13th INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

IJSO

BALI, INDONESIA 2016

Science for Creative Innovation

THEORY COMPETITION

SOLUTIONS AND MARKING SCHEME

Problem I. Chemistry

Question	Content	Points	Total
I.1	As a weak acid (HA), eugenol is partly dissociate in water to give H_3O^+ and A^- ions, according to the following equilibrium reaction: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$ The dissociation constant is given by Ka = $[H_3O^+][A^-]/[HA]$; From the equation, it is understood that $[H_3O^+] = [A^-]$ 1.64 g of eugenol = 1.64 g / 164 g.mol^{-1} = 0.01 mol Since it is dissolved in 1 L solution, the concentration of eugenol = 0.01 M	0.5	1.5
	Therefore $[H_3O^+]^2 = K_a[HA]$ or $[H_3O^+] = \sqrt{(K_a[HA])} = \sqrt{(6.5 \times 10^{-11} \times 0.01)} = 8.06 \times 10^{-7}$; since pH= -log$[H_3O^+]$, then **pH = 6.1**	1.0	
I.2	Hydrogen = 6/16 x 128 g = **48 g**	0.25	0.5
	Carbon = 60/16 x 128 g = **480 g**	0.25	
I.3	The mass of the product (ethyl eugenolate and hydrogen bromide) is equal to the sum of the masses of the eugenol and ethyl bromide consumed. The mass of materials not involved in the reaction are unchanged. Therefore, the total mass after reaction is **41.0 g**		0.5
I.4	As a weak acid (HA), eugenol is partly dissociate in water to give H_3O^+ and A^- ions, according to the following equilibrium reaction: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$ The dissociation constant is given by Ka = $[H_3O^+][A^-]/[HA]$; From the equation, it is understood that $[H_3O^+] = [A^-]$ Therefore $[H_3O^+]^2 = K_a[HA]$ or $[H_3O^+]$ from eugenol = $\sqrt{(Ka[HA])} = \sqrt{(6.5 \times 10^{-11} \times 0.02/2)} = 8.06 \times 10^{-6}$ As a strong acid HCl completely dissociate in water to give $[H_3O^+]$ = 0.02/2 = 0.01 M Hence the total $[H_3O^+]$ in the solution = $[H_3O^+]_{eugenol} + [H_3O^+]_{HCl} = (0.01 + 8.06 \times 10^{-6}) \approx 0.01$ M Hence, the pH of the solution = -log $[H_3O^+]$ = **-log 0.01 = 2**		1.0
I.5	Since the stoichiometric of the reaction is 1:1, it means that one mole of eugenol requires 1 mole of diethyl sulphate. Mr of Eugenol = (10 x 12) + (12 x1) + (2 x 16) = 164 g.mol^{-1} Mr of diethyl sulphate = (4 x 12) + (2 x 5) + (1 x 32) + (4 x 16) = 154 g.mol^{-1} Hence 82.0 g of eugenol = 82 g/164 g. mol^{-1} = 0.5 mol, and 115.5 g of diethyl sulphate = 115.5 g/154 g.mol^{-1} = 0.75 mol Therefore, the remaing reactant is 0,25 mole of **diethyl sulphate** = 0,25 mol x 154 g/mole = **38.5 g of diethyl sulphate.**	0.5 0.5 0.5	1.5

I.6	Initial KOH= 30 mL x 0.25 mmol/mL = 7.5 mmol	0.3	1.5
	The excess of KOH= 10 mL x 0.25 mmol/mL = 2.5 mmol	0.3	
	KOH consumed for determination of acid value: (7.5-2.5) mmol = 5 mmol	0.3	
	mg KOH consumed for 2 g of sample = 5 mmol x 56 mg/mmol = 280 mg	0.3	
	Acid Value = 280 mg/2g = 140 mg KOH/g sample	0.3	
I.7	The polarity of carboxylic acid increase with the decrease in the number of carbon, so the lauric acid with 12 carbon is the most polar followed by myristic and palmitic acids. Since the stationary phase is a polar materials and the solvent is non-polar, the lauric acid will have retardation factor (R_f) lowest and followed by myristic and palmitic acids, or (1) R_f lauric acid < (2) R_f myristic acid < (3) R_f palmitic acid		1.0
I.8 (1.5)	Mr of $C_{11}H_{23}COOH$ = (12 x 12) + (24 x 1) + (2 x 16) = 200 $g.mol^{-1}$ Mr of CH_3OH = (1 x 12) + (4 x 1) + (1 x 16) = 32 $g.mol^{-1}$ Mass of CH_3OH = 160 mL x 0.8 $g.mL^{-1}$ = 128 g Mole of CH_3OH = 128 g/32 $g.mol^{-1}$ = 4 mol Mole of $C_{11}H_{23}COOH$ = 100 g/200 $g.mol^{-1}$ = 0.5 mol Suppose the ester formed = x mol, the H_2O produces x mol, then The remaining lauric acid = (0.5-x) mol and the remaining methanol = (4.0-x) $K_{eq} = x.x/(0.5-x)(4.0-x) \rightarrow 0.1x^2 + 4.05\,x - 1.8 = 0$ By using abc formula, we have x = 0.45 mol	1.0	1.5
	Hence, the ester formed = 0.45 mol x 214 $g.mol^{-1}$ = **96.3** g	0.5	
I.9	26 g C_2H_2 = 26 g : 26 mol . g^{-1} = 1.0 mol 40 g HCl = 40 g : 36.5 mol . g^{-1} = 1.1 mol	0.5	1.0
	As mol C_2H_2 is smaller than mol HCl, so the formed C_2H_3Cl will be equal to the mol of C_2H_2, i.e. 1.0 mol or equivalent to **62.5 g**	0.5	
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