Section Two : The Microscopic World

Unit Seven : Bonding 化學鍵 --- How Atoms Join Together

P.1

Experiment: To study the conductivity 導電性 of compounds

Classify these compounds into two groups by completing the table below:

Group A Compounds formed between non-metals and non-metals	Group B Compounds formed between metals and non-metals
wax, $C_xH_y(s)$	*sodium chloride, $NaCl(s)$*
water, $H_2O(l)$	*lead(II) bromide, $PbBr_2(s)$*
cyclohexane, $C_6H_{12}(l)$	*lead(II) iodide, $PbI_2(s)$*
alcohol, $C_2H_5OH(l)$	*copper(II) chloride, $CuCl_2(s)$*
sugar, $C_6H_{12}O_6(s)$	

1. a) No
   b) No mobile ions / No free electrons
   c) No
   d) No charged movable particles (ions).
2. a) sodium chloride, lead(II) bromide, lead(II) iodide, copper(II) chloride
   b) No
   c) Yes
   d) When the compounds formed between metals and non-metals dissolve in water, mobile ions formed.

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II. Formation of Ions

- ✧ **Group 2** elements: ___**positive 2 (+2)**___ **charged** ions.
- ✧ **Group 3** elements: ___**positive 3 (+3)**___**charged** ions.
- ✧ **Group 7** elements: ___**negative 1 (-1)**____**charged** ions.

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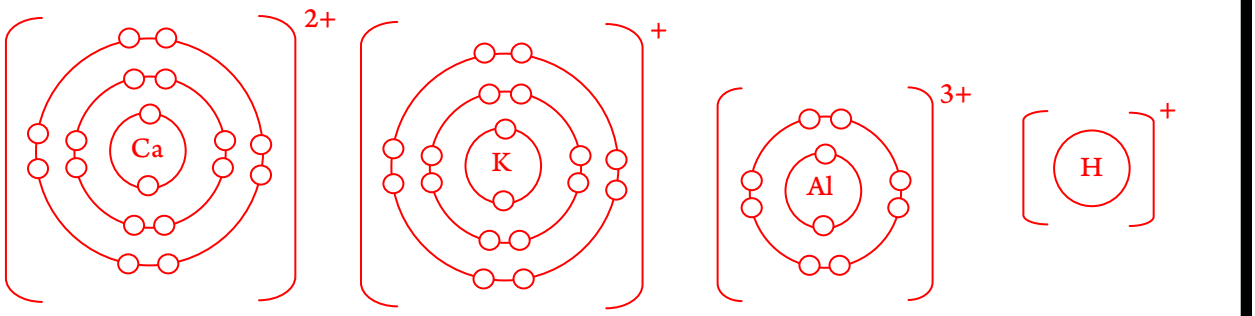
A. Positive ions (Cations)陽離子

- Each sodium atom loses one electron and becomes a sodium ion.

(1) Calcium **(2) Potassium** **(3) Aluminium** **(4) Hydrogen**



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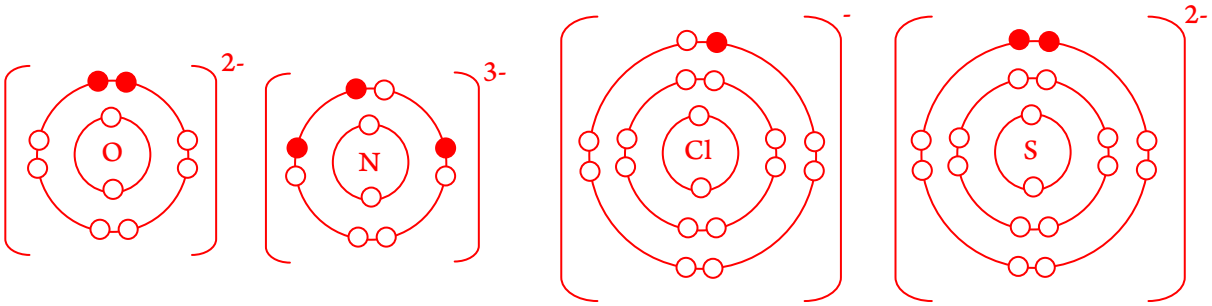
B. Negative ions (Anions)陰離子

- Each chloride atom gains one electron and becomes a chloride ion of one negative charge .

