Question 1.

Four compounds, each having the molecular formula $C_3H_5NO$, have the IR spectra summarized below.

What are their structures?

a. One sharp band above 3000 cm$^{-1}$; one strong band at about 1700 cm$^{-1}$.

\[
\text{NH}_2\text{CH}_2\text{COOH}
\]

b. Two sharp bands above 3000 cm$^{-1}$; two bands between 1600 and 1700 cm$^{-1}$.

\[
\text{NH}_2\text{CO}_2\text{H}
\]

c. One strong broad band above 3000 cm$^{-1}$; a band at about 2200 cm$^{-1}$.

\[
\text{OH}\text{C}_2\text{N}
\]

*Hint* - in the absence of supporting spectroscopic information, it may be useful to use your knowledge of functional groups to write down all possible structures for $C_3H_5NO$.

Question 2.

Explain briefly (in one or two short sentences) the meaning of the following basic stereochemical terms.

a. chirality

*The geometric property of a rigid object (or spatial arrangement of points or atoms) of being non-superposable on its mirror image; such an object has no symmetry elements of the second kind (a mirror plane, a centre of inversion, a rotation-reflection axis). If the object is superposable on its mirror image the object is described as being achiral.*

b. constitution
The description of the identity and connectivity (and corresponding bond multiplicities) of the atoms in a molecular entity (omitting any distinction arising from their spatial arrangement).

c. configuration

In the context of stereochemistry, the term is restricted to the arrangements of atoms of a molecular entity in space that distinguishes stereoisomers, the isomerism between which is not due to conformation differences.

d. conformation

The spatial arrangement of the atoms affording distinction between stereoisomers which can be interconverted by rotations about formally single bonds. Some authorities extend the term to include inversion at trigonal pyramidal centres and other polytopal rearrangements.

e. stereoisomers

Isomers that possess identical constitution, but which differ in the arrangement of their atoms in space.

Question 3.
Under what circumstances is a molecule or object chiral?

An object is chiral when it lacks an internal plane of symmetry and has a non-superimposable mirror image.

Question 4.
What relationship do the following pairs of compounds have with each other?

(a) configurational isomers (enantiomers)  
(b) Conformational isomers  
(c) Conformational isomers (duh!)  
(d) Constitutional isomers
Question 5.
Which of the following molecules are chiral, which are achiral? If necessary, draw diagrams to justify your answers.

![Diagrams showing chiral and achiral molecules]

Question 6.
Draw the structure of all possible stereoisomers of 2-methylcyclohexan-1-ol.

What relationship do these isomers have to one another?
Question 7.
Using the Cahn–Ingold–Prelog (CIP) priority rules, determine the absolute configuration and assign an $R$ or $S$ descriptor to each chirality center within the following molecules.

![Molecules](image)

Question 8.
Which of the following properties or methods can be used to distinguish between $R$-(-)-carvone and $S$-(+)-carvone?

a. boiling point
b. refractive index
c. melting point
d. smell
e. optical rotation
f. dipole moment
g. IR spectroscopy
Question 9.
Mark all the chirality centers in the structure of the lipid-lowering drug Lovastatin and the cytotoxic alkaloids Luotonin A and Ritterazine N with an asterisk (*). How many chirality centers are present in each structure?

Lovastatin: 8 Stereogenic (chiral) centers
Luotonin A: 0 Stereogenic (chiral) centers
Ritterazine N: 20 Stereogenic (chiral) centers

Maximum possible stereoisomers = 1,048,576
Question 10.
For each of the following hydroboration-oxidation reactions, draw all of the possible stereoisomeric products. Assume that the hydroboration step is regioselective.
Question 11.
For each of the following transformations, check the boxes which appropriate describe the observed stereo and regiochemical outcome.

\[
\begin{array}{c}
\text{Regioselective} \\
\text{Enantioselective} \\
\text{Diastereoselective} \\
\text{Stereospecific}
\end{array}
\]

Question 12.
The chromatographic purification of 1.0 g of ethyl R-(-)-lactate with an enantiomeric excess (e.e.) of 85% yields, without any loss of material, the enantiomeric pure (-)-enantiomer. How many grams of the (+)-enantiomer were separated?

\[
\text{ee} = 85\% \\
\text{ee} = 100\%
\]

An enantiomeric excess of 85% corresponds to a 92.5/7.5 ratio of (-)-ethyl lactate to (+)-ethyl lactate. In other words, 1 gram of "(-)-ethyl lactate with an enantiomeric excess (ee) of 85%" is a mixture of 925 mg of the (-)-enantiomer together with 75 mg of the (+)-enantiomer.