Riverside's Dilemma: Problem Handouts

Riverside's Dilemma

Part 1

The town of Riverside has a decision to make. Historically a manufacturing center in upstate New York, Riverside has watched its many factories close down over the years, due to changing market interests and other economic factors. Now, because of improvements in the transportation infrastructure of the area, the town has caught the attention of Chemex, a multinational corporation; the company has offered to buy several of these factories, with the intention of starting up three new operations: a metal-refining center, a paper mill, and a fine chemicals synthesis unit.

The problem is that the original design of the factories calls for the emission of waste streams directly into the nearby river;any major retrofitting of the factories looks, at first glance, to be prohibitively expensive. Chemex has offered the following projection for expected emissions from each plant:

- paper mill: 2.5 g of NaOH produced per liter of waste
- synthesis unit: 1.1 g of aniline or 1.5 g of benzoic acid per liter of waste (product depends on process being run)
- metal refinery: 2.0 g of H_2SO_4 produced per liter of waste

The town council has to decide whether to approve the sale of these factories for this intended use; while eager for the chance to revitalize Riverside, they are also very concerned about the potential environmental impact of these industries.

You have been hired to help prepare a report on the latter. Your first concern is with the effect of these waste streams on the health of the river. The town has mandated that each plant effluent have a pH within the range of 6.8 - 7.2 before the stream is allowed to be discharged into the river. Questions to be addressed in the report include:

1. What will the pH of each waste stream be, based on the company's projected emission data?
2. One way to reach the target pH is through dilution of the waste stream. What level of dilution will be required for each, in order to reach an acceptable pH value? Will dilution be able to deal with the problem at hand?

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Part 2

In preparing your report to Chemex, you have concluded that dilution is not a reasonable solution to the problem because of the vast quantities of water that would be required. You have now looking into the feasibility of neutralizing the waste streams, in order to meet the target pH range of 6.8 - 7.2. Hydrogen chloride gas and sodium hydroxide are the cheapest neutralization agents available to you. Your task now is to decide how much of the appropriate agent it would require to neutralize each of the waste streams in question, and whether this pretreatment will, in fact, bring the pH of each waste stream into the range needed for compliance with the town council's mandate.

In this report, you should address several issues for the readers:

1. What is meant by the term "neutralization"?
2. What equation describes this process for each case? Can you estimate an equilibrium constant for each?
3. What quantity of HCl or NaOH is needed to carry out each reaction?
4. What will the pH of the solution be after the reaction has been carried out?

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Part 3

Back in Riverside, one of the town council members who has read your first two reports asks whether combining any of the waste streams before they're released into the river would be a feasible way to bring the pH into the allowed range.

Write a reply that addresses the following points:

1. Which of these wastes could, in principle, be combined to accomplish this goal?
2. If this process is feasible, in what proportions would the waste streams need to be combined, in order to achieve the desired pH?
3. What assumptions have you made in the course of this analysis?
4. Are there any other factors or considerations that you feel should be mentioned?