How about the following examples? How can these elements form ions?

(1) Oxygen **(2) Nitrogen** **(3) Chlorine** **(4) Sulphur**



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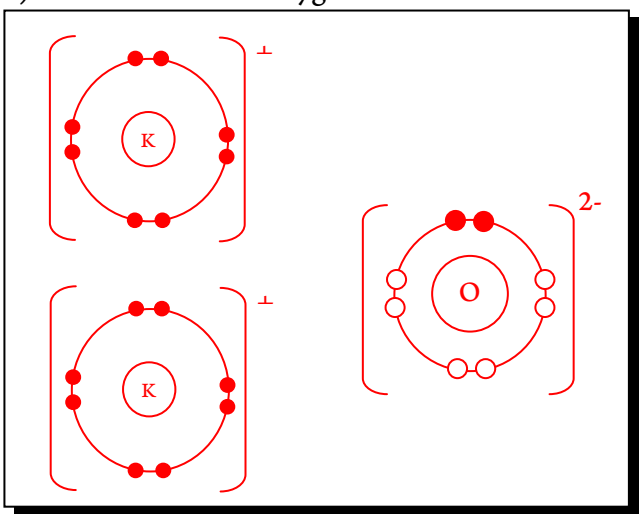
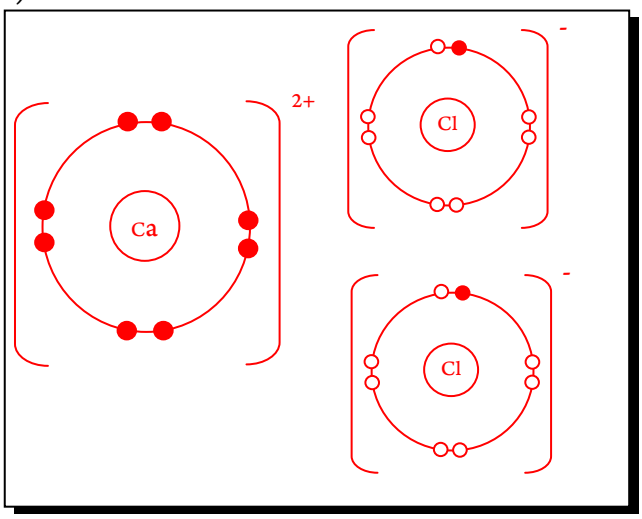
Exercise: Draw the electronic structure (show the outermost shell electrons only) of the compound formed between

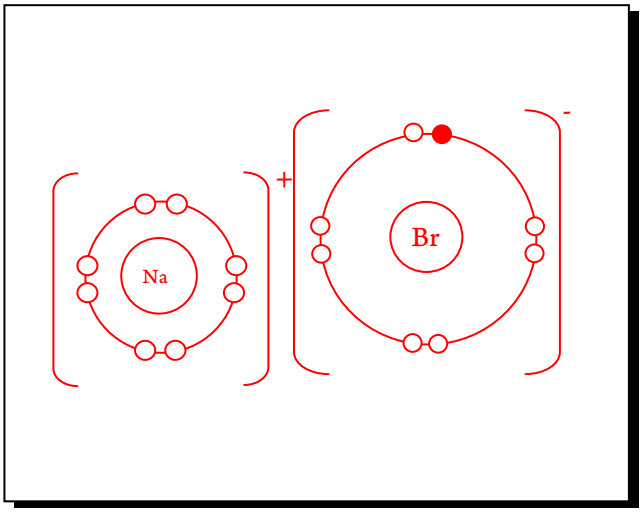
a) Potassium and Oxygen



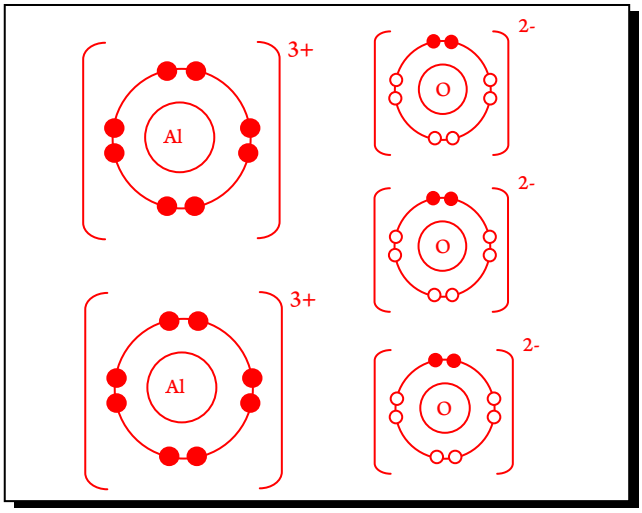
b) Calcium and Chlorine



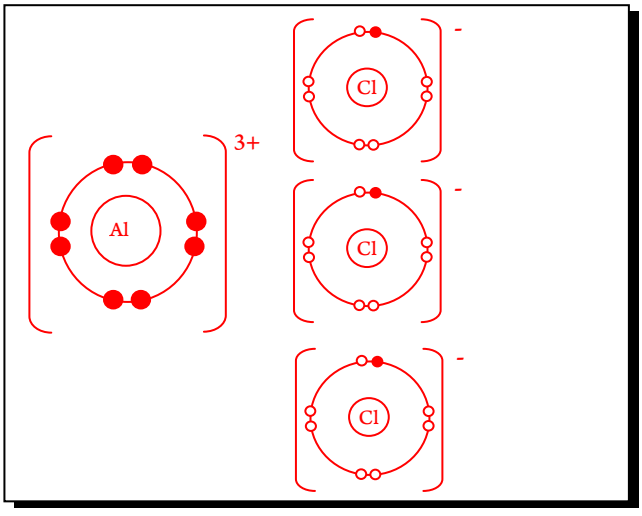
c) Sodium and Bromine



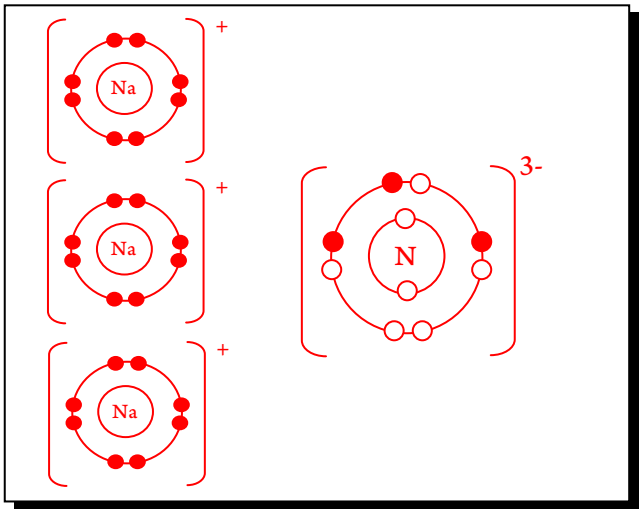
d) Aluminium and Oxygen



e) Aluminium and chlorine



f) Sodium and nitrogen



V. Simple ions 簡單離子 and Polyatomic ions 多原子離子

Positive ions (Cations)

+1 ions		+2 ions		+3 ions	
Name	**Symbol**	**Name**	**Symbol**	**Name**	**Symbol**
Lithium ion	Li^+	Magnesium ion	Mg^{2+}	Aluminium ion	Al^{3+}
Sodium ion	Na^+	Calcium ion	Ca^{2+}	Iron(III) ion	Fe^{3+}
Potassium ion	K^+	Barium ion	Ba^+	Chromium(III) ion	Cr^{3+}
Silver ion	Ag^+	Lead(II) ion	Pb^+		
Copper(I) ion	Cu^+	Copper(II) ion	Cu^{2+}		
Hydrogen ion	H^+	Zinc ion	Zn^{2+}		
Ammonium ion	NH^+	Iron(II) ion	Fe^{2+}		
		Mercury(II) ion	Hg^{2+}		
		Manganese(II) ion	Mn^{2+}		
		Cobalt(II) ion	Co^{2+}		
		Nickel(II) ion	Ni^{2+}		

Negative ions (Anions)

-1 ions		-2 ions		-3 ions	
Name	**Symbol**	**Name**	**Symbol**	**Name**	**Symbol**
Fluoride ion	F^-	Oxide ion	O^{2-}	Nitride ion	N^{3-}
Chloride ion	Cl^-	Sulphide ion	S^{2-}	Phosphate ion	PO_4^{3-}
Bromide ion	Br^-	Sulphate ion	SO_4^{2-}	Phosphide ion	P^{3-}
Iodide ion	I^-	Sulphite ion	SO_3^{2-}		
Hydroxide ion	OH^-	Thiosulphate ion	$S_2O_3^{2-}$		
Nitrate ion	NO_3^-	Chromate ion	CrO_4^{2-}		
Nitrite ion	NO_2^-	Dichromate ion	$Cr_2O_7^{2-}$		
Hydrogencarbonate ion	HCO_3^-	Carbonate ion	CO_3^{2-}		
Hydrogensulphate ion	HSO_4^-				
Permanganate ion	MnO_4^-				
Hypochlorite ion	ClO^-				

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Experiment: Colour of Ions

1. Ammonium chloride, magnesium sulphate, potassium carbonate, lead(II) chloride and sodium nitrate.
2. Cation: ammonium, magnesium, potassium, lead(II) and sodium ion
   Anion: chloride, sulphate, carbonate and nitrate ion
3.

Compound	Colour	Ion responsible for colour
K_2CrO_4	Yellow	CrO_4^{2-}
$KMnO_4$	Purple	MnO_4^-
$FeSO_4$	Pale green	Fe^{2+}
$CoCl_2$	Pale pink	Co^{2+}
$K_2Cr_2O_7$	Orange	$Cr_2O_7^{2-}$
$CuSO_4$	Blue	Cu^{2+}
$FeCl_3$	Yellow / Pale brown	Fe^{3+}
$NiSO_4$	Green	Ni^{2+}

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Name of Ion	**Formula**	**Colour**
Copper(II)	Cu^{2+}	Blue
Iron(II)	Fe^{2+}	Green
Iron(III)	Fe^{3+}	Brown / yellow
Nickel(II)	Ni^{2+}	Green
Cobalt(II)	Co^{2+}	Pale pink
Chromium(III)	Cr^{3+}	Green
Chromate	CrO_4^{2-}	Yellow
Dichromate	$Cr_2O_7^{2-}$	Orange
Permanganate	MnO_4^-	Purple
Manganese(II)	Mn^{2+}	Pale pink

Experiment: Seeing ions move

Part A

1. Green
   No
2. a) Orange
   b) Dichromate
   c) Negative
   d) Blue / green
   e) Copper
   f) Positive

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Part B

2. Permanganate ion
   Negative
3. a) The purple colour moves in the opposite direction.
   b) Since the permanganate ions are negatively charged, they always move towards the positive terminal.

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Part C

2. Put a few crystals of silver nitrate at the end connected to the positive terminal of the cell.
   Put a few crystals of sodium chromate at the end connected to the positive terminal of the cell.
   Leave for a few minutes.
3. Red

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(a) ***Potassium sulphate***

Ions	K^+	SO_4^{2-}
Ratio	2	1
Formula	K_2SO_4	

(b) ***Calcium hydroxide***

Ions	Ca^{2+}	OH^-
Ratio	1	2
Formula	$Ca(OH)_2$	

Exercise:

1. a) $Al_2(SO_4)_3$
   b) $(NH_4)_2SO_4$
   c) MgO
   d) FeS
   e) Cu_3PO_4
   f) $NaNO_3$
2. a) Potassium bromide
   b) Iron(III) oxide
   c) Barium nitrate
   d) Manganese sulphate
   e) Potassium dichromate
   f) Ammonium phosphat

