

**SECTION A (50scores)**  
**(Compulsory)**

**Item 1**

Sodium chloride is a nutritive salt used in homes as a food additive and preservative. In Uganda, the salt is chiefly mined from Lake Katwe with trace quantities of calcium and magnesium chlorides in concentrations 1M and 0.5M respectively.

Karibu is a foreign investor whose factory refines the salt (NaCl) from its impurities. The purification process is done by precipitation of the saturated solution using hydrogen chloride. Theoretically, the solubility product of sodium chloride is known to be  $36.8\text{Moldm}^{-3}$ , the solubilities of Calcium chloride and magnesium chlorides are  $811\text{gl}^{-1}$  and  $8.0\text{g}/100\text{ml}$  respectively.

One day, the factory offices caught fire and almost all the important documents perished. This led the factory manager to be fired so that the new manager could be recruited. The new factory manager on his first attempt bubbled hydrogen chloride into a  $300\text{gl}^{-1}$  solution of the salt but the salt failed to precipitate out which made him worried and uncomfortable at work. What else made him surprised and confused was the culture of his industrial workers to add excess aqueous ammonia to the remaining solution after precipitating out the sodium chloride salt. After treatment with excess ammonia, they pass the resultant mixture through a filtration system to obtain solid particles which are dried and later heated strongly to obtain a white solid powder which they add in excess to aqueous hydrogen chloride, the resultant solution is crystallized by evaporation to obtain solid X that is packed and sold for their side earning. The manager seeks to understand what is chemically going on and has consulted you as a knowledgeable chemist.

**Task**

- a) Help the manager to
  - i) Understand the meaning of a saturated solution, solubility of a salt and its solubility product. **(3scores)**
  - ii) Determine the solubility in  $\text{gdm}^{-3}$  of the salt obtained from Lake Katwe. **(2scores)**
  - iii) Determine the ionic product of the salt in the  $300\text{gl}^{-1}$  solution. **(4scores)**
  - iv) Understand the chemistry behind the action of passing hydrochloric acid through a saturated solution of the sodium chloride salt. **(3scores)**
- b) Explain to the new manager why magnesium chloride and calcium chloride do not precipitate out in this industrial process? (Illustrate your response with explanations, expressions and calculations where necessary.) **(7scores)**
- c) Help the manager to understand the identity of the crystalline solid X (Show him the details of its formation). **(6score)**