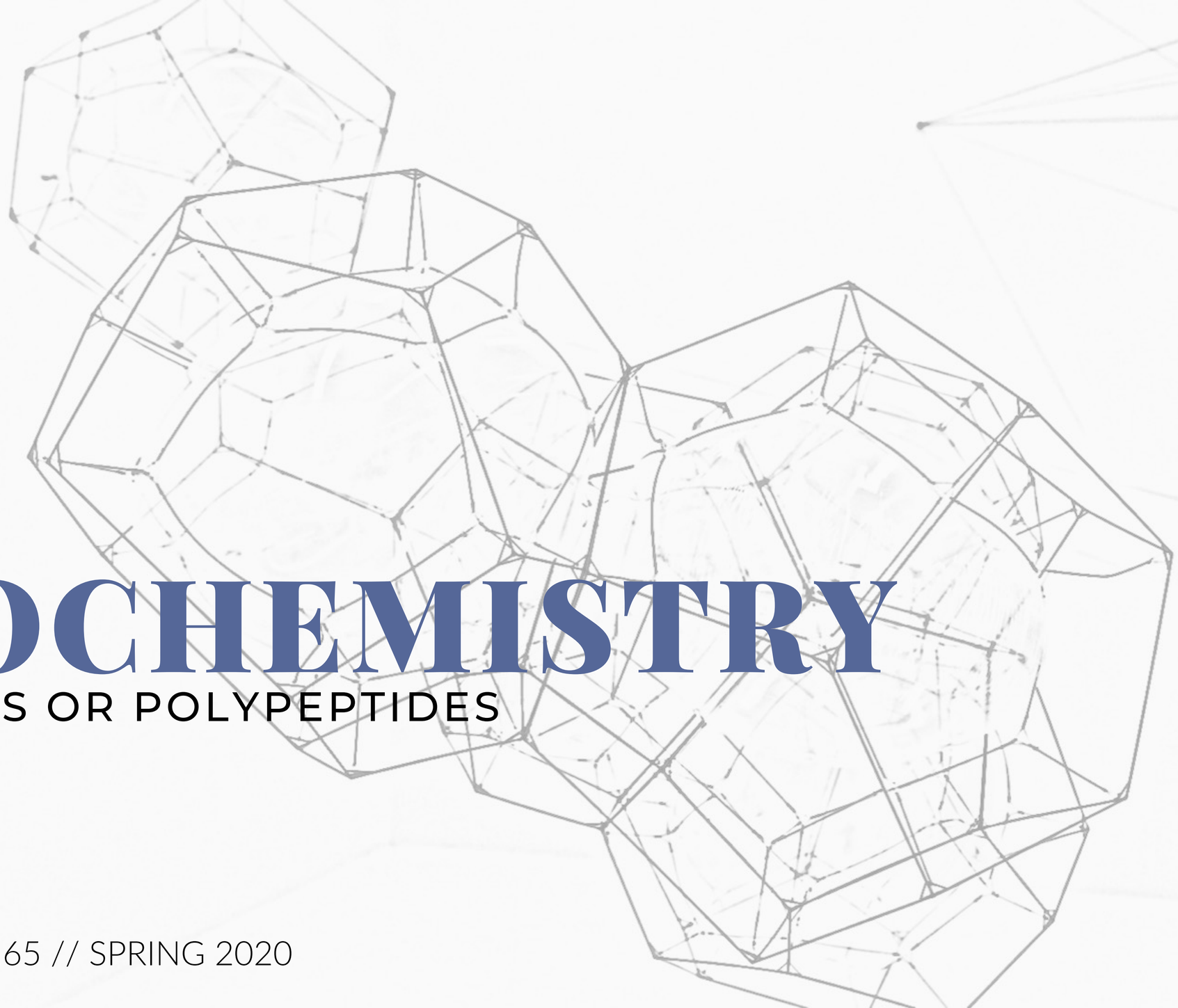


BIOCHEMISTRY

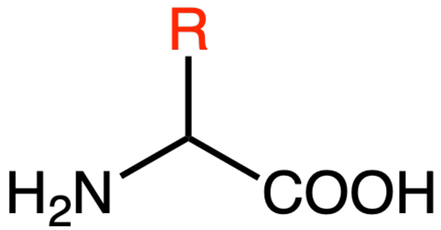
PROTEINS OR POLYPEPTIDES

CHEMISTRY 165 // SPRING 2020

DR. MIOY T. HUYNH | 2020

The amino acids

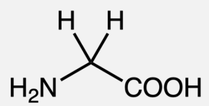
In biochemistry, we are most interested in 20 amino acids (drawn and named to the right) with the general formula $H_2NCHRCOOH$ and the structure:

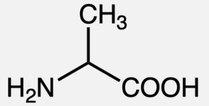


The R **group** is called the **sidechain**.

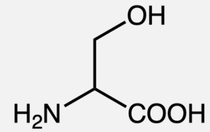
Amino acids combine via condensation reactions to form proteins or polypeptides.

