**Practice NZIC Scholarship Chemistry (93102) 2024**

**Suggested Assessment Schedule**

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| **Question** | **Evidence** | **Suggested mark allocation** |
| **ONE (a)**  **(b)**  **(c)**  **(d)** | 2H2 + O2 ⎯→ 2H2O  Mass of fuel = 745 – 27 = 718 tonnes  Let *x* = no. of moles of O2 present  Then *n*(H2) = 2*x*  Mass of H2 = 4*x*; mass of O2 = 32*x*  4*x* + 32*x* = 718; i.e. 36*x* = 718  *x* = 718/36 = 19.94 mol  ⇒ Mass H2 = 4 × 19.94 = 80 (79.78) tonnes;  Mass of O2 = 32 × 19.94 = 638 (638.22) tonnes  OR 718 tonnes of H2O, so 39889 mol. Thus 39889 mol H2 = 80 (79.8) tonnes and 19944mol O2 = 638 tonnes  Mass of oxygen = 6.14 × 105 kg or 6.14 × 108 g  Volume = 6.14 × 108/1.141 = 5.38x108 cm3 (1 m3 = 1 × 106 cm3)  = 5.38 × 102 m3  Mass of hydrogen = 1.04 × 108 g  Volume = 1.04 × 108/0.0708 = 1.47 × 109  = 1.47 × 103 m3  Total volume = 1.47 × 103 + 0.538 × 103 m3 = 2008 m3  10Al(s) + 6NH4ClO4(s) ⎯→ 4Al2O3(s) + 2AlCl3(s) + 12H2O(l) + 3N2(g)  ∆r*H*° = Σ∆f*H*° (products) – Σ∆f*H*° (reactants)  = (4×(-1675.7) + 2×(-704.2) + 12×(-285.8) + 0) - (0 + 6×(-295.3))  = -11541 – (-1771.8)  = - 9769 kJ mol–1  16% of 450 tonnes = 72 tonnes  7.2 × 107 g  *n*(Al) = 7.2 × 107/27.0  = 2.67 × 106 mol  10 mol releases 9769 kJ of energy  So 2.67 × 106 mol will release 2.67 × 106/10 × 9769 = 2.61 × 109 kJ. | **7 – 8 marks**  Shows an understanding of principles of chemistry by:  completing all parts with no more than a minor arithmetical error  **5 – 6 marks**  Shows an understanding of principles of chemistry by:  (a) correct and  Completing correctly at least two of (b), (c) and (d) and correct method for the third  **1 – 4 marks**  Shows an understanding of principles of chemistry by:  attempting all parts with viable methods but unable to complete calculations |

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| **TWO**  **Part A** | vitamin A.eps | **7 – 8 marks**  Shows an understanding of principles of chemistry by:  Part A correct  Part B correct  Part C Uses correct reagents (or equivalent)  Recognises the need to protect the secondary OH group on Y and identifies the minor product in the elimination reaction  **5 – 6 marks**  Shows an understanding of principles of chemistry by:  Parts A and B correct with minor error  Part C Uses correct reagents (or equivalent)  Does not protect the secondary OH group on Y  But the sequence is substantially correct  **1 – 4 marks**  Shows an understanding of principles of chemistry by:  Makes a genuine attempt at all parts but a number of errors.  Shows some understanding of the products from reactions and the reagents needed to carry out steps |
| **Part B** | Q2B ans.eps |
| **Part C** | If alcohol on compound Y is not protected as ketone all the way through, then two problems –  1 Major product of elimination will form double bond in wrong place  2 There will be a competing internal esterification reaction within compound Y.  Minor product (bottom left) is from elimination with KOH(alc) which would form a different isomer of X |

