



RIVER VALLEY HIGH SCHOOL

YEAR 6 PRELIMINARY EXAMINATION II

CANDIDATE
NAME

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CLASS

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CENTRE
NUMBER

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INDEX
NUMBER

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H2 CHEMISTRY

9647/02

Paper 2 Structured Questions

13 September 2016

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class, centre number and index number on all the work you hand in.

Write in dark blue or black pen on both sides of paper.

You may use a soft pencil for any diagrams, graphs or rough working.

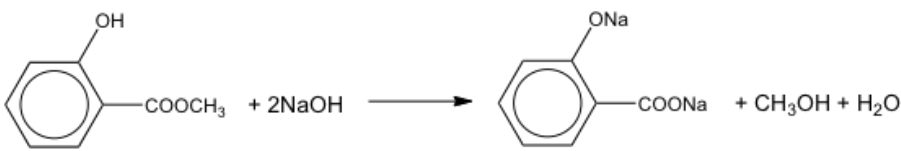
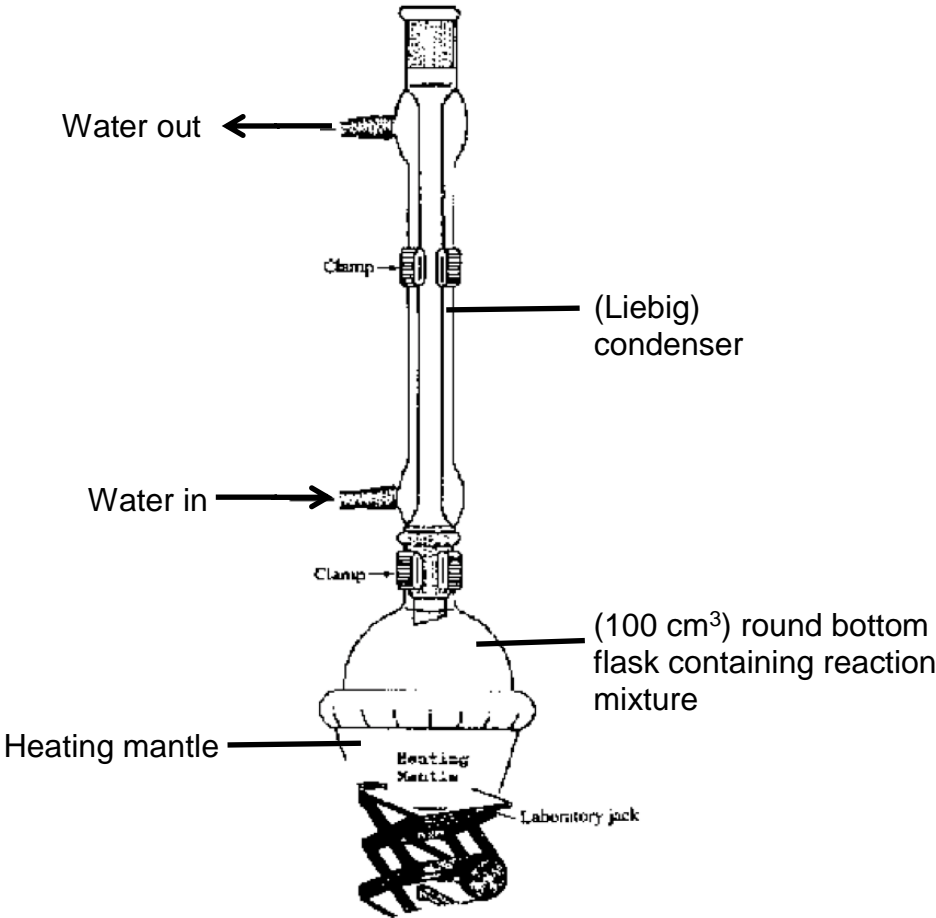
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the space provided.

A Data Booklet is provided. Do NOT write anything on it.

