

أسس تصحيح مادة الكيمياء

Exercise 1 (7 points)

Decomposition of Javel Water

Q.	Answer	Mark
1.1	During dilution, the number of moles of solute is conserved : $C_o \times V_o = C_s \times V_s$ The dilution factor $F = \frac{C_o}{C_s} = \frac{V_s}{V_o} = 5$ ; then $V_o = 20$ ml The glassware: 100 mL volumetric flask, 20 mL volumetric pipet and a 100 ml beaker	1
1.2	$[ClO^-] = \frac{C_o}{F} = \frac{1.3}{5} = 26 \times 10^{-2} \text{ mol.L}^{-1}$ .	0.5
2.1.1	$Co^{2+}$ is a catalyst since it accelerated the reaction (gas release is observed in the beaker 2) and it remains unaltered at the end of reaction ( the mixture remains pink)	0.75
2.1.2	$C = \text{constant}$ the initial quantity of catalyst in beaker 3 is greater than that of beaker 2 ( $n = C.V$ ). Abundant gas release is observed in beaker 3 therefore the rate of decomposition of hypochlorite ions in the beaker 3 is greater than that in the beaker 2. As the concentration of cobalt (II) chloride increases, the rate of the reaction increases.	0.75
3.1	$n(ClO^-)_o = n(ClO^-)_{disap} + n(ClO^-)_t$ but $n(ClO^-)_{disap} = 2 \times n(O_2)_t$ $n(ClO^-)_t = n(ClO^-)_o - 2 \times n(O_2)_t$ $n(ClO^-)_t = n(ClO^-)_o - 2 \times \frac{V(O_2)t \times 10^{-3}}{V_m}$ ; divided by $V_{solution}$ $[ClO^-]_t = [ClO^-]_o - 2 \times \frac{V(O_2)t \times 10^{-3}}{V_m \times V(s)} = [ClO^-]_t = 26 \times 10^{-2} - \frac{V(O_2) \times 10^{-3}}{22.4 \times 0.1}$ $[ClO^-]_t = 26 \times 10^{-2} - \frac{V(O_2)}{1120}$	1
3.2	At the end of the reaction $[ClO^-]_{\infty} = 0 \text{ mol.L}^{-1}$ ; so $0 = 26 \times 10^{-2} - \frac{V_{O_2\infty}}{1120}$ ; $V_{(O_2)\infty} = 291.2 \text{ mL}$	0.5
3.3		1
3.4	The kinetic factor responsible for the decrease in the rate of decomposition of hypochlorite ions is the concentration of hypochlorite ions ( $ClO^-$ )	0.5
3.5	Half-life time is the time needed for the disappearance of half the initial quantity of the reactant.	

	$[ClO^-]_{t_{1/2}} = \frac{26 \times 10^{-2}}{2} = 13 \times 10^{-2} \text{ mmol} \cdot \text{min}^{-1}$ Graphically $t_{1/2} = 130 \text{ s}$	<b>1</b>
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**Exercise 2 (7 points)**
**Weak Acids**