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| **THREE**  **Part A**  **(a)**  **(b)**  **(c)** | H3AsO3  + H2O ⎯→ H3AsO4 + ~~2H~~~~+~~ +~~2e~~~~–~~  H2O2 + ~~2H~~~~+~~ +~~2e~~~~–~~ ⎯→ 2H2O  H3AsO3  + H2O2 ⎯→ H3AsO4 + H2O  As H+ ions don’t feature in the net ionic equation, either as reactants or products, the change in pH must be due to the acids themselves  As H3AsO3 solution has a higher pH than H3AsO4 solution it must react to a lesser extent with water so H3AsO3 is a weaker acid than H3AsO4  The precipitation reactions are in the form (where *x* = 3 or 4)  3Ag+(aq) + AsO*x*3–(aq) eq arrow.eps Ag3AsO*x*(s)  On addition of acid  AsO*x*3–(aq) + H3O+ eq arrow.eps HAsO*x*2–(aq) + H2O  The weaker acid has the stronger base so AsO33– reacts with ethanoic acid sufficiently to lower the concentration of AsO33– to the extent that *K*s(Ag3AsO3) is not exceeded.  This does not happen with the weaker base (of the stronger acid), AsO43–, and the weak acid and it requires a strong acid to dissolve the precipitate. | **7 – 8 marks**  Shows an understanding of principles of chemistry by:  Part A Shows an understanding of the concepts involved and provides an explanation of the observations  Part B correct  Part C at least one of each type of reaction discussed correctly with *E*° values included.  **5 – 6 marks**  Shows an understanding of principles of chemistry by:  Part A Completes (a) and some progress on (b) and (c).  Part B correct with one arithmetical error acceptable  Part C Shows an understanding of the requirements and at least one equation correct.  **1 – 4 marks**  Shows an understanding of principles of chemistry by:  Part A completes (a) but little progress with parts (b) and (c)  Part B Correct method but incomplete or incorrect answer.  Part C Shows some understanding of what is required |
| **Part B** | 2Al + 3O2 ⎯→ Al2O3  0.70% of 46.0 g Al = 0.322 g (assuming 0.70% by mass)  n(Al) = 0.322/27 mol  = 0.0119 mol  Al ⎯→ Al3+ + 3e  *n*(electrons) = 3 x 0.0119 mol  = 0.0358 mol  Which is equal to 0.0358 F or  3452 C  3452 = 0.850 x t  t = 3452/0.850  = 4061 seconds  or 1.13 hours (67.68 min) |

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| **Part C** | HOCl will disproportionate  2HOCl + 2H+ + 2e– ⎯→ Cl2 + 2H2O Eo = +1.63V  HOCl + 2H2O ⎯→ ClO3– + 5H+ + 4e– Eo = -1.43V  5HOCl + ⎯→ 2Cl2 + 2H2O + H+ + ClO3– Eo = +0.20V  Iodine would be involved in comproportionation  IO3– + 6H+ + 6e– ⎯→ I–  + 3H2O Eo = +1.20V  2I–  ⎯→ I2 + 2e– Eo = -0.54V  IO3– + 6H+ + 5I–  ⎯→ 3I2 + 3H2O Eo = +0.66V  And so will sulfur  SO2 + 4H+ + 4e– ⎯→ S + 2H2O Eo = +0.50V  H2S ⎯→ S + 2H+ + 2e– Eo = -0.17V  SO2 + 2H2S ⎯→ 3S + 2H2O Eo = +0.33V |  |
| **FOUR**  **Part A** | |  |  |  | | --- | --- | --- | | Species &  Bond angle | Structure | Explanation | | NO2  134° | NO2.eps | In the NO2 molecule, there are 3 regions of negative charge around the central nitrogen atom. These repel each other as far as possible, resulting in a trigonal planar arrangement. If all the repulsions were equal, the bond angle would be 120°; however, the two bonding regions have more electrons than the non-bonding region which has only 1 electron. They thus take up more space, and the bond angle is 134°.  In the NO2+ ion, there are only 2 regions of negative charge around the central nitrogen atom. These repel each other as far as possible, resulting in a linear arrangement, with bond angles of 180°.  In the NO2– ion, there are 3 regions of negative charge around the central nitrogen atom. These repel each other as far as possible, resulting in a trigonal planar arrangement, as in the NO2 molecule above. The non-bonding region is held closer to the nitrogen atom than are the two bonding regions, and so takes up more space, giving a bond angle of 115°.  In the NO3– ion, there are also 3 regions of negative charge around the central nitrogen atom, which repel each other as far as possible, resulting in a trigonal planar arrangement. All of the regions are bonding, giving a planar triangle shape and the bond angle is 120°. | | NO2+  180° | NO2+.eps | | NO2–  115° | NO2-.eps | | NO3–  120° | NO3-.eps | | **7 – 8 marks**  Shows an understanding of principles of chemistry by:  Part A Lewis diagrams and explanations correct with one error acceptable  Part B (a) correct (b) method correct one arithmetical error acceptable. (c) explanation correctly uses two concepts to explain the decision that the reaction is endothermic  **5 – 6 marks**  Shows an understanding of principles of chemistry by:  Part A Lewis diagrams and explanations substantially correct with minor errors acceptable  Part B (a) correct (b) method correct but incorrect answer due to more than one error. (c) states the reaction is endothermic and provides one explanation  **1 – 4 marks**  Shows an understanding of principles of chemistry by:  Part A At least two Lewis diagrams and two explanations correct. A correct explanation from an incorrect Lewis diagram is acceptable  Part B (a) correct method  (b) shows some insight into how to go about the calculation but does not complete it.  (c) states the reaction is endothermic without justification |

