# Section A

|  |  |  |
| --- | --- | --- |
| **A1.** | (a) | M1: Be more electronegative than Mg  M2: Difference in electronegativity between Mg and Cl larger than difference in electronegativity between Be and Cl  M3: larger difference in electronegativity means more ionic |
|  | (b) | M4: Cl- more polarizable than F-  M5: because it is larger  M6: Cl- is polarised to form a covalent bond more than F-  [max 5] |
| **A2.** | (a) | M1: decreases  M2: larger cationic size  M3: weaker attraction between cations and delocalised electrons or weaker metallic bonding |
|  | (b) | M4: increases  M5: more electrons per molecule or larger surface area per molecule  M6: more/stronger Van der Waal’s forces  [max 5] |
| **A3.** | (a) | M1: 2Na + 2H2O 🡪 2NaOH + H2  M2: Mg + H2O 🡪 MgO + H2  M3: 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 Na  M6: MgO or Mg(OH)2 insoluble  [max 5] |
| **A4.** | (a) | M1: No reaction when bromine added to sodium chloride  M2: Solution darkens or yellow/brown colour when bromine added to sodium iodide |
|  | (b) | M3: Br2 + 2I- 🡪 2Br- + I2  M4: 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: 1s22s22p63s23p64s13d5  M2: Cr2+: 1s22s22p63s23p63d4  M3 Cr3+: 1s22s22p63s23p63d3 |
|  | (b) | M4: Number of d-electrons lost can vary  M5: Energy required to remove d electrons  M6: Is sometimes recovered in bonding  [max 5] |

# Section B

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **B1.** | (a) | M1: Li2O  M2: Na2O2  M3: 4Li + O2 🡪 2Li2O and 2Na + O2 🡪 Na2O2  M4: 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: Li3N  M2: 6Li + N2 🡪 2Li3N  M3: sodium does not react with nitrogen | | |
|  | (c) | M1: Be2C  M2: CaC2  M3: 2Be + C 🡪 Be2C and Ca + 2C 🡪 CaC2  M4: 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 alkalis  M2: CaO is basic or does not react with alkalis  M3: 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 density  M2: 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 energy  M4: which can accept lone pairs/form coordinate or dative bonds with ligands/water  M5: to form [M(H2O)6]2+ (accept any suitable example) |
|  | (f) | M1: small size or high charge density compared to other ions in group  M2: 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 precipitate  M4: Ag+(aq) + Cl-(aq) 🡪 AgCl(s)  M5: Br- ions give cream precipitate  M6: Ag+(aq) + Br-(aq) 🡪 AgBr(s)  M7: Cl- ions give white precipitate  M8: Ag+(aq) + I-(aq) 🡪 AgI(s)  (penalise lack of state symbols only once across M4, M6 and M8) | | |
|  | (b) | (i) | M1: Reducing power increases  M2: Ions become larger or more shells or more shielding  M3: Electrons less strongly held or easier to remove | |
|  |  | (ii) | M4: +6 | |
|  |  | (ii) | M5: H2SO4 + Cl- 🡪 HSO4- + HCl or H2SO4 + 2Cl- 🡪 SO42- + 2HCl  M6: +6 | |
|  |  | (iii) | H2SO4 + 2H+ + 2Br- 🡪 SO2 + Br2 + 2H2O  M7: SO2 and Br2 formed; M8: all other species correct and balanced equation  M9: +4 | |
|  |  | (iv) | H2SO4 + 6H+ + 6I- 🡪 S + 3I2 + 4H2O or H2SO4 + 8H+ + 8I- 🡪 H2S + 4I2 + 4H2O  M10: S or H2S and I2 formed; M11: all other species correct and balanced equation  M12: 0 (if S formed in equation), -2 (if H2S formed in equation) | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | (c) | (i) | | M1: both species negative  M2: 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]3d5  M2: Zn2+: 1s22s22p63s23p63d10 or [Ar]3d10 | | | | |
|  | (b) | (i) |  | | M1: [Zn(H2O)6]2+  M2: clearly octahedral  M3: coordination number = 6 | |
|  |  | (ii) |  | | M4: [FeCl4]-  M5: clearly tetrahedral  M6: coordination number = 4 | |
|  |  | (iii) |  | | M7: [Fe(H2NCH2CH2NH2)3]3+  M8: at least one isomer clearly octahedral  M9: at least one bidentate ligand clearly attached  M10: two mirror images correctly drawn  M11: 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 formed  M2: 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 possible  M5: Zn2+ has completely filled d-orbitals so transition is not possible | | | | |
|  | (e) | M1: reference to hydrated complex ions  M2: reference to high polarising power of cations  M3: pulls electron density away from H atoms in H2O  M4: which can be lost or can dissociate to make H+ ions  M5: 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 | | | | |