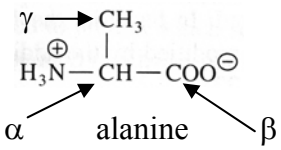
3.091 OCW Scholar

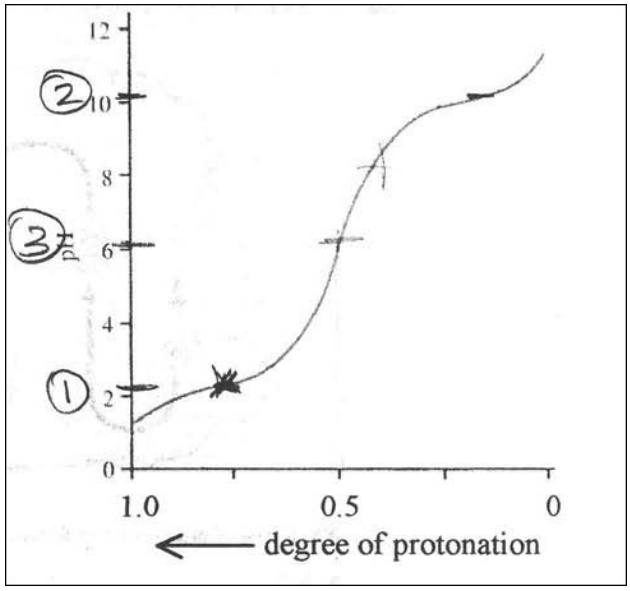
# Self-Assessment Exam
# Organic Materials

# Solution Key

## Final Exam, Problem #5

The skeletal structure of the amino acid, alanine, is given below as it exists as the neutral zwitterion. To the right is shown its titration curve in aqueous solution. The abscissa expresses concentration in terms of degree of protonation, so that at a value of 0.5 the neutral zwitterion is the only species present, at a value of 0 alanine is totally deprotonated, and at a value of 1.0 alanine is totally protonated.




(a) What is the hybridization of each of the three carbons in alanine?

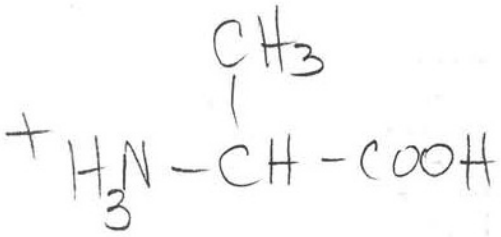
α $sp^3$

β $sp^2$

γ $sp^3$

(b) Indicate on the titration curve (1) the $pK_a$ for protonation of the zwitterion, (2) the $pK_a$ for deprotonation of the zwitterion, and (3) the isoelectric point.

(c) Draw the skeletal structure of alanine when it is solvated in an aqueous solution at extreme acidity, i.e., $p$H < 1.




(d) For an aqueous solution of alanine calculate the ratio of the concentration of neutral alanine zwitterion to the concentration of deprotonated anion when the $p$H is 8.091.

$$H^+ + A^- = HA$$

$$K = \frac{[HA]}{[H^+][A^-]}$$

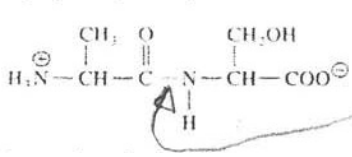
$$\log K = \log\frac{[HA]}{[A^-]} - \log[H^+]$$

$$\log\frac{[HA]}{[A^-]} = -pH + pK_a = -8.091 + 10 = 2$$

$$\therefore \frac{[HA]}{[A^-]} = 100$$

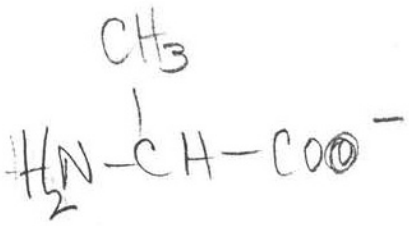
## Final Exam, Problem #6

(d) The dipeptide, alanylserine shown below, is derived from alanine and serine.

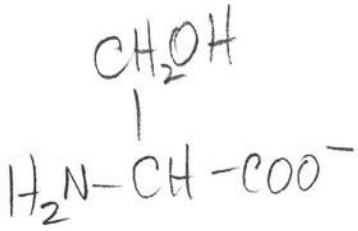


(i) Indicate the position of the peptide bond.

