**Section A**

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| **A1.** | (a) | 2Al + 3H2SO4 🡪 Al2(SO4)3 + 3H2  2Tl + H2SO4 🡪 Tl2SO4 + H2  M1: H2 produced in both equations  M2: correct salt in either equation  M3: two correct equations | | | | | | | |
|  | (b) | M4: Al +3 and Tl + 1  M5: due to inert pair effect in Tl  [5] | | | | | | | |
| **A2.** | (a) | M1: SiCl4 has 3d orbitals  M2: which can accept an electron pair from water  M3: CCl4 has no empty orbitals of low energy | | | | | | | |
|  | (b) | M4: SiCl4 + H2O 🡪 SiO2 + 4HCl  M5: White fumes  [5] | | | | | | | |
| **A3.** | (a) | M1: N≡N  M2: | | (b) | M3: N favours triple bonds but P favours single bonds  M4: good p-orbital overlap possible with N but not with P  M5: 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 state  M2: 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 equation  M2: NaAl(OH)4(aq) 🡪 Al(OH)3(s) + NaOH(aq) or suitable seeding equation  M3: 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 ionic  M2: reference to reduction of BCl3 or B2O3 with hydrogen  M3: 2BCl3 + 3H2 🡪 2B + 6HCl or B2O3 + 3H2 🡪 2B + 3H2O  (3) | | |
|  | (d) | (i) |  | M1: BF3 monomer  M2: Al2Cl6 dimer  M3: dative π-bond from F to B  M4: evidence of resonance in BF3  M5: 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 number  M2: H can be oxidised  M3: 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 planar  M2, 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 larger  M7: so good p-orbital overlap not possible  (7) |
|  | (b) | (i) | M1: CO2 simple molecular and SiO2 macromolecular/giant covalent  M2: CO2 linear (or sp) and SiO2 tetrahedral (or sp3)  M3: weak Van der Waal’s forces need to be broken to melt CO2  M4: 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 O  M8: Si and O different in size (ORA) so good p-orbital overlap not possible (ORA)  (8) |
|  | (c) | (i) | M1: PbO2 + 4HCl 🡪 PbCl2 + Cl2 + 2H2O  M2: SnO2 + 4HCl 🡪 SnCl4 + 2H2O |
|  |  | (ii) | M3: redox reaction with PbO2  M4: 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 + 2H2O  M2: 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 3d  M2: to increase its valency to 5  M3: N has no available d-orbitals  (3) | | | | | | |
|  | (b) | (i) |  | | | M1: P4O6  M2: all bonds correct on diagram (ignore shape)  M3: P4O10  M4: 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 valencies  M12: without forming N-O-N single bonds which are very weak  M13: 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 F  general 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 electrons  Low 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 | | | | | |