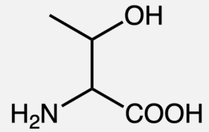
SMALL

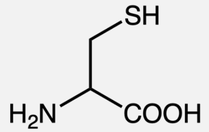

Glycine (Gly, G)


Alanine (Ala, A)

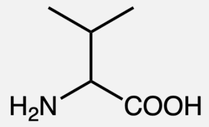
NUCLEOPHILIC

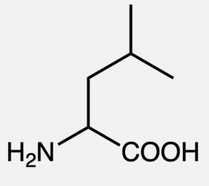

Serine (Ser, S)
pK_a ~ 16

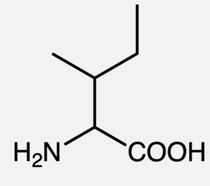

Threonine (Thr, T)
pK_a ~ 16

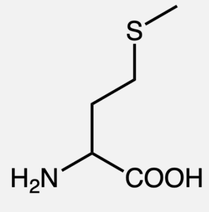

Cysteine (Cys, C)
pK_a = 8.35

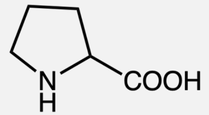
HYDROPHOBIC


Valine (Val, V)

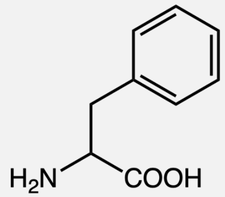

Leucine (Leu, L)

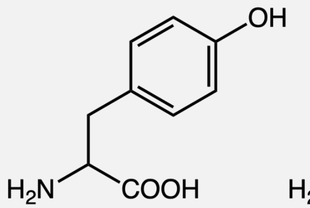

Isoleucine (Ile, I)

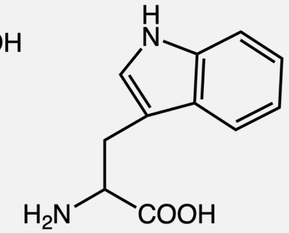

Methionine (Met, M)


Proline (Pro, P)

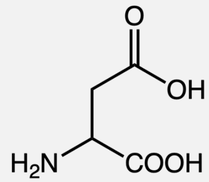
AROMATIC

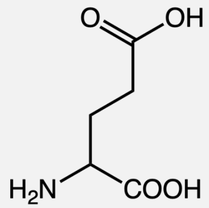

Phenylalanine (Phe, F)


Tyrosine (Tyr, Y)

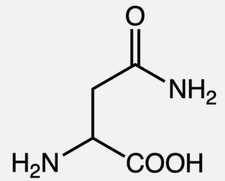

Tryptophan (Trp, W)

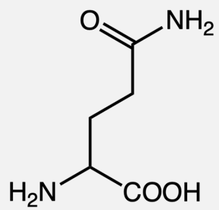
ACIDIC


Aspartic Acid (Asp, D)
pK_a = 3.9

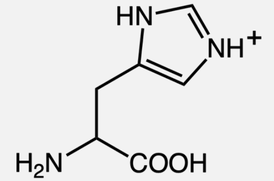

Glutamic Acid (Glu, E)
pK_a = 4.07

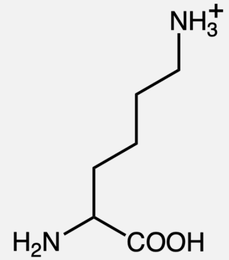
AMIDE

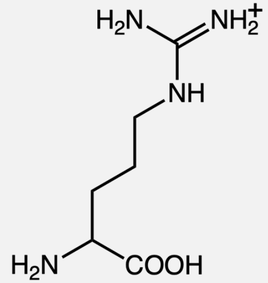

Asparagine (Asn, N)


Glutamine (Gln, Q)