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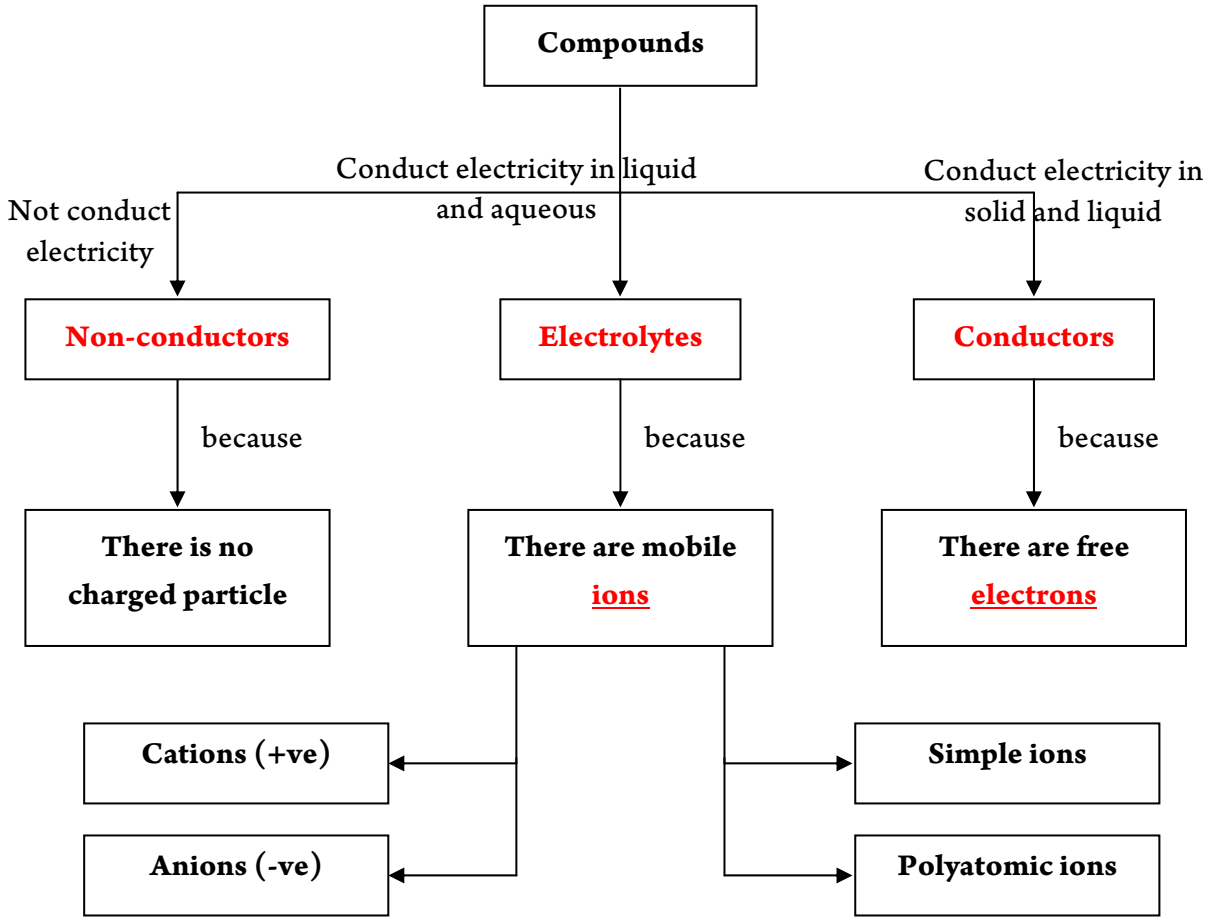
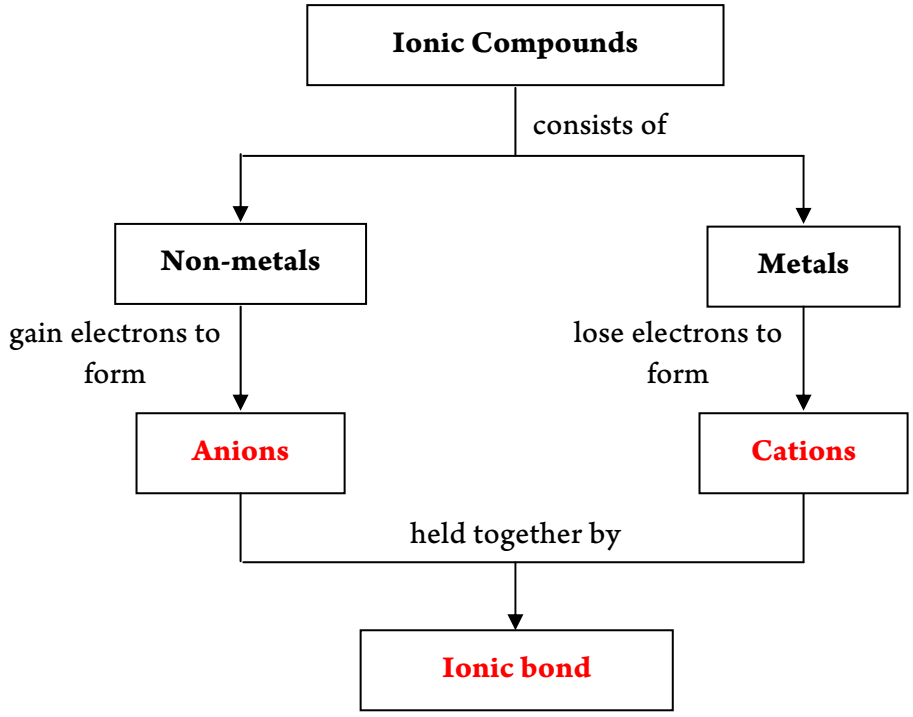
Concept Map





