**Section A**

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| **A1.** | (a) | 2Al + 3H2SO4 🡪 Al2(SO4)3 + 3H22Tl + H2SO4 🡪 Tl2SO4 + H2M1: H2 produced in both equationsM2: correct salt in either equationM3: two correct equations |
|  | (b) | M4: Al +3 and Tl + 1M5: due to inert pair effect in Tl[5] |
| **A2.** | (a) | M1: SiCl4 has 3d orbitalsM2: which can accept an electron pair from waterM3: CCl4 has no empty orbitals of low energy |
|  | (b) | M4: SiCl4 + H2O 🡪 SiO2 + 4HClM5: White fumes[5] |
| **A3.** | (a) | M1: N≡NM2:  | (b) | M3: N favours triple bonds but P favours single bondsM4: good p-orbital overlap possible with N but not with PM5: N-N single bond weak due to repulsion between p-orbitals[5] |
| **A4.** | SO42- | SO32- | S2O32- | S4O62- | S2O72- | S2O82- |
|  | +6 | +4 | +2 | +2.5 | +6 | +6 |
|  |  |  |  |  |  |  |
|  | Any three anions with corresponding ON and structure (ignore 3D shape)M1: any 2 correct, M2: any 4 correct, M3: any 6 correct, M4: any 8 correct, M5: all 9 correct (no errors)All marks must come from max three oxoanions[5] |
| **A5.** | (a) | M1: It forms a + 1 cation in aqueous solution/ can exist in +1 oxidation stateM2: It has one electron in its outer shell |
|  | (b) | M3, M4, M5: it is not a metal, it is much less electropositive than the other alkali metals, it cannot form +1 ions in the solid state, it can also exist as a -1 ion/oxidation number (max 3, 1 mark for each) [5] |

# Section B

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| **B1.** | (a) | M1, M2: saucepans, aircraft, overhead power lines, furniture, food cans (any two sensible suggestions)M3, M4: low density, strong, resistant to corrosion (any 2)(4) |
|  | (b) | (i) | M1: Al2O3 + 2NaOH + 3H2O 🡪 2NaAl(OH)4 or suitable alternative equationM2: NaAl(OH)4(aq) 🡪 Al(OH)3(s) + NaOH(aq) or suitable seeding equationM3: 2Al(OH)3(s) 🡪 Al2O3(s) + 3H2O(g)M4: idea that Al2O3 dissolves in first equation (can be shown from state symbols)M5: idea that Al(OH)3 is crystallised/seeded in second equation (can be shown from state symbols)M6: heat needed for third equation or cooling needed for second equation |
|  |  | (ii) | M7: amphoteric |
|  |  | (iii) | M8: energy or electricity (8) |
|  | (c) | M1: B2O3 is covalent or not ionicM2: reference to reduction of BCl3 or B2O3 with hydrogenM3: 2BCl3 + 3H2 🡪 2B + 6HCl or B2O3 + 3H2 🡪 2B + 3H2O(3) |
|  | (d) | (i) |   | M1: BF3 monomerM2: Al2Cl6 dimerM3: dative π-bond from F to BM4: evidence of resonance in BF3M5: two dative σ-bonds from Cl to Al on adjacent monomer (M1 – M5) can all be awarded from diagram only)  |
|  |  | (ii) | Good p-orbital overlap possible between B-F (ORA)Due to small size of atoms (ORA)(7) |
|  | (e) | M1: Both contain H- or H in -1 oxidation numberM2: H can be oxidisedM3: lone pair on H- attracted to/can attack nucleophiles(3)Total 25 marks |

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| **B2.** | (a) | (i)  | M1: Diamond sp3 or tetrahedral and graphite sp2 or planarM2, M3: both giant covalent or macromolecular, graphite forms layers, graphite layers held together by Van der Waal’s forces, but diamond 3D macromolecular (any 3 = 2, any 2 = 1)M4, M5: one electron per atom in graphite delocalised, due to p-orbital overlap, but no electrons in diamond delocalised (any 3 = 2, any 2 = 1)any of above marks available from suitable diagrams |
|  |  | (ii) | M6: Si atoms largerM7: so good p-orbital overlap not possible(7) |
|  | (b) | (i) | M1: CO2 simple molecular and SiO2 macromolecular/giant covalentM2: CO2 linear (or sp) and SiO2 tetrahedral (or sp3) M3: weak Van der Waal’s forces need to be broken to melt CO2M4: strong covalent bonds need to be broken to melt SiO2 |
|  |  | (ii)  | M5: Si and O different in size (ORA)M6: so good p-orbital overlap not possible (ORA) |
|  |  | (iii) | M7: CO stabilised by extra π-bond between C and OM8: Si and O different in size (ORA) so good p-orbital overlap not possible (ORA) (8) |
|  | (c) | (i) | M1: PbO2 + 4HCl 🡪 PbCl2 + Cl2 + 2H2OM2: SnO2 + 4HCl 🡪 SnCl4 + 2H2O |
|  |  | (ii) | M3: redox reaction with PbO2M4: acid-base reaction with SnO2 |
|  |  | (iii) | M5: PbO2 is an oxidising agent (ORA)M6: Because Pb (II) is more stable than Pb (IV) (ORA)M7: Due to inert paid effect(7) |
|  | (d) | M1: PbO2 + H2SO4 + 2H+ + 2e- 🡪 PbSO4 + 2H2OM2: Pb + H2SO4 🡪 PbSO4 + 2H+ + 2e (M4)M3: both equations form +2, suggesting that +2 is the most stable oxidation state of Pb(3)Total 25 marks |

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| **B3.** | (a) | M1: P can promote an electron from 3p into 3dM2: to increase its valency to 5M3: N has no available d-orbitals(3) |
|  | (b) | (i) |  | M1: P4O6M2: all bonds correct on diagram (ignore shape)M3: P4O10M4: all bonds correct on diagram (ignore shape) |
|  |  | (ii) | N2O | NO | NO2 | N2O4 | N2O5 |
|  |  |  | (either) |  |  |  |  |
|  |  |  | M5, M6: two correct molecular formulae (1 mark for each)M7, M8: two correct structures (1 mark for each, ignore shape)M5 – M8 must come from two structures only |
|  |  | (iii) | M9: P and O cannot form good p-orbital overlap (ORA)M10: due to difference in size (ORA) |
|  |  | (iv) | M11: N and O cannot easily form their desired valenciesM12: without forming N-O-N single bonds which are very weakM13: no single oxide significantly more stable than any other(max 2)(12) |
|  | (b) | (i) | M1: correctly identifies anomalous electron affinity and X-X bond enthalpy of Fgeneral decrease in first electron affinity down group:M2 and M3: due to more shells, more shielding, weaker attraction between electron and nucleus (any 2, 1 mark for each)Low first electron affinity for F:M4 and M5: F is small atom, so large repulsion between p-electrons, so easy to add electron (any 2, 1 mark for each)Decrease in H-X or X-X bond enthalpy down group:M6 and M7: larger atoms, greater distance/ more shielding between nuclei and bonding electrons, less attraction between nuclei and bonding electronsLow bond dissociation enthalpy for F-F:M8: repulsion between p-orbitals on adjacent atoms |
|  |  | (ii) | M9: H-F bond much stronger than H-Cl bond (ORA)M10: hetrolytic fission or dissociation into H+ and X- less likely (ORA)(10)Total 25 marks |