## Anderson Serangoon Junior College 2021 JC2 Preliminary Examination H2 Chemistry (9729) Paper 2 Suggested Solutions

1 (a) Describe and explain the trend in the electronegativity of elements across Period 3 from sodium to chlorine. [2]

Electronegativity increases across Period 3.

- <u>Nuclear charge increases</u> across Period 3.
- <u>Shielding effect</u> between nucleus and valence electrons are <u>similar</u> since successive elements in the period have an <u>additional electron in the same valence shell/same no. of inner shells</u>.
- There are <u>stronger (electrostatic) forces of attraction between the nucleus and the electron pair in a covalent bond</u>.
- (b) Some ionic radii are listed in the *Data Booklet*.
  - (i) Explain the trend in ionic radius down Group 2.

Ionic radius increases down the group.

- <u>Nuclear charge increase</u> but <u>number of (inner) electronic shells increases</u>.
- Outer electrons experienced greater shielding effect and are further from the nucleus.
- there are <u>weaker electrostatic forces of attraction between the nucleus and the outer</u> <u>electrons</u>.
- (ii) Explain the differences between the ionic radii of  $P^{3-}$ ,  $Cl^{-}$  and  $Ca^{2+}$ . [1]

Ionic radius decreases from  $P^{3-}$  to  $Cl^{-}$  to  $Ca^{2+}$ .

- P<sup>3-</sup>, C<sup>*I*-</sup> and Ca<sup>2+</sup> are <u>isoelectronic/same number of electrons</u> and
- <u>number of protons / nuclear charge increases</u> from P<sup>3-</sup> to Ca<sup>2+</sup> while the <u>shielding</u> <u>effect remains the same</u>,
- resulting in an increasing attraction between the nucleus and outer electrons.

(accept there is an <u>increasing attraction</u> between the <u>increasing number of protons</u> and the <u>same number of electrons</u>.)

(iii) Hence, suggest a value for the ionic radius of a potassium ion, K<sup>+</sup>.

[1]

[2]

0.138 nm (any value between 0.099 and 0.181)

 $K^{+}$  is isoelectronic with the ions in **(b)(ii)** and its nuclear charge is between that of  $Cl^{-}$  and  $Ca^{2+}$ . Hence, its ionic radius will be between 0.099 and 0.181 nm.

(iv) Explain the difference in size between the radius of potassium ion and the radius of a potassium atom.
 [1]

Radius of  $K^+$  ion is <u>smaller</u> than that of K atom

- <u>nuclear charge</u> remains the <u>same</u>.
- the cation has <u>one less electronic shell</u> than the atom.
- the outer electrons in the cation are <u>less shielded</u> and <u>closer</u> to the nucleus.
- there are <u>stronger</u> electrostatic forces of attraction between the nucleus and the outer electrons in cation.
- (c) Anodisation of aluminium is a process which coats an oxide layer on aluminium objects.
  - (i) Draw a labelled diagram of the electrolysis cell used to anodise a small piece of aluminium object. Include details of the cathode, anode and electrolyte. [1]



(ii) Complete Table 1.1 to show the type of reaction occurring, with the relevant half-equations, during the anodisation of the aluminium object. [2]

Table 1.1

type of reaction occurring		half-equation(s)	
anode	oxidation	2A/ + 3H₂O → A/₂O₃(s) + 6H⁺ + 6e⁻	
cathode	reduction	2H <sup>+</sup> + 2e <sup>-</sup> → H <sub>2</sub>	

(d) The molecules of alcohol **P**, C<sub>7</sub>H<sub>16</sub>O, are optically active and does not react with hot, acidified Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>(aq).

On treatment with  $Al_2O_3$ , **P** produces a mixture of four different isomeric alkenes with the formula  $C_7H_{14}$ , **only two** of which are cis–trans isomers of each other.

Suggest the structural formula of compound **P** and the four alkenes. [4]



- (e) The following equilibrium exists in a sample of aluminium chloride vapour.  $Al_2Cl_6(g) \rightleftharpoons 2AlCl_3(g)$ 
  - (i) Draw a dot–and–cross diagram of the Al<sub>2</sub>Cl<sub>6</sub> molecule, including its co–ordinate bonds.



