

SERANGOON JUNIOR COLLEGE General Certificate of Education Advanced Level Higher 1

CANDIDATE NAME		
CLASS		
CHEMISTRY		8872/02
Preliminary Exami	nation	26 Aug 2009
Paper 2 Mark Sche	eme	2 hr
Additional Materials:	Data Booklet Answer Paper	

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in. Write in dark blue or black pen on both sides of the paper. You may use a soft pencil for any diagrams, graphs or rough work.

SECTION A:

Answer **<u>all</u>** questions in the space provided.

SECTION B:

Answer any **two** questions on separate answer paper.

At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use				
MCQ P1	/30			
A1	/10			
A2	/10			
A3	/10			
A4	/10			
B5	/20			
B6	/20			
B7	/20			
Total	/110			
Percentage				
Grade				

For Examiner's Use

1	The synth from follow	industrial preparation of the polymer, poly(tetrafluoroethene), is based on the ithesis of its monomer, tetrafluoroethene (C_2F_4). Tetrafluoroethene is produced in the thermal cracking of chlorodifluoromethane (CHC lF_2), as shown by the owing equation:						
			$2CHClF_2(g) \rightarrow C_2F_4(g) + 2HCl(g)$					
	(a)	Use re	Use relevant data from the <i>Data Booklet</i> to calculate the enthalpy change of the reaction. State any assumptions that you have made.					
		$\begin{vmatrix} H & F \\ C l - C & F \\ C & F & F \\ P & $						
		Let Bl	E(C-F) be x.					
		$\Delta H_{rxn} = \sum BE(rxts) - \sum BE(pdts)$ = 2[BE(C-Cl) + BE(C-H) + 2BE(C-F)] - [BE(C=C) + 4BE(C-F) + 2BE(H-Cl)] = [2(340 + 410 + 2x)] - [610 + 4x + 2(431)] [1] = 1500 + 4x - 1472 - 4x = <u>+28 kJ mol⁻¹</u> [1]						
		Assumption: The <u>average bond energy</u> of <u>C –F</u> is the <u>same in CHC/F₂-and C₂F₄. [1]</u>						
_	(b)	By using your answer to (a) and the following information,						
		$\Delta H_{f}(CHC/F_{2}(g)) = -485 \text{ kJ mol}^{-1}$ $\Delta H_{f}(HC/(g)) = -92 \text{ kJ mol}^{-1}$						
		calculate the enthalpy change of formation of $C_2F_4(g)$.						
		$\Delta H_{rxn} = \sum \Delta H_{f}(\text{ products}) - \sum \Delta H_{f}(\text{reactants})$						
		$\begin{array}{l} 28 = \left[2 \ x \ \Delta H_{\rm f} \left({\rm HCI} \right) + \Delta H_{\rm f} \left({\rm C_2F_4} \right) \right] - \left[2 \ x \ \Delta H_{\rm f} ({\rm CHCIF_2}) \right] \left[1 \right] \\ 28 = \left[2 \ x \ (-92) + \Delta H_{\rm f} \left({\rm C_2F_4} \right) \right] - \left[2 \ x \ -485 \right] \\ 28 = \Delta H_{\rm f} \left({\rm C_2F_4} \right) + 786 \end{array}$						
		$\Delta H_{f} (C_{2}F_{4}) = -758 \text{ kJ mol}^{-1} [1] $ [2]						
	(c)	(i) Explain the following phenomenon: Chlorine can react with oxygen to form ClO^- , ClO_2^- , ClO_3^- and Cl_2O_7 but fluorine can react with oxygen to form OF_2 only.						
			Chlorine can react with oxygen to form OF ₂ only. Chlorine can react with oxygen to form compounds of varying oxidation states as it is able to <u>expand its octet</u> using the <u>empty 3d-orbitals</u> [0.5] since it is in <u>period 3</u> [0.5] OR					
			OR Fluorine is in <u>period 2</u> . [0.5] Can only form OF ₂ as it <u>cannot expand its</u> <u>octet</u> as there are <u>no empty 3d orbitals</u> available. [0.5]					