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| **FOUR**  **Part B**  **(a)**  **(b)**  **(c)** | If [N2O4] = 0.070 mol L-1  [NO2] = (1 – 0.070) × 2  = 1.86 mol L-1  *K*c  = [NO2]2/[N2O4]  = 3.46/0.070  = 49  If the equilibrium concentration of N2O4 is *x* mol L–1, that of NO2 is 2(1.00 – *x*) mol L–1.  *K*c = [NO2 (g)]2 / [N2O4 (g)]  0.00590 = (2 – 2*x*)2 / *x*  0.00590*x* = 4 – 8 *x* + 4 *x*2  4 x2– 8.0059 *x* + 4 = 0  *x* = ( 8.0059 +/– √(8.00592– 64) ) / 8  *x* = ( 8.0059 +/– √(64.09444 – 64) ) / 8  *x* = ( 8.0059 +/– √(0.09444) ) / 8  *x* = ( 8.0059 +/– 0.3073 ) 8  *x* = 1.04 (not possible; *x* must be <1.00) or *x* = 0.962  The concentration of N2O4 is 0.962 mol L–1, and the concentration of NO2 is 0.0754 mol L–1  OR  If x mol L–1 N2O4 reacts [N2O4] = 1 – x; [NO2] is 2*x* mol L–1.  Kc = [NO2 (g)]2 / [N2O4 (g)]  0.0059 = (2*x*)2 / 1 – *x*  4*x*2 = 0.0059 – 0.0059*x*  4*x*2 + 0.0059*x* – 0.0059 = 0  *x* = (-0.0059 +/– √(0.00592– 16× (-0.0059)) ) / 8  *x* = ( -0.0059 +/– √(3.481 × 10–5 + 0.0944) ) / 8  *x* = (- 0.0059 +/– √(0.09444) ) / 8  *x* = ( -0.0059 +/– 0.3073 ) 8  *x* = 0.0377 (ignoring the negative answer}  The concentration of N2O4 is 1 – 0.0377 = 0.962 mol L–1,  and the concentration of NO2 = 2*x* = 2 × 0.0377 = 0.0754 mol L–1  The dissociation reaction N2O4(g) eq arrow.eps 2NO2(g) only involves breaking the N-N bond in the dimer.  As bond breaking is an endothermic process the forward reaction must be endothermic.  Secondly at 25 °C *K*c = 0.00590 and at 120 °C *K*c = 49. A increase in temperature has resulted in an increase in *K*c. i.e. more products less reactants, the forward reaction is favoured. A increase in temperature favours the endothermic reaction so the forward reaction is endothermic. |  |

