**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 presentThen *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) tonnesOR 718 tonnes of H2O, so 39889 mol. Thus 39889 mol H2 = 80 (79.8) tonnes and 19944mol O2 = 638 tonnesMass of oxygen = 6.14 × 105 kg or 6.14 × 108 gVolume = 6.14 × 108/1.141 = 5.38x108 cm3 (1 m3 = 1 × 106 cm3)= 5.38 × 102 m3Mass of hydrogen = 1.04 × 108 g Volume = 1.04 × 108/0.0708 = 1.47 × 109= 1.47 × 103 m3Total volume = 1.47 × 103 + 0.538 × 103 m3 = 2008 m310Al(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–116% of 450 tonnes = 72 tonnes 7.2 × 107 g*n*(Al) = 7.2 × 107/27.0 = 2.67 × 106 mol10 mol releases 9769 kJ of energySo 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 andCompleting 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 correctPart B correctPart 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 errorPart 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~~~~–~~ ⎯→ 2H2OH3AsO3  + H2O2 ⎯→ H3AsO4 + H2OAs 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 themselvesAs 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 H3AsO4The 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 acidAsO*x*3–(aq) + H3O+ eq arrow.eps HAsO*x*2–(aq) + H2OThe 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 observationsPart B correctPart 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 acceptablePart 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 ⎯→ Al2O30.70% of 46.0 g Al = 0.322 g (assuming 0.70% by mass)n(Al) = 0.322/27 mol = 0.0119 molAl ⎯→ Al3+ + 3e*n*(electrons) = 3 x 0.0119 mol  = 0.0358 mol Which is equal to 0.0358 F or3452 C3452 = 0.850 x tt = 3452/0.850 = 4061 secondsor 1.13 hours (67.68 min) |

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| **Part C** | HOCl will disproportionate2HOCl + 2H+ + 2e– ⎯→ Cl2 + 2H2O Eo = +1.63VHOCl + 2H2O ⎯→ ClO3– + 5H+ + 4e– Eo = -1.43V5HOCl + ⎯→ 2Cl2 + 2H2O + H+ + ClO3– Eo = +0.20VIodine would be involved in comproportionationIO3– + 6H+ + 6e– ⎯→ I–  + 3H2O Eo = +1.20V2I–  ⎯→ I2 + 2e– Eo = -0.54VIO3– + 6H+ + 5I–  ⎯→ 3I2 + 3H2O Eo = +0.66VAnd so will sulfurSO2 + 4H+ + 4e– ⎯→ S + 2H2O Eo = +0.50VH2S ⎯→ S + 2H+ + 2e– Eo = -0.17VSO2 + 2H2S ⎯→ 3S + 2H2O Eo = +0.33V |  |
| **FOUR****Part A** |

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| 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 acceptablePart 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 acceptablePart 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 acceptablePart 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–1ORIf 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–1The 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 molThe 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–]initiallet [OH–] = *x**x*2 = 3.39 × 10–7 × 0.0333 = 1.13 × 10–8*x* = [OH–] = 1.06 × 10–4 mol L-1pOH = 3.97pH = 14 – 3.97 = 10.03As [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) correctPart 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 errorsContinued next page |

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| **FIVE****Part B****(a)** | For a pH = 7 the reaction predominantly involved isH2PO4– + 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 = 0.6166Assume all the H3PO4 is converted to H2PO4–. Then initial *n*H2PO4– = 0.100 molIf *n*HPO42– = *x* molAt 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 molvol NaOH required = 0.138/1 = 0.138 L = 138 mLTotal 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) correctPart 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 answersPart 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–1One school of thought is that [ ] means concentration in mol L–1 so units not essential here. |