BASIC


Histidine (His, H)
pK_a = 6.04

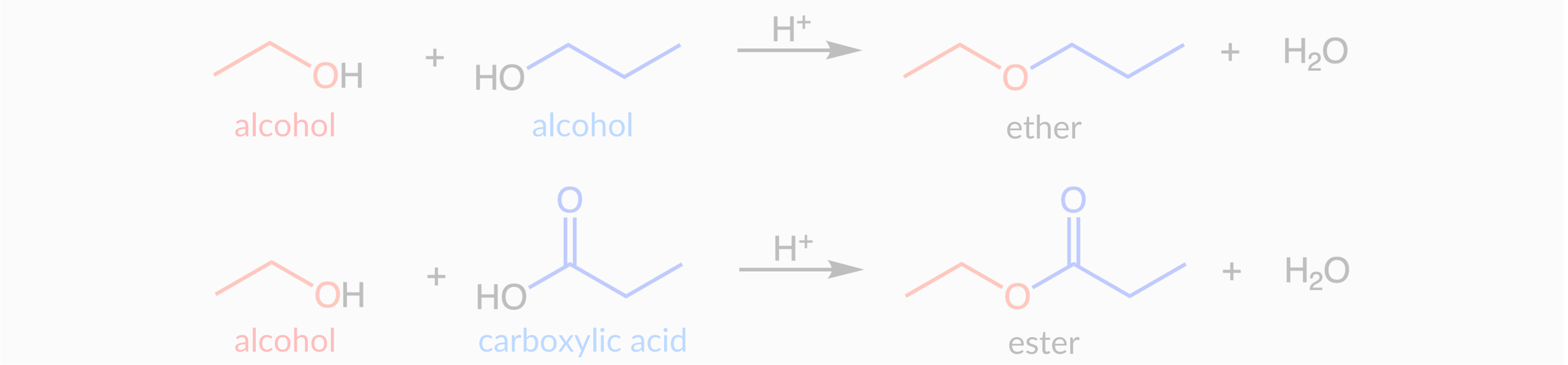

Lysine (Lys, K)
pK_a = 10.79


Arginine (Arg, R)
pK_a = 12.48

Recall: Making amides via condensation

In general terms, condensation reactions are: A + B → A-B + small molecule (such as: H_2O, NH_3, HCl, etc.)

Reaction: combine two oxygenates into another oxygenate; requires an acid catalyst (H^+) or activator.

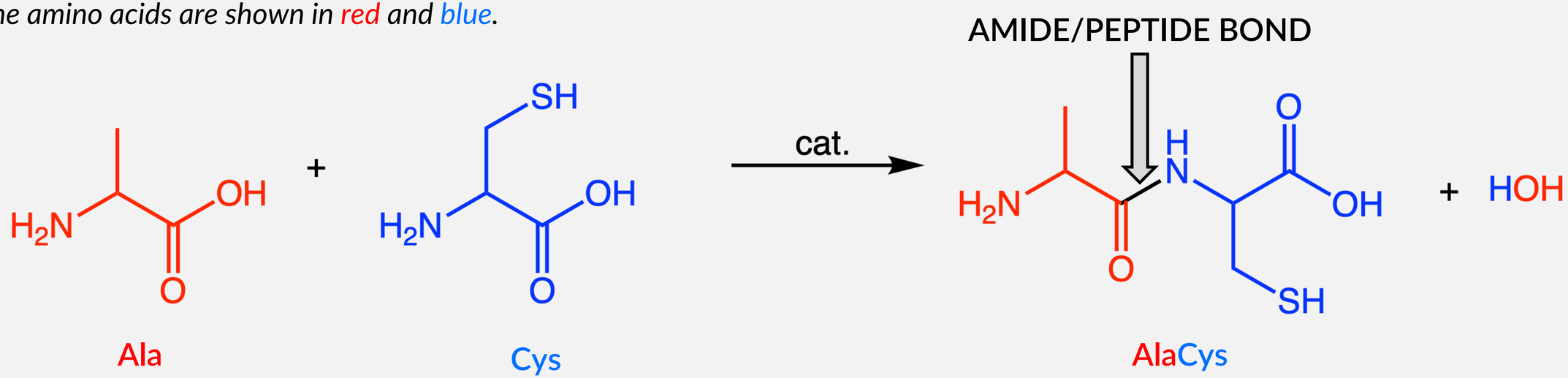


Making proteins from amino acids

Consider a small protein (a dipeptide) made from condensation of alanine (Ala) and cysteine (Cys):

The amide/peptide bonds are shown with black bonds.

The amino acids are shown in red and blue.



These condensation reactions typically require a catalyst, in the form of an enzyme.