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

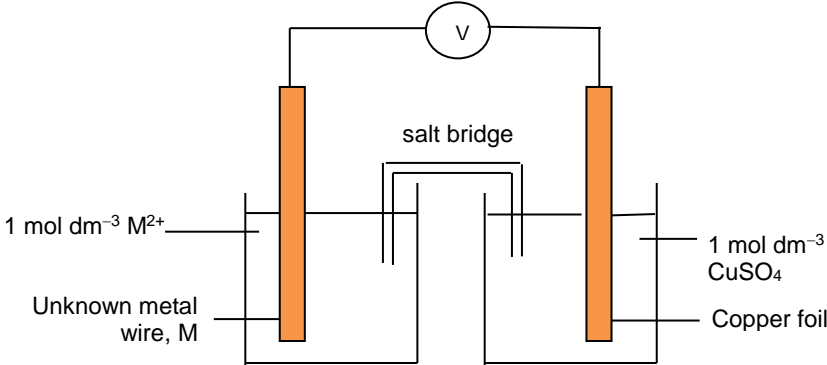
For Examiner's Use								
Paper 2								
Question Number	1	2	3	4	5	6		Total (Paper 2)
Marks	12	13	8	9	16	14		72
Paper 1	40		Paper 3		80	Total		192

1	(a)	(i)	 $\text{C}_6\text{H}_4(\text{OH})\text{COOCH}_3 + 2\text{NaOH} \longrightarrow \text{C}_6\text{H}_4(\text{ONa})\text{COONa} + \text{CH}_3\text{OH} + \text{H}_2\text{O}$	[1]
		(ii)	<p>Amount of salicylic acid in 10 g = $\frac{10}{138} = 0.0725 \text{ mol}$</p> <p>Theoretical amount of salicylic acid = $\frac{0.0725}{60} \times 100 = 0.121 \text{ mol}$</p> <p>Amount of methyl salicylate required = 0.121 mol</p> <p>Mass of methyl salicylate required = $0.121 \times 152 = 18.4 \text{ g}$</p> <p>Volume of methyl salicylate required = $\frac{18.4}{1.174} = \underline{15.7 \text{ cm}^3}$</p> <p>Amount of sodium hydroxide required = $0.121 \times 2 = 0.242 \text{ mol}$</p> <p>Volume of sodium hydroxide required = $\frac{0.242}{6.0} \times 1000 = \underline{40.3 \text{ cm}^3}$</p>	[2]
	(b)		 <p>Water out</p> <p>Clamp</p> <p>(Liebig) condenser</p> <p>Water in</p> <p>Clamp</p> <p>(100 cm³) round bottom flask containing reaction mixture</p> <p>Heating mantle</p> <p>Heating Mantle</p> <p>Laboratory jack</p>	

		<ol style="list-style-type: none"> Using a <u>25 cm³ measuring cylinder</u>, measure <u>16 cm³</u> (accept up to 20 cm³) of methyl salicylate and place it in a <u>100 cm³ round bottom flask</u>. Using a <u>50 cm³ measuring cylinder</u>, measure <u>41 cm³</u> (accept up to 50 cm³) of aqueous sodium hydroxide and place it into the 100 cm³ round bottom flask. Add some <u>boiling chips</u> to the mixture. Set up the reflux set-up shown in the above diagram and heat the mixture for 30 minutes. Allow the reaction mixture to cool down to room temperature and remove the boiling chips. Place the round bottom flask in an <u>ice bath</u>. Add concentrated hydrochloric acid to the reaction mixture slowly, with stirring. Test the acidity of the mixture with a blue <u>litmus paper</u>. Filter the mixture and <u>wash</u> the residue (crude salicylic acid) with a <u>small amount of cold water</u>. Transfer the crude salicylic acid to a <u>clean 100 cm³ conical flask</u>. Add a <u>small volume of water</u> and heat the mixture until all the crude product <u>dissolves</u>. Filter the hot solution, using a <u>fluted filter paper</u>, into a <u>pre-warmed</u> clean and dry conical flask. Allow the solution to cool down slowly for crystals to form. When the solution is cooled to room temperature, submerge the conical flask into an <u>ice bath</u> to allow more crystals to form. <u>Filter the mixture</u> to obtain the pure salicylic acid crystals and <u>pat dry</u> the crystals using <u>filter paper</u>. 	[9]
			[Total: 12]

