(D) The reaction will always form the least stable carbocation
(E) The reaction coordinate diagram will have more than one transition state

Part 2: Short answer Questions. Write your answers in the designated space. Please note that in some cases it may be better for you to work out your answer on practice paper and copy a neat version to the examination paper.

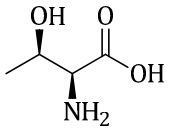
Messy and/or incoherent answers that are difficult to read or interpret may receive reduced or zero credit*

Question 22. For each of the following, clearly indicate which side of the equilibrium is favoured by writing the word **LEFT** or **RIGHT** above the equilibrium arrows. Note that all non-zero formal charges have been shown, but no lone pairs of electrons are drawn. ***Briefly*** rationalize your choice in the space provided (note that listing the pK_a values is not a sufficient explanation).





Question 23. The structure of the amino acid L-threonine is given below. In the boxes below, provide the predominant structure of this amino acid at the specified pH.

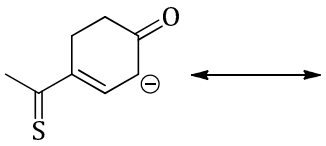


L-threonine

Structure of L-threonine at pH = 2.4

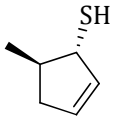
Structure of L-threonine at pH = 13

Question 24. Draw the major contributing resonance structures for the following structure. *Include all lone pairs of electrons, non-zero formal charges*. Including incorrect structures may reduce your grade for this question.



Circle the single most contributing resonance structure from **question 24** (above). Provide ONE reason for your choice, providing more than one answer may reduce your grade for this question.

Question 25. Predict the major organic product(s) for each of the following transformations. Include stereoisomers if appropriate. You do not need to include by-products or a mechanistic rationale for these reactions.

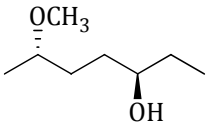


a) Na^+H^-, solvent

b) CH_3CH_2Cl

c) workup

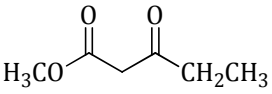
product(s) of this transformation



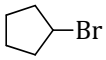
a) excess PBr_3, solvent

b) workup

product(s) of this transformation



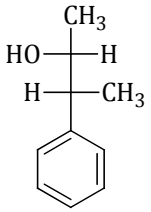
a) LDA, solvent

b) 

, solvent

c) workup

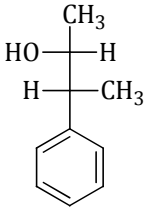
product(s) of this transformation



a) NaH, solvent
b) CH_3CH_2Br, solvent

then *workup*

product(s) of this transformation



1. a) $SOCl_2$, solvent
   b) *workup*

2. $NaSCH_3$, solvent
   then *workup*

product(s) of this transformation

Question 26. In the space provided below, briefly explain why diethyl ether does not mix with water, but tetrahydrofuran (THF) mixes well with water. ***NOTE: Picture = 1000 words***

Tetrahydrofuran (THF)

Diethyl ether (Et_2O)

Question 27. Draw the line bond structure of (*E*)-4-methyl-2-pentene.

Question 28. Draw the Fischer projection of (*S,S*)-2,3-dichlorobutane.

Question 29. Using arrows to represent electron movement, draw a step-by-step mechanistic rationale for the following transformation. Include all relevant lone pairs of electrons, formal charges and reaction intermediates.