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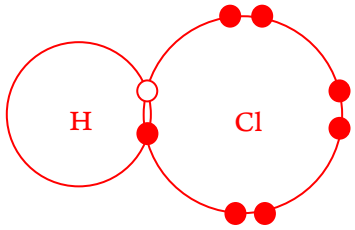
VIII. Further Examples and Structural Formulae of Molecules

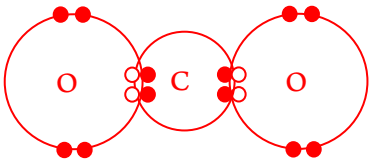
Exercise: Draw the electronic diagrams and structural formulae of the following covalent compounds.

HCl



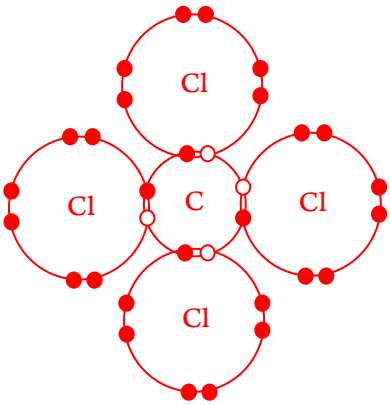
Hydrogen chloride

CO_2



Carbon dioxide

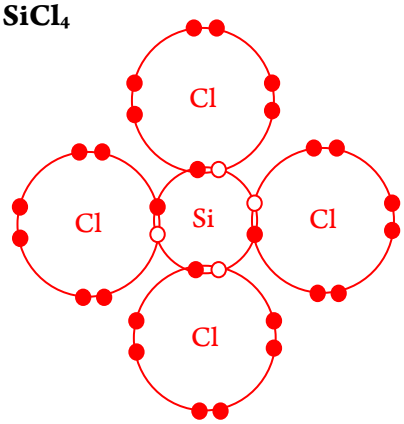
CCl_4



Carbon tetrachloride

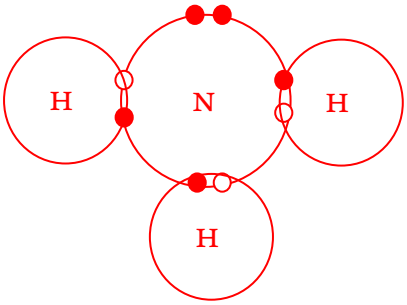
OR Methane

$SiCl_4$



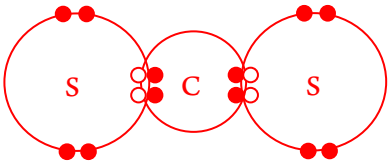
Silicon tetrachloride

NH_3



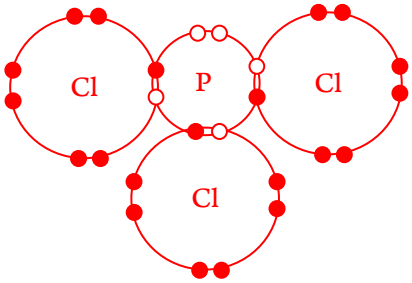
Ammonia

CS_2



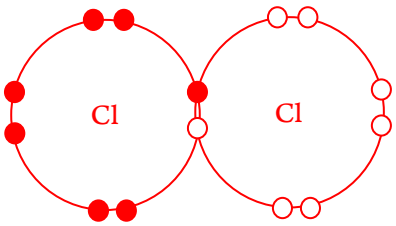
Carbon disulphide

PCl_3



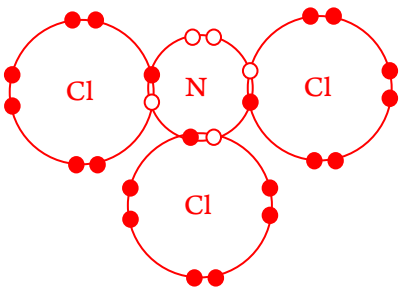
Phosphorus trichloride

Cl_2



Chlorine

NCl_3



Nitrogen trichloride

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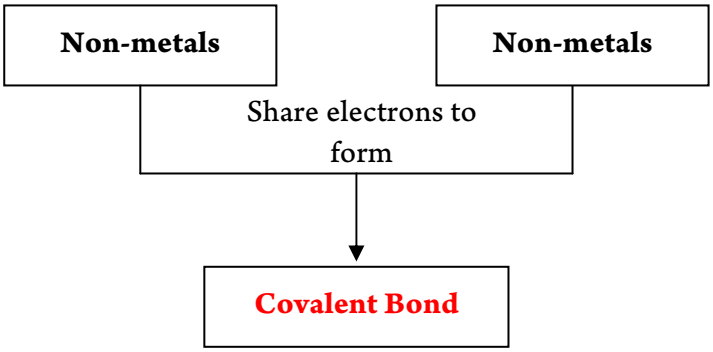
Concept Map



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Supplementary Exercise

1. (a) C
   (b) J
   (c) G
   (d) C, F
   (e) A, H
   (f) C, D, G
   (g) A and J
   (h) (1) Period
   (2) D and G
   (i) D and E
   (j) (1) Nitrogen atom
   (2) Nitrogen atom forms triple bond with another atom, which is very strong that it requires large amount of energy to break.
   (k) (1) Chloride ion
   (2) Add acidified silver nitrate solution to it, if white precipitate appears it indicates the presence of Cl^-.
   (l) (1) Sodium atom
   (2) Under paraffin oil

2. (a) eight
   (b) ten
   (c) Yes. Since Al^{3+} has eight electrons in its outermost shell
   (d) isoelectronic
   (e) $Al^{3+} < Mg^{2+} < Na^+ < Ne < F^- < O^{2-}$
   (f) (1) Aluminium atom, since it has one more electron shell than aluminium ion.
   (2) Chloride ion. Since chloride ion has one more electron in the outermost shell than chlorine atom, as a result, the repulsion between the electrons of outermost shell increases so the size increase as well
   (3) For the same element the size of the anion is large than that of neutral atom while the size of the cation is smaller than that of neutral atom.