(ii) Assuming the gaseous mixture behaves ideally, calculate the average  $M_r$  of the mixture. Give your answer to **four** significant figures. [2]

$$M = \frac{mRT}{pV}$$

$$M = \frac{(1.50)(8.31)(500)}{(1.16 \times 10^{5})(250 \times 10^{-6})}$$

$$= 214.9 \text{ g mol}^{-1}$$
Average *M*<sub>c</sub> of mixture = 214.9

(iii) Using the following relationships, calculate the mole fraction of  $Al_2Cl_6$ , x and the mole fraction of  $A/Cl_3$ , y, in the mixture.

$$x + y = 1$$
  
average  $M_r = 267x + 133.5y$  [1]

Given the mole fraction of  $Al_2Cl_6$  be x and mole fraction of  $A/Cl_3$  be y.

[2(27.0) + 6(35.5)]x + [27.0 + 3(35.5)]y = 214.9 and x + y = 1267x + 133.5(1 - x) = 214.9 133.5x = 214.9 - 133.5 x = 0.610y = 0.390 [1]

(iv) Hence calculate the partial pressures of  $Al_2Cl_6$  and  $A/Cl_3$  in this mixture.

[1]

(v) Write an expression for  $K_p$  for the reaction, and calculate its value. Include units in your answer. [2]

$$K_{p} = \frac{p_{A/CI_{3}}^{2}}{p_{A/2CI_{6}}}$$
$$= \frac{(45240)^{2}}{70729}$$
$$= 28900 Pa$$

**2** (a) When Group 2 iodates(V), M(IO<sub>3</sub>)<sub>2</sub>, is heated, it behaves in a similar way to the Group 2 carbonates. Upon heating, it decomposes as shown.

 $2M(IO_3)_2(s) \rightarrow 2MO(s) + 2I_2(g) + 5O_2(g)$  (where M is a Group 2 metal)

(i) Using your knowledge of Group 2 carbonates, suggest and explain the trend in thermal stabilities of the Group 2 iodate(V). [2]

Down the group, ionic radius of  $M^{2+}$  increases. As a result, the <u>charge density</u> of the  $M^{2+}$  decreases, the  $M^{2+}$  becomes <u>less</u> <u>polarising</u>. The <u>electron cloud of  $IO_3^-$  anion is less distorted</u>. The I–O covalent bond within the  $IO_3^-$  anions is <u>less weakened</u> down the group. Thermal stability of Group 2 iodate increases down the group.

**X**, **Y** and **Z** are Group 2 metals (Mg to Ba, not necessarily in that order).

 $X(IO_3)_2$ ,  $Y(IO_3)_2$  and  $Z(IO_3)_2$  are Group 2 iodates(V). The three graphs in Fig. 2.1 show the change in mass when 2.00 g each of  $X(IO_3)_2$ ,  $Y(IO_3)_2$  and  $Z(IO_3)_2$  were heated separately at a temperature T °C.



(ii) With reference to the information from Fig. 2.1, show, by calculations, that none of the above iodate(V) samples contains Mg(IO<sub>3</sub>)<sub>2</sub>.
 [2]

Assume one iodate(V) given is Mg(IO<sub>3</sub>)<sub>2</sub>. Molar mass of Mg(IO<sub>3</sub>)<sub>2</sub> = 374.1 g mol<sup>-1</sup> Amount of Mg(IO<sub>3</sub>)<sub>2</sub> =  $\frac{2.00}{374.3}$  = 5.346 x 10<sup>-3</sup> mol

Amount of MgO formed =  $5.346 \times 10^{-3}$  mol Molar mass of MgO = 40.3 g mol<sup>-1</sup> Mass of MgO formed =  $(5.346 \times 10^{-3})(40.3)$ = 0.215 g

Since the mass of the oxide calculated does not correspond to that of either XO, YO or ZO,  $Mg(IO_3)_2$  is not among the given iodate(V).

(iii) Hence, suggest the identities of the three iodates(V). [No calculation is required.]

[1]

iodates(V)	<b>X</b> (IO <sub>3</sub> ) <sub>2</sub>	Y(IO <sub>3</sub> ) <sub>2</sub>	<b>Z</b> (IO <sub>3</sub> ) <sub>2</sub>
identity	Sr(IO <sub>3</sub> ) <sub>2</sub>	Ba(IO <sub>3</sub> ) <sub>2</sub>	Ca(IO <sub>3</sub> ) <sub>2</sub>

- (b) When a salt such as a Group 2 sulfate dissolves in water, the lattice energy must be overcome.
  - (i) How will the **magnitude** of the lattice energy of Group 2 sulfates change from MgSO<sub>4</sub> to BaSO<sub>4</sub>? [1]

Magnitude decreases from MgSO<sub>4</sub> to BaSO<sub>4</sub>.

