(iii) Sulphur exists as S_8 molecule while phosphorus as P_4 molecule thus; the strength of the van der waal force is stronger in sulphur than in phosphorus.

(f). It changes from ionic in the oxide of Na Mg, intermediate ionic-covalent in Al to covalent in the rest as electronegativity increases across the period.

(g). (i) $Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$

(ii) $SiCl_{4(l)} + 4H_2O_{(l)} \longrightarrow SiO_2.2H_2O + 4HCl_{(aq)}$

SET 6 : SECTION B (CGCEB 2014)

Inorganic (Mineral) Chemistry

4. (a) (i) metal which forms at least one stable ion or compound with a partially filled d-subshell.

(ii) d-d electron transitions

(iii) $CuSO_4.5H_2O$, *Blue*

MnO_4^-, *Purple*

$Cr_2O_7^{2-}$, *Orange*

CuO, Black etc.

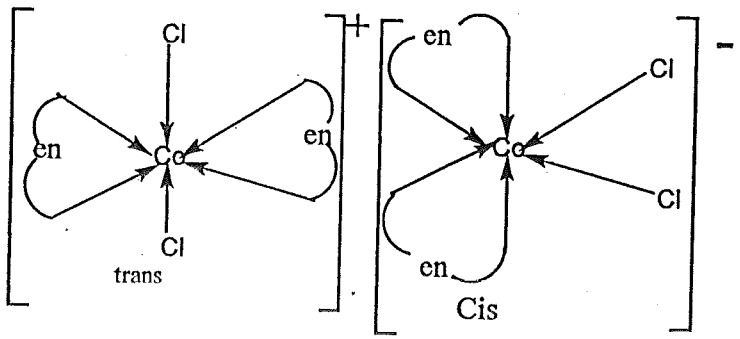
(b) (i) The elements are small and highly charge with an available low laying empty d-orbital for dative covalent bond formation.

(ii) ~~tetraamminedibro~~mochromium(III) chloride.

(iii) A white precipitate of AgCl is observed since the chloride ion is outside the coordination sphere.

(c) (i) Each molecule of the ligand forms two coordinate bonds with the centre metal ion using two donor atoms.

(ii)



(d) (i)

(ii) The 3d and the 4s electrons are similar in energy and can be used in bonding.

(iii) The Haber process

$$N_{2(g)} + 3H_{2(g)} \underset{450^oC\text{-}500^oC}{\overset{Fe}{\rightleftharpoons}} 2NH_{3(g)}$$

250 atm

(e) (i) $Cl_2 + H_2O_{(l)} \longrightarrow HCl_{(aq)} + HClO_{(aq)}$

(ii)

$3Cl_2 + 6OH^-_{(aq)} \rightarrow 5Cl^-_{(aq)} + ClO^-_{3(aq)} + H_2O_{(l)}$

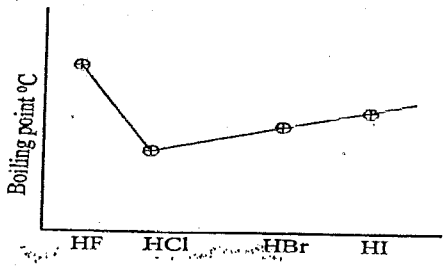
(f) (i)

$H_2SO_{4(aq)} + 2NaCl_{(s)} \xrightarrow[\Delta]{} Na_2SO_{4(aq)} + 2HCl_{(g)}$

$PBr_{3(s)} + 3H_2O_{(l)} \rightarrow H_3PO_{3(aq)} + 3HBr_{(g)}$

Or $H_3PO_{4(aq)} + NaBr_{(s)} \rightarrow NaH_2PO_{3(aq)} + HBr$

(ii)



(iii) The boiling point of HF is higher than those of HCl, HBr, HI because of the presence of H-bond existing between the molecules. The increase from HCl to HI is due to an increase in the strength of the van der waal forces which increases with an increase in molar weight.