Q	Answer	Mark
<b>1.1</b>	The equation of the reaction : $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$	<b>0.5</b>
<b>1.2</b>	$\begin{array}{cccc} \text{CH}_3\text{COOH} & + & \text{H}_2\text{O} & \rightleftharpoons & \text{CH}_3\text{COO}^- & + & \text{H}_3\text{O}^+ \\ C_1 & & \text{slv} & & 0 & & 0 \\ C_1 - x & & \text{slv} & & x & & x \end{array}$ $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]} = \frac{x^2}{C_1 - x}$ With $x = 10^{-\text{pH}} = 10^{-2.9}$ $K_a = 1.78 \times 10^{-5}$ $\text{pKa} (\text{CH}_3\text{COOH} / \text{CH}_3\text{COO}^-) = -\log K_a = 4.75$	<b>1</b>
<b>2.1.1</b>	the glassware used to withdraw the volume $V_2$ : 10 mL pipet	<b>0.25</b>
<b>2.1.2</b>	The glassware used to add the sodium hydroxide solution: 25 mL graduated buret.	<b>0.25</b>
<b>2.2</b>	The equation of the titration reaction is: $\text{CH}_3\text{COOH} + \text{HO}^- \rightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$	<b>0.5</b>
<b>2.3</b>	The pH at the equivalence is basic since this is a titration between a weak acid and a strong base; so cresol red of basic pH range of color change must be used.	<b>0.75</b>
<b>2.4</b>	At the equivalence point: $n (\text{CH}_3\text{COOH})$ introduced into the beaker = $n (\text{HO}^-)$ added to reach equivalence $C_2 \times V_2 = C_b \times V_{\text{bE}}$ ; so the concentration of the solution (S) is : $C_2 = \frac{C_b \times V_{\text{bE}}}{V_2} = \frac{5 \times 10^{-3} \times 20}{10} = 1 \times 10^{-2} \text{ mol} \cdot \text{L}^{-1}$	<b>1</b>
<b>2.5</b>	$C_1 > C_2$ and $\text{pH}_1 = \text{pH}_2$ , The $[\text{H}_3\text{O}^+]$ in the two solutions is the same even though $C_1 > C_2$ this can be explained only by the fact that the reaction of the weak acid HA with water is more advanced than that of the ethanoic acid with water therefore HA is a stronger acid than ethanoic acid.	<b>0.75</b>
<b>3.1.1</b>	at half-equivalence $\frac{[A^-]}{[HA]} = 1$ $\begin{array}{ccccccc} \text{CH}_3\text{COOH} & + & \text{HO}^- & \rightarrow & \text{CH}_3\text{COO}^- & + & \text{H}_2\text{O} \\ \text{At } t=0 & C_2 V_2 = 1.10^{-4} \text{ mol} & C_b V_b = 0.5.10^{-4} \text{ mol} & & 0 & & \text{solvent} \\ \text{At } t_f & 0.5.10^{-4} & 0 & & 0.5.10^{-4} & & \text{solvent} \end{array}$ Since they have the same final volume so $[A^-] = [HA]$ and $\frac{[A^-]}{[HA]} = 1$	<b>1</b>
<b>3.1.2</b>	Since HA is a stronger acid than ethanoic acid therefore pKa of the pair HA/A <sup>-</sup> is less than that of the pair (CH <sub>3</sub> COOH / CH <sub>3</sub> COO <sup>-</sup> ) which is equal to 4.75 So b- pH <sub>3</sub> = 3.75	<b>1</b>

**Exercise 3 (6 points)**
**Pear Perfume**

Q	Answer	Mark
1.1	According to stoichiometric ratios : $\frac{n_{\text{alcohol}}}{1} = \frac{n_{\text{C}_n\text{H}_{2n}\text{O}}}{1} = 0.1\text{mol}; n_{\text{alcohol}} = \frac{m}{M}; M = \frac{m}{n} = \frac{8.8}{0.1} = 88\text{g}\cdot\text{mol}^{-1}$	0.5
1.2	Amylic alcohol is a saturated non- cyclic monoalcohol of general formula $\text{C}_n\text{H}_{2n+2}\text{O}$ . $M = 12n + 2n + 2 + 16 = 88; 14n = 70; n = 5$ . So the molecular formula of alcohol is $\text{C}_5\text{H}_{12}\text{O}$	0.75
1.3.1	Since compound (A) gives a positive test with 2,4-DNPH and a positive test with Schiff's reagent so the compound (A) is an aldehyde.	0.5
1.3.2	The organic compound (A) is an aldehyde with a non-branched chain so (A) is pentanal $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CHO}$	0.75
1.3.3	The alcohol is 1-pentanol	0.25
1.4	$\text{CH}_3 - \text{COOH} + \text{HO} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \rightleftharpoons \text{CH}_3 - \text{COO} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 + \text{H}_2\text{O}$	0.75
2.1	Since the yield of the esterification reaction of an equimolar mixture of a carboxylic acid and a primary alcohol is 66%, and since experiment 1 is an equimolar mixture and the alcohol is primary so $n(\text{ester})_{\text{equilibrium}} = 0.66 \text{ mol}$ . The curve c corresponds to experience 1 In experiment 2 the reacting mixture is non- equimolar so the yield is greater than 66% but less than 100% since the reaction is reversible. The curve b corresponds to the experiment 2. In experiment 3 we use ethanoyl chloride instead of ethanoic acid, so the reaction is complete and the yield is 100% so $n(\text{ester})_{\text{max}} = 1 \text{ mol}$ . The curve (a) corresponds to experiment 3.	0.5 0.5 0.5
2.2	Sulfuric acid is a catalyst that increases the rate of the reaction.	0.25
2.3	$\text{CH}_3 - \text{COCl}$	0.25
2.4	False. Since the reaction is athermic reaction so the increase in the temperature does not affect the yield of the reaction, therefore the number of moles of the ester obtained at the end of the evolution of the reacting system does not change.	0.5