(ii) Suggest a reason for this trend.

$$\begin{split} & \left| \Delta \mathsf{H}_{\mathsf{iatt}} \right| \alpha \left| \frac{\mathsf{q}^+ \times \mathsf{q}^-}{\mathsf{r}^+ + \mathsf{r}^-} \right| \\ & \mathsf{charges of cation and anion and anionic radius remain unchanged} \\ & \underline{\mathsf{Cationic radius increases from Mq^{2+} to Ba^{2+}} \\ & \underline{\mathsf{Interionic distance increases thus electrostatic forces of attraction between the metal cation and SO4^{2-} becomes weaker} \end{split}$$

[1]

(iii) Draw a simple diagram to show how a water molecule can be attached to a magnesium cation, and to a sulfate anion, Label each diagram to show the type of interaction involved and show the displayed structure of the sulfate anion. [3]



- **3** Trisoxazoline are organic molecules that can function as ligands. Despite their huge molecular structure, they are able to form stable complexes with metals. Metal complexes with trisoxazoline are commonly used as catalyst in organic synthesis.
  - (a) With an aid of the Boltzmann distribution, explain how a catalyst increases the rate of reaction.



As shown on the diagram, in the presence of a catalyst, at a certain temperature T,

- Catalyst provides an alternative pathway of a lower activation energy  $(E_a' < E_a)$ .
- More molecules have energies greater than or equal to the lowered activation energy E<sub>a</sub>.
- This results in an increase in the frequency of effective collisions.
- The rate constant, k, increases and hence rate of reaction increases

[3]



(iv) Compound P in Fig 3.1 can be synthesised from ethane via a two-step reaction scheme show below.



Suggest the reagents required for each step.



(c) Other than copper(II) ions, it was found that copper(I) ions are also able to form complexes with trisoxazoline.

Complete the full electronic configuration of copper(I) ions.

[1]

[2]

Cu: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>10</sup>4s<sup>1</sup> Cu<sup>+</sup>: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>10</sup>

(d) Copper is in increasing demand for use in electric vehicles, solar energy, consumer electronics and other energy efficient targets. Most current copper extraction processes burn sulfide minerals in air which produces sulfur dioxide which is harmful to the environment.

Describe and explain with the aid of suitable equations, the role of NO<sub>2</sub> in the oxidation of atmospheric sulfur dioxide. [2]

NO<sub>2</sub>(g) is a homogeneous <u>catalyst.</u>

(<u>NO<sub>2</sub>(g) oxidises SO<sub>2</sub> to SO<sub>3</sub></u>, and <u>itself reducing to NO</u>, hence reducing the [SO<sub>2</sub>] in the atmosphere.)

 $SO_2(g) + NO_2(g) \longrightarrow SO_3(g) + NO(g)$  $NO(g) + \frac{1}{2}O_2(g) \longrightarrow NO_2(g)$ 

- 4 (a) A 2.00 g sample of an organic substance Z containing only C, H and O was burned completely. The only combustion products were 2.90 g of carbon dioxide and 1.20 g of water.
  - Define the term relative molecular mass. (i) [1] The average mass of one molecule of the substance relative to  $\frac{1}{12}$  the mass of one atom of <sup>12</sup>C.
  - (ii) Given that the relative molecular mass of the organic substance Z is 90.0, show that the molecular formula is  $C_3H_6O_3$ . [2]

Amount of CO<sub>2</sub> in 2.90 g =  $\frac{2.9}{44}$  = 0.06591 mol Since  $CO_2 \equiv C$ 

Amount of C in 2.90 g = 0.06591 mol Mass of C in compound = 0.06591 x 12.0 = 0.7909 g

Amount of H<sub>2</sub>O in 1.2 g =  $\frac{1.2}{18}$  = 0.06667 mol

Since  $H_2O \equiv 2H$ Amount of H in 1.2 g = 0.06667 x 2 = 0.1333 mol Mass of H in compound = 0.1333 x 1.0 = 0.1333 g

