CHE2NAC Assignment 1

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# Activity 1: A water sample from the Olinda Creek was subjected to analysis by gas chromatography (GC) and was found to contain $0.453$g/L of $2,4−$dimethylphenol ((CH$\_{3}$)$\_{2}$C$\_{6}$H$\_{3}$OH).

## (i) Write a balanced chemical equation to describe the complete oxidation of $2,4−$dimethylphenol in the water sample.

$$(CH\_{3})\_{2}C\_{6}H\_{3}OH+\frac{21}{2}O\_{2}\rightarrow 8CO\_{2}+5H\_{2}O$$

## (ii) Calculate the theoretical oxygen demand of $2,4−$dimethylphenol on this water sample.

The water sample contained $0.453$g/L $2,4−$dimethylphenol. The relative molar mass of $2,4−$dimethylphenol is $122.16$g/mol. Therefore the concentration of $2,4−$dimethylphenol in the water sample can be found by

$$\frac{0.453g L^{−1}}{122.16g mol^{−1}}=0.003708M$$

From **(i)** , the ratio of $2,4−$dimethylphenol to oxygem molecules required is $2:21$. Therefore the requred oxygen concentration can be found by

$$\frac{21}{2}⋅0.003708M=0.03894M$$

Oxygen gas has a molar mass of $31.9988g mol^{−1}$. Therefore the oxygen demand can be found by

$$\begin{matrix}0.03894M⋅31.9988g mol^{−1}&=1.246g L^{−1}\\&=1250mg L^{−1}\end{matrix}$$

## (iii) Discuss whether the value calculated in (ii) represents the likely BOD of water from the Olinda Creek. Give reasons to support your response.

The above value does not represent the overall BOD of Olinda Creek’s water. Rather, represents the oxygen required to fully oxidise the $2,4−$dimethylphenol present in the creek. These two values differ, firstly as there are other reactions going on in the creek that also require oxygen, such as the breakdown of other organic molecules and the respiration of aquatic life. Secondly, the oxygen demand calculated above is for the *complete* oxidation of $2,4−$dimethylphenol, which does not occur under natural conditions due to the presence of the hydrocarbon ring.

# Activity 2: The Winkler method for Dissolved Oxygen involves three separate redox reactions; one in the field and two others in the lab. A 250 mL water sample was taken immediately downstream of the outflow from a food processing plant. The sample was “fixed” on-site and transported back to the lab for the analysis of dissolved oxygen using the Winkler Method. This required the addition of 2.23mL of a 0.0250M sodium thiosulfate solution to reach the end-point.

## (i) For the initial redox reaction that occurs in the field, identify the oxidant and reductant and write the associated redox half-reactions. Then write the overall equation for the redox reaction.

Immediately after the sample is collected, manganese(II) hydroxide (Mn(OH)$\_{2}$) is added, as well as an alkali solution. The disolved oxygen gas acts as an oxidant, oxidising the Mn$^{2+}$ (the reductant). The reactions are as follows:

$$\begin{matrix}Oxidation:Mn(OH)\_{2}+2OH^{−}&\rightarrow MnO\_{2}+2e^{−}+2H\_{2}O\\Reduction:O\_{2}+4e^{−}+2H\_{2}O&\rightarrow 4OH^{−}\\Overall:2Mn(OH)\_{2}+O\_{2}&\rightarrow 2MnO\_{2}+2H\_{2}O\end{matrix}$$

## (ii) Similarly, for the final redox reaction that occurs in the lab, identify the oxidant and reductant and write the associated redox half-reactions. Then write the overall equation for the redox reaction.

In the final stage of the Winkler test, sodium thiosulfate (Na$\_{2}$S$\_{2}$O$\_{3}$) is added to titrate the iodine formed in the second stage. The iodine acts as an oxidant, oxidising the S$\_{2}$O$\_{3}^{2−}$ (the reductant). The reactions are as follows:

$$\begin{matrix}Oxidation:2S\_{2}O\_{3}^{2−}&\rightarrow S\_{4}O\_{6}^{2−}+2e^{−}\\Reduction:I\_{2}+2e^{−}&\rightarrow 2I^{−}\\Overall:2S\_{2}O\_{3}^{2−}+I\_{2}&\rightarrow S\_{4}O\_{6}^{2−}+2I^{−}\end{matrix}$$

## (iii) Determine the amount of DO in mg/L present in the original water sample.

The ratio of dissolved oxygen molecules in the initial sample to thiosulfate ions required to reach the endpoint in the final stage is 1:4. If 2.23mL of 0.0250M Na$\_{2}$S$\_{2}$O$\_{3}$ solution was required, the moles used can be found by:

$$0.00223L⋅0.0250M=55.80μmol$$

Moles of oxygen gas dissolved in the initial sample can therefore by found by:

$$\frac{55.80μmol}{4}=13.90μmol$$

Oxygen gas has a molar mass of $31.9988$ g mol$^{−1}$. Therefore the mass of oxygen in the initial sample can be found by

$$13.90μmol⋅31.9988g mol^{−1}=446.0μg$$

As the initial sample was 250mL, the dissolved oxygen in the initial sample was

$$\begin{matrix}\frac{446.0μg}{0.250mL}&=0.001780g L^{−1}\\&=1.78mg L^{−1}\end{matrix}$$

## (iv) Give reasons as to whether this level of DO would be able to support a healthy aquatic ecosystem.

This level of dissolved oxygen would not support a healthy aquatic ecosystem. The minimum DO required for a healthy aquatic ecosystem is around 4-6mg/L, depending on the average local water temperatures. More oxygen can dissolve in cooler water, so aquatic life in cooler regions has evolved to make use of higher DO levels. So while some warmwater fish such as pike and minnows can tolerate DO levels between 1-1.5mg/L indefinitely, the majority of freshwater fish species would die after exposure to DO levels this low. Coldwater fish such as salmon and trout are particularly vulnerable, dying if the DO drops below 6mg/L.