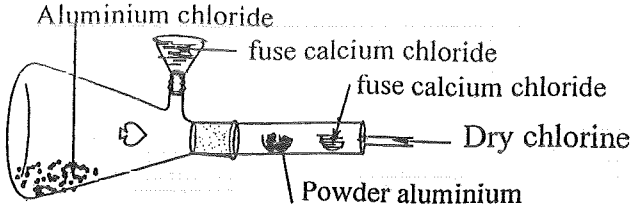
$Al_{(s)} + Cl_{2(g)} \rightarrow Al_3Cl_{6(s)}$



The aluminium trichloridc formed sublimes on heating when the aluminium trichloride is cooled, it dimerises to form aluminium hexachloride (Al_2Cl_6).

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6. (a) (i) Finely divided iron

(ii) To speed up the rate of the reaction. It provides a large surface through which reactants come to closc contact.

(iii) Whcn a system at equilibrium is subjected to change, the system turn to shift in a direction to minimise the change.

(iv) (A) A decrease in temperature increases the yield of ammonia OR increase in temperature decreases the yield of ammonia. Since the reaction is exothermic, a decrease temperature the reaction moves to the right to generate heat to raise the temperature.

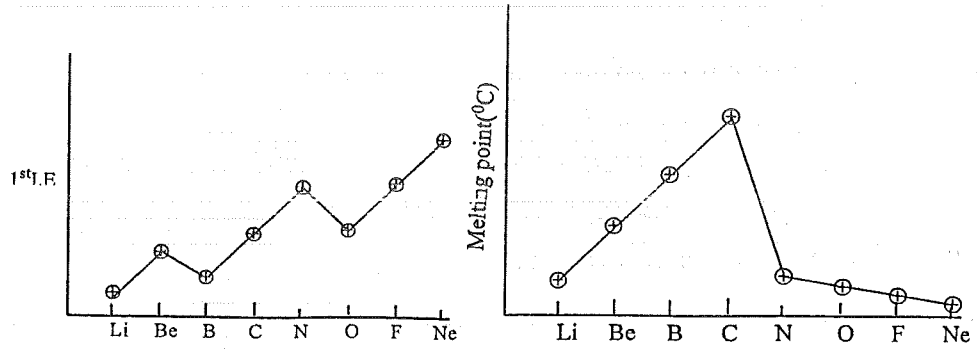
(B) Increase in pressure increases the yield of ammonia while decrease in pressure decreases the yield of ammonia OR Increase in pressure favours direction of less number of moles of gas, direction of yield of ammonia

(v) Use as fertilizers like ammonium phosphate to improve crop yield.

(b)

Oxidation state	Formula compound	Name
-3	NH_3	Ammonia
+3	HNO_2 or	Nitrous acid
	N_2O_3	Dinitogen trioxide
+4	NO_2 or	Nitrogen dioxide
	N_2O_4	Dinitrogen tetroxide
+5	HNO_3 or	Nitric acid
	N_2O_5	Dinitrogen pentoxide

(c) (i)



(d) (i) $BaCl_2$, (ii) $MgCl_2$

(ii) It decreases (less exothermic) down the group because of increase in cationic size.

(iv) $MgCl_2$

SET 3 : SECTION B CGCEB 2011

Inorganic (Mineral) Chemistry

4.(a) (i) The energy required to remove one mole of electrons from one mole of a gaseous atoms to give one mole of gaseous positive ions

(ii) $Mg_{(g)} \rightarrow Mg^{+}_{(g)} + e^{-}$

(iii) The first ionisation energy increases across the period due to increase in effective nuclear charge and decrease in atomic radius as electrons are added onto the same shell from the nucleus.

(iv)

	Na	Mg	Al	Si	P	Ar
ECF	$3s^1$	$3s^2$	$3s^23p$	$3s^23p^2$	$3s^23p^3$	$3s^23p^6$

(v) The first electron in Mg is removed from 3s orbital which is completely filled, more stable and closer to the nucleus while in Al, the first electron is removed from 3P orbital which is further from the nucleus, partially filled, less stable and shielded by the inner filled 3s electrons.

(b) (i) It decreases across the period

Due to increase in effective nuclear charge as the number of protons in the nucleus increases across while electrons enter the same shell from the nucleus.

(ii) Na^+, Mg^{2+} and Al^{3+}, P^{3-}, S^{2-} and Cl^-

(iii)

Element	Al	P
Oxidation state	+3	-3 or +5

(c) (i) Elements whose outer electrons enter the s-subshell.

