All questions are to be attempted with balanced equations whenever possible.

**Question I:** (30 marks)

**Answer the following questions:**

1- Methyl red indicator has a complete color change when the pH of the solution changes from 4.2 to 6.3. Explain why? \( \text{pK}_a = 5.0 \)  

2- Titration curve of phosphoric acid with NaOH has 2 distinct inflection points. Explain why? \( \text{pK}_1 = 1.95 \quad \text{pK}_2 = 6.95 \quad \text{pK}_3 = 12.95 \)  

3- Calculate the pH of the solution that results when 40.0 mL of 0.1 M NH₄OH is mixed with 20 mL of 0.2 M NH₄Cl solution. \( \text{pK}_b = 4.76 \)  

4- Calculate the pH of 0.1 M solution of sodium acetate. \( \text{pK}_a = 4.75 \)  

5- What will happen when a 0.1 M NaOH is added to a solution composed of acetic acid and sodium acetate? Explain why?  

6- Which indicators you would use for the following titrations:  
   a) HBr with NaOH  
   b) Glyceroborate with NaOH  
   c) CH₃NH₂ with HCl  
   d) Benzoic acid with TBAH.  

7- The pKₐ of two monoprotic acids HA and HB are 5.9 and 8.1 respectively. Which of the two is the stronger acid? Why?  

8- Titration curve of H₂SO₄ with NaOH has only one break. Explain why?  

9- Compare between primary standards for acidic non aqueous titrants and acidic aqueous titrants. (Give examples)  

10- What solvents and titrants would you use for titration the followings?  
   a) Phenol  
   b) Aniline  
   c) Sulfathiazole  
   (Give your answer in a table form)  

**Questions II:** (20 marks)

**How can you analyze the following compounds?**

**Give the principle with equations** (Give your answer in a table form).  

**Specify (titrant, indicator, end point)**
Questions III: 
(12 marks) 
By means of illustrations explain the followings

1- Titration of \( \text{Na}_2\text{CO}_3 \) with \( \text{HCl} \). Determine the suitable indicator.
2- Titration of acetic acid with \( \text{NaOH} \). How can you calculate the pH at the equivalence point?
3- Colour change of phenolphthalein indicator at pH 8. (Give structure)
4- Colour change of methyl orange at pH 4.4. (Give structure)

Question IV: 
(18 marks) 
Complete the Followings:

1- Reasons for non aqueous titrations are:
   i- ..............................................................
   ii- ..............................................................
   iii- ..............................................................

2- Factors to choose non aqueous solvents are:
   i- ..............................................................
   ii- ..............................................................
   iii- ..............................................................
   iv- ..............................................................

3- Methanol is .......... solvent.
   ............................................ is a protophilic solvent.
   ............................................ is aprotic solvent, while glacial acetic acid is ............... solvent.

4- Titration in isobutyl methyl ketone. (Give brief account)
   ..............................................................

5- When a solution of ethylamine is to be titrated with a standard \( \text{HCl} \), the pH during titration can be calculated according to the following equation:
   pH = ..............................................................
   and at the equivalence point the pH = ..............................................................

6- Mercuric oxide can be determined by .............................................................. (Give the equation only)

7- \( \text{HCHO} \) can be determined by .............................................................. using .............................................................. as indicator.

8- Luminous indicators are .............................................................. example:
   While screen indicators are .............................................................. example:

Best Wishes