

Atomic Structure

GCE O Levels & iGCSE Exams

Notes

Fahad Hameed Ahmad

Whatsapp : +92 323 509 4443

www.megalecture.com

www.youtube.com/megalecture



Scan: free demo class

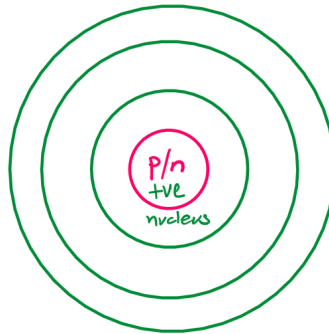