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5. (a) (i) The purple colouration is as a result of Al^{3+} or Ca^{2+}, K^+, Li^+

(ii) White precipitate which is soluble in excess NaOH indicates the presence of an amphoteric compound. Therefore, Al^{3+} or Pb^{2+} is present forming a complex with excess sodium hydroxide. e.g. $[Al(OH)_4]^-$

(iii) A white precipitate which is insoluble in excess ammonia shows the absence of Pb^{2+} since aqueous ammonia will not form a complex with aluminium but it forms a complex with zinc and lead. $Al^{3+} + 3OH^- \rightarrow Al(OH)_3$

(iv) A white precipitate $BaCl_2$which is insoluble in HCl in indicate the presence of a sulphate and the absence of Sulphite and nitrites.

$Ba^{2+} + SO_4{}^{2-} \rightarrow BaSO_4$

Thus Y is $Al_2(SO_4)_3$

(b) (i) Increase in metallic strength in magnesium because each atom donates an extra electron into the sea of delocalised electrons.

(ii) Si has a giant covalent (molecular) structure; thus strong covalent bond has to be broken

(iii) Sulphur exist as an S_8 molecule while phosphorus as P_4 molecule; thus the strength of the van der waal force is stronger in sulphur than in phosphorus.

(c) (i) Chlorine (Cl_2)

(ii) Silicon (Si)

(d) (i) sodium and chlorine or magnesium and sulphur

(ii) Phosphorus and chlorine or Aluminium and chlorine

(e) (i) $PbCl_2$ and $SnCl_2$

(ii) CCl_4 and $SiCl_4$

(f) (i) $SiCl_{4(aq)} + 2H_2O_{(l)} \rightarrow SiO_{2(s)} + HCl_{(aq)}$

(ii) $CCl_{4(aq)} + H_2O_{(l)} \rightarrow$ no hydrolysis

CCl_4 does not hydrolyze in water because carbon lacks available low laying d-orbital to accept lone pairs of electrons from water for dative bond formation while Si has. OR The Si-Cl is longer and weaker the C-Cl bond length which is shorter and stronger. This makes the chlorine atoms to crowd around the carbon atoms preventing attact by water molecules

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6. (a) (i) Change in ligand, change in the oxidation state of the central metal ion and change coordination in number of the ligand around the metal.

(ii) (A) change in the ligand around the metal ion

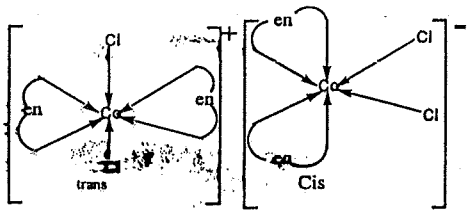
(B) Change in coordination number.

(b) Ethylenediamminetetraacetate (EDTA)

(c) (i) $[Cr(H_2O)_6]_2(SO_4)_3$

(ii) $[Co(en)_2(Cl_2)]Cl$

(d)



(e) (i) Copper is a good conductor of electricity because it is made up of metallic bond containing free mobile electrons while silicon dioxide is made up of giant covalent structure with strong covalent bonds holding the electrons

(ii) SiO_2 has a giant covalent structure with strong covalent bond which has to be broken before the substance is melted but Cu has metallic bonds which are not as strong as covalent bonds.

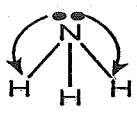
(iii) SiO_2 is a poor conductor of heat and electricity (insulator) because of its high melting point and high resistant.

(f) (i) $2Cl^- \rightarrow Cl_2 + 2e^-$

$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + H_2O$

(g) (i) Valence shell electron pair repulsion theory (VSEPR)

(ii)



(iii) The lone pairs of electrons on nitrogen repairs the bonded pairs as far apart more than the way the bonded pair repel each other. Thus the bond angle drops from 109.5° to 107°

(iv) This is because of the great difference in electronegativity between the nitrogen and the hydrogen atoms, the bonded pair of electrons are pull more toward the nitrogen atom creating asymmetrical molecule.

