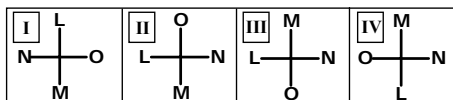


NAME: \_\_\_\_\_ ANSWER KEY \_\_\_\_\_ ENTRY #: \_\_\_\_\_ Grp. #: \_\_\_\_\_

1) From among the structures I, II, III and IV, shown below, as Fischer projections, identify which structures represent a pair of identical molecules and those which a pair of mirror image isomers.



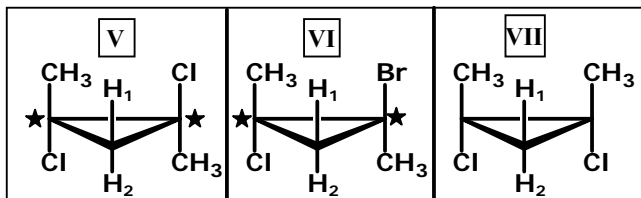
Identical Molecules: **I, II and IV are identical**

[Marking Scheme: All 3 - 1 mark ; Only 2 - 0.5 mark]

Mirror Image Isomers: **I & III, II & III and IV & III are enantiomeric pairs**

[ 1, 1 ]

2) Identify the 'topicity' of the -CH<sub>2</sub>- groups in the cyclopropane structures V, VI and VII shown below.



In structure V the 'topicity' is: **HOMOTOPIC**

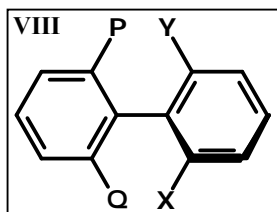
In structure VI the 'topicity' is: **DIASTEREOTOPIC**

In structure VII the 'topicity' is: **DIASTEREOTOPIC**

[Marking scheme: Each - 1 mark]

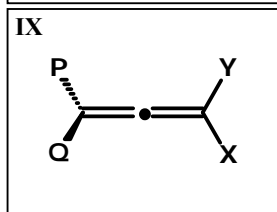
[ 1, 1, 1 ]

3) Give the *relative priority* of groups P, Q, X and Y such that structure VIII represents S<sub>a</sub> chirality and structure IX represents R<sub>a</sub> chirality.



Priority such that structure VIII represents S<sub>a</sub> chirality

**P > Q AND X > Y**



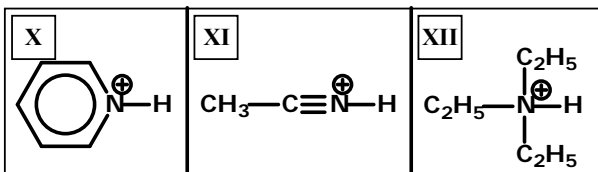
Priority such that structure IX represents R<sub>a</sub> chirality

**P > Q AND X > Y**

[Marking Scheme: ONLY 1 OPTION - 1 MARK ; BOTH POSSIBILITIES - 1.5 MARKS]

[ 1.5 x 2 = 3 ]

4) Arrange the *conjugate acids* X, XI and XII, shown below, in order of their *increasing acid strengths*.



Weakest Acid		Strongest Acid
XII	X	XI
STRONGEST / LEAST STABLE CONJUGATE BASE lp IN sp <sup>3</sup> ORBITAL		WEAKEST / MOST STABLE CONJUGATE BASE lp IN sp ORBITAL

Explain your ordering scheme

**Strength of acids increases as the stability of the conjugate base, formed by the loss of H<sup>+</sup>, increases.**

**Here the conjugate bases, in order in increasing stability are:**

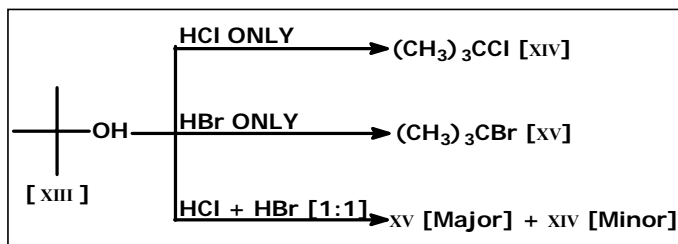
**(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>N: < C<sub>6</sub>H<sub>5</sub>N: < CH<sub>3</sub>CN:**

**Orbital containing lone pair of electrons:**

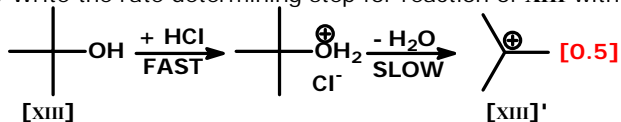
**sp<sup>3</sup> < sp<sup>2</sup> < sp**

[ 1, 1 ]

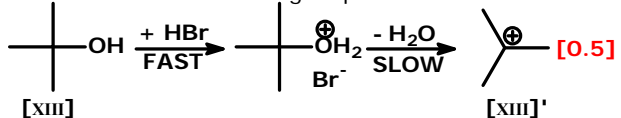
5) Study the reactivity patterns summarised below and answer the questions which follow.



a) Write the rate determining step for reaction of XIII with HCl.



b) Write the rate determining step for reaction of XIII with HBr.



c) Is the intermediate species formed in both cases [ a) and b) above ] the same or different?