(ii) It increases down the two groups and decreases between the two groups from group I to group II

(iii) (A) Increase in metallic bond strength

In group II because each atom donates two electrons into the sea of delocalisation while group I donates only one electron per atom

(B) The solvation (hydration) energy is increasing faster than the lattice energy in group I than in group II.

(d) (i)

$$Li_2CO_{3(s)} \xrightarrow[\Delta]{} Li_2O_{(s)} + CO_{2(g)}$$

$$MgCO_{3(s)} \xrightarrow[\Delta]{} MgO_{(s)} + CO_{2(g)}$$

(ii) Due to similarity in electronegativity, atomic and ionic radii.

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5. (a) (i)

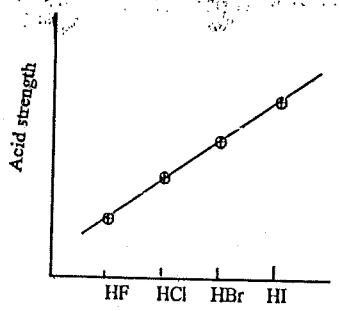
Halogen	Physical state	Colour
Fluorine	gas	Pale yellow
Chlorine	Gas	Greenish yellow
Bromine	liquid	Reddish brown
Iodine	Solid	Shiny black
astatine	Solid	Black

(ii) $HOCl: Cl + -2 + 1 = 0 \Rightarrow Cl = +1$

$HClO_3: Cl + -2(3) + 1 = 0 \Rightarrow Cl = +5$

(iii) $KI_{(aq)} + KIO_{3(aq)} + 6H^+_{(aq)} \longrightarrow I_{2(aq)} + 2K^+_{(aq)} + 3H_2O_{(l)}$

(iv)



(ii). Bond length become longer and weaker from HF to HI hence ease ionization.

(b) (i) $Na_2S_2O_3$

H_2SO_4

(ii) $I_{2(aq)} + 2S_2O^{2-}_{3(aq)} \longrightarrow S_2O^{2-}_{6(aq)} + 2I^-_{(aq)}$

oR $H_2SO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$

(iii) Reducing the temperature. This will increase the yield but the reaction will be too slow. A compromised temperature of 450°C to 500°C is used. i

- Increase the pressure
- Increase the concentration of SO_2 or removed SO_3 as it is formed

(c)

Nutrition	Amino acid
Agriculture	Ammonium sulphate Ammonium nitrate
Industry	Nitric acid

6. (a) (i) Transition metal is a metals which forms at least one stable ion or compound with a partially filled d-orbital. While a d-block element is an element whose valence electrons enter the inner d-subshell.

(ii) Scandium, zinc

(iii) They have variable oxidation state

- They form coloured compounds
- They form complex ions or compounds
- They have catalytic activity
- Some are paramagnetic or diamagnetic

(b) (i) Change in the oxidation state of the central metal ion

- Ligand exchange
- Change in the coordination number around the central metal ion

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

(B) Ligand exchange. H_2O is displaced by Cl^- ion.

(c) (i) It is ligand which can form a ring structure together with the central metal ion. Or can form many coordinate bonds with the central metal ion.

(ii) $[Cu(en)_2]^{2+}$ $[Cr(en)_2Cl_2]^+$ en = ethylenediamine

$Cu(EDTA)^{2-}$, $[Cr(EDTA)]^-$ EDTA=Ethylenediaminetetraacetate

(iii) (P) $CuSO_4.5H_2O$

(Q) $[Cu(H_2O)_6]^{2+}$

(R) $Cu(OH)_2$

(S) $[Cu(NH_3)_6]^{2+}$

(T) CuS

(U) $CuCO_3$

(d) (i) CO

(ii) SiO_2

(iii) $SnCl_2$ or $GeCl_2$

(iv) CCl_4

(e) (i)

$PbO_{2(s)} + 2OH^- \rightarrow PbO_3^{2-} + H_2O_{(l)}$

$PbO_{2(s)} + 4H^+ \rightarrow Pb^{+4} + 2H_2O_{(l)}$

SET 4 : SECTION B : CGCEB 2012

Inorganic (Mineral) Chemistry

4. (a) (i)

Element	Colour	Solid/liquid
Bromine	Reddish brown	Liquid
Iodine	Shiny black	Solid

(ii) Astatine black solid

(b) (i)

$IO^-_{3(aq)} + 5I^-_{(aq)} + 6H^+_{(aq)} \rightarrow 3H_2O_{(l)} + 3I_{2(aq)}$

(ii) Starch

(c) (A) No observation (no change)

(B) An orange (Or reddish brown) coloration is observed due to the displacement of bromine by chlorine

(d) HBr > HCl > HF

(e) Chlorofluorocarbons (CFC) cause the depletion of the ozone layer.

(f) (i) (A) ns^2np^2

(B) +4 and +2

(ii) The stability of the +4 oxidation state decreases down the group while that of the +2 increases due to inert pair effect

(e) (i)

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

$CCl_{4(l)} + 2H_2O_{(l)} \rightarrow$ ***no reaction***

(ii) $CCl_{4(l)}$ does not hydrolyses in water because carbon lacks available low lying d-orbital to accept lone pairs of electrons from water molecules for dative bond formation while Si has. OR *The Si-Cl is longer and weaker than the C-Cl bond length which is shorter and stronger. This makes the chlorine atoms to crowd around the carbon atoms preventing attack by water molecules

(h) (i) Ionic bond

(ii) Simple covalent bond

(i) * Carbon has the ability to catenate (Carbon has the ability to form strong C-C, C=C, C≡C, C≡N, C=S, and C=O with itself and other elements on the periodic table)

*Carbon lacks available low laying d-orbital so its compounds are kinetically stable

* it has a maximum covalency of 4

*The oxides of carbon are gases while those of other group IV elements are solids at room temperature

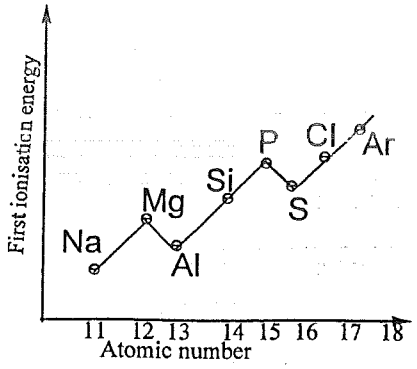
*Carbon show allotropy but other do not

---

5. (a) The way the physical and chemical properties of elements and their compounds show a repeating pattern when ordered by the atomic number. Or The reoccurrence of the physical and chemical properties of elements and their compounds with atomic number

across the period and down the group. Or the variation in the physical and chemical properties of and elements with atomic number across the period and down the group

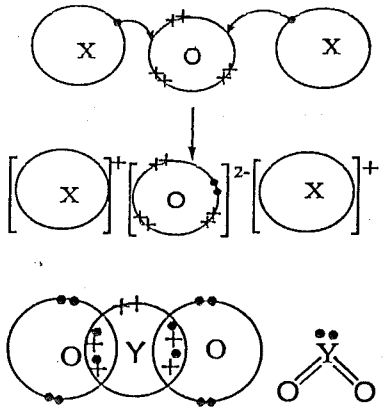
(b)



(c) (i) (X) Group I (Y) Group VI

NB: The oxide with YO_2 could possibly be SiO_2 but SiO_2 is insoluble in water.

(ii)



(iii) YO_3: acidic

(d)

Na	Mg	Al	Si	P	S	Cl
NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3 PCl_5	S_2Cl_2	Cl_2

(ii) The bonding changes from ionic in Na, and Mg, ionic/covalent in aluminium to covalent in the rest

(e) (i) $Na^+ = 1s^2 2s^2 2p^6$

$Mg^{2+} = 1s^2 2s^2 2p^6$

(ii) The ions are isoelectronic therefore; they have the same electronic structure.

(iii) Na^+ because it has one proton less thus the effective nuclear charge is smaller than that of Mg^{2+} OR Mg^{2+} has 2 protons, charge of 2+ exert a greater pull on outer electrons

(f) The increase is due to increase in number of shells, screening or shielding effect of outer electrons by inner electrons down the group.

(g) Increase in metallic strength in the group II since each atom donates two electrons into the sea of delocalization whereas in group I each atom donates only an electron into the sea of electron delocalisation.

(h) Because the hydration energy increases faster than the lattice energy in group I than in group II

(i) (a) Due to similarity in their electronegativity, atomic size and ionic size

(c)

$$4LiNO_{3(s)} \xrightarrow[\Delta]{} 2Li_2O_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

$$2Mg(NO_3)_{2(s)} \xrightarrow[\Delta]{} 2MgO_{(s)_{(s)}} + 4NO_{2(g)} + O_{2(g)}$$

$$Li_2CO_{3(s)} \xrightarrow[\Delta]{} Li_2O_{(s)} + CO_{2(g)}$$

$$MgCO_{3(s)} \xrightarrow[\Delta]{} MgO_{(s)} + CO_{2(g)}$$

$$6Li_{(s)} + N_{2(g)} \xrightarrow[\Delta]{} 2Li_3N_{(s)}$$

$$6Mg_{(s)} + 2N_{2(g)} \xrightarrow[\Delta]{} 2Mg_3N_{2(s)}$$

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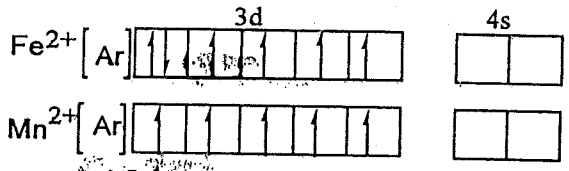
6. (a) (i) Their valence electrons enter the inner d-subshell

(ii) They form at least one stable ion or compound with a partially filled d-subshell.

(b) (i)



(ii) Fe^{2+} will easily be oxidized to Fe^{3+} because Fe^{3+} will have a half filled 3d-orbital which is more stable while Fe^{2+} has a partially filled 3d-orbitl which is less stable. Mn^{2+} has a more stable half filled 3d-orbital which is more stable than a partially filled 3d in Mn^{3+}.

(c) (i) $Co + 4(0) + 2(-1) = +1 \Rightarrow Co = 1 + 2 = +3$

(ii) (A) $CoCl_4^-$, tetrahedral in shape

(B) $[Co(CN)_4]^{2-}$, square planar

(d) (i)

$$4NH_{3(g)} + 5O_2 \xrightarrow{\text{Platinum-rhodium}} 4NO_{(g)} + 6H_2O_{(g)}$$

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$$

(ii)

$$S_{(s)} + O_2 \longrightarrow SO_{2(g)}$$

$$2SO_{2(g)} + O_2 \xrightarrow{V_2O_5} 2SO_{3(g)}$$

(e) Passing it through an electric chamber or dust precipitator.

(f) (i) nitrogen dioxide (NO_2) and sulphur dioxide (SO_2)

(ii) NO_2 and SO_2 combined with other atmospheric particles to form mist and fog which cause blurred vision.

*React with atmospheric moisture to form acid which burn trees.

(iii) It promotes the corrosion of metals

*It causes a decrease in the pH of water making it intolerant for aquatic life

*It increases the soil acidity

*It causes the leaching of aluminium from the soil as well as nutrients and minerals which are required for plant growth

(g) Use to manufacture nitrogenous fertilizers
*Use as precursors for nylon.
*Manufacture of explosives

SET 5: SECTION B: GCEB 2013

Inorganic chemistry

4. (a) (i) the physical states change from gas to liquid to solid. Due to an increase in the strength of van der waal force as molar weight and number of electrons increases down the group.

(ii) Oxidizing power increases up the group due to increase in electronegativity.

(iii) The acid strength of H-X (hydrogen halide) increases down the group because the H-X bond length becomes longer and weaker from HF to HI hence eases ionization.

(b) (i) A reaction in which a species (atoms, molecule or ions) is simultaneously reduced and oxidized.

(ii) Dilute KOH

$$Cl_{2(g)} + 2KOH_{(aq)} \rightarrow KCl_{(aq)} + KClO_{(aq)} + H_2O_{(aq)}$$

Conc. KOH

$$3Cl_{2(g)} + 2KOH_{(aq)} \rightarrow 5KCl_{(aq)} + KClO_{3(aq)} + 3H_2O_{(aq)}$$

(c). (i)

$$2NaCl_{(aq)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2HCl_{(aq)}$$

$$2NaI_{(aq)} + 2H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)} + I_{2(aq)}$$

(ii) Sulphuric acid is a stronger oxidizing agent than HI thus it will oxidize HI to iodine.