	(ii)	Predict, with reasoning, the shape of OF ₂ .				
		F F				
		There are <u>2 bond pairs</u> and <u>2 lone pairs around O.</u> [0.5] To <u>minimize repulsion</u> , the <u>4</u> electron pairs are directed to the corners of a tetrahedron, [0.5]				
		Lone pair-lone pair repulsion > lone pair-bond pair repulsion > bond				
		pair – bond pair repulsion. [0.5] Shape of OF, is bont [0.5]				
		[2]				
	(iii)	Predict, with reasoning, the solubility of OF_2 in CCl_4 .				
		OF_2 has a <u>simple molecular</u> [0.5] structure with <u>weak intermolecular</u> <u>Van der Waals' forces of attraction</u> . [0.5] It is <u>soluble</u> [0.5] in CCl_4 as it is able to form <u>favourable solute-solvent interactions</u> [0.5] with CCl_4 molecules.				
		[2]				
		[Total: 10]				



(b)	Sugge iodop [3]	est a chemical test ropane, statin	to distinguish 2-c g clearly	hloropropa the	ane, 2-bromopropa observations	ne and 2- made.			
		Add <u>aqueous sod</u> of <u>dilute HNO₃ [</u> 0.	ium hydroxide 5] and <u>aqueous</u>	and <u>reflux</u> silver nitr	[0.5], followed by a ate. [0.5]	addition			
		N.B. r.t.p is optional for the addition of silver nitrate.							
		Observations:							
		2-chloropropane	white precipita	<mark>ate</mark> is obta	ined. [0.5]				
		2-bromopropane	<u>cream precipi</u>	<u>tate</u> is obta	ained [0.5]				
		2-iodopropane	<u>yellow precipi</u>	<u>tate</u> is obt	ained. [0.5]				
					[Total: 10]			

3(a)	Propanol can be converted to propanoic acid under appropriate condition. Suggest the type(s) of hybridisation of all the carbon atoms in propanoic acid.							
		H H—C ₁ —0 H	$ \begin{array}{ccc} H & O \\ L & \mathbb{H} \\ C_2 & & C_3 & & OH \\ H & & & \\ H & & & \\ \end{array} $					
		C ₁ : <u>sp³</u>						
			C ₂ : <u>sp³</u>					
			C ₃ : <u>sp</u> ²					
			[1] / 0					
(b)	Prop este natu prod	byl propanoate is synthesised in rification reaction of propanol an ire. This mixture will reach dy luced at a yield of 65%. With the aid of an appropriate dynamic equilibrium.	ndustrially mainly via the classic Fischer nd propanoic acid which is exothermic in <i>namic equilibrium</i> and the ester will be rate-time graph, explain what is meant by					
		Graph [1] Axes not labeled [-0.5] Fwd / bkward rate not labeled [-4 Labelling of t ₁ optional	b.5] Forward rate Backward rate t_1 Time by the rate of forward reaction = rate of					
		$\frac{backward reaction}{The substances} are \frac{still}{concentration} of the reactants are still the reactant are still the rea$	reacting together even though the and products remains constant [0.5]					
	(ii)	Given that the equilibrium mixtur	e at 298 K contains the following:					
		Propanol Propanoia acid	0.33 mol					
		Propyl Propanoate	0.66 mol					
		Water	0.66 mol					
		Calculate the value of K_c at 298	K for the reaction.					
		$CH_{3}CH_{2}COOH(l) + CH_{3}CH_{2}CH(l)$	$I_2OH(l) \rightleftharpoons CH_3CH_2CO_2CH_2CH_2CH_3(l) + H_2O$					

		$\mathcal{K}_{c} = \frac{\left[CH_{3}CH_{2}COOCH_{2}CH_{2}CH_{3}\right]\left[H_{2}O\right]}{\left[CH_{3}CH_{2}COOH\right]\left[CH_{3}CH_{2}CH_{2}OH\right]}$						
		$K_{c} = \frac{\left(\frac{0.66}{V}\right)^{2}}{\left(\frac{0.33}{V}\right)^{2}} = 4.00$ [0.5] [0.5]						
		Volume missing [-0.5]						
	(iii)	Predict, with reasoning, the effect on the value of K_c (if any) when more propanol is added to the equilibrium mixture.						
		$CH_{3}CH_{2}CH_{2}OH + CH_{3}CH_{2}CO_{2}H \rightleftharpoons CH_{3}CH_{2}CO_{2}CH_{2}CH_{2}CH_{3} + H_{2}O$						
		When more propanol is added, by Le Chatelier's Principle, <u>equilibrium</u> position will shift right [0.5] favoring the formation of ester and water.						
		<u>K_c</u> value will <u>remain constant</u> . [0.5] (K_c is dependent on temperature and not concentration)						
	(iv)	Predict, with reasoning, the composition of the equilibrium mixture when the system in (b)(ii) is subjected to an increase in temperature?						
		exo $CH_3CH_2CH_2OH + CH_3CH_2CO_2H \rightleftharpoons CH_3CH_2CO_2CH_2CH_3 + H_2O$ endo $\Delta H = -ve$						
		When temperature is increased,						
		By Le Chatelier's Principle, the position of the equilibrium shifts to <u>the left</u> so as to <u>absorb the heat</u> , favouring the <u>endothermic</u> reaction. [0.5]						
	The new equilibrium mixture contains more $CH_3CH_2CH_2OH$ and $CH_3CH_2CO_2H$ / more reactants but less $CH_3CH_2CO_2CH_2CH_2CH_3$ and H_2O / less products. [0.5]							
(c)	The belo	The esters responsible for the aroma of pineapple and apple are illustrated below:						
	ו H—(ו	H H						
	Describe appropriate chemical test(s) to distinguish the two esters. In your description, state clearly the reagents and conditions used, and the observations made in each case.							
	Test	: Add NaOH (aq) into the two esters and reflux. [0.5]						



4	(a)	Many new cars have air bags which rapidly inflate during an accident to protect the front passengers. The air bag contains sodium azide (NaN_3) , silicon dioxide and potassium nitrate. To determine the amount of sodium azide in an impure sample, the azide present is first reacted with excess iodine:
		$2N_3^- + I_2 \rightarrow 3N_2 + 2I^-$
		The amount of unreacted iodine is then titrated with standard sodium thiosulphate solution:
		$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$
		0.120 g of an impure sample of sodium azide was dissolved in water. The mixture was reacted with 25.0 cm ³ of 0.050 mol dm ⁻³ of aqueous iodine. The excess iodine was found to require 23.10 cm ³ of 0.040 mol dm ⁻³ aqueous sodium thiosulphate for reaction.
		Calculate the percentage purity of sodium azide in the sample. [3]
		Amt of $S_2O_3^{2-}$ = 23.10 / 1000 x 0.04 = 0.000924 mol
		$I_2 \equiv 2S_2O_3^{2-1}$
		Amt of I ₂ (excess) = 0.000924 /2 = 0.000462 mol [0.5]
		<u>Initial</u> amt of I ₂ = 25 / 1000 x 0.05 = 0.00125 mol
		Amt of I ₂ <u>reacted</u> = 0.00125 – 0.000462 = 0.000788 mol [0.5]
		$2N_3^- \equiv I_2$ Since NaN ₃ $\equiv N_3^-$,
		Amt of N_3^- = Amt of NaN_3 = 0.000788 x 2 = 0.001576 mol [0.5]
		Mass of NaN ₃ = 0.001576 x [(23+3(14)] = 0.10244g [0.5]
		% Purity = 0.10244 / 0.120 x 100% = <u>85.4%</u> (3sf) <mark>[1]</mark>
	(b)	A compound F of sulphur has the formula SO_xCl_2 . 23.8 g of compound F is made to react with water (in excess) and the chloride ion is completely precipitated as 57.4 g of silver chloride.
		Calculate the relative molecular mass of F and determine the value of x . [2]
		$SO_xCl_2 \equiv 2Cl^2$ $Cl^2 \equiv Ag^+ \equiv AgCl$
		Amt of AgC <i>l</i> = 57.4 / (108+35.5) = 0.4000 mol [0.5]



(ii)	obtained. Thus when [OH-] decreases, rate remains constant [0.5], order of reaction is <u>0</u> with respect to <u>OH-</u> [0.5] Gradient of conc-time graph measures rate of reaction.
	when [C ₆ H ₅ CH ₂ Br] = 1.0 mol dm ⁻³ Gradient of straight line = - (0.01-0.005) / (0-2x) = <u>0.0025 mol dm⁻³ hr⁻¹</u> [0.5]
	when $[C_6H_5CH_2Br] = 2.0 \text{ mol dm}^{-3}$ Gradient of straight line = - (0.01-0.005) / (0-x) = <u>0.005 mol dm}^{-3} hr^{-1} [0.5]</u>
	Thus when $[C_{6}H_{5}CH_{2}Br] doubles$ (1 mol dm ⁻³ \rightarrow 2 mol dm ⁻³), <u>rate</u> <u>doubles</u> [1] (0.0025 mol dm ⁻³ hr ⁻¹ \rightarrow 0.005 mol dm ⁻³ hr ⁻¹)
	Order of reaction is <u>1</u> with respect to <u>C₆H₅CH₂Br</u> . [0.5]
	Rate = k [C ₆ H₅CH₂Br] [0.5]
	Using graph when $[C_6H_5CH_2Br] = 2.0 \text{ mol dm}^{-3}$,
	Rate = $k [C_6H_5CH_2Br]$
	k = 0.005 / 2 = <u>0.00250 hr ⁻¹ [0.5] for value, [0.5] for units</u>
	[Total: 10]

SRJC 2009

Section B

Answer any <u>two</u> questions from this section on separate answer paper.

5	(a)	Compound G has the following composition by mass:						
		C, 31.9%; H, 5.3%; C <i>l</i> , 62.8%.						
	(i)	Given that the relative molecular mass of compound G is 113.0, determine its						
		molecular formula.						
			C	Ц	CI			
		% by mass	31.9	<u>п</u> 53	62 8			
		Ar	12	1	35.5			
		Amt	2.66	5.3	1.77			
		Molar ratio	1.5	3	1			
			≈ 3	≈ 6	≈2			
		Empirical formula: C			[Table: 1]			
		Empirical lottilula. <u>C3</u>						
		Let the molecular form	nula be $(C_3H_6Cl_2)_n$.					
		$p(2y12 \pm 6 \pm 2y25 5)$	- 112					
		n(3x 12 + 0 + 2x 35.5)	- 115					
		Hence, molecular forr	nula is <u>C₃H₅C/₂ [</u> 1]					
_	(ii)	Draw all the structur	ral isomers of compo	ound G and identify t	he type of structural			
		isomerism present.						
		i ype of isomerism: <u>pe</u>	ositional isomerism [1]				
		(Award: 3m for 4 cor	rect isomers; -1m fo	r each wrongly drawr	n isomer; naming			
		not reqd.)						
			`Н_СН_	CI				
		[] C	I CI	CI-CH-0	CH ₂ —CH ₃			
		1,2-dichlo	ropropane	1,1-dichlor	ropropane			
			CI	C				
		ĊH ₂ —C	H ₂ —ĊH ₂	$CH_3 - C$	C-CH ₃			
		1,3-dichlo	ropropane	C				
				2.2-dichlor	ropropane			
	(iii)	Compound H of mo	lecular formula, C₄H	8, exists as four isor	ners. The structures			
	. ,	of two of the isomer	s are shown below.					
		$(CH_3)_2 C = CH_2 $						
		Draw the structural formulae of the other two isomers of C ₄ H ₈ and state their						
		geometry.						
			1]	D1				
		CH ₃	CH ₃ CH ₃	_ ^H				
		Ĺ Á	<u> </u>	CH₃				
		SRJC 2009 8872/02/PRELIM/2009						

[Turn Over

	<u>Cis</u> isomer	0.5] <u>trans</u> is	somer [0.5]		[10]
(b)	40 cm ³ of 3.0 mol dm ⁻³	methanoic acid, HCC	OOH, was added to	60 cm ³ of 1.4 mol	dm ⁻³
	potassium hydroxide	in a polystyrene cu	ip The maximum	temperature rise	was

recorded as 10.5 °C.

Given that the specific heat capacity of the solution = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

(i) Define what is meant by the standard enthalpy change of neutralisation.

Standard enthalpy change of neutralisation (ΔH_n^{θ}) is the <u>energy change / evolved</u> [0.5] when <u>one mole of water</u> [0.5] is formed from the neutralisation between acid and alkali under standard conditions.

(ii) Write a balanced chemical equation for the neutralisation of methanoic acid with potassium hydroxide.

HCOOH (aq) + KOH (aq) \rightarrow HCOO⁻K⁺ (aq) + H₂O (I) [1] accept ionic eqn

(iii) Calculate the standard enthalpy change of neutralisation for the reaction in (b)(ii).

HCOOH (aq) + KOH (aq) \rightarrow HCOO⁻K⁺ (aq) + H₂O (I)

Amount of HCOOH = 40/1000 x 3 = 0.1200 mol [1]

Amount of KOH = 60/1000 x 1.4 = 0.08400 mol

KOH is the limiting reagent. [0.5] or able to use 0.840 mol in calculation of ΔH_n^{θ}

Q = mc Δ T = 100 x 4.2 x 10.5 = 4410 J [0.5] $\Delta H_n^{\theta} = -\frac{Q}{n_{H_2O}}$ = -4410 / 0.084 [0.5] = -52500 J mol⁻¹ = -52.5 kJ mol⁻¹ [0.5]

(iv) How would you expect the enthalpy change calculated in (b)(iii) to compare with the enthalpy change of neutralisation of nitric acid with potassium hydroxide? Explain your answer.

The enthalpy change of neutralisation involving HCOOH and KOH is <u>less</u> exothermic [0.5] than enthalpy change of neutralisation involving HNO_3 and KOH.

HCOOH is a weak acid and HNO₃ is a strong acid. [1]

Some of the energy evolved from the neutralisation process is used to <u>further</u> <u>dissociate the weak acid</u> [0.5] completely / to cause <u>ionisation of the</u> <u>undissociated weak acid</u>. [7] (c) Refractory material is used to line the interior of a furnace because of its high melting point and low reactivity. By comparing the lattice energy of calcium nitride, Ca₃N₂ and beryllium nitride, Be₃N₂, predict and explain which compound would make a better refractory material.

Since $|\Delta H_{\text{latt}}| \propto \frac{q^+q^-}{r^++r^-}$ [0.5] <u>Ionic radius</u> of cation: <u>Be²⁺ < Ca²⁺</u> [0.5]

 $\begin{array}{l} |\Delta H_{\text{latt}}\left(Be_{3}N_{2}\right)| > |\Delta H_{\text{latt}}\left(Ca_{3}N_{2}\right)| \\ \textbf{OR} \ \Delta H_{\text{latt}}\left(Be_{3}N_{2}\right) \text{ is } \underline{\textbf{more exothermic}} \ \textbf{[0.5]} \ \text{than } \Delta H_{\text{latt}}\left(Ca_{3}N_{2}\right) \end{array}$

<u>Electrostatic forces of attraction</u> between Be^{2+} and N^{3-} ions are <u>stronger</u> [0.5] than that between Ca^{2+} and N^{3-} ions.

<u>Melting point</u>: $Be_3N_2 > Ca_3N_2$ [0.5]

<u>**Be**</u>₃**N**₂ is a <u>better</u> refractory material. [0.5]

[Total: 20]

- 6 (a) The compound Na_3CrO_4 is a green solid. When mixed with dilute H_2SO_4 , it disproportionates to yield Cr^{3+} (aq) and $Cr_2O_7^{2-}$ (aq).
 - (i) Write balanced half equations for each of the following reactions:

 $CrO_4{}^{3-}$ to Cr^{3+} and $CrO_4{}^{3-}$ to $Cr_2O_7{}^{2-}$ $CrO_4{}^{3-}$ + 8H⁺ + 2e \rightarrow 4H₂O + Cr^{3+} [1] $2CrO_4{}^{3-}$ + 2H⁺ \rightarrow H₂O + $Cr_2O_7{}^{2-}$ + 2e [1]

(ii) Another sample containing 25.0 cm³ of 0.200 mol dm⁻³ acidified K₂Cr₂O₇ was titrated with a sample of 0.075 mol dm⁻³ of Fe²⁺, calculate the volume of Fe²⁺ solution required for complete reaction.

From data booklet,

$$Cr_{2}O_{7}^{2^{2}} + 14 H^{+} + 6e \rightarrow 2Cr^{3^{+}} + 7H_{2}O \quad [R]$$

$$Fe^{2^{+}} \rightarrow Fe^{3^{+}} + e \quad [O]$$

$$Cr_{2}O_{7}^{2^{-}} (aq) + 6Fe^{2^{+}} (aq) + 14H^{+} (aq) \rightarrow 2Cr^{3^{+}} (aq) + 6Fe^{3^{+}} (aq) + 7H_{2}O (l) OR$$

$$Cr_{2}O_{7}^{2^{-}} = 6Fe^{2^{+}} [1]$$

$$Amount of Cr_{2}O_{7}^{2^{-}} in 25.0 \text{ cm}^{3} = \frac{25.0}{1000} \times 0.020 = \underline{5.000 \times 10^{-4} \text{ mol } [0.5]}$$

$$Amount of Fe^{2^{+}} = 5.000 \times 10^{-4} \times 6 = \underline{3.000 \times 10^{-3} \text{ mol } [0.5]}$$

$$Volume of Fe^{2^{+}} required = \frac{3 \times 10^{-3}}{0.075} = \underline{0.0400 \text{ dm}^{3} \text{ or } 40.0 \text{ cm}^{3} [1]}$$
[5]

(b) The major acidic component of sour milk is lactic acid, $CH_3CH(OH)CO_2H$:



Structural formula of lactic acid:

When 10.0 cm³ of a solution of lactic acid (monoprotic acid) was titrated against 0.050 mol dm⁻³ sodium hydroxide, the following graph was obtained:



Graph of pH against volume of NaOH added

Volume of NaOH added / cm³

(i) Calculate the initial concentration of H^+ (aq) in lactic acid.

pH = -lg [H⁺] = 2.5 [H⁺] = $10^{-2.5}$ = <u>3.16 x 10⁻³ mol dm⁻³ [1]</u>

(ii) Suggest a suitable indicator for the titration, giving a reason for your choice.

<u>Phenolphthalein</u> [1] Its <u>pH transition range</u> ($\approx 8 - 9.8$) <u>lies within</u> the region of <u>rapid pH change</u> over the equivalence point. [1]

(iii) From the graph, deduce the equivalence volume of sodium hydroxide used.

From graph, equivalence volume of NaOH = <u>15.75 cm³</u> [1] (accept range:15.5 – 16cm³) (iv) Write a balanced equation for the reaction between lactic acid and sodium hydroxide. Hence, calculate the initial concentration of lactic acid in the solution.

CH₃CH(OH)CO₂H + NaOH → CH₃CH(OH)CO₂-Na⁺ + H₂O [0.5] Amount of NaOH = $0.050 \times \frac{15.75}{1000} = \frac{7.875 \times 10^{-4} \text{ mol}}{1000}$ [0.5] CH₃CH(OH)CO₂H ≡ NaOH

Amount of CH₃CH(OH)CO₂H = <u>7.875 x 10⁻⁴ mol [0.5]</u>

Initial [CH₃CH(OH)CO₂H] =
$$\frac{7.875 \times 10^{-4}}{10/1000}$$
 = 0.0788 mol dm⁻³ [0.5]

(v) Comparing your answers in (b)(i) and (b)(iv), state and account for the difference between the two sets of results.

 $[CH_3CH(OH)CO_2H] >> [H^+]$ [0.5]

 $CH_3CH(OH)CO_2H$ is a <u>weak acid</u> [1] as it <u>dissociates partially</u> [0.5] in solution to give low [H⁺].

(vi) Predict and explain whether lactic acid or propan-1-ol will be a stronger acid.

<u>Negative charge</u> on the <u>carboxylate anion</u> is <u>delocalized over two oxygen</u> <u>atoms</u>. [1] The conjugate base is <u>stabilised</u> [0.5]. Hence lactic acid is a <u>stronger</u> acid than propan-1-ol. [0.5]

(vii) Suggest a chemical test to confirm the presence of lactic acid in milk.

Add $\underline{Na_2CO_3}$ to lactic acid at <u>rtp</u>. [1] <u>Effervescence</u> [1] of CO₂ produced. OR Add <u>PCl₅</u> to lactic acid at <u>rtp</u>. [1] <u>White fumes</u> [1] of HC*l* produced.

[12]

(c) (i) What do you understand by the term "buffer solution"?

A buffer solution is one which is capable of <u>maintaining a fairly constant pH</u> (by resisting pH change) when <u>a small amount of H^{\pm} or OH^E is added to it. [1]</u>

(ii) Explain how a mixture of lactic acid, $CH_3CH(OH)CO_2H$ and its salt, $CH_3CH(OH)CO_2$ ⁻Na⁺ can act as a buffer.

 $CH_{3}CH(OH)CO_{2}H (aq) \implies H^{+}(aq) + CH_{3}CH(OH)CO_{2}^{-}(aq) [0.5]$ $CH_{3}CH(OH)CO_{2}^{-}Na^{+}(aq) \rightarrow Na^{+}(aq) + CH_{3}CH(OH)CO_{2}^{-}(aq) [0.5]$

When a **small amount of acid**, H^{+} is added: $CH_{3}CH(OH)CO_{2}^{-}(aq) + H^{+}(aq) \rightarrow CH_{3}CH(OH)CO_{2}H(aq)$ either/or [0.5] The added H^{+} is <u>removed</u> as <u>CH_{3}CH(OH)CO_{2}H(aq)</u>. Hence pH remains fairly constant.

When a **small amount of base, OH**⁻ is added:

CH₃CH(OH)CO₂H (aq) + OH⁻ (aq) → CH₃CH(OH)CO₂⁻ (aq) + H₂O (I) either/or The added OH⁻ is <u>removed</u> as <u>CH₃CH(OH)CO₂⁻ (aq)</u> and H₂O (I). \int [0.5] Hence pH remains fairly constant.

> [3] [Total: 20]

7 (a) Some data for eight elements, lettered **P** to **W** are given below. (These letters do not correspond to the chemical symbols of the respective element)

Element	Р	Q	R	S	Т	U	V	W
Atomic no	n	n+1	n+2	n+3	n+4	n+5	n+6	n+7
1 st ionisation	1090	1400	1310	1680	2080	494	736	577
energy / kJ mol ⁻¹								

- (i) Using the above information, predict and explain whether elements **P** to **W** belong to the same period in the Periodic Table.
 - They **<u>do not</u>** belong to the same period. [1]
 - There is <u>no increasing trend</u> in the 1st IE from P to W. [1] There is a <u>big drop</u> in 1st IE <u>from T to U indicating a change in period</u>. [1] OR
 - Across a period, there are generally <u>two dips</u> / <u>anomalies in 1st IE</u> [1] between the elements in Group II and Group III and also between Group V and VI. However, from P to W, there are <u>three dips</u> [1] which contradict the general trend.
- (ii) Hence, deduce the Group number, physical state at room temperature and chemical structures of elements **T** and **U**.

T is in Group VIII / 0, [0.5] is a gas [0.5] and has a simple molecular structure. [0.5]

U is in Group I, [0.5] is a solid [0.5] and has a giant metallic structure. [0.5]

- [6]
- (b) Magnesium oxide, MgO, and phosphorous oxide, P_4O_{10} , are oxides of two elements from period 3 in the Periodic Table.
 - (i) Illustrate the nature of the two oxides by writing balanced equation(s) to show their reaction(s), if any, with aqueous sodium hydroxide and aqueous hydrochloric acid.

MgO is <u>basic</u>. [0.5] MgO (s) + 2HCl (aq) \rightarrow MgCl₂ (aq) + H₂O (l) [1]

 P_4O_{10} is <u>acidic</u>. [0.5] P_4O_{10} (s) + 12NaOH(aq) \rightarrow 4Na₃PO₄(aq) + 6H₂O(I) [1] s.s not required

(ii) The following statements regarding the properties of oxides were found on a website:

"Both magnesium oxide and phosphorous oxide do not conduct electricity at room temperature. However, when heated above their respective melting points, one of the two oxides can conduct electricity."

Explain the above statements in terms of structure and bonding.

- MgO has a giant ionic structure. [0.5]
- Solid state: ions can only <u>vibrate about fixed positions[0.5]</u> and there are no free and mobile ions to conduct electricity
- Molten state: ions are free and mobile [0.5] to conduct electricity
- P₄O₁₀ has a **simple molecular** [0.5] structure.
- Non conductor of electricity in any state: <u>absence of free mobile ions</u> [0.5] or <u>delocalised electrons</u> [0.5] to conduct electricity.

[6]

- (c) When heated in chlorine, magnesium and phosphorus form chlorides. Describe the reactions, if any, of the chlorides with water, suggesting the pH of the resulting solutions and writing equations where appropriate.
 - $MgCl_2(s) \rightarrow Mg^{2+}(aq) + Cl(aq)$ [1] or $[Mg(H_2O)_6]^{2+} \implies [Mg(OH)(H_2O)_5]^{+} + H^{+}$
 - MgCl₂ dissolves readily, slight hydrolysis[0.5]
 - pH = <u>about 6.5</u> [0.5]
 - $PCI_3(I) + 3H_2O(I) \rightarrow H_3PO_3(aq) + 3HCl (aq)$ [1]
 - **OR** $PCI_5(I) + 4H_2O(I) \rightarrow H_3PO_4(aq) + 5HCl (aq)$
 - chlorides <u>hydrolyse</u> in water to form HCl <u>strong acid [0.5]</u>
 - pH = <u>0-3</u> [0.5]

[4]

(d) The boiling points of the three compounds are shown in the table below:

Compound	Boiling point
SO ₂	-14 °C
SO ₃	45 °C
H ₂ O	100 °C

With reference to their chemical structures, explain the differences in boiling points of the three compounds.

- H₂O has **simple molecular** structure with **intermolecular hydrogen bonds**. [0.5]
- SO₂ and SO₃ have <u>simple molecular</u> structures <u>with intermolecular Van der Waals'</u> forces of attractions. [0.5]
- <u>More energy</u> [0.5] is required to overcome the <u>stronger hydrogen bond</u> [0.5] between H_2O , hence it has a higher boiling point.
- SO₃ has a <u>greater number of electrons</u> [0.5] which will lead to a <u>greater</u> <u>unsymmetrical distribution</u> of the <u>shared electron cloud</u> [0.5].
- Hence in SO₃, <u>more energy</u> [0.5] is required to overcome <u>the more extensive</u> [0.5] Van der Waals' forces of attraction. Therefore, it has a higher boiling point than SO₂.

[4]

[Total: 20]