Mass of O in compound = 2.00 - 0.7909 - 0.1333 = 1.076 g

	С	н	0
Mass	0.7909	0.1333	1.076
Amount in mole (i.e. mass/Ar)	$\frac{0.7909}{12.0} = 0.06591$	$\frac{0.1333}{1.0} = 0.1333$	$\frac{1.076}{16.0}$ = 0.06725
Simplest mole ratio	$\frac{0.06591}{0.06591} = 1.0$	$\frac{0.1333}{0.06591} = 2.0$	$\frac{0.06725}{0.06591} = 1.0$

Empirical formula of compound: CH<sub>2</sub>O

Let molecular formula be  $(CH_2O)_n$ . n( 12.0 + 2 + 16.0) = 90.0 n = 3Molecular formula: C<sub>3</sub>H<sub>6</sub>O<sub>3</sub>

Alternative method

 $C_aH_bO_c$  + (a + b/4 - c/2)  $O_2 \rightarrow aCO_2$  + b/2  $H_2O$ Amount of CO<sub>2</sub> in 2.90 g =  $\frac{2.9}{44}$  = 0.06591 mol

Amount of H<sub>2</sub>O in 1.2 g =  $\frac{1.2}{18}$  = 0.06667 mol Amount of Z in 2.0 g =  $\frac{2.0}{90}$  = 0.02222 mol

$$\frac{a}{1} = \frac{n(CO_2)}{n(Z)}$$

$$\frac{a}{1} = \frac{0.065909}{0.02222}$$

$$a = 3$$

$$\frac{b}{2}$$

$$\frac{b}{2} = \frac{n(H_2O)}{n(Z)}$$

$$\frac{b}{2}$$

$$\frac{b}{2} = \frac{0.06667}{0.02222}$$

$$b = 6$$

$$M_r C_3 H_6 O_c = 90.0$$

$$3(12.0) + 6(1.0) + c(16.0) = 90.0$$

$$c = 3$$
Molecular formula: C\_3 H\_6 O\_3

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(b) Complete the reaction scheme in Fig. 4.1 to show how compound E could be synthesised from ethylbenzene in three steps using suitable reagents.
 Show the structures of the intermediate compounds and state the reagents and conditions for each step.





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- 5 This question is about the chemistry of compounds containing halogen.
  - (a) Bromoalkane can undergo two different mechanisms for nucleophilic substitution  $S_N 1$  and  $S_N 2$ .

Experiments were conducted in two different set-ups to measure the relative rates of nucleophilic substitution for three bromoalkanes. Set-up 1 and 2 use different nucleophiles.

Table 5.1 summarises the relative rates of three bromoalkanes in the two experiments.

Та	ble	5.1	

bromoalkane	$CH_3CH_2Br$	(CH <sub>3</sub> ) <sub>2</sub> CHBr	(CH₃)₃CBr
relative rate in set-up 1	4 x 10 <sup>-2</sup>	1	4 x 10 <sup>6</sup>
relative rate in set-up 2	30	1	5 x 10 <sup>−5</sup>

(i) Predict the predominant mechanism for set–up 2. Explain your answer.

<u>S<sub>N</sub>2</u>.

The rate of reaction is fastest for the <u>primary</u> bromoalkane ( $CH_3CH_2Br$ ). This favors  $S_N2$  as the C bonded to Br is <u>less sterically hindered</u> which allows the nucleophile to approach it more easily.

(ii) Explain the relative rate of  $(CH_3)_3CBr$  in set–up 1.

The rate is fastest for  $(CH_3)_3$ CBr as it forms the <u>most stable</u> carbocation. The <u>three electron</u> donating alkyl group bonded to the C+ <u>dispersed the positive charge</u> on the carbocation to a <u>larger extent</u> and stabilises the carbocation to a larger extent. This favors the S<sub>N</sub>1 mechanism in set–up 1.

(b) 2-iodobutane can be readily converted into 2-aminobutane using ethanolic ammonia.

 $CH_3CHICH_2CH_3 + 2NH_3 \longrightarrow CH_3CH(NH_2)CH_2CH_3 + NH_4I$ 

In order to determine the rate equation for this reaction, an investigation was carried out at a constant temperature. Equal volume of 0.20 mol dm<sup>-3</sup> 2–iodobutane and 4.00 mol dm<sup>-3</sup> ethanolic ammonia were mixed. At suitable time intervals, 10 cm<sup>3</sup> of the reaction mixture was pipetted into a conical flask and quenched.

