CHEMISTRY 3A3B

ASSIGNMENT #4

Total Marks: 50

1. A group of students was given the task of determining the percentage of ethanoic acid in a sample of vinegar. To begin with, they placed a sample of sodium carbonate in an oven at 110°C for twenty four hours. They took a 9.700 gram sample of this sodium carbonate and using distilled water, dissolved it and transferred it into a 500 mL volumetric flask and made it up to the mark. 20.00 mL aliquots of this standard solution were titrated against an HCl solution and the following results were obtained:

Trial	1	2	3	4
Volume of HCl (mL)	20.20	19.90	19.85	19.80

$V(AV) = 19.85$ mL

A solution of sodium hydroxide was prepared and standardised against this HCl solution. 25.00 mL aliquots of the HCl solution required an average of 17.50 mL of the sodium hydroxide solution to complete the titration.

25.00 mL of the vinegar solution was transferred to a 250 mL volumetric flask and made up to the mark with distilled water. 20.00 mL aliquots of the dilute vinegar solution were titrated against the standardised sodium hydroxide solution. The following results were obtained:

Trial	1	2	3	4	5
Initial reading (mL)	0.15	3.75	7.15	10.15	13.15
Final reading (mL)	3.75	7.15	10.15	13.15	16.15
TITRE	3.60	3.40	3.00	3.00	3.00

If the density of the pure vinegar was 1.02 gcm^{-3}, determine the percentage by mass of ethanoic acid in the pure vinegar. [15 marks]

2. A bottle of hydrochloric acid in the laboratory has no concentration value written on it.

   a) Calculate the concentration of the aqueous solution of hydrochloric acid, HCl, if its pH is measured as 3.00. [1 mark]

   b) What volume of water is needed to dilute 100 mL of the hydrochloric acid solution to pH 4.00? [3 marks]

   c) A students added 100 mL of 0.100 M sodium hydroxide, NaOH, solution to 100 mL of the original hydrochloric acid solution. Calculate the pH of the solution remaining after the neutralization reaction. [6 marks]

CHEM 3A3B — ASSIGNMENT 4.

(1.) $m(Na_2CO_3) = 9.700\,g$
$V = 500.0\,mL$

$n = \frac{m}{M} = \frac{9.700}{105.99} = 0.09152\ mol$ (1)
(1)

$c = \frac{n}{V} = 0.1830\ mol\,L^{-1}$. (1)

$V(Na_2CO_3) = 20.00\ mL$
$c(Na_2CO_3) = 0.1830\ mol\,L^{-1}$
$V(HCl) = 19.85\ mL$
$c(HCl) = ?$

(1)
$c(HCl) = \frac{2 \times 20.00 \times 0.1830}{19.85}$ (1)
$= 0.3688\ mol\,L^{-1}$. (1)

$V(HCl) = 25.00\ mL$
$c(HCl) = 0.3688\ mol\,L^{-1}$
$V(NaOH) = 17.50\ mol\,L^{-1}$
$c(NaOH) = ?$

$c(NaOH) = \frac{25.00 \times 0.3688}{17.50}$ (1)
$= 0.5269\ mol\,L^{-1}$. (1)

$V(\text{DIL.}) = 20.00\ mL$
$c(\text{DIL}) = ?$
$V(NaOH) = 3.00\ mL$
$c(NaOH) = 0.5269\ mol\,L^{-1}$

$c(\text{DIL}) = \frac{3.00 \times 0.5269}{20.00}$ (1)
$= 0.07904\ mol\,L^{-1}$ (1)

$c(CH_3COOH) = 0.7904\ mol\,L^{-1}$ (1)

IN 100 mL: $m(CH_3COOH) = 0.07904 \times 60.052 = 4.746\,g$ (1)
(1)

$\%$ BY MASS $= \frac{4.746}{102} \times 100\% = 4.65\%$. (1)
(1)

(2) (a) $[HCl] = 10^{-3}\ mol\,L^{-1}$. (1)

(1) (1) (1)
(b) $pH = 4$ MEANS $[H^+] = 10^{-4}\ mol\,L^{-1}$ DILUTE 10x, SO $V_{WATER} = 900\ mL$ ADDED.

