Determining Splitting Patterns in Benzene Derivatives

Monosubstituted Benzene Rings

A monosubstituted benzene ring will always have symmetry. Therefore, $H_a$ is equivalent to $H_e$ and $H_b$ is equivalent to $H_d$.

$H_a$ has only one neighbor ($H_b$) and therefore it should be a doublet.
$H_b$ has two neighbors ($H_a$ and $H_c$) and therefore it should be a triplet.
$H_c$ has two neighbors ($H_b$ and $H_d$) and therefore it should be a triplet.

Therefore, the observed splitting pattern should be:
one doublet with integration of 2H, one triplet with integration of 2H, and one triplet with integration of 1H.

1,2 - Disubstituted Benzene Rings

When $R_1$ is different from $R_2$ there is no plane of symmetry and therefore each proton is unique.

$H_a$ has only one neighbor ($H_b$) and therefore it should be a doublet.
$H_b$ has two neighbors ($H_a$ and $H_c$) and therefore it should be a triplet.
$H_c$ has two neighbors ($H_b$ and $H_d$) and therefore it should be a triplet.
$H_d$ has only one neighbor ($H_c$) and therefore it should be a doublet.

Therefore, the observed splitting pattern should be:
two doublets with integration of 1H each and two triplets with integration of 1H each.

When $R_1$ is the same as $R_2$, $H_a$ and $H_d$ are equivalent due to symmetry. Analogously, $H_b$ and $H_c$ are also equivalent due to symmetry.

Therefore, the observed splitting pattern should be:
one doublet with integration of 2H and one triplet with integration of 2H.

1,3 - Disubstituted Benzene Rings

When $R_1$ is different from $R_2$ there is no plane of symmetry and therefore each proton is unique.

$H_a$ has no neighbors and therefore it should be a singlet.
$H_b$ has one neighbor ($H_c$) and therefore it should be a doublet.
$H_c$ has two neighbors ($H_b$ and $H_d$) and therefore it should be a triplet.
$H_d$ has one neighbor ($H_c$) and therefore it should be a doublet.

Therefore, the observed splitting pattern should be:
one singlet with integration of 1H, two doublets with integration of 1H each, and one triplet with integration of 1H.

When $R_1$ is the same as $R_2$, $H_b$ and $H_d$ are equivalent due to symmetry.

Therefore, the observed splitting pattern should be:
one singlet with integration of 1H, one doublet with integration of 2H, and one triplet with integration of 1H.

1,4 - Disubstituted Benzene Rings

A 1,4-disubstituted benzene ring will always have symmetry. Therefore, $H_a$ is always equivalent to $H_d$ and $H_b$ is always equivalent to $H_c$.

$H_a$ has one neighbor ($H_b$) and therefore it should be a doublet.
$H_b$ has one neighbor ($H_a$) and therefore it should be a doublet.

Therefore, the observed splitting pattern should be:
two doublets with integration of 2H each.

Trisubstituted Benzene Rings

These are the three possible choices for regiochemistry in the trisubstituted benzenes. As an exercise you should use the example above and determine what kinds of splitting patterns you would expect to see in each case.