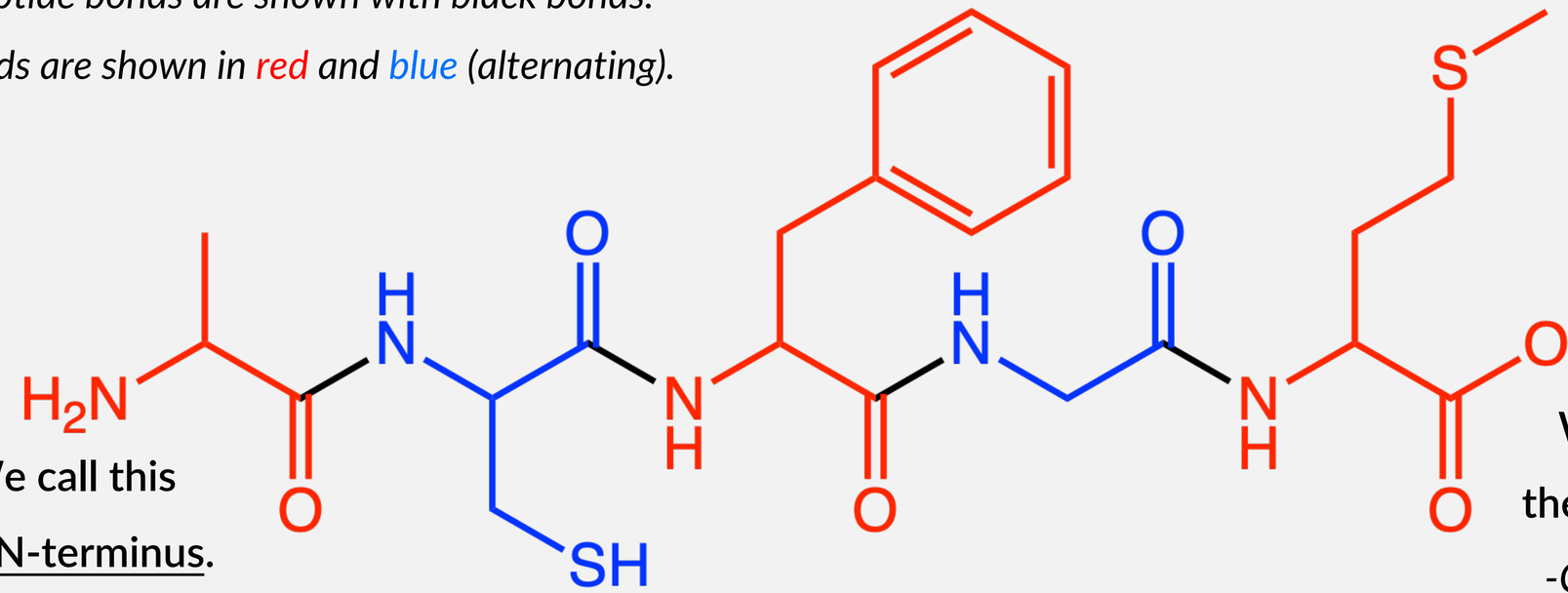
The new amide bond formed between the amino acids is sometimes also called a peptide bond.

Naming proteins (polypeptides)

Consider now the larger protein (a polypeptide):

The amide/peptide bonds are shown with black bonds.

The amino acids are shown in red and blue (alternating).



We call this the N-terminus.

-NH_2 group

We call this the C-terminus.

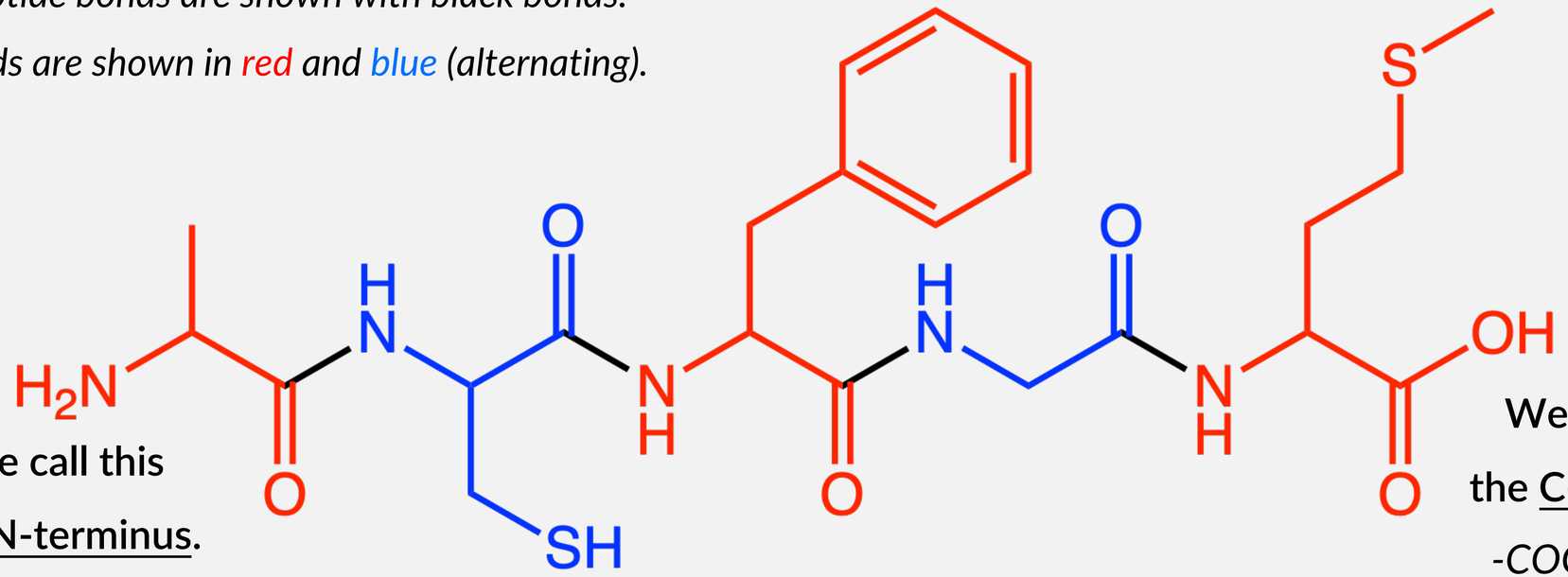
-COOH group

We name proteins from the N-terminus (left) to the C-terminus (right), so: AlaCysPheGlyMet

Properties of proteins: Acid-base + charge

The amide/peptide bonds are shown with black bonds.

The amino acids are shown in red and blue (alternating).



We call this the N-terminus.

-NH_2 group

We call this the C-terminus.

-COOH group

We name proteins from the N-terminus (left) to the C-terminus (right), so: AlaCysPheGlyMet

Because the amino acids that comprise this protein are all pH-neutral, the overall protein is also pH-neutral.

As such, we also expect this protein to be charge-neutral at pH ~ 6 since the constituent amino acids have pI ~ 6.

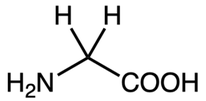
PRACTICE PROBLEM 1

Estimate the overall charge on the protein at pH = 6:

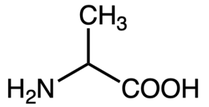
ArgProProGlyPheSerProPheArg.

— answer —

SMALL

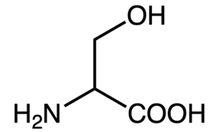


Glycine (Gly, G)

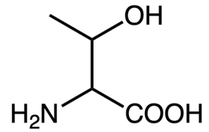


Alanine (Ala, A)

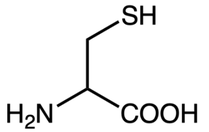
NUCLEOPHILIC



Serine (Ser, S)
pK_a ~ 16

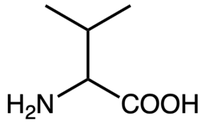


Threonine (Thr, T)
pK_a ~ 16

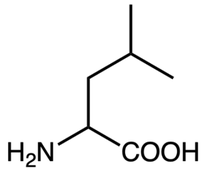


Cysteine (Cys, C)
pK_a = 8.35

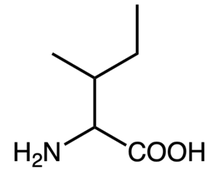
HYDROPHOBIC



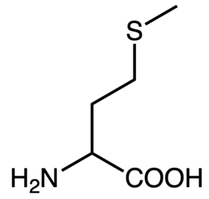
Valine (Val, V)



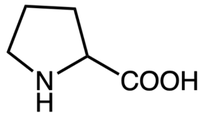
Leucine (Leu, L)



Isoleucine (Ile, I)

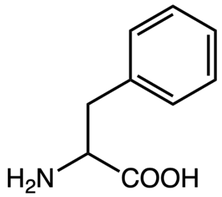


Methionine (Met, M)

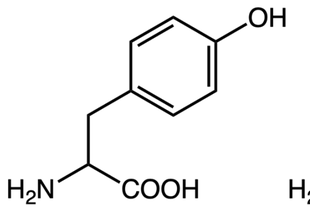


Proline (Pro, P)

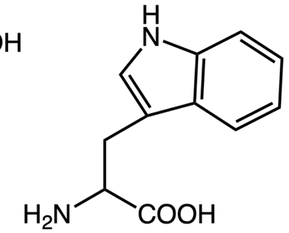
AROMATIC



Phenylalanine (Phe, F)

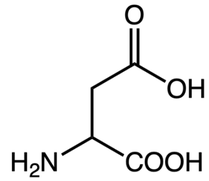


Tyrosine (Tyr, Y)

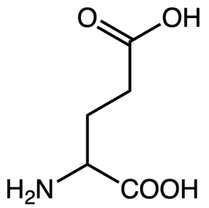


Tryptophan (Trp, W)

ACIDIC

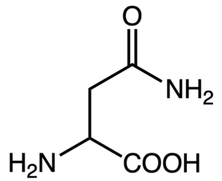


Aspartic Acid (Asp, D)
pK_a = 3.9

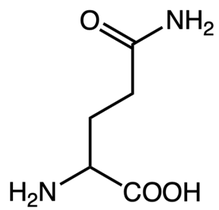


Glutamic Acid (Glu, E)
pK_a = 4.07

AMIDE

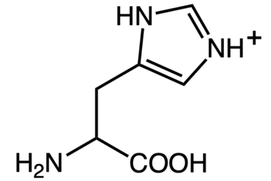


Asparagine (Asn, N)

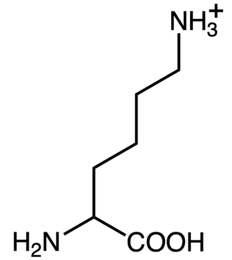


Glutamine (Gln, Q)

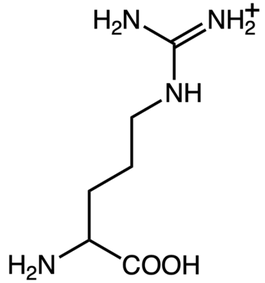
BASIC



Histidine (His, H)
pK_a = 6.04



Lysine (Lys, K)
pK_a = 10.79



Arginine (Arg, R)
pK_a = 12.48

PRACTICE PROBLEM 1

Estimate the overall charge on the protein at pH = 6:

ArgProProGlyPheSerProPheArg.