Chlorine gas was bubbled into the aliquot and excess chlorine gas was subsequently removed. Iodine is liberated by the following reaction.

 $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$ 

The iodine was then titrated with 0.0250 mol dm<sup>-3</sup> sodium thiosulfate in the presence of an indicator.

$$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$$

Fig 5.1 shows the volume of sodium thiosulfate used against time for this experiment.

[2]

[1]



(i) Prove that the volume of  $S_2O_3^{2-}$  required when the reaction between 2–iodobutane and ethanolic ammonia goes to completion in this investigation is 40 cm<sup>3</sup>. [1]

 $\begin{aligned} & [2-iodobutane] = 0.20 \div 2 = 0.10 \text{ mol dm}^{-3} \\ & n(2-iodobutane) = 10/1000 \times 0.10 = 0.001000 \text{ mol} \\ & \text{When the reaction goes to completion, } n(I^{-}) \text{ formed } = 0.001000 \text{ mol} \\ & n(I_2) = 0.001000 \div 2 = 0.0005 \text{ mol} \\ & n(S_2O_3^{2^-}) \text{ required } = 0.0005 \times 2 = 0.001000 \text{ mol} \\ & \text{V}(S_2O_3^{2^-}) \text{ required } = \frac{0.001000}{0.0250} = 0.04000 \text{ dm}^3 = 40.00 \text{ cm}^3 \end{aligned}$ 



(ii) Hence, use Fig 5.1 to deduce the order of reaction with respect to 2–iodobutane. [2]

Time taken when volume of sodium thiosulfate increases from 0 to 20 cm<sup>3</sup> = 9.5 min. Time taken when volume of sodium thiosulfate increases from 20 to 30 cm<sup>3</sup> = 9.5 min.

Since  $t_{1/2}$  is constant, it is  $1^{st}$  order with respect to 2–iodobutane

(iii) The concentration of ethanolic ammonia is halved and a new series of experiments was carried out at the same temperature.

It is known that that the order of reaction with respect to ethanolic ammonia is one.

Suggest how the gradient at each point will change when a similar graph like the one in Fig. 5.1 was plotted. [1]

Since the reaction is first order with respect to ethanolic ammonia, when <u>concentration</u> <u>of ethanolic ammonia is halved</u>, <u>rate will be halved</u> as well. Thus, the <u>gradient</u> at each point <u>will be halved</u>.

(iv) Hence, construct the rate equation for the reaction between 2–iodobutane and ethanolic ammonia. [1]

rate = k[2–iodobutane][ammonia]

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(v) Calculate the value of the rate constant for the reaction between equal volumes of 0.20 mol dm<sup>-3</sup> 2–iodobutane and 4.00 mol dm<sup>-3</sup> ethanolic ammonia and its units. [2]

rate = k[2–iodobutane][ethanolic ammonia] Since ethanolic ammonia is in large excess, rate = k' [2–iodobutane], where k' = k [ethanolic ammonia]

 $t_{1/2} = \frac{\ln 2}{k'} = \frac{\ln 2}{k \text{ [ethanolic ammonia]}}$ 

[ethanolic ammonia] in the reaction mixture =  $4.00 \div 2 = 2.00$ 

 $9.5 = \frac{\ln 2}{k (2.00)}$ 

 $k = 0.0365 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ 

OR

Initial rate of disappearance of 2–iodobutane = [40x0.025/10]/15= 6.67 x 10<sup>-3</sup>  $k = 6.67 x 10^{-3}/(0.1 x 2.00)$ =  $0.0333 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$  18

(c) lodide ions,  $I^-$ , can react with peroxodisulfate,  $S_2O_8^{2^-}$ .

$$S_2O_8^{2-} + 2I^- \longrightarrow 2SO_4^{2-} + I_2$$

A student wanted to investigate the effect of changes in volume used on the rate of this reaction.

