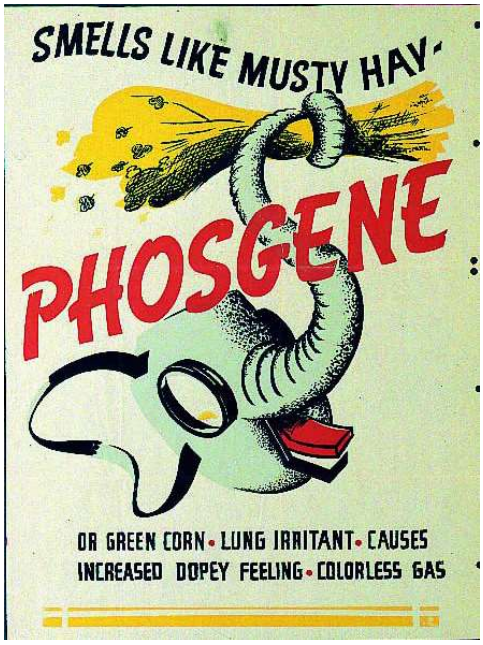
3. This question is about acyl chlorides and related functional groups

Acyl chlorides, RCOCl, are highly reactive compounds which rapidly react with water to give carboxylic acids, and with alcohols to give esters.

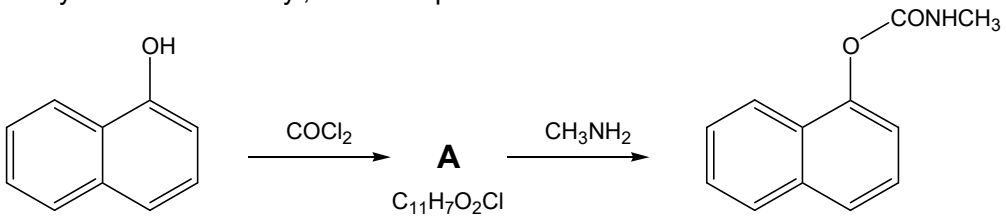
Other oxochlorides containing bonds to chlorine and double bonds to oxygen such as phosphoryl chloride (phosphorus trichloride oxide, $POCl_3$) and thionyl chloride (sulfur dichloride oxide, $SOCl_2$) react in an analogous fashion.



(a) Write a balanced equation for the reaction between ethanoyl chloride and water.

(b) Write a balanced equation for the reaction of propanoyl chloride with ethanol.

Phosgene (carbonyl chloride, $COCl_2$), which can be thought of as a diacyl chloride, reacts similarly with alcohols. It is often used in synthesis, despite its toxicity. It has been used in the synthesis of Carbaryl, a broad-spectrum insecticide.



Carbaryl

(c) Draw the structure for compound **A**.

(d) Draw the structures of phosphoryl chloride and thionyl chloride, clearly indicating their shapes. What are the oxidation states of the phosphorus and the sulfur in these compounds?

(e) Write an equation for the reaction between thionyl chloride and water.

(f) Give the structure of the phosphate ester formed when 1 mole of $POCl_3$ reacts with **i)** 1 mole of methanol and **ii)** 2 moles of methanol.

1 mole of $POCl_3$ reacts with 3 moles of water to produce phosphoric acid, H_3PO_4. When pure phosphoric acid is heated with $POCl_3$ another phosphorus-containing acid, **B**, is produced. The addition of aqueous silver nitrate to a solution of acid **B** produces a white precipitate which contains 71.3% by mass silver and 10.2% by mass phosphorus, the remainder being oxygen.

(g) Suggest a structure for the acid **B** and write an equation for its formation from phosphoric acid and $POCl_3$, given that the only other product is HCl.