— answer —

Assign charges to each of the amino acids at pH = 6:

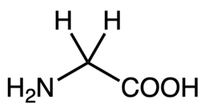
- Arg → pI ~ 11 → charge = +1
- Pro → pI ~ 6 → charge = 0
- Gly → pI ~ 6 → charge = 0
- Phe → pI ~ 6 → charge = 0
- Ser → pI ~ 6 → charge = 0

The overall charge on the protein is the sum of the charges on the individual amino acids. In this case, the two Arg groups contribute a +1 charge each, and all other amino acids contribute 0 charge.

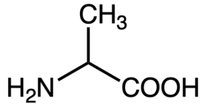
Overall charge = +2

The protein is also basic because of the basic Arg groups.

SMALL

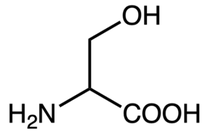


Glycine (Gly, G)

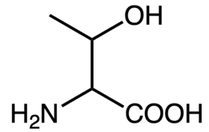


Alanine (Ala, A)

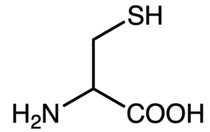
NUCLEOPHILIC



Serine (Ser, S)
pK_a ~ 16

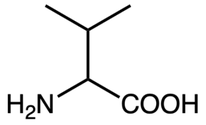


Threonine (Thr, T)
pK_a ~ 16

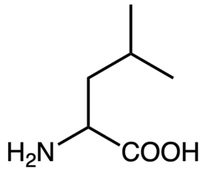


Cysteine (Cys, C)
pK_a = 8.35

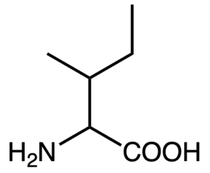
HYDROPHOBIC



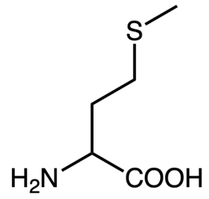
Valine (Val, V)



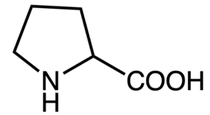
Leucine (Leu, L)



Isoleucine (Ile, I)

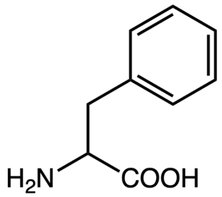


Methionine (Met, M)

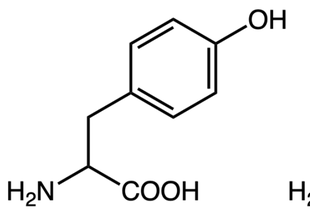


Proline (Pro, P)

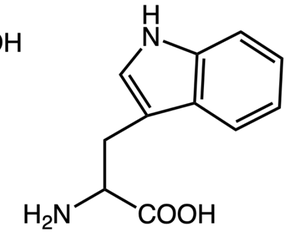
AROMATIC



Phenylalanine (Phe, F)

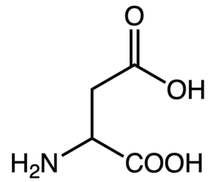


Tyrosine (Tyr, Y)

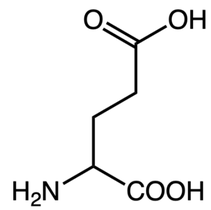


Tryptophan (Trp, W)

ACIDIC

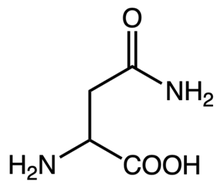


Aspartic Acid (Asp, D)
pK_a = 3.9

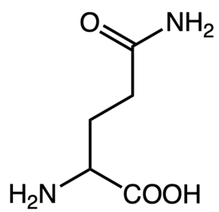


Glutamic Acid (Glu, E)
pK_a = 4.07

AMIDE

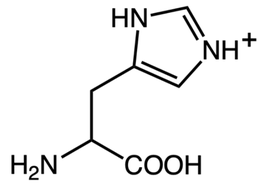


Asparagine (Asn, N)

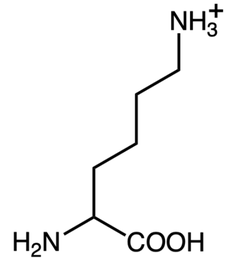


Glutamine (Gln, Q)

