1. Suggest mechanisms for the following, commenting on your choice of $S_N1$ or $S_N2$.

\[
\begin{align*}
\text{Br} & \quad \text{PhS} & \quad \text{S}^\ominus & \quad \text{Na}^\ominus & \quad \text{PhSMe} \\
\text{Br} & \quad \text{O} & \quad \text{SO} & \quad \text{OMe} & \quad \text{PhS} & \quad \text{OH} & \quad \text{Br} & \quad \text{OH} & \quad \text{S}^\ominus & \quad \text{PhSMe}
\end{align*}
\]

$S_N2$ due to methyl group electrophile

2. Predict the stereochemistry of these products.

\[
\begin{align*}
\text{Ph} & \quad \text{O} & \quad \text{OH} & \quad \text{N} & \quad \text{Ph} \\
\text{O} & \quad \text{OTs} & \quad \text{OTs} & \quad \text{H}_2\text{S} & \quad \text{KOH} & \quad \text{Ph} & \quad \text{S} & \quad \text{Ph}
\end{align*}
\]

Product is a single diastereoisomer but not a single enantiomer as the two sides of attack on the epoxide are possible.
3. State, with reasons whether these reactions are $S_N1$ or $S_N2$.

This is an unusual $S_N2$ reaction at a tertiary centre. The carbonyl accelerates the $S_N2$ due to orbital overlap in the transition state. The azide is also a small nucleophile so it is less affected by steric effects.

Goes by $SN1$ due to cation stabilisation of neighbouring oxygen.
1. Draw mechanisms for these reactions, explaining why the particular products are formed.

There is a choice of leaving group, both are secondary, the Cl next to the oxygen leaves in preference via an $S_N^1$ mechanism.

As the primary centre is the site of reaction the mechanism must be $S_N^2$.

2. Describe the stereochemistry of the products of these reactions.

The intramolecular cyclisation is $S_N^2$ so gives inversion of configuration and a cis-fused product.

3. State, with reasons whether these reactions are $S_N^1$ or $S_N^2$. 
The acid catalyst makes a better leaving group. Favours $S_N 1$.

Steric hindrance from the OH favours this diastereoisomer.

$S_N 2$ gives inversion. Base catalysis favours $S_N 2$ by improving the nucleophile.