

SERANGOON JUNIOR COLLEGE General Certificate of Education Advanced Level Higher 2

CANDIDATE NAME

CLASS

CHEMISTRY

Preliminary Examination Paper 2 Structured Questions (SPA) 9647/02 22 August 2014 2 hours

Candidates answer on the Question Paper. Additional Materials: Data Booklet.

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.

Answer <u>all</u> questions in the space provided. You are advised to spend **30 minutes** on question 1.

At the end of the examination, fasten all your work securely together.

The number of marks is given in the brackets [] at the end of each question or part questions.

For Ex	aminer's Use
P1	/40
P2	/72
P3	/80
GRAND	
TUTAL	/192
%	
GRADE	

For Ex	aminer's Use
1(P)	/12
2	/20
3	/13
4	/12
5	/15
TOTAL P2	/72

1	Plan	ning (P)				
		Borax, also known as sodium tetraborate decahydrate, $Na_2B_4O_5(OH)_4.10H_2O$, is a controlled poison in Singapore and cannot be bought off the shelf.				
		Borax dissolves slightly in water to form an alkaline solution:				
		$Na_2B_4O_5(OH)_4(s) \approx 2Na^+(aq) + [B_4O_5(OH)_4]^{2-}(aq)$				
		$[B_4O_5(OH)_4]^{2\text{-}}(aq) + 5H_2O(l) \rightleftharpoons 4H_3BO_3(aq) + 2OH^{\text{-}}(aq)$				
		The solubility product of borax at 30°C can be determined via volumetric analysis using hydrochloric acid solution.				
	(a)	Assuming that \mathbf{a} cm ³ of 0.500 mol dm ⁻³ HC <i>l</i> is required for titrating 25.0 cm ³ of borax solution at 30°C, calculate the solubility product of borax (excluding units) in terms of \mathbf{a} .				
		n _{HC/} = a /1000 × 0.500 = 5.000 × 10 ⁻⁴ a mol				
		$2HC_{1} = 2OH^{2} = IP_{1}O_{1}(OH)^{12} = N_{2}(P_{1}O_{1}(OH))^{1}$				
		$2 C_l = 2 C_l = [D_4 C_5 (C_1)_4] = Na_2 [D_4 C_5 (C_1)_4]$				
		Amt of Na ₂ [B ₄ O ₅ (OH) ₄] = 5.000 x 10 ⁻⁴ / 2 = 2.500 x 10 ⁻⁴ a mol				
		$[borax] = \frac{0.0002500a}{25 \times 10^{-3}} = 0.01000 a \text{ mol dm}^{-3}$				
		[Na⁺] = 0.02000 a mol dm⁻³ [tetraborate anion] = 0.01000 a mol dm⁻³				
		$K_{sp} = [Na^+]^2 [tetraborate anion] = (0.02000 a)^2 (0.01000 a)$ = <u>4.00 x 10⁻⁶ a³</u>				
		[3]				
	(b)	Deduce the sign for ΔS for the dissolution of borax. Hence, predict whether this process will be more or less feasible at a higher temperature, given that ΔH is endothermic.				
		Since $\Delta G = \Delta H - T\Delta S$				
		Since ΔH and ΔS are both positive , as there is a change in state from solid to aqueous in the dissolution process which results in an increase of disorderliness .				
		When T increases from 30°C to 60°C, Δ G becomes more negative. Dissolution process is more feasible .				
		[2]				

