1. Tautomers are structural isomers which are related by migration of a hydrogen atom and the exchange of a single bond and adjacent double bond.
compound

2. (a) Which pair (or pairs) are constitutional isomers? (a) and (e)
(b) Which pair (or pairs) are diastereoisomers? (c)
(c) Which pair (or pairs) are enantiomers? (b)
(d) Which pair (or pairs) are ( $E$ )- / (Z)-isomers? (c)
(a)
 and


Both compounds are $\mathrm{C}_{4} \mathrm{H}_{8}$ but differ in the nature and sequence of bonding, hence constitutional isomers.
(b)
 and


Same nature and sequence of bonding and not simply conformations of the same compound thus these compounds are configurational isomers.

Interconversion of the two compounds can only be achieved by breaking one of the bonds and reforming the molecule in the opposite configuration. Non-superimposable mirror images, hence enantiomers.
(c)

and


Same nature and sequence of bonding and not simply conformations of the same compound thus these compounds are configurational isomers.

Interconversion of the two compounds can only be achieved by breaking the double bond and reforming it in the opposite configuration. These are (E)/(Z)-isomers, a subset of the configurational isomers class:
diastereoisomers (non-superimposable, not mirror-image related).
(d)
(e)


These are the same compound. Rotation of the first anticlockwise, around the $\mathrm{C}-\mathrm{COOH}$ bond. bonding, hence constitutional isomers.
3.


achiral - plane of symmetry passing through centre of $\mathbf{C}=\mathbf{C}$ and CHCl group



Information for answering questions 4 and 5:
The sequence rules for assigning priorities to substituents on a stereogenic centre are:
(i) Look at the four atoms directly attached to the stereogenic centre and assign priorities in order of decreasing atomic number.
(ii) If a decision about priority can not be reached by applying rule 1, compare atomic numbers of the second atoms of each substituent, continuing outwards if necessary until the first point of difference is reached.
(iii) Multiple-bonded atoms are considered as an equivalent number of single bonded atoms.
4. After assigning priorities to the groups on each end of the $\mathbf{C}=\mathbf{C}$ bond as above, the structure is then viewed with the substituent with the lowest priority projecting backwards.

If a curved arrow drawn from the highest to second-highest to third-highest priority substituent is clockwise, the configuration is $(R)$.

If the curved arrow is anticlockwise, the configuration is $(S)$.

$\mathrm{a}-\mathrm{b}-\mathrm{c}$ is anticlockwise: $\boldsymbol{S}$

need to reorientate with d at the back


need to reorientate with d at the back

$\mathrm{a}-\mathrm{b}-\mathrm{c}$ is clockwise: $\boldsymbol{R}$

a - b-c is clockwise: $\boldsymbol{R}$
5. After assigning priorities to the groups on each end of the $\mathbf{C}=\mathbf{C}$ bond as above, the arrangement is $\boldsymbol{Z}$ if both the substituents of higher priority are on the same side and $E$ if they are on opposite sides.


E

$Z$


E
(a) The starting material is achiral and the reaction gives rise to the generation of a chiral carbon. Both faces of the alkene double bond are equally accessible to the $\mathrm{Br}_{2}$ and hence compound ( F ) is obtained as the racemic mixture.
(b) The priorities of the substituents on the chiral carbon in $\mathbf{F}$ are:

$$
\mathrm{Br}>\mathrm{CH}_{2} \mathrm{Br}>\mathrm{CH}_{2} \mathrm{CH}_{3}>\mathbf{H}
$$

The ( $R$ ) enantiomer has the configuration shown below in order to get a clockwise arrow from $\mathrm{Br} \rightarrow \mathrm{CH}_{2} \mathrm{Br} \rightarrow \mathrm{CH}_{3} \mathrm{CH}_{3}$ with the H placed at the back:


