7.012 Problem Set 1

Your answers to this problem set must be inserted into the large wooden box on wheels outside 68-120 by 4:30 PM, Thursday, September 15. Problem sets will not be accepted late. Solutions will be posted on the web. (http://web.mit.edu/7.01x/7.012/)

Question 1

A.

a) Define:

i) hydrogen bond

ii) covalent bond

iii) ion

iv) isotope

b) Which of the following bonds is a covalent bond? Circle the correct answers.

- ionic
- hydrogen
- van der Waals
- disulfide bond
- none of these

c) Write in the appropriate descriptive term(s) from below adjacent to the molecules listed. Choose from:

cation  anion  polar non-charged  nonpolar non-charged

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Term(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O</td>
<td></td>
</tr>
<tr>
<td>Na⁺</td>
<td></td>
</tr>
<tr>
<td>Cl⁻</td>
<td></td>
</tr>
<tr>
<td>CH₄</td>
<td></td>
</tr>
</tbody>
</table>

d) Explain why ethane (C₂H₆) is a non-polar molecule while ethanol (C₂H₅ - OH) is a polar molecule.
B. 

Match the letter of the organelle or structure on the left with the function or characteristic on the right.

<table>
<thead>
<tr>
<th>Organelle/Structure</th>
<th>Function or Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Nucleolus</td>
<td>Prepares proteins for export from the cell</td>
</tr>
<tr>
<td>b. Nucleus</td>
<td>Digests macromolecules</td>
</tr>
<tr>
<td>c. Plasma Membrane</td>
<td>Organelle catalyzing protein synthesis</td>
</tr>
<tr>
<td>d. Lysosome</td>
<td>Contains all genomic DNA</td>
</tr>
<tr>
<td>e. Rough Endoplasmic Reticulum</td>
<td>Surrounds cells</td>
</tr>
<tr>
<td>f. Ribosome</td>
<td>Where ribosomal RNA is made</td>
</tr>
<tr>
<td>g. Golgi Apparatus</td>
<td>Site of exported protein synthesis</td>
</tr>
<tr>
<td>h. Mitochondria</td>
<td>&quot;Powerhouse&quot; of the cell</td>
</tr>
</tbody>
</table>

C. 

![DNA Structure](image)

a) What is the general name of this macromolecule above?

Polypeptide DNA RNA Lipid Carbohydrate

b) What is the chemical difference between the pentose sugar in DNA and the pentose sugar in RNA? (See pages 47 and 55 in the text book.)
Question 2

The following structure is found in many biological systems.

Professor Eric Lander drew a representation of this molecule like this.

a) This is an example of what type of biological molecule? _____________________________

b) Where exactly are these molecules found in a living cell? _____________________________

c) If you were to add many of these molecules → to the glass of water shown below, draw one of three configurations these molecules would assume.

d) What is the name of your configuration? _____________________________

e) Explain briefly why the molecules take this shape.
Question 3

One day in lab while studying an enzyme, Bioroxase, you discover the following potential interactions that could occur between this amazing enzyme and its substrate.

a) Determine if a favorable interaction is likely to take place, at each site between the chemical group on the substrate and the closest side chain of an amino acid on Bioroxase. If, and only if, a favorable interaction is likely to take place, give the name for the strongest direct intermolecular interaction. Choose from ionic interaction, covalent bond, hydrogen bond, and van der Waals force.

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Will a favorable interaction take place?</th>
<th>Strongest Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Circle one.</td>
<td>ionic interaction, covalent bond, hydrogen bond, or van der Waals force.</td>
</tr>
<tr>
<td>Asp</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>Asn</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>Ile</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>Arg</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>Lys</td>
<td>Yes/No</td>
<td></td>
</tr>
</tbody>
</table>

b) For all cases where a potential interaction seemed unfavorable, explain why that interaction may be unfavorable.
c) Explain what a van der Waals force is.

d) Recent studies have suggested that geckos (small lizards) can stick to walls and ceilings using van der Waals forces alone. How might this be possible?

e) In your continuing work with Bioroxase you discover that this enzyme is also a transmembrane protein (the protein transverses the lipid bilayer of the cell). Box the portion(s) of the protein sequence below from Bioroxase that you would expect to be found in the membrane.


f) Why would the section(s) you boxed likely to be found in the membrane?
Question 4
Which of the following substrates would fit favorably in the enzyme binding site depicted below?
STRUCTURES OF AMINO ACIDS at pH 7.0

ALANINE (ala)

ARGININE (arg)

ASPARAGINE (asn)

ASPARTIC ACID (asp)

CYSTEINE (cys)

GLUTAMIC ACID (glu)

GLUTAMINE (gln)

GLYCYNE (gly)

HISTIDINE (his)

ISOLEUCINE (ile)

LEUCINE (leu)

LYSINE (lys)

METHIONINE (met)

PHENYLALANINE (phe)

PROLINE (pro)

SERINE (ser)

THREONINE (thr)

TRYPTOPHAN (trp)

TYROSINE (tyr)

VALINE (val)