Serangoon Junior College Preliminary Examination 2014 H2 Paper 2 Solutions

(c)	The solubility of borax can also be defined as 30 g of solid that will dissolve in 100 g of water at 60°C.						
	Other than volumetric analysis, write a plan to validate the above information						
	Your plan should also include						
	 steps to prepare a saturated solution steps to maintain the temperature throughout the experiment 						
	• steps to maintain the temperature throughout the experiment						
	1. <u>Weigh</u> approximately <u>x</u> g of <u>solid borax</u> using a <u>weighing balance</u> .						
	2. Using a <u>100 cm[°] measuring cylinder</u> , place <u>100 cm[°] of distilled</u>						
	3. Weigh again with the distilled water inside to obtain the mass of the						
	distilled water.						
	4. <u>Maintain the temperature</u> of the mixture at <u>60°C</u> using a <u>water bath</u> .						
	 Add the solid to water and <u>stir with a glass rod</u> to dissolve the solid add more solid to the water until more solid dissolves. 						
	6. Allow the mixture to stand for a period of time to establish						
	equilibrium.						
	7. Filter the mixture to obtain the residue and transfer the residue to a						
	pre-weighed dry evaporating dish.						
	8. <u>Heat the residue to dryness</u> by placing the evaporating dish on top of a bunsen burner with tripod						
	9. Cool and reweigh the evaporating dish to obtain mass of the residue.						
	10. Repeat the heating, cooling and weighing until a constant mass						
	is obtained.						
	11. Calculate using the formula:						
	Solubility						
	Total mass of solute added – mass of residue						
	$= \frac{1}{mass of water} \times 100$						
(1)							
(a)	you would minimise this risk.						
	Borax is poisonous / hydrochloric acid is <u>corrosive</u> .						
	Hence, gloves / goggles must be worn OR conduct experiment in fume hood.						
	r1						
	[Total: 12						

2 Sodium and chlorine are two common elements on Earth. Elemental chlorine is commercially produced from brine, also known as concentrated sodium chloride, by electrolysis. The electrolysis of brine solution containing neutral litmus solution is carried out in the following apparatus using graphite electrodes. The colour changes of the litmus solutions around regions A and B were observed during the process. graphite electrodes brine solution with neutral purple litmus solution В Α asbestos diaphragm (a) (i) With the aid of the Data Booklet, account for the colours changes observed around regions A and B. Include balanced equations where appropriate. **Colour of litmus** Region Reason solution the anode, Cľ At is preferentially oxidised due to Х its high concentration $2Cl \rightarrow Cl_2 + 2e$ Next. Cl_2 undergoes disproportionation in water Litmus solution first OR turned red, and then Cl_2 (g) + H₂O (l) \rightarrow HCl (aq) + turned colourless HClO (aq) red, due to formation of HCl /HClO/H⁺ and colourless due to bleaching action of HClO At the cathode, H_2O is preferentially reduced: Y $2H_2O + 2e \rightarrow H_2 + 2OH^-$ Litmus solution turned OR blue As such, blue is caused by OH⁻ formed.





		Assumptions made: 298K (25°C) [Not necessary to state concentration of electrolyte (1.0 mol dm ⁻³) and pressure as 1 atm because no aqueous electrolyte is used and there is no gas reactant involved.]
	(iii)	Using your answer in (ii) , suggest a replacement half-cell for sodium metal to generate a higher voltage reading than 2.00 V.
		Lithium / Barium / calcium / potassium (because E _{oxid} for these metals are more negative than E _{Na+/Na} .
	(iv)	Suggest one precaution to take in storing the sodium-sulfur battery.
		As sodium is very reactive, the battery must be protected from water / air / oxidising atmospheres/acid
		[Total: 20 marks]



	(ii)	Explain, with the aid of equations, why the green precipitate of $Cr(OH)_3$ dissolved in excess concentrated ammonia to form the purple solution D .				
		Cr ³⁺ (aq) + 3OH ⁻ (aq) ≈ Cr(OH) ₃ (s) Eqn (1) [Cr(H ₂ O) ₆] ³⁺ (aq) + 6NH ₃ (aq) ≈ [Cr(NH ₃) ₆] ³⁺ (aq) + 6H ₂ O (/) Eqn (2) • When excess NH ₃ is added, <u>ligand exchange / NH₃ ligands displace</u> H ₂ O ligands to form the more stable purple [Cr(NH ₃) ₆] ³⁺ complex. [Cr ³⁺] decreases. • • The equilibrium position in Eqn (1) shifts to the left to increase [Cr ³⁺]. •				
	(ii)	Constr peroxic	uct an equati de to form the y	on for the reaction of Na /ellow solution E .	₃[Cr(OH) ₆] with hydrog	en
		[O]: [C [R]: H ₂ 2[Cr(O	$(OH)_6]^{3-} + 2OHO_2 + 2H_2O + 2OHO_2 + 2H_2O + 2OHO_2 + 2H_2O_2$	$ \begin{array}{l} \stackrel{\mathrm{d}^{-}}{\to} \mathrm{CrO_4}^{2^{-}} + 2\mathrm{H_2O} + 2\mathrm{H_2O} + \\ \stackrel{\mathrm{d}^{-}}{\to} 2\mathrm{H_2O} + 2\mathrm{OH}^{-} \\ \stackrel{\mathrm{d}^{-}}{\to} 2\mathrm{CrO_4}^{2^{-}} + 2\mathrm{OH}^{-} + 8\mathrm{H_2O} \end{array} $	3e	
	(ii)	Explair carbon	n why Cr(OH); ate is added to	$_{3}$ and not $Cr_{2}(CO_{3})_{3}$ is formed solution C .	ed when aqueous sodi	um
						[8]
		Cr^{3+} has <u>high charge density</u> and hence will <u>polarise the water molecules</u> <u>to produce H⁺</u> , forming an acidic solution. This solution will react with aq Na ₂ CO ₃ through an acid-base reaction to produce CO ₂ gas and the hydroxide is formed instead of the carbonate.				
(b)	Two chromium(III) complexes with the formula $Cr(H_2O)_6Cl_3$ can be prepared unconversion conditions. Each complex contains a cation in which the coordination number of chromium is 6. The amount of lead(II) chloride precipitated whaqueous lead(II) nitrate is added is shown in the table below:			nder tion hen		
Co		mplex	Colour	Amount (in mol) of PbCl ₂ precipitated per mole of complex	Presence of dipole moment	
		F	dark green	0.5	yes	
		G	dark green	0.5	no	
	(i)	Using	the results of t	he reaction with lead(II) nitra	ate, suggest the structu	ral
		tormula	a for the cation	present in F and G .		
	0.5 mol of PbCl₂ precipitated => 1 mole of free Cl ⁻ per mole of complex / 2 moles of Cl ⁻ as ligand per mole of complex => cation is [Cr(H₂O)₄Cl₂] ⁺					

	(ii)	Explain the presence or absence of a dipole moment for complexes F and G respectively.
		[2]
		The dipole moment of the 2 Cr–C <i>l</i> bonds which are on <u>the same side in F do</u> <u>not cancel</u> each other so it has an overall dipole moment. The dipole moment of the 2 Cr–C <i>l</i> bonds which are on <u>opposite sides in G</u> <u>cancel out each other</u> so net dipole moment is zero.
(c)	Chro nutr	omium, together with calcium and magnesium, are key mineral nutrients with itional influences on blood sugar.
	(i)	Explain why the atomic radius of calcium is larger than that of magnesium.
		 For calcium, <u>valence electrons</u> are <u>added</u> to the <u>next quantum shell</u>. The <u>distance</u> between the <u>nucleus</u> and the <u>valence electrons is larger</u>. <u>Electrostatic forces of attraction</u> between the <u>nucleus</u> and <u>valence</u> <u>electrons is weaker</u>.
	(ii)	Explain why the reaction of calcium with hydrochloric acid is more vigorous than the reaction of magnesium with hydrochloric acid.
		[3]
		Reactivity <u>increases</u> down the group due to the <u>increase in reducing power</u> of the metals. / Ca is a <u>stronger reducing agent</u> than magnesium.