(ii) Draw the skeletal structure of each constituent amino acid as it would be present in an aqueous solution of extreme basicity, i.e., *p*H > 12.

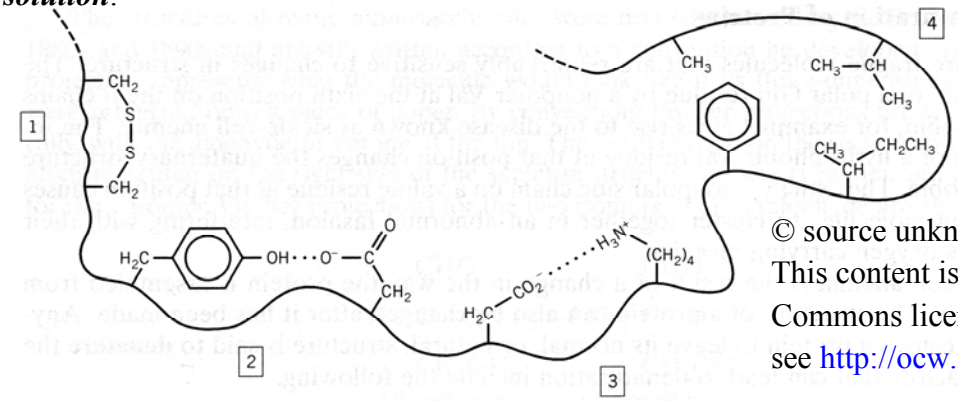


alanine



serine

(e) The figure below shows various features of the tertiary structure along a length of protein ***in aqueous solution***.



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At each of the four numbered positions, name one chemical change to the environment of the protein that would destabilize the associated feature in the tertiary structure. Explain the relevant chemistry.

① reducing agent such as $H_2$ would break the S-S linkage & give $-S-H$ $H-S-$

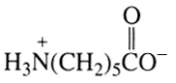
② drop in pH would break the H-bond ~~free~~ protons act as plasticizers

③ ~~change~~ rise in salinity would provide ions of opposite charge in sol'n to pair with ions in side groups & break the electrostatic attraction

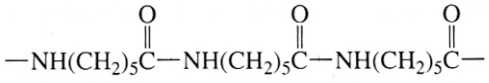
④ addition of a detergent would destabilize hydrophobic pocket. ~~the~~ hydrophobic tail of detergent binds to nonpolar side groups while hydrophilic head binds to water

## Final Exam, Problem #13

(a) Name the type of polymerization reaction that will convert 6-aminohexanoic acid into nylon 6.



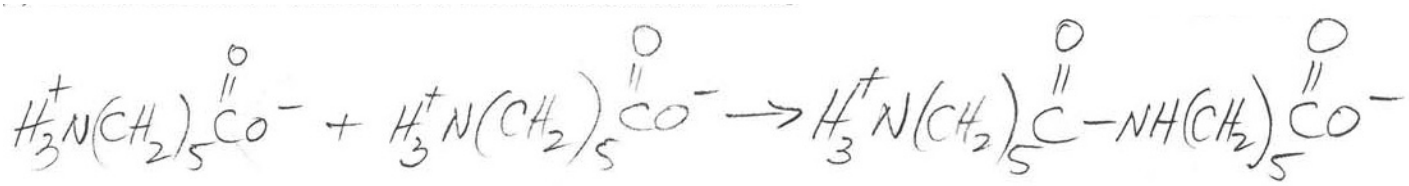
6-aminohexanoic acid



nylon 6

condensation

(b) Write the reaction that converts two molecules of 6-aminohexanoic acid into a dimer of nylon 6.



(c) Calculate the molecular weight of nylon 6 for which the degree of polymerization, *n*, is 3091.

mer unit is $NH(CH_2)_5CO \Rightarrow 14+11+72+16 = 113$

$\therefore$ polymer mass is $113 \times 3091 = 3.49 \times 10^5$ Da

(d) Is it possible to convert nylon 6 into an elastomer? If so, describe how, i.e., specify the necessary change in the chemistry. If not, explain why this is the case.

no. you need double bonds along the backbone in order to be able to form sulfide linkages between chains

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3.091SC Introduction to Solid State Chemistry

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