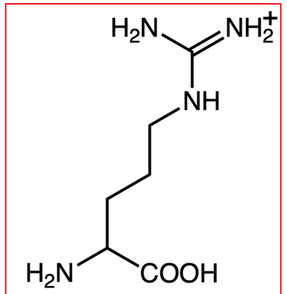
BASIC



Histidine (His, H)
pK_a = 6.04



Lysine (Lys, K)
pK_a = 10.79



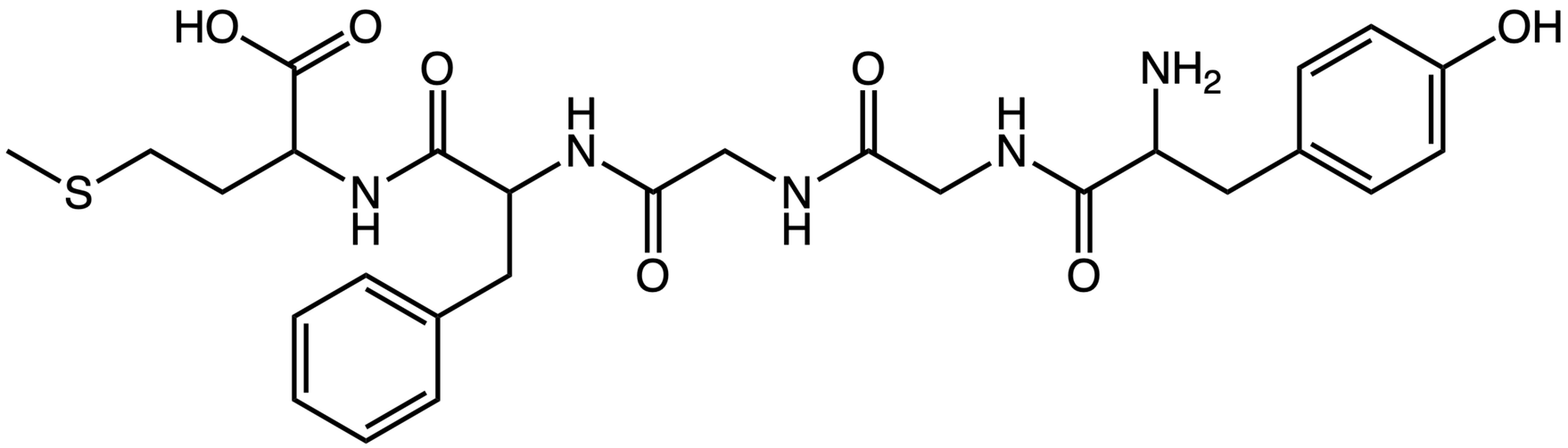
Arginine (Arg, R)
pK_a = 12.48

PRACTICE PROBLEM 2

Identify the amino acids that comprise the following protein.

Is this protein acidic, basic, or neutral overall?

— answer —



PRACTICE PROBLEM 2

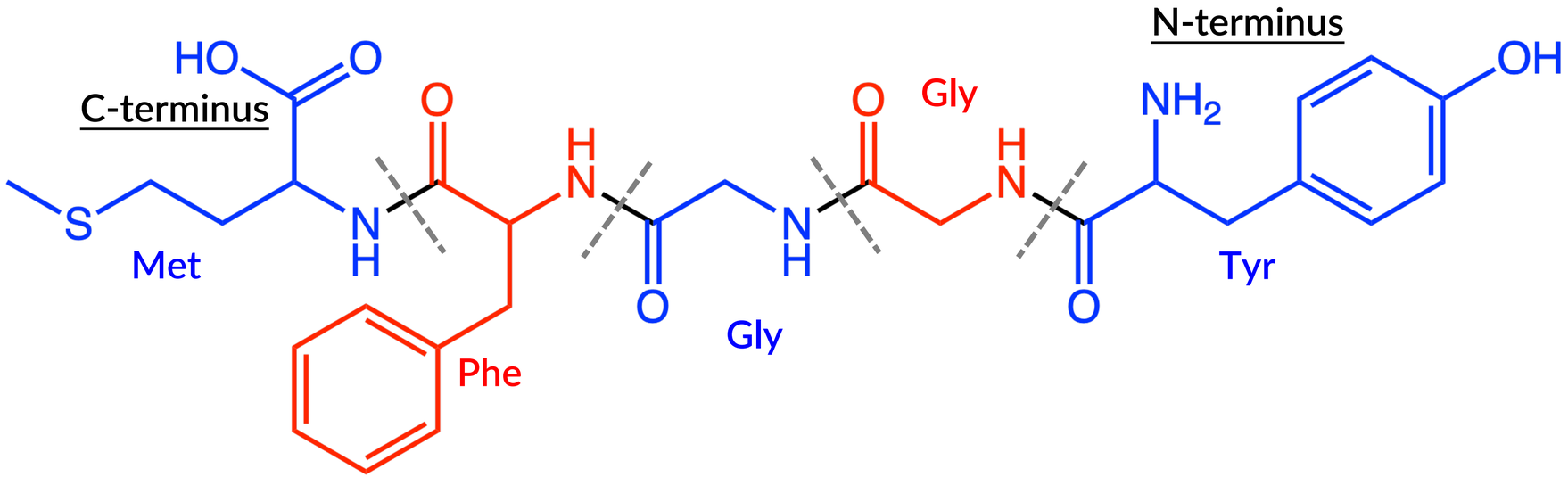
Identify the amino acids that comprise the following protein.