2	(a)	$pV = nRT$ $(150 \times 10^3)(60 \times 10^{-3}) = n(8.31)(300 + 273)$ Amount of nitrogen gas = <u>1.89 mol</u> Amount of sodium azide = $\frac{1.89}{3/2} = 1.26 \text{ mol}$ Mass of sodium azide = $1.26 \times 65.0 = \underline{81.9 \text{ g}}$		[2]
	(b)	(i)	$\Delta S = (51.3 + \frac{3}{2} \times 191.6) - 70.5 = \underline{+268.2 \text{ J mol}^{-1} \text{ K}^{-1}}$	[1]
		(ii)	ΔH is negative, ΔS is positive, <u>$-T\Delta S$ is negative</u> . Since $\Delta G = \Delta H - T\Delta S$, <u>ΔG is always negative</u> regardless of temperature.	[1]

		(iii)	The activation energy of the reaction is very high.	[1]
(c)	(i)		Lattice energy of sodium oxide is the enthalpy change when <u>one mole of solid sodium oxide</u> is formed from its <u>constituent gaseous ions Na⁺ and O²⁻</u> .	[1]
	(ii)		<p>Energy / kJ mol⁻¹</p> <p>Diagram showing the formation of Na₂O(s) from its constituent ions. The energy levels are as follows:</p> <ul style="list-style-type: none"> 2Na⁺(g) + O²⁻(g) at +702 kJ mol⁻¹ from 2Na⁺(g) + 2e⁻ + O(g) 2Na⁺(g) + 2e⁻ + O(g) at 2(+494) kJ mol⁻¹ from 2Na(g) + O(g) 2Na(g) + O(g) at 2(+107) + ½(+496) kJ mol⁻¹ from 2Na(s) + ½O₂(g) 2Na(s) + ½O₂(g) at 0 kJ mol⁻¹ Na₂O(s) at -416 kJ mol⁻¹ from 2Na(s) + ½O₂(g) <p>LE (Na₂O) = -416 - 2(+107) - ½(+496) - 2(+494) - (+702)</p> <p>= <u>-2568 kJ mol⁻¹</u></p>	
				[3]
	(iii)		<p>2nd electron affinity = +702 - (-142) = <u>+844 kJ mol⁻¹</u></p> <p>The positive sign of 2nd EA means that <u>energy is required to overcome the repulsion between the anion and the electron to be added</u> since both are negatively charged.</p>	[2]
(d)			<p>Safe depressurisation rate = $\frac{(150 - 101)}{2 - 0.04} = 25 \text{ kPa s}^{-1}$</p> <p>Since the airbag being tested depressurises <u>more slowly</u> than the safe depressurisation rate, it is <u>not safe</u> for use.</p>	[2]
[Total: 13]				

3	(a)	What do you understand by the term standard electrode potential?	
		Standard electrode potential, E^\ominus , of an electrode is the <i>relative</i> potential of this electrode under <u>standard conditions compared with the standard hydrogen electrode</u> whose electrode potential is assigned as 0 V. The standard hydrogen electrode consists of <u>$\text{H}_2(\text{g})$ at 1 atm bubbling over platinum electrode coated with finely divided platinum which is dipped into $1 \text{ mol dm}^{-3} \text{H}^+(\text{aq})$ at 298 K.</u>	[2]
	(b)	<p>The following cell was set up between a copper electrode and an unknown metal electrode $\text{M}^{2+}(\text{aq})/\text{M}(\text{s})$. The standard cell potential was found to be 0.76 V, and the copper foil was connected to the positive end of the voltmeter.</p> <div style="text-align: center;"> <div style="border: 1px solid black; padding: 5px; margin: 10px auto; width: fit-content;">Direction of electron flow</div>  </div>	
	(i)	Use the Data Booklet to calculate the standard electrode potential of the $\text{M}^{2+}(\text{aq})/\text{M}(\text{s})$ system.	
		<p>Since copper is the positive electrode of the galvanic cell, it is the cathode.</p> <p>Standard electrode potential of the $\text{M}^{2+}(\text{aq})/\text{M}(\text{s})$</p> <p>$= 0.34 - 0.76 = -0.42 \text{ V}$</p>	[1]
	(ii)	Draw an arrow in the box above to show the direction of electron flow through the voltmeter.	
		<div style="border: 1px solid black; width: 100px; height: 30px; margin: 0 auto;"></div>	[1]
	(iii)	Predict the outcomes of the following situations. Describe what you will see and write ionic equations, with state symbols, for any reactions that occur.	