Table 5.2 shows the results obtained when a series of experiments was carried out using different volumes of the two reagents, each solution being made up to the same total volume with water, where necessary.

experiment	volume of KI / cm <sup>3</sup>	volume of Na <sub>2</sub> S <sub>2</sub> O <sub>8</sub> / cm <sup>3</sup>	volume of water / cm <sup>3</sup>	initial rate / mol dm <sup>-3</sup> s <sup>-1</sup>
1	10	20	10	0.0200
2	5	20	15	0.0100
3	30	10	0	0.0303

Table 5.2

Given that the order of reaction with respect to  $I^{-}$  is 1, determine the order of reaction with respect to  $S_2O_8^{2-}$ . [1]

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Let rate = k[I^{-}][S_2O_8^{2-}]^n
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Comparing experiment 1 and 3,

\frac{0.0200}{0.0303} = \frac{k(10)(20)^{n}}{k(30)(10)^{n}}

n = 0.985

n \approx 1

Order = 1
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6 (a) Ammonia can act as a weak base.

$$NH_3(aq) + H_2O(I)$$
  $\longrightarrow$   $NH_4^+(aq) + OH^-(aq)$   $pK_b = 4.75$ 

 $(NH_4)_2SO_4$  is a weak acid. Calculate the pH of 0.10 mol dm<sup>-3</sup> (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>(aq).

 $[NH_{4}^{+}] = 2 \times 0.10 = 0.20 \text{ mol dm}^{-3}$   $pK_{a} \text{ of } NH_{4}^{+} = 14 - 4.75 = 9.25$   $K_{a} = \frac{[NH_{3}][H^{+}]}{[NH_{4}^{+}]} = \frac{[H^{+}]^{2}}{(2 \times 0.10)} = 10^{-9.25}$   $[H^{+}]^{2} = 1.124 \times 10^{-10}$   $[H^{+}] = 1.060 \times 10^{-5} \text{ mol dm}^{-3}$ 

 $pH = -lg(1.060 \times 10^{-5}) = 4.97$ 

(b) A buffer solution with a pH 8.90 is made by adding 150 cm<sup>3</sup> of solution B containing ammonium chloride to 100 cm<sup>3</sup> of 0.0200 mol dm<sup>-3</sup> aqueous NH<sub>3</sub>. Calculate the concentration of ammonium chloride in solution B. [3]

$$K_{b} = \frac{[NH_{4}^{+}][OH^{-}]}{[NH_{3}]} = \frac{\left(\frac{0.15x}{0.100 + 0.150}\right)(10^{-5.1})}{\left(\frac{0.100 \times 0.02}{0.100 + 0.150}\right)} = 10^{-4.75} = 1.778 \times 10^{-5}$$

$$x = 0.0298 \text{ mol dm}^{-3}$$
Or
$$pOH = pK_{b} + \lg \frac{[salt]}{[base]}$$

$$5.1 = 4.75 + \lg \frac{150 \times x}{100 \times 0.02}$$

$$x = 0.0298 \text{ mol dm}^{-3}$$
Or
$$K_{a} = \frac{[NH_{3}][H^{+}]}{[NH_{4}^{+}]} = \frac{\left(\frac{0.100 \times 0.02}{0.100 + 0.150}\right)(10^{-8.90})}{\left(\frac{0.15x}{0.100 + 0.150}\right)} = 10^{-9.25} = 5.623 \times 10^{-10}$$

$$x = 0.0298 \text{ mol dm}^{-3}$$

$$x = 0.0298 \text{ mol dm}^{-3}$$

(c) Write equations to explain how the  $NH_3(aq)/NH_4^+(aq)$  buffer system helps to maintain the pH.

[2]

Therefore pH remains fairly constant

9729/02/H2

[2]

(d) Malaria is a serious and sometimes fatal mosquito-borne disease. Primaquine is an antimalaria drug used to prevent relapse of malaria infections.



## primaquine

Two of the  $pK_b$  values of primaquine are 4.1 and 9.8.

(i) Using the information, write the  $pK_b$  values for the nitrogen–containing groups *a* and *b* in primaquine. [1]

nitrogen-containing	group a	group b
ρΚь	9.8	4.1

(ii) Suggest an explanation for the for your assignment of  $pK_b$  values in (d)(i). [2]

The <u>alky group</u> in **group b** exerts an <u>electron–donating effect</u>. This makes the <u>lone pair</u> <u>on N atom more available to accept a proton</u>.

The <u>lone pair of electrons</u> on N in **group a** is <u>delocalised into the  $\pi$  electron cloud of the</u> <u>benzene ring</u>. This makes the <u>lone pair on N atom less available to accept a proton</u>.