(iii)

Oxidation state	Formula of compound	Name of compound
+6	H_2SO_4 Na_2SO_4 SO_3	Sulphuric acid Sodium Sulphate Sulphur trioxide
+4	SO_2 Na_2SO_3	Sulphur dioxide Sodium sulphite
+2	$Na_2S_2O_3$ SCl_2	Sodium thiosulphate Sulphur dichloride
-2	H_2S FeS Na_2S	Hydrogen sulphide Iron(II) sulphide Sodium sulphide

(e). (i) $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

$H_2S_{(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)} + S_{(s)}$

$2H_2S_{(g)} + 3O_{2(g)} \rightarrow 2SO_{2(g)} + 2H_2O_{(l)}$

(ii) $2I^-_{(aq)} + S_2O_8^{2-} \rightarrow I_{2(aq)} + 2SO_4^{2-}$

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

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

(f). It causes atmospheric pollution by dissolving in water to form acid rain which promote corrosion

(g). Use as fertilizers e.g.$(NH_4)_2SO_4$, NH_4NO_3

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5. (a) (i) d-block arc element whose valence electrons enter the inner d-subshell while transition metals are elements that form at least one stable ion or compound with a partially filled d-orbital

(ii) Transition metals are elements that form at least one stable ion with a partially filled d-orbital

(iii) (A) Scandium, zinc (B) titanium, copper, Vanadium, nickel, manganese, chromium, cobalt, iron etc

(b) (i) $Cu^+ = [Ar]3d^{10}4s^0$

$Cu^{2+} = [Ar]3d^9 4s^0$

$Cu^{2+}$is more stable than Cu^+ because high charge density of Cu^{2+}increases salvation.

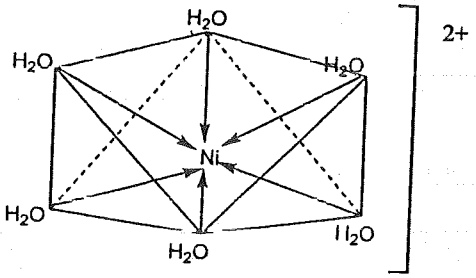
	Explanation	Example
Bidentate	It is a ligand which forms two coordinate bond (with the central metal ion with two donor atoms)	*Ethylenediamine *Ethandioate *2-hydroxylbenzoate
polydentate	A ligand which forms more than two coordinate bonds with the central metal ion using more than two donor atoms	Ethylenediaminetetraacetate(EDTA)

(c) (i) $x + 6(0) = +2 \Rightarrow x = +2$

NB: water is a neutral ligand.

The oxidation state is +2

(ii) hexaaquanickel(II) ion



(iii)$[Ni(EDTA)]^{2-}$

(iv)6

(v)Use to absorb poisonous metal from the body, it can also be used in titration to determine the concentration of metal ions in solutions

Use as water softener

(e) (i) It decreases down the group because of faster decrease in hydration energy and compared to the decrease in lattice energy.

(ii) It decreases up the group because of faster increase in lattice energy and as compared to increase in hydration energy.

(iii)It decreases down the group due to decrease in the polarizing power of the cation as the ionic size increases causing the resulting oxide to be less stable

(f). (i) A white precipitate is observed when few drops were added which is insoluble in excess sodium hydroxide.

(ii) A white precipitates insoluble in excess reagent.

(iii) No precipitate was observed when few drops were added $Mg(OH)_2$ is slightly soluble and precipitates immediately

$Mg^{2+}_{(aq)} + OH^-_{(aq)} \rightleftharpoons Mg(OH)_{2(aq)}$

$Ba(OH)_2$ is more soluble

$Ba(OH)_{2(aq)} \longrightarrow Ba^{2+}_{(aq)} + OH^-_{(aq)}$

---

6. (a) (i) CO carbon monoxide

(ii) SiO_2 silicon dioxide

(iii) $GeCl_2$ germanium (II) chloride

Or $SnCl_2$ tin(II) chloride

(iv)CCl_4 carbon tetrachloride

(b) Because the +2 oxidation state is more stable in lead compounds than the +4 oxidation state due to inert pair effect.

(c) (i) Diamond and graphite

(ii) Graphite

Because only 3-electrons per atom are involved in covalent bond formation and one electron per atom is donated to a sea of delocalize electrons in the crystal.

(d) (i) $2NaOH_{(aq)} + SiO_{2(s)} \longrightarrow Na_2SiO_{3(s)} + H_2O_{(l)}$

(ii) $PbO_{(s)} + 2HNO_{3(aq)} \longrightarrow Pb(NO_3)_{2(aq)} + H_2O_{(l)}$

(e) Sn, Sn^{2+} is a good reducing agent which ends up being oxidized

(f) Because of the strength of the C-C, C=C, and C ≡ C bond and the ability of carbon to catenate than other group IV elements.

(g) (i) chlorine

(ii) Argon

(e). (i) Increase in metallic strength in magnesium because of one extra electron per atom donated to the sea of delocalize electron

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