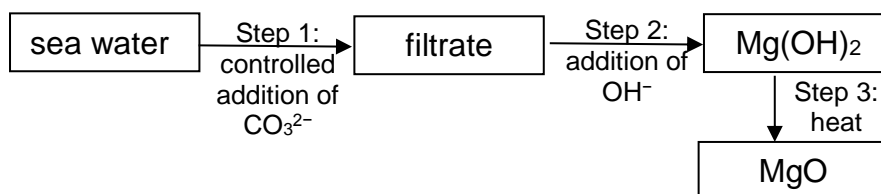
		I	A rod of metal M is dipped into a solution of 1 mol dm ⁻³ CuSO ₄ .	
			Metal M dissolves in (blue) solution and pink solid of Cu is formed. (Blue solution lightens in colour.) $\text{M(s)} + \text{Cu}^{2+}(\text{aq}) \longrightarrow \text{Cu(s)} + \text{M}^{2+}(\text{aq})$	[2]
		II	Dilute sulfuric acid is added into a beaker containing a powdered sample of metal M.	
			Efferversence is observed; colourless odourless gas evolved that extinguishes a lighted splint with a pop sound. Metal M dissolves in (colourless) solution. $2\text{H}^+(\text{aq}) + \text{M(s)} \longrightarrow \text{M}^{2+}(\text{aq}) + \text{H}_2(\text{g})$	[2]
			[Total: 8]	

4

The four most abundant salts in sea-water are as follows.

Salt	kg per m ³
Sodium chloride	27.5
Magnesium chloride	6.75
Magnesium sulfate	5.625
Calcium sulfate	1.80

Magnesium oxide is obtained from sea-water by the following steps.

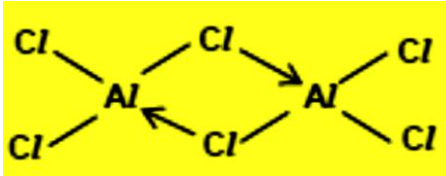


The relevant numerical values of the solubility products are given below.

	Salt		K_{sp}	
	Sodium carbonate		-	
	Calcium carbonate		5.0×10^{-9}	
	Magnesium carbonate		1.0×10^{-5}	
	Magnesium hydroxide		1.5×10^{-11}	
	Calcium hydroxide		7.9×10^{-6}	
	(a)	Explain why the addition of carbonate ions in Step 1 is necessary and has to be controlled.		
		<p>Both calcium carbonate and magnesium carbonate are <u>sparingly soluble salts</u>. Carbonate ions are added to <u>precipitate out calcium carbonate first</u>.</p> <p>In Step 1, the addition of carbonate must be controlled such that <u>little/no magnesium carbonate is precipitated/magnesium ions remain in the filtrate</u>.</p>		[2]
	(b)	Suggest why the K_{sp} value of sodium carbonate is not provided.		
		Sodium carbonate is <u>not a sparingly soluble salt</u> /it is <u>very soluble in water</u> .		[1]
	(c)	Using the reaction scheme above, Barny used 1 dm^3 of sea water to extract magnesium oxide.		
		(i)	Calculate the concentration of Mg^{2+} in sea water.	
			<p>In 1 dm^3 of sea water,</p> <p>Amount of $\text{MgCl}_2 = \frac{6.75 \times 10^3}{10^3} \div (24.3 + 35.5 \times 2)$ $= 7.08 \times 10^{-2} \text{ mol}$</p> <p>Amount of $\text{MgSO}_4 = \frac{5.625 \times 10^3}{10^3} \div (24.3 + 32.1 + 16.0 \times 4)$ $= 4.67 \times 10^{-2} \text{ mol}$</p> <p>$[\text{Mg}^{2+}] = 0.118 \text{ mol dm}^{-3}$</p>	[2]

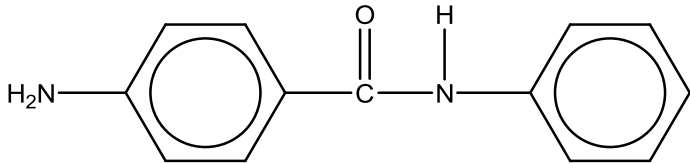
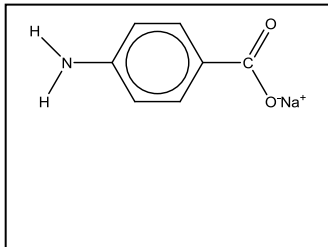
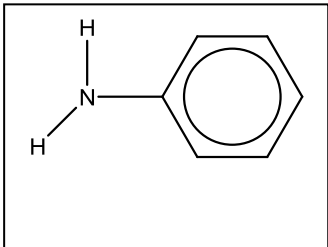
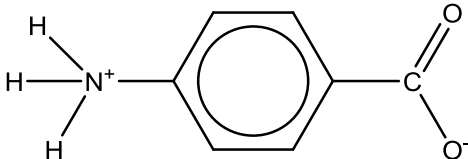
		(ii)	<p>Barny chose a pH of 9.5 to carry out the extraction of $\text{Mg}(\text{OH})_2$. Calculate the maximum mass of magnesium oxide that can be obtained at pH 9.5.</p> <p>You may assume that negligible volumes of CO_3^{2-} and OH^- were used.</p>	
			<p>At pH 9.5, $[\text{OH}^-] = 10^{-4.5} \text{ mol dm}^{-3}$</p> <p>$K_{\text{sp}} = [\text{Mg}^{2+}][\text{OH}^-]^2$</p> <p>Max $[\text{Mg}^{2+}]$ after addition of $\text{OH}^-(\text{aq}) = 1.5 \times 10^{-11} \div (10^{-4.5})^2$ $= 0.0150 \text{ mol dm}^{-3}$</p> <p>Amount of Mg^{2+} precipitated = $0.118 - 0.0150 = 0.103 \text{ mol}$</p> <p>Maximum mass of $\text{MgO} = 0.103 \times (24.3 + 16.0) = \underline{\underline{4.13 \text{ g}}}$ (or 4.15 g)</p>	[3]
		(iii)	Suggest how Barny can modify his experiment to improve on the yield of MgO ?	
			<p>He can use a <u>higher pH</u> to lower the concentration of $\text{Mg}^{2+}(\text{aq})$ to increase his yield/He can <u>lower the temperature</u> to lower the K_{sp}/ He can add $\text{NaOH}(\text{aq})$ directly to sea water in a controlled manner.</p>	[1]
			[Total: 9]	

5	(a)	In the periodic table, elements can exhibit either single or variable oxidation states. One example of an element which can exhibit variable oxidation state is manganese, Mn, while aluminium, Al is an example of an element which cannot exhibit variable oxidation state.		
		(i)	Draw a dot and cross diagram for aluminium chloride, AlCl_3 .	
				[1]
		(ii)	<p>In the vapour state, the M_r of aluminium chloride was found to be 267. However, when aluminium chloride is in the solid state, its M_r was found to be 133.5.</p> <p>With the aid of suitable diagram, explain this behaviour exhibited by aluminium chloride and the type of bonding involved.</p>	

		<p>Aluminium chloride molecules can form dimers (between themselves) where one aluminium chloride molecule forms dative covalent bonds with another Aluminium chloride molecule. Hence, the observed M_r of the dimer is 267 at vapour state.</p>  <p>Dative bond is formed. The <u>lone pair on the Cl atom</u> of AlCl_3 is donated to the <u>empty orbital of the electron-deficient Al</u> in AlCl_3 to form a <u>dative (covalent) bond</u> so that Al can attain a stable octet configuration.</p>	[3]
	(b)	<p>Manganese is often found in minerals in combination with iron. Manganese is a metal with important industrial metal alloy uses, particularly in stainless steels. Manganese is found in various black minerals known as pyrolusite. Pyrolusite consists mainly of manganese(IV) oxide. Manganese(IV) oxide is the most common starting material for the production of compounds of manganese in other oxidation states.</p> <p>Manganese(IV) oxide undergoes a 2-step reaction to produce Y and Z.</p> $\text{MnO}_2 \xrightarrow[\text{I}]{\text{Oxidation in alkaline medium}} \text{MnO}_4^{2-} \xrightleftharpoons[\text{II}]{\text{Hot water / alkaline medium}} \text{Brown black solid Y in a purple solution containing Z}$	
	(i)	Define the term <i>transition element</i> .	
		A transition element is a d-block element which forms at least one stable simple ion in which there is a partially-filled d subshell.	[1]
	(ii)	Write the electronic configuration of Mn.	
		$\text{Mn} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$	[1]
	(iii)	Explain why manganese can exhibit variable oxidation state.	
		3d and 4s electrons are of similar energies, hence a variable number of 3d and 4s electrons can be involved in bonding (ionic or covalent).	[1]

		(iv)	The brown black solid Y contains 63.8% by mass of manganese and 36.2% by mass oxygen. Determine the empirical formula of Y .																
			<table><tr><td>element</td><td>Mn</td><td>O</td></tr><tr><td>mass ratio</td><td>63.8</td><td>36.2</td></tr><tr><td>mole ratio</td><td>$\frac{63.8}{54.9} = 1.16$</td><td>$\frac{36.2}{16.0} = 2.26$</td></tr><tr><td>simplest ratio</td><td>$\frac{1.16}{1.16} = 1.00$</td><td>$\frac{2.26}{1.16} = 1.94$</td></tr><tr><td></td><td>1</td><td>2</td></tr></table> Empirical formula: MnO ₂ .	element	Mn	O	mass ratio	63.8	36.2	mole ratio	$\frac{63.8}{54.9} = 1.16$	$\frac{36.2}{16.0} = 2.26$	simplest ratio	$\frac{1.16}{1.16} = 1.00$	$\frac{2.26}{1.16} = 1.94$		1	2	[1]
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	1	2																	
		(v)	Suggest the identity of Z and state the type of reaction that occurs at step II . Hence, construct a balanced equation for the reaction.																
			Z is MnO ₄ [−] Step II is a disproportionation/redox reaction. $3\text{MnO}_4^{2-} + 2\text{H}_2\text{O} \rightarrow 2\text{MnO}_4^{-} + \text{MnO}_2 + 4\text{OH}^{-}$	[3]															
		(vi)	With reference to your answer in (v), suggest how bubbling carbon dioxide gas into the hot solution of MnO ₄ ^{2−} increases the yield of Y and Z .																
			CO ₂ is <u>acidic</u> in nature. It can <u>remove the OH[−]</u> . <u>Equilibrium position</u> of $3\text{MnO}_4^{2-} + 2\text{H}_2\text{O} \rightleftharpoons 2\text{MnO}_4^{-} + \text{MnO}_2 + 4\text{OH}^{-}$ <u>shifts to the right</u> to <u>replenish the OH[−]</u> , hence it helps in the disproportionation.	[2]															
	(c)		Manganese(II) carbonate, MnCO ₃ , undergoes thermal decomposition in a similar way to a Group II carbonate. MnCO ₃ decomposes at 200 °C while CaCO ₃ decomposes at 840 °C.																
		(i)	Write an equation, with state symbols, for the thermal decomposition of MnCO ₃ .																
			MnCO ₃ (s) → MnO(s) + CO ₂ (g)	[1]															
		(ii)	Explain why MnCO ₃ decompose at a lower temperature than CaCO ₃ .																

		<p>The <u>ionic radius of Mn^{2+} is smaller</u>, hence <u>Mn^{2+} has a higher charge density than Ca^{2+}</u>.</p> <p>As a result, the <u>ability of Mn^{2+} to polarise the large CO_3^{2-} anion is greater</u> and the <u>C–O bonds are weakened to a larger extent</u>. Hence MnCO_3 decomposes at a lower temperature than CaCO_3.</p>	[2]
		[Total: 16]	

6	(a)	<p>4-Amino-N-phenylbenzamide, the structure of which is drawn below, is used in the treatment of epilepsy.</p> <div style="text-align: center;">  <p>4-amino-N-phenylbenzamide</p> </div>	
	(i)	<p>4-Amino-N-phenylbenzamide is hydrolysed by warm aqueous sodium hydroxide. Draw the displayed formulae of the two hydrolysis products below.</p>	[2]
		<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>A</p> </div> <div style="text-align: center;">  <p>B</p> </div> </div>	
	(ii)	Which of the two hydrolysis product A & B is a liquid?	[1]
		B	
	(iii)	<p>When the other product is carefully neutralised with an aqueous mineral acid to pH 7, C is obtained.</p> <p>Draw the structure of C.</p>	[1]
		<div style="text-align: center;">  </div>	

		(iv)	Upon evaporation of all the solvent from the solution of C , a white solid is obtained. Suggest a physical property of the solid.	[1]
			High melting and boiling point / conduct electricity in molten or aqueous state	
	(b)	State the reagents and conditions required for the conversion of benzene into phenylamine in two steps. In your answer, identify the structure of the intermediate.		[3]
		Step 1: concentrated H_2SO_4 , concentrated HNO_3 , 55°C Step 2: Sn, Concentrated HCl , heat, followed by NaOH(aq) Intermediate: nitrobenzene		
	(c)	The following structure shows part of a protein molecule.		
		$ \begin{array}{ccccccc} \text{H} & \text{H} & \text{O} & \text{H} & \text{H} & \text{O} & \text{H} & \text{H} & \text{O} \\ & & & & & & & & \\ \text{---N---C---C---N---C---C---N---C---C---} \\ & & & & & & & & \\ \text{CH}_2 & & & & \text{CH}_2 & & & (\text{CH}_2)_4 & \\ & & & & & & & & \\ \text{OH} & & & & \text{CO}_2\text{H} & & & \text{NH}_2 & \end{array} $		
		(i)	Using suitable diagrams, describe two interactions that the protein fragment above can exhibit in its tertiary structure	[3]
			<p>Hydrogen bonding between serine and aspartic acid/serine and lysine (reject aspartic acid and lysine)</p> <p>Ionic interactions between aspartic acid and lysine</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> $\begin{array}{ccc} \text{---CH}_2\text{COO}^- & \text{---} & ^+\text{H}_3\text{N---}(\text{CH}_2)_4\text{---} \\ \text{(asp)} & \nearrow & \text{(lys)} \\ \text{ionic interactions} & & \end{array}$ </div> <p>E.g. of hydrogen bonding</p> $ \begin{array}{ccc} & \delta^- & \delta^+ & & \delta^- \\ & & & & \\ \text{---}(\text{CH}_2)_4\text{---N---H---} & \cdots & \text{O---CH}_2\text{---} \\ & & \\ \text{H} & & \text{H} \\ \delta^+ & & \delta^+ \\ \text{(Lys)} & & \text{(Ser)} \\ \text{hydrogen bonding} & & \end{array} $	

		(ii)	In solution, amino acids exist as zwitterions. Choose one of the amino acids that can be hydrolysed from the protein molecule above to illustrate what is meant by this term.	[1]
			$ \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2^- \\ \\ \text{CH}_2 \\ \\ \text{OH} \end{array} \quad \text{OR} \quad \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2^- \\ \\ \text{CH}_2 \\ \\ \text{CO}_2\text{H} \end{array} \quad \text{OR} \quad \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2^- \\ \\ (\text{CH}_2)_4 \\ \\ \text{NH}_2 \end{array} $	[1]
		(iii)	Amino acids act as buffers in solution. By means of equations, show how your chosen amino acid can act as a buffer when (I) dilute hydrochloric acid (II) dilute sodium hydroxide is added to its solution.	[2]
			$ \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2^- \\ \\ \text{CH}_2 \\ \\ \text{OH} \end{array} + \text{H}^+ \rightarrow \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2\text{H} \\ \\ \text{CH}_2 \\ \\ \text{OH} \end{array} $ $ \begin{array}{c} \text{H} \\ \\ {}^+\text{H}_3\text{N}-\text{C}-\text{CO}_2^- \\ \\ \text{CH}_2 \\ \\ \text{OH} \end{array} + \text{OH}^- \rightarrow \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{N}-\text{C}-\text{CO}_2^- \\ \\ \text{CH}_2 \\ \\ \text{OH} \end{array} + \text{H}_2\text{O} $	
			[Total: 14]	