Is this protein acidic, basic, or neutral overall?

— answer —

First, find the N-terminus, which will have a free $-NH_2$ on one of the ends of the protein. In this case, it is on the right side.

Second, cut the protein at the amide/peptide bond: shown as black bonds with dashed gray lines bisecting bond.



Then identify/name each of the amino acids: TyrGlyGlyPheMet.

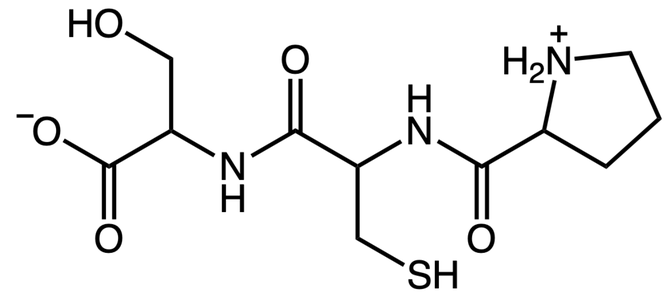
Since all of the amino acids are pH-neutral, the overall protein is also pH-neutral.

PRACTICE PROBLEM 3

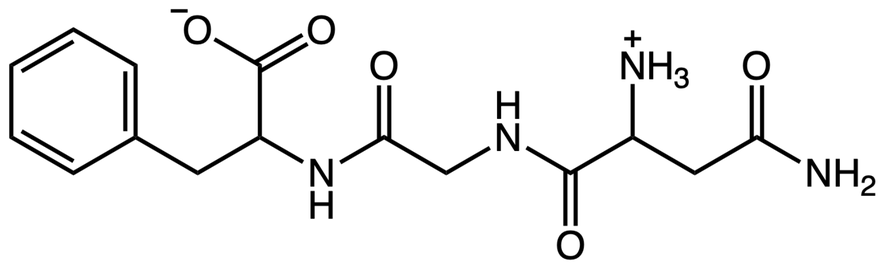
Which of the following tripeptides is/are acidic?

— answer —

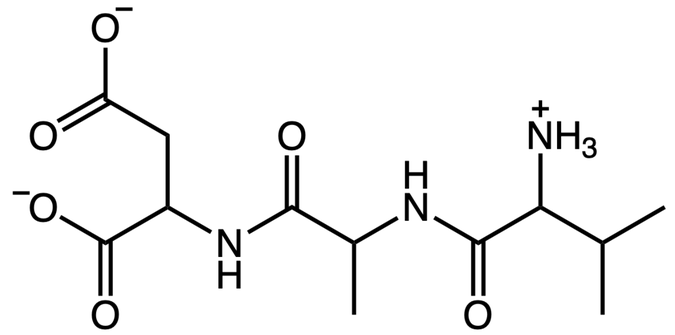
A



B



C



PRACTICE PROBLEM 3

Which of the following tripeptides is/are acidic?

— answer —

For each tripeptide, first identify the amino acids and name the tripeptide starting from the N-terminus (the side a free $-NH_2$ group).

A) ProCysSer

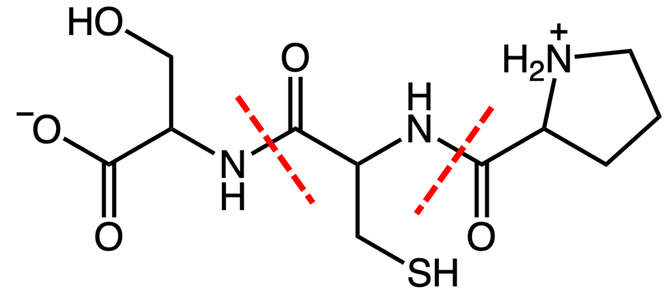
B) AsnGlyPhe

C) ValAlaAsp

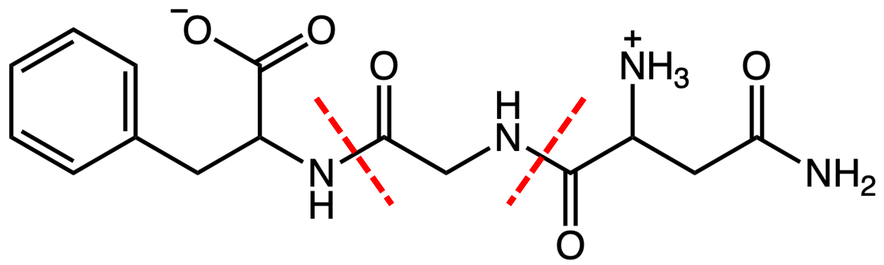
Because tripeptides A and B are only composed of pH-neutral amino acids (Pro, Cys, Ser, Asn, Ala, Phe) both are pH-neutral tripeptides.

Tripeptide C is acidic because of the acidic amino acid Asp (aspartic acid).

A



B



C