# Section A

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| **A1.** | (a) | M1: Be more electronegative than MgM2: Difference in electronegativity between Mg and Cl larger than difference in electronegativity between Be and ClM3: larger difference in electronegativity means more ionic |
|  | (b) | M4: Cl- more polarizable than F-M5: because it is largerM6: Cl- is polarised to form a covalent bond more than F-[max 5] |
| **A2.** | (a) | M1: decreasesM2: larger cationic sizeM3: weaker attraction between cations and delocalised electrons or weaker metallic bonding |
|  | (b) | M4: increasesM5: more electrons per molecule or larger surface area per moleculeM6: more/stronger Van der Waal’s forces[max 5] |
| **A3.** | (a) | M1: 2Na + 2H2O 🡪 2NaOH + H2M2: Mg + H2O 🡪 MgO + H2M3: Na: room temperature or cold water (can get mark from H2O(l) or NaOH(aq) in equation) AND Mg: above 100 oC or steam (can get mark from H2O(g) in equation) |
|  | (b) | M4: Mg smaller or higher nuclear charge or needs to lose 2 electrons (ORA)M5: Electrons more easily lost in Na or lower ionisation energy in Na or weaker metallic bonding in NaM6: MgO or Mg(OH)2 insoluble[max 5] |
| **A4.** | (a) | M1: No reaction when bromine added to sodium chlorideM2: Solution darkens or yellow/brown colour when bromine added to sodium iodide |
|  | (b) | M3: Br2 + 2I- 🡪 2Br- + I2M4: Bromine weaker oxidising agent than chlorine or bromide stronger reducing agent than chloride (ORA)M5: Iodine weaker oxidising agent than bromine or iodide stronger reducing agent than bromide (ORA)[5] |
| **A5.** | (a) | M1: Cr: 1s22s22p63s23p64s13d5M2: Cr2+: 1s22s22p63s23p63d4M3 Cr3+: 1s22s22p63s23p63d3 |
|  | (b) | M4: Number of d-electrons lost can varyM5: Energy required to remove d electronsM6: Is sometimes recovered in bonding[max 5] |

# Section B

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| **B1.** | (a) | M1: Li2OM2: Na2O2M3: 4Li + O2 🡪 2Li2O and 2Na + O2 🡪 Na2O2M4: Na2O2 is a peroxide or O has ON of -1 or ion is O22-M5: O has ON of -2 or ion is O2- in Li2O |
|  | (b) | M1: Li3NM2: 6Li + N2 🡪 2Li3NM3: sodium does not react with nitrogen |
|  | (c) | M1: Be2CM2: CaC2M3: 2Be + C 🡪 Be2C and Ca + 2C 🡪 CaC2M4: Be2C is a methanide or C has ON of -4 or ion is C4-M5: CaC2 is an ethanide/acetylide/percarbide or C has ON of -1 or ion is C22- |
|  | (d) | M1: BeO is amphoteric or reacts with alkalisM2: CaO is basic or does not react with alkalisM3: BeO + 2NaOH 🡪 Na2BeO2 + H2O or BeO + 2NaOH 🡪 Na2Be(OH)4 + H2O or ionic equation for either or any balanced equation to produce a 4-coordinate oxoanion or hydroxoanion of Be |
|  | (e) | (i) | M1: other ions have lower charge densityM2: so do not form complex ions or do not form coordinate/dative covalent bonds with ligands/water |
|  |  | (ii) | M3: other ions have empty d-orbitals of low energyM4: which can accept lone pairs/form coordinate or dative bonds with ligands/waterM5: to form [M(H2O)6]2+ (accept any suitable example) |
|  | (f) | M1: small size or high charge density compared to other ions in groupM2: so stabilise smaller anions or have higher polarising power[25] |
| **B2.** | (a) | M1: Add dilute nitric acid or HNO3(aq)M2: followed by silver nitrate solution or AgNO3(aq)M3: Cl- ions give white precipitateM4: Ag+(aq) + Cl-(aq) 🡪 AgCl(s)M5: Br- ions give cream precipitateM6: Ag+(aq) + Br-(aq) 🡪 AgBr(s)M7: Cl- ions give white precipitateM8: Ag+(aq) + I-(aq) 🡪 AgI(s)(penalise lack of state symbols only once across M4, M6 and M8) |
|  | (b) | (i)  | M1: Reducing power increasesM2: Ions become larger or more shells or more shieldingM3: Electrons less strongly held or easier to remove |
|  |  | (ii) | M4: +6 |
|  |  | (ii) | M5: H2SO4 + Cl- 🡪 HSO4- + HCl or H2SO4 + 2Cl- 🡪 SO42- + 2HClM6: +6 |
|  |  | (iii) | H2SO4 + 2H+ + 2Br- 🡪 SO2 + Br2 + 2H2OM7: SO2 and Br2 formed; M8: all other species correct and balanced equationM9: +4 |
|  |  | (iv) | H2SO4 + 6H+ + 6I- 🡪 S + 3I2 + 4H2O or H2SO4 + 8H+ + 8I- 🡪 H2S + 4I2 + 4H2OM10: S or H2S and I2 formed; M11: all other species correct and balanced equationM12: 0 (if S formed in equation), -2 (if H2S formed in equation) |

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|  | (c) | (i) | M1: both species negativeM2: so they repel |
|  |  | (ii)  | M3: S2O82- + 2Fe2+ 🡪 2SO42- + 2Fe3+M4: 2Fe3+ + 2I- 🡪 2Fe2+ + I2 |
|  |  | (iii) | M5: ability to form more than one stable oxidation state or ability to vary oxidation state[25] |
| **B3.** | (a) | M1: Fe3+: 1s22s22p63s23p63d5 or [Ar]3d5M2: Zn2+: 1s22s22p63s23p63d10 or [Ar]3d10 |
|  | (b) | (i) |  | M1: [Zn(H2O)6]2+M2: clearly octahedralM3: coordination number = 6 |
|  |  | (ii) |  | M4: [FeCl4]-M5: clearly tetrahedralM6: coordination number = 4 |
|  |  | (iii) |  | M7: [Fe(H2NCH2CH2NH2)3]3+M8: at least one isomer clearly octahedralM9: at least one bidentate ligand clearly attachedM10: two mirror images correctly drawnM11: both structures clearly octahedral showing three bidentate ligands each.M12: optical isomerism |
|  |  | M13: majority of ligands shown as dative bonds between O and Zn, Cl and Fe or N and Fe |
|  | (c) | M1: increase in entropy when multidentate complex ions are formedM2: is greater than when monodentate complex ions are formed |
|  | (d) | M1, M2, M3: Ligands split d-orbitals, d-electrons can absorb light, jump from low energy d-orbitals to high energy d-orbitals, resulting light is coloured (max 3)M4: Fe3+ has partially filled d-orbitals so transition is possibleM5: Zn2+ has completely filled d-orbitals so transition is not possible |
|  | (e) | M1: reference to hydrated complex ionsM2: reference to high polarising power of cationsM3: pulls electron density away from H atoms in H2OM4: which can be lost or can dissociate to make H+ ionsM5: this happens more in Fe3+ than Zn2+ (ORA)M6: because charge is higher and so charge density is higher(max 5)(5)Max 25 marks |