4	The	amino acid	s tyrosine, lysine	and glycine are cons	stituents of many prot	eins.
			Ö	Q		o O
		H ₂	₂N−CH−C−OH	$H_2N-CH-C$	OH H ₂ N-CH-	Ш_—ОН
			CH ₂	(CH ₂) ₄	н́	
				NH ₂		
			Tyrosine	Lysine	Glycine	9
	(a)	State the r	eagents and con	ditions you could use	e to break proteins int	o amino acids. [1]
	<i>(</i> ,)	HCI (aq), I	heat for several	hours or NaOH(aq),	, heat for several ho	ours
	(b)	Electropho	oresis can be use	ed to separate amino	acids.	
		Use glycin	e (isoelectric poi	nt = 5.97) as an exar	nple, fill in the followi	ng table explain why
				bH < 5.97	pH = 5.97	ری pH > 5.97
			Structural			
			formula			
			Direction of			
			movement			
				рН < 5.97	At isoelectric	pH > 5.97
				(in acidic medium)	point, pH = 5.97	(in basic medium)
			Structure	H	Н	H
				⁺ H₃N—Ċ—COOH H	⁺H ₃ N—Ċ—COO ⁻ H	H₂N−Ċ−−COO ⁻ ⊣ H
			Direction of	cathode	Stationary	anode
			movement	(negative electrode)	(without migration)	(positive electrode)
					· · · · · · · · · · · · · · · · · · ·	

9647/02/Prelim/2014

(c) The diagram below shows the results of electrophoresis in neutral solution. At the start of the experiment, a spot of solution containing a mixture of amino acids P, Q, R and S was placed in the middle of the plate. before Mixture of amino acids after Ρ Q R S Assuming amino acids **R** and **S** carry the same charge when in this buffer solution, which is likely to be the larger molecule? Explain your answer. [2] R is the larger molecule. Given the same charge, the rate of migration is inversely proportional to the mass/Mr of the molecule. (d) Gastrin is a hormone produced by the stomach which stimulates the release of gastric acid. It is a heptadecapeptide (17 amino acids) hormone. The digestion of gastrin by two enzymes are given below: Enzvme T: Glu-Glu-Glu-Glu Ala-Ala-Tyr-Trp-Met Asp-Phe Glu-Gly-Pro-Gly-Trp-Leu Enzyme U: Glu-Gly-Pro-Gly-Trp Ala-Tyr-Trp Met-Asp-Phe Leu-Glu-Glu-Glu-Ala State a possible primary structure of gastrin based on the information given above. [2] Glu-Gly-Pro-Gly-Trp-Leu-Glu-Glu-Glu-Glu-Ala-Ala-Tyr-Trp-Met-Asp-Phe Enzymes are large protein molecules that adopt a highly specific three-dimensional (e) structure. With reference to the R group interactions, explain how enzymes lose their (i) catalytic effectiveness above 40 °C. Heating will disrupt the weak Van der Waals' forces of attraction (and to a lesser extent, hydrogen bonds) holding the quaternary, tertiary and secondary structures, resulting in a more disordered arrangement.

	(ii)	When food enters our stomach, gastric juice containing hydrochloric acid and pepsin are released to aid in the digestion of proteins into short polypeptides. The graph below shows the variation of pepsin activity with pH: Activity 0 1 2 3 4 5 pH Explain the shape of the graph as fully as you can.
		Pepsin is <u>most effective at pH 2</u> where activity is the highest. At extreme pH , activity is lowered because the <u>ionic bonds</u> holding the tertiary and quaternary structures is <u>disrupted</u> .
	(iii)	The diagram below shows the reaction pathway of an enzyme-catalysed reaction. On the diagram, sketch the pathway if the enzyme was denatured. $Energy 1 \qquad $
		Energy reactants Reaction pathway

Turn Over]

5	Hypo dichr hypo	ochlorous acid, HC/O is a readily available and safe oxidising agent as compared to romates. It can be formed by treating household bleach, which contains sodium ochlorite, NaC/O, with acetic acid.						
		NaClO + CH ₃ COOH → HClO + CH ₃ COO ⁻ Na ⁺						
	Cyclo	hexanone can	be prepared by the hy	pochlorite oxidatio	on of cyc	clohexanol.		
	$OH + HC/O \rightarrow OH + HC/I + H_2O$							
	C	Compound	Boiling point / °C	Density / g cm ⁻³	Mr	Solubility in water]	
	Сус	lohexanol	161.5	0.96	100	slightly soluble		
	Сус	lohexanone	155	0.947	98	slightly soluble		
	Ace	tic acid	118	1.05	60	soluble	_	
	Diet	hyl ether	34.6	0.714	18	insoluble	-	
	va		100	1.00	10			
	 Place 8 cm³ of cyclohexanol and 4.0 cm³ of acetic acid into a 250 cm³ conical flask. Introduce a thermometer and slowly add 115 cm³ of bleach into the flask over a course of about 15 minutes. After the addition is complete, continue stirring for 20 minutes. 						a era for	
	3 4	Test for excess hypochlorite ion in the reaction mixture using starch-iodide paper. Add aqueous NaOH with stirring to the reaction mixture.						
	5	Transfer the mixture into a round-bottomed flask and collect the crude sample by distillation.						
							[2]	
	(a)	In step 2, the	temperature of the mixt	ture must be kept	within 4	0 – 50°C.		
		Suggest a reason why the temperature cannot go below 40°C.						
		Oxidation w organic mole	<u>ill not go to complet</u> ecules must be broke	<u>ion / rate is too</u> n for many of the	<u>slow /</u> <u>eir react</u>	<u>covalent bonds ions to take plac</u>	<u>in</u> <u>e.</u>	
							[1]	