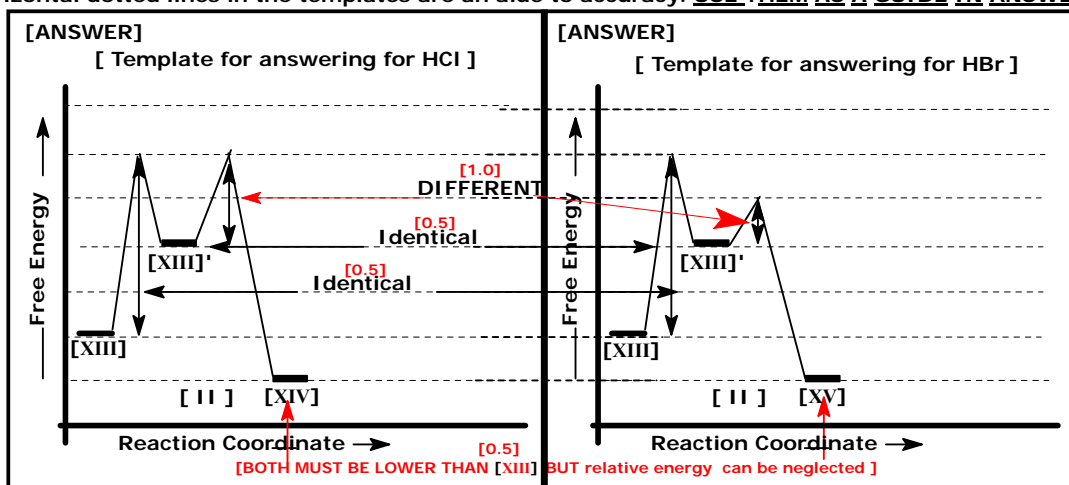
**SAME [0.5]**

d) Based on your answers to the questions a), b) and c) above, using the templates provided below, draw an accurate Free Energy vs. Reaction Coordinate diagram that explains the reactivity shown below.

[ Assume that the overall reaction for both HCl & HBr is exothermic. ]

[ Your diagram **MUST CLEARLY SHOW** why, when HCl & HBr are in a 1:1 ratio, XV is the Major product. ]

[ Horizontal dotted lines in the templates are an aide to accuracy. **USE THEM AS A GUIDE IN ANSWERING** ]



**$E_a$  for  $\text{Cl}^-$  attack on  $[\text{XIII}]'$   $\gg$   $E_a$  for  $\text{Br}^-$  attack on  $[\text{XIII}]'$**

[ 0.5, 0.5, 0.5, 0.5, 0.5, 1, 0.5 ]

6) An enantiomerically pure, chiral 3, 4-dimethyl-pentan-2-one was reduced with  $\text{NaBH}_4$ , followed by acidic work up. A secondary alcohol so obtained had R chirality at the new chiral centre created.

a) What is the chirality of the original chiral centre in the reactant?

Given the information provided in the question

**IT CAN BE EITHER R OR S TYPE CHIRALITY.**

**[ If both R & S are given – 1 mark ; If only one is mentioned – 0.5 mark ]**

b) To which face of the pro-chiral ketone did the  $\text{H}^-$  add?

**IF the reactant ketone is the R enantiomer**

**THEN the 2° alcohol with R chirality at the new chiral centre created is obtained by addition to the 'Si' face of the pro-chiral reactant. [0.5]**

**IF the reactant ketone is the S enantiomer**

**THEN the 2° alcohol with R chirality at the new chiral centre created is obtained by addition to the 'Re' face of the pro-chiral reactant. [0.5]**

**[ ONLY 1 SPECIFIED – 0.5 ; BOTH GIVEN – 1.0 ]**

c) Is the product obtained the major or the minor product of the reduction?

