1 a Write an equation for the reaction of chlorine with water.

\[ \text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HOCl} \]

b Describe and explain what you would see if universal indicator was added to a solution of chlorine in water.

- Would go red initially due to the presence of acid
- Would then be bleached / lose its colour / go colourless due to \( \text{HOCl} / \text{OCl}^- \)

c By referring to oxidation states, explain why this is a disproportionation reaction.

Chlorine is both oxidised and reduced as it goes from 0 in \( \text{Cl}_2 \) to \(-1\) in \( \text{HCl} \) and \(+1\) in \( \text{HOCl} \)

2 a When concentrated sulfuric acid is added to solid sodium bromide, white fumes and orange fumes are formed. Complete the table about the formation of these substances.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Formula of gas</th>
<th>Equation for formation</th>
<th>Type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>White fumes</td>
<td>HBr</td>
<td>( \text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HBr} )</td>
<td>Acid-base</td>
</tr>
<tr>
<td>Orange fumes</td>
<td>( \text{Br}_2 )</td>
<td>( \text{H}_2\text{SO}_4 + 2\text{H}^+ + 2\text{Br}^- \rightarrow \text{SO}_2 + 2\text{H}_2\text{O} + \text{Br}_2 )</td>
<td>Redox</td>
</tr>
</tbody>
</table>

b What would you see if a similar reaction was done using solid sodium chloride with concentrated sulfuric acid? Explain any difference in detail.

- Would only see white fumes of \( \text{HCl} \)
- As \( \text{Cl}^- \) is weaker reducing agent than \( \text{Br}^- \) and it cannot reduce \( \text{H}_2\text{SO}_4 \)
- \( \text{Cl}^- \) is weaker reducing agent because ion is smaller and there is less shielding and so it loses an electron less easily than \( \text{Br}^- \)