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| **FIVE**  **Part A**  **(a)**  **(b)** | *n*HOCl = 0.0150 × 0.1 = 1.50 × 10–3 mol  The resultant solution is 45.0 mL  [OCl–] = 1.50 × 10–3 /0.045 = 0.0333 mol L–1  *K*b(OCl–) = 1 × 10–14/2.95 × 10–8 = 3.39 × 10–7  OCl– + H2O eq arrow.eps HOCl + OH–  *K*b = [OH–]2/[OCl–]  Assume [OCl–]eq = [OCl–]initial  let [OH–] = *x*  *x*2 = 3.39 × 10–7 × 0.0333 = 1.13 × 10–8  *x* = [OH–] = 1.06 × 10–4 mol L-1  pOH = 3.97  pH = 14 – 3.97 = 10.03  As [OH–] = 1.06 × 10-4 mol L-1  % dissociation = 1.06 × 10-4/0.0333 x100  = 0.318 | **7 – 8 marks**  Shows an understanding of principles of chemistry by:  Part A (a) and (b) correct  Part B (a) Recognises 2nd reaction as the key one makes some sensible calculations to reach an answer  (b) Uses answers from (a) and *K*a expressions appropriately to get answers. Accept minor arithmetical errors  Continued next page |

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| **FIVE**  **Part B**  **(a)** | For a pH = 7 the reaction predominantly involved is  H2PO4– + H2O eq arrow.eps H3O+ + HPO42– p*K*a2 = 7.21; *K*a = 6.166 × 10–8  *K*a = [H3O+][HPO42–]/[H2PO4–]  [HPO42–]/[H2PO4–] = *K*a/[H3O+] = 6.166 × 10–8 / 1 × 10–7 = 0.6166  Assume all the H3PO4 is converted to H2PO4–. Then initial *n*H2PO4– = 0.100 mol  If *n*HPO42– = *x* mol  At Equilibrium *n*H2PO4– = 0.100 – *x*  *x*/(0.100 – *x*) = 0.6166.  *x* = 0.06166 – 0.6166*x.* 1.6166x = 0.06166  *x* = 0.06166/1.6166 = 0.03814  ⇒*n*HPO42– = 0.0381  *n*H2PO4– = 0.1 – 0.0381 = 0.0619  *n*NaOH required = 0.0617 + 2 × 0.0381  = 0.138 mol  vol NaOH required = 0.138/1 = 0.138 L = 138 mL  Total volume of solution once pH = 7 is achieved = 1138 mL | Continued from previous page  **5 – 6 marks**  Shows an understanding of principles of chemistry by:  Part A (a) and (b) correct  Part B (a) Recognises 2nd reaction as the key one makes progress towards an answer  (b) Uses answers from (a) and recognises the need to use *K*a expressions appropriately to get answers. Incomplete calculations  **1 – 4 marks**  Shows an understanding of principles of chemistry by:  Part A Correct method for (a) and (b) but incorrect answers  Part B (a) & (b)  Makes some progress but does not complete the calculation |
| **Part B**  **(b)** | [HPO42–] = 0.0381/1.138 = 0.0335 mol L–1  [H2PO4–] = 0.0619/1.138 = 0.0544 mol L–1  [Na+] = 0.138/1.138 = 0.121 mol L–1  *K*a1 = 7.586 × 10–3 = [H3O+][H2PO4–]/[H3PO4]  [H3PO4] = 1 × 10–7 × 0.0544/7.586 × 10–3 = 7.17 × 10–7 mol L–1  *K*a3 = 2.138 × 10–13 = [H3O+][PO43–]/[HPO42–]  [PO43–] = (2.138 × 10–13 × 0.0335)/1 × 10–7 = 7.16 × 10–8 mol L–1  One school of thought is that [ ] means concentration in mol L–1 so units not essential here. |