**IF the reactant ketone is the R enantiomer**

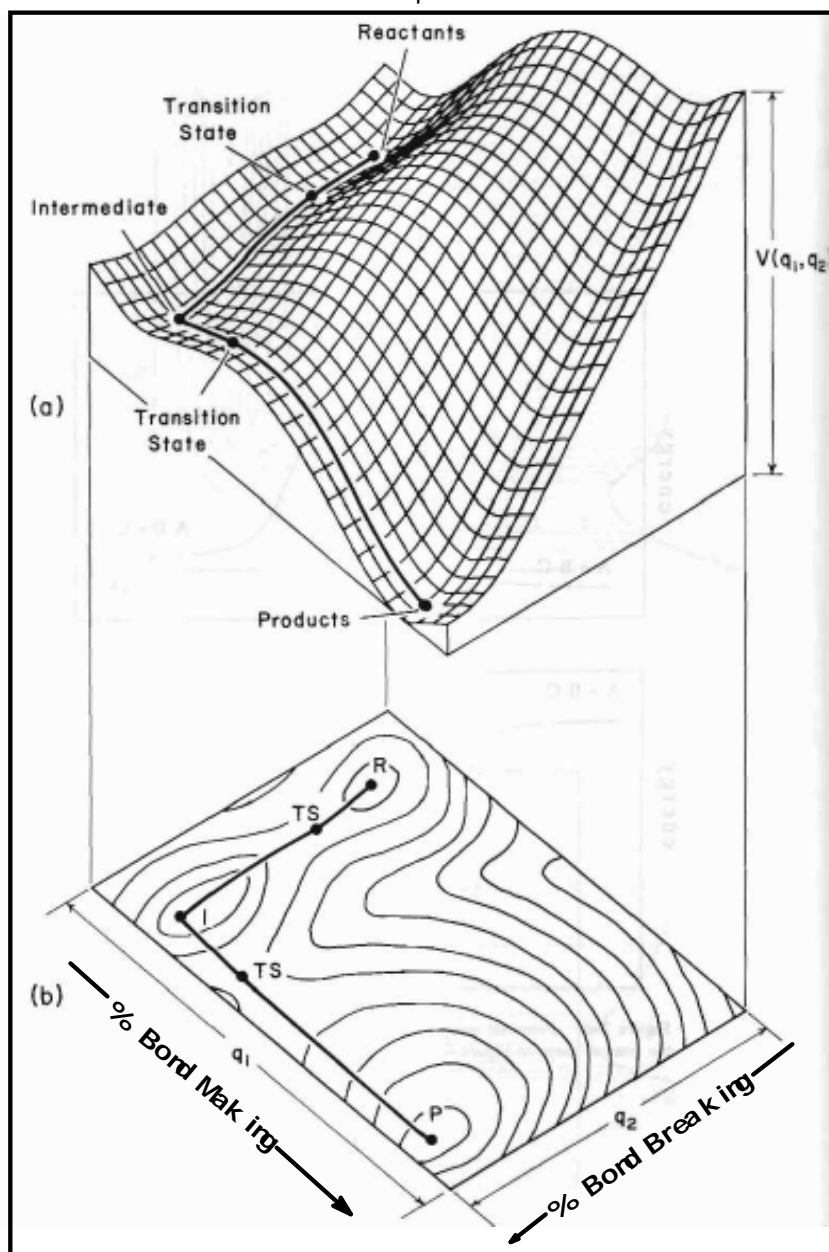
**THEN the 2° alcohol with R chirality at the new chiral centre created is the MINOR product. [0.5]**

**IF the reactant ketone is the S enantiomer**

**THEN the 2° alcohol with R chirality at the new chiral centre created is the MAJOR product. [0.5]**

**[ ONLY 1 SPECIFIED – 0.5 ; BOTH GIVEN – 1.0 ]**

7) Study the figure shown below and answer the questions which follow.



a) What is this kind of graph called?

**Potential Energy Surface [0.5]**

b) What does the graph depict / show?

**It depicts / shows the changes in energy undergone during a chemical transformation (Eg. Reactants converted to Products) as a function of Bond Breaking and Bond Making.**

[Marking Scheme: 0.5 for including underlined ideas]

c) Which type of reaction(s) does the figure shown above describe? Explain your answer.

**It could describe either S<sub>N</sub>1, E1 or Electrophilic Aromatic Substitution.**

[Marking Scheme: 0.5 for ANY 1 REACTION TYPE ; 1.0 for TWO OR MORE REACTION TYPES]

d) In terms of its energy requirement, is the reaction type shown in the figure above 'endo' type or 'exo' type? Explain your answer.

**This is an 'exo' type of a reaction.**

[Marking Scheme: 0.5 for including underlined idea]

**Because the Products MORE STABLE than Reactants.**

[Marking Scheme: 0.5 for including underlined idea]