SET 7 : SECTION B (CGCEB 2015)

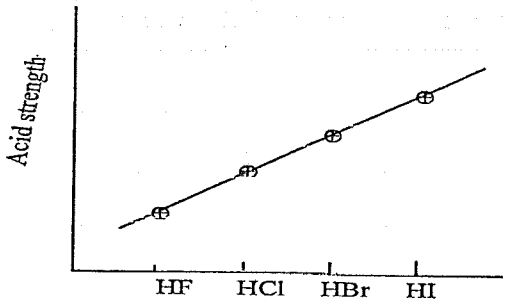
Inorganic (Mineral) Chemistry

3. (a) (i) (A) Fluorine cannot expand it octate to accommodate other electrons. OR fluorine lacks available d-orbital required for octet expansion.

B Chlorine has available empty d-orbital to accommodate lone pair of electrons hence it can expand its octet

(ii). $HClO_3$

(b). (i)



(iii). Bond length become longer and weaker from HF to HI hence easc ionization.

(c). (i) $Cl_{2(g)} + 2KOH_{(aq)} \rightarrow KCl_{(aq)} + KClO_{(aq)} + H_2O$

(ii). $3Cl_{2(g)} + 6KOH_{(aq)} \rightarrow 5KCl_{(aq)} + KClO_{3(aq)} + 3H_2O$

(d).

Oxidation state	Formula of compound	Name of sulphur compound
±2	SCl_2 $Na_2S_2O_3$	Sulphur dichloride Sodium thiosulphate
+4	SO_2 SO_3^{2-}	Sulphur dioxide Sulphite
+6	H_2SO_4 SO_4^{2-} $H_2S_2O_7$	Sulphuric acid Sulphate oleum

(e). (i) oxidation

$S + O_{2(g)} \rightarrow SO_{2(g)}$

$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$

$Na_2S_2O_{3(aq)} + I_{2(aq)} \rightarrow 2I^-_{(aq)} + Na_2S_2O_{6(aq)}$

$H_2S + Cl_2 \rightarrow S + 2HCl$

(ii). Reduction

$Cu + 2H_2SO_{4(aq)} \rightarrow CuSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)}$

$Na_2SO_{3(aq)} + 2HCl_{(aq)} \rightarrow SO_{2(g)} + H_2O_{(l)} + 2NaCl$

(iii). Disproportionation

$Na_2S_2O_{3(aq)} + HCl \rightarrow S + SO_{2(g)} + H_2O + NaCl$

$H_2O + S_2Cl_2 \rightarrow S + SO_2 + HCl_{(aq)}$

(f). (i) A compromise temperature of 450°C to 500°C is needed. OR since the reaction is exothermic in the forward direction, decrease in temperature; will favour the production of SO_3. The reaction will be slow so a temperature of 450°C to 500°C is applied.

(ii). Sulphur trioxide is dissolved in concentrated sulphuric acid followed by calculated volume of water.

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

4. (a) (i)

element	Li	Be	B	C	N	O	F	Ne
Formula of hydride	LiH	BeH_2	BH_3, B_2H_6	CH_4	NH_3	H_2O	HF	

(ii). $H_2O + LiH \rightarrow LiOH + H_2$

$HF + H_2O \rightarrow H_2O^+ + F^-$

Explanation

LiH is ionic and reacts with water to form an alkaline solution while HF simple molecular and hydrolyses in water to form an acidic solution

(iii). Carbon lacks available empty d-orbital for octet expansion.

(b). d-block elements have their valence electrons filling in the inner d-sub-shell. E.g. Sc, Zn
Transition elements form at least one stable ion with a partially filled d-sub-shell. E.g. Ti, Cu, Ni, Mn, Co, V, Fe, Cr, etc

(c). The atomic radius decreases across the series from Sc to Cu due to increase in effective nuclear charge. The decrease is only slightly to Cu due to screening of s-electrons by completely filled d-subshell. Then increase to Zn.

(d). (i) Due to partially filled d-subshell which can lead to d-d-transition of electrons when the atom absorb light in the visible region of the electromagnetic spectrum.

(ii). Cupper has a fully filled d-subshell in some of its compounds thus there will be no empty orbital in the higher energy level for d-d transition of electrons to take place.

(e). (i)

Oxidation state	+2	+4	+6	+7
Formula of oxide of manganese	MnO	MnO_2	Mn_2O_6	Mn_2O_7 $KMnO_4$

(ii). All the $3d^5$ and $4s^2$ electrons are similar in energy and are used in bonding

(f). $S_2O^{2-}_{3(aq)} + 2I^-_{(aq)} \xrightarrow{Fe^{2+}_{(aq)}} 2SO^{2-}_{4(aq)} + I_{2(aq)}$

SET 8: SECTION B (CGCEB 2016)

Inorganic (Mineral) Chemistry

3. (a) (i) ns^2np^5

(ii) A Decrease down the group due to increase in the strength of van der waals forces

B Increase down the group due to increase in size (number of shells) down the group and screening effect

(b) (i) $2NaOH + Cl_{2(g)} \longrightarrow NaCl_{(aq)} + NaClO_{(aq)} + H_2O$

(ii) Disproportionation reaction

(C) (i)

conc $H_2SO_{4(aq)} + CaF_{2(s)} \longrightarrow 2HF_{(g)} + CaSO_{4(aq)}$

Conc $H_3PO_{4(l)} + NaI_{(s)} \longrightarrow HI_{(g)} + NaH_2PO_{4(aq)}$ OR

Conc $H_3PO_{4(l)} + 3NaI_{(s)} \longrightarrow 3HI_{(g)} + Na_3PO_{4(aq)}$

(ii) HI is more reducing than HF and therefore can easily be oxidized by conc H_2SO_4 to I_2 HF is least reducing and cannot be oxidized by conc H_2SO_4

(d) (i) Haber process

(ii) $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(l)}$

(iii) 700^0C–900^0C, Platinum-Rhodium catalyst

(iv) $4NO_{2(g)} + 2H_2O_{(l)} + O_{2(g)} \longrightarrow 4HNO_3$

(e) (i) pressure of 1 atmosphere is required because high pressure installations are too costly, hence not economical.

(ii) V_2O_5

(f) (i) $SO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2SO_{3(aq)}$

(ii) A: Fe^{3+} ion: the brownish colour of the Fe^{3+} solution is rapidly converted to pale green solution of Fe^{2+}

B: MnO_4^-: the purple solution of MnO_4^- is completely discharged (becomes colourless) (with no yellow precipitate formed)

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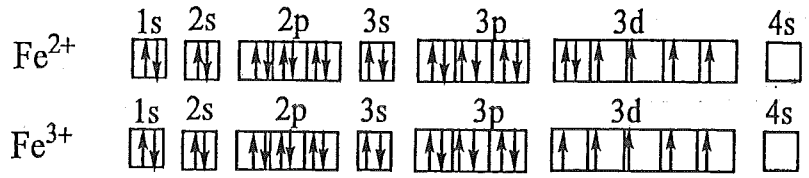
4. (a) (i) An element whose highest energy valence electrons enter the d-subshell

(ii) One that forms at least one stable ion or compound with a partially filled d-subshell

(b) (i)



(ii) Stability of half- filled subshell Fe^{3+}, due to the half-filled 3d sub-shell which gives the ion extra stability than the partially filled 3d sub-shell of Fe^{2+}

(c) (i) Increases slightly from Sc to Zn due to a slight increase in effective nuclear charge as electrons enter an inner 3d sub-shell

(ii) Decreases slightly from Sc to Cu and increase to Zn due to increase in effective nuclear charge and it is gradual because the electrons enter the inner d-subshell which are poor screeners. The increase from Cu to Zn is due to completely filled d-orbitals

(d) (i)

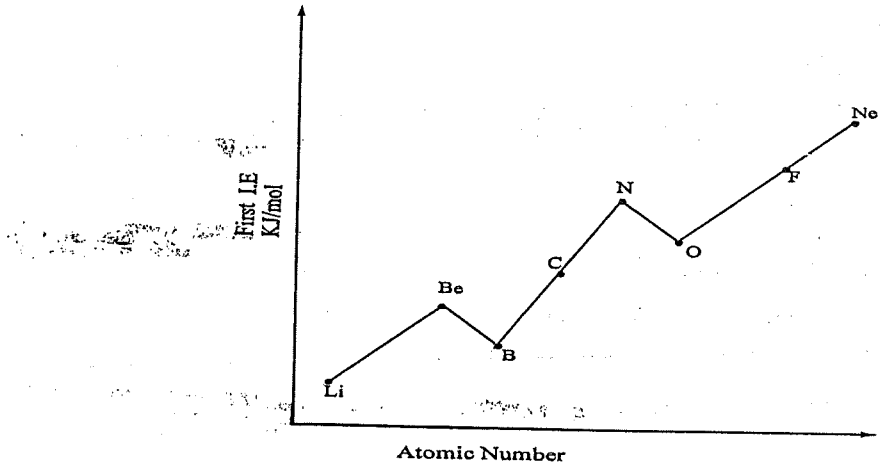
Elements	Li	Be	B	C	N	O	F	Ne
Formula of Oxide	Li_2O	BeO	B_2O_3	CO_2	NO_2	O_2	OF_2	

(ii) A: Li

B: N:

C: Be

(iii)



(iv) A: $B_2O_{(s)} + H_2O_{(l)} \longrightarrow$ No reaction

B: $B_2O_{3(s)} + 3H_2O_{(l)} \rightleftharpoons 2H_3BO_{3(aq)}$ (BORIC ACID)

SET 9: SECTION B (CGCEB 2017)

Inorganic (Mineral) Chemistry

3a (i) Regular variation in chemical and physical properties of elements across a period in the periodic table and from one period to another.

(ii) A: It reduces from Li to Ne

Explanation: Due to increase in effective nuclear attraction across the period.

B: It increases from Li to Ne

Explanation: Due to increase in effective nuclear attraction across the period.

b (i) NH_3

(ii) CH_4 or H_2O

(iii) HF

(c)A: Ability of an element to form chains and rings of identical atoms through covalent bonds leaving only the p-orbital electrons to take part in bonding.

B: Tendency of the pair of outer s-electrons to remain paired and not participates in bonding leaving only the p-orbital electrons to take part in bonding

(ii)A: $PbCl_2$

B: $SiCl_4$ or $GeCl_4$, $SnCl_4$, $PbCl_4$, $SiCl_2$, $GeCl_2$ or $SnCl_2$

d(i) The C-Cl bond length is short and strong but that of Pb-Cl is very long and weak, hence easily breaks upon heating.

Or down the group, the +2 oxidation state becomes more stable hence $PbCl_4$ readily decomposes to give the stable $PbCl_2$.

(ii) CO_2 exists in simple molecular structures and hence gaseous while SiO_2 exists in giant molecular structures and hence solid.

(e)A: - Sn and C both exhibit allotropy

- Both CO_2 and SnO_2 are stable to heat
- Both Sn and C form monoxides

B: - C catenates but Sn does not

- CO_2 is a gas while SnO_2 is a solid

f(i) $2NH_4Cl(s) + Ca(OH)_2(s) \longrightarrow CaCl_2(s) + 2NH_3(g) + 2H_2O(g)$ (1 *mk*)

Or hydrolysis of Li_3N

(ii) $NH_3 + HNO_3 \longrightarrow NH_4NO_3$ (1 mk)

(g) $2NO_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$ (1 mk)

Or $3HNO_2(aq) \longrightarrow HNO_3(aq) + 2NO_2(g) + H_2O(l)$

4a(i) Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu and Zn

(ii)A: Decreases gently(slightly)

B: Explanation: Due to slight increase in effective nuclear charge as electrons are added to an inner d-subshell

b(i) -Variable oxidation states

Or – Formation of coloured compounds

- Magnetic properties
- Catalytic activity

(ii)

Property	Example
- Variable oxidation states	Fe^{2+} and Fe^{3+}
- Formation of coloured compounds	Fe^{2+} is green and Fe^{3+} is brown

c(i)A: It increases

Explanation: Due to increase in effective nuclear charge

B: It decreases

Explanation: Due to increase in screening effect on valence electrons

d(i) Burn Mg in pure oxygen and MgO will be formed

Or the thermal decomposition of the NO_3^-, CO_3^{2-} or OH^- of Mg.

(ii) Heat Na in a stream of Cl_2 and NaCl will formed

$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$ (1 mk)

Or the neutralisation of NaOH and HCl then evaporation to dryness

e(i) Pale yellow(cream) precipitate of AgBr is formed which is insoluble in aqueous ammonia

(ii) Purple fumes of iodine are produced

(iii) Reddish brown (1 mk) solution of iodine is seen.

(iv) $Cl_2(aq) + 2KI(aq) \longrightarrow 2KCl(aq) + I_2(aq)$ (1 *mk*)

Difference: In (ii), iodine is gaseous while in (iii) it dissolves to form an aqueous solution

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SET 10: SECTION B (CGCEB 2018)

Inorganic (Mineral) Chemistry

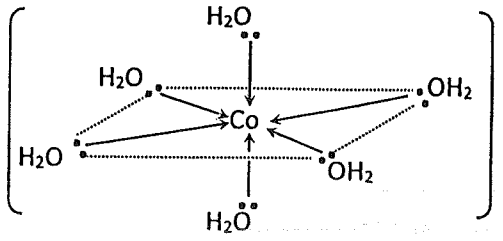
3. (a) (i) Zn, Zn forms only one ion (Zn^{2+}) with a completely filled d-sub shell.

(ii) A d-block element is an element whose last electron (highest energy electron) fills the d-sub shell while a transition metal is an element which forms at least one stable ion or compound with a partially filled d-sub shell.

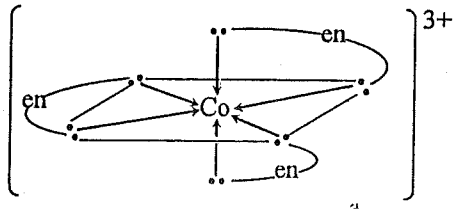
(iii) One or more ligands donate(s) two or more lone pairs of electrons into two or more empty orbitals in the valence shell of the transition metal ion or atom to form a complex.

(iv) Coordination number is the number of dative covalent(coordinate) bonds formed between ligand(s) and central metal ion or atom in a complex.

(v) Hexaaquacobalt(II) ion,



Trisethylenediaminecobalt(III) ion



Others include: Hexaamminecobalt(II) ion, Hexaaquacobalt(III) ion,

(b) (i) ns^2np^5.

(ii) +1, HOCl, NaOCl, ClF, Cl_2O.

+7, Cl_2O_7, $HClO_4$, $NaClO_4$.

(iii) $Cl_{2(g)} + H_2O_{(l)} = HCl(aq) + HOCl_{(aq)}$.

OR $Cl_{2(g)} + 2NaOH_{(aq)} \rightarrow NaCl(aq) + NaOCl_{(aq)} + H_2O_{(l)}$.

OR $6NaOH(aq) + 3Cl_{2(g)} \rightarrow 5NaCl_{(aq)} + NaClO_{3(aq)} + 3H_2O_{(l)}$.

OR $2NaOH(aq) + 2ClO_{2(g)} \rightarrow NaClO_{2(aq)} + NaClO_{3(aq)} + H_2O_{(l)}$.

OR $2NaOH(aq) + Cl_2O_{6(g)} \rightarrow NaClO_{3(aq)} + NaClO_{4(aq)} + H_2O_{(l)}$.

OR $H_2O_{(l)} + Cl_2O_{6(g)} \rightarrow HClO_{2(aq)} + HClO_{3(aq)}$.

OR $H_2O_{(l)} + ClO_{2(g)} \rightarrow HClO_{3(aq)} + HClO_{4(aq)}$.

OR $3OCl^-_{(g)} \rightarrow 2Cl^-_{(aq)} + ClO_3^-{}_{(aq)}$.

(iv) $HClO_4 > HClO_3 > HClO_2 > HClO$.

With each additional oxygen atom, the chlorine atom becomes effectively more electronegative due to electron withdrawal effects of the oxygen atoms. This makes the O – H bond more polarised and weakened, hence H^+ casily released.

(b) (i)

Oxidation state	Name	Formula
	Hydrogen sulphide	
+2		$S_2O_3^{2-}$
+6	Sulphuric acid or any sulphate	
+7		

$SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$.

$H_2S_2O_{7(g)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$.

4. (a) (i) Stronger metallic bonding in transition metals lattices than groups I and II metals since transition metals form smaller cations with more delocalised electrons than groups I and II metals.

Element	Flame colour
Sodium	Golden yellow flame or bright yellow flame
Calcium	Brick red flame