(c) $n(NaOH)_{LEFT} = 0.0100 - 0.0001 = 0.0099\ mol$ (1)
$V_{NEW} = 200\ mL$ (1)
$c_{NEW} = \frac{0.0099}{0.200} = 0.0495\ mol\,L^{-1}$ (1)
$c(H^+) = \frac{10^{-14}}{0.0495} = 2.02 \times 10^{-13}\ mol\,L^{-1}$ (2)
$pH = -\log[H^+] = 12.7$. (1)

3. Titratable acidity is a measure of the concentration of all available hydrogen ions that can be neutralised by a base. It is an important measurement in the analysis of many foods including milk and wine. In the wine industry titratable acidity is recorded as: g(Tartaric Acid)/100 ml sample. Tartaric acid has the molecular formula of $C_4H_6O_6$ and is a **diprotic acid.**
The following experiment was carried out:

Procedure:
Pipette 5.00 mL of wine into flask. Add approximately 100 mL distilled water and a few drops of phenolphthalein. Titrate against 0.100 M NaOH.

Results

Burette readings (mL)	Titrations			
	1	2	3	4
Final volume	6.50	11.40	17.25	23.25
Initial volume	0.00	5.50	11.30	17.25
Titre	6.50	5.90	5.95	6.00

(1)

(a) Complete the table and calculate the titration volume. [2 marks]

(b) Calculate the concentration of available hydrogen ions in the original sample of wine in $molL^{-1}$. [4 marks]

(c) Assuming the acidity is caused solely by tartaric acid, convert this to the concentration as grams of tartaric acid per 100 mL sample of wine. [4 marks]

(d) Suggest a difficulty that may arise if red wine is used in this experiment. [1 marks]

4. An experiment was carried out to calculate the purity of a sample of calamine ($ZnCO_3$).
4.54 g of impure calamine was added to 50.0 mL of 2.00 mol L^{-1} HCl.

The resulting solution was filtered into a volumetric flask and made up to 250.0 mL.
25.00 mL aliquots of this solution were then titrated against 0.105 mol L^{-1} of NaOH solution and the results shown below:

Burette readings (mL)	Titrations		
	1	2	3
Final volume	32.50	37.25	43.15
Initial volume	0.00	5.50	11.30
Titre	32.50	31.75	31.85

(1)

(a) Complete the table and calculate the titration volume. [2 marks]

(b) Calculate the number of moles of hydrochloric acid present in the 25.00 mL aliquots. [3 marks]

(c) Calculate the total number of moles of hydrochloric acid present in the 250.0 mL flask and hence calculate the % purity of the calamine. [9 marks]

3. (a) $V_{TITRE} = 5.95\ mL$ (1)

(b) $c(H^+) = \frac{5.95 \times 0.100}{5.00}$ (3)

$c(H^+) = 0.119\ mol\,L^{-1}$ (1)

(c) $c(T.ACID) = \frac{c(H^+)}{2} = 0.0595\ mol\,L^{-1}$ (1)

IN 1L: $m(ACID) = 0.0595 \times 150.088$ (1)

$= 8.93\ g$ (1)

$\therefore$ $c(ACID) = 0.893\ g\ /100\ mL$ WINE. (1)

(d) PHENOLPHTHALEIN COLOUR CHANGE IS MASKED. (1)

4. (a) $V_{TITRE} = 31.80\ mL$ (1)

(b) $n(HCl) = \overset{(1)}{1 \times n(NaOH)} = \overset{(1)}{31.80 \times 10^{-3}\ L \times 0.105\ mol\,L^{-1}}$

$= 3.339 \times 10^{-3}\ mol.$ (1)

(c) IN 250 mL: $n(HCl) = 10 \times 3.339 \times 10^{-3}$ (1)

$= 3.339 \times 10^{-2}\ mol.$ (1)

- THIS IS $n(HCl)$ LEFTOVER

$n(HCl)_{TOTAL} = 50.0 \times 10^{-3}\ L \times 2.00\ mol\,L^{-1}$ (1)

$= 0.100\ mol$ (1)

$\therefore$ $n(HCl)_{REACTED} = n_{TOTAL} - n_{LEFTOVER}$

$= 0.06661\ mol.$ (1)

$n(ZnCO_3) = \frac{1}{2}\, n(HCl)_{REACTED} = 0.0333\ mol.$ (1)

$m(ZnCO_3) = n \times M = 0.0333 \times 125.39$ (1)

$= 4.176\ g$ (1)

$\%\ PURITY = \frac{4.176}{4.54} \times 100 = 91.985 = 92.0\ \%.$ (1)