(e)	(i)	Explain why cyclohexanone is slightly soluble in water.				
		Cyclohexanone can form some favourable hydrogen bonds with water.				
	However, the presence of bulky/ large hydrophobic/ non-polar group					
	(ii)	In step 7, diethyl ether was added to extract the organic compound from the				
		aqueous layer. Explain why cyclohexanone is more soluble in diethyl ether				
		than in water.				
		The presence of bulky/ large hydrophobic/ non-polar group on cyclobexapone will allow more favourable. Van der Waals' forces of				
		attraction with diethyl ether.				
		[2]				
(f)	In th	e separation process in step 7, cyclohexanone was distributed between both				
	the c	riganic phase as well as the aqueous phase.				
		Cyclohexanone (in water) 🛁 Cyclohexanone (in organic solvent)				
	The	ratio of the concentrations of the solute in the two solvents at equilibrium is a				
	cons	tant value called the <i>partition coefficient</i> , K.				
		[malohowanono in organia columnt]				
	$K = \frac{[cyclohexanone in organic solvent]}{[cyclohexanone in organic solvent]}$					
	[cyclonexanone in water]					
	The K of cyclohexanone between diethyl ether and water is 38.6 at room					
	temperature.					
	<i>(</i> i)	A solution containing 5.00 g of cyclobexanone in 1 dm ³ of water was shaken				
	(י)	with 20 cm ³ of diethyl ether. The mass of cyclohexanone extracted in diethyl				
	ether at equilibrium is b g.					
	Express the concentration of cyclohexanone (in g dm ^{\sim}) left in the aqueous layer in terms of h					
		Mass of cyclohexanone extracted by 20 cm ² of diethyl ether = $(5-b)$ g				
		[cyclohexanone in water] = (5- b) q dm ⁻³				
	(ii)	Hence, calculate the value of b , given $K = 38.6$				
		h				
		$[cyclohexanone in organic solvent] = \frac{20}{20/1000} = 38.6$				
		$ [cyclohexanone in water] - \frac{5-b}{1} = 30.0 $				
		b = <u>2.18</u> g				

	(iii)	If the extraction is done using two successive portions of 10 cm ³ diethyl ether instead, 2.40 g of cyclohexanone will be extracted. Hence, state whether it is more efficient to use one 20 cm ³ portion of diethyl other for extraction		
		More efficient to use two successive portions.		
(g)	Anhy the ir	[3] drous magnesium sulfate was used to remove an impurity in step 8. Identify mpurity and explain how it was removed.		
	MgSO ₄ is able to remove <u>water</u> as <u>Mg²⁺ has a high charge density</u> and is <u>readily hydrated / able to attract water molecules</u> strongly / <u>form ion-dipole</u> <u>interactions with water</u> . The process is exothermic.			
(h)	Desc cyclo	cribe one simple test-tube reaction` you could carry out to distinguish phexanol from cyclohexanone.		
	Test: Obse Cycle Cycle	Add 2,4-DNPH to each of the compound separately at <u>rtp</u> . ervations: ohexanone: <u>Orange ppt formed.</u> ohexanol: <u>No orange ppt formed.</u>		
		[2] [Total: 15 marks]		

END OF PAPER