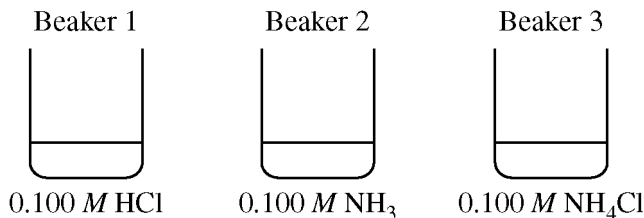


**2011 AP<sup>®</sup> CHEMISTRY FREE-RESPONSE QUESTIONS****CHEMISTRY****Section II****(Total time—95 minutes)****Part A****Time—55 minutes****YOU MAY USE YOUR CALCULATOR FOR PART A.**

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the pink cover. Do NOT write your answers on the green insert.

Answer Questions 1, 2, and 3. The Section II score weighting for each question is 20 percent.



1. Each of three beakers contains 25.0 mL of a 0.100 M solution of HCl, NH<sub>3</sub>, or NH<sub>4</sub>Cl, as shown above. Each solution is at 25°C.
- (a) Determine the pH of the solution in beaker 1. Justify your answer.
- (b) In beaker 2, the reaction  $\text{NH}_3(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_4^+(aq) + \text{OH}^-(aq)$  occurs. The value of  $K_b$  for  $\text{NH}_3(aq)$  is  $1.8 \times 10^{-5}$  at 25°C.
- (i) Write the  $K_b$  expression for the reaction of  $\text{NH}_3(aq)$  with  $\text{H}_2\text{O}(l)$ .
- (ii) Calculate the  $[\text{OH}^-]$  in the solution in beaker 2.
- (c) In beaker 3, the reaction  $\text{NH}_4^+(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_3(aq) + \text{H}_3\text{O}^+(aq)$  occurs.
- (i) Calculate the value of  $K_a$  for  $\text{NH}_4^+(aq)$  at 25°C.
- (ii) The contents of beaker 2 are poured into beaker 3 and the resulting solution is stirred. Assume that volumes are additive. Calculate the pH of the resulting solution.
- (d) The contents of beaker 1 are poured into the solution made in part (c)(ii). The resulting solution is stirred. Assume that volumes are additive.
- (i) Is the resulting solution an effective buffer? Justify your answer.
- (ii) Calculate the final  $[\text{NH}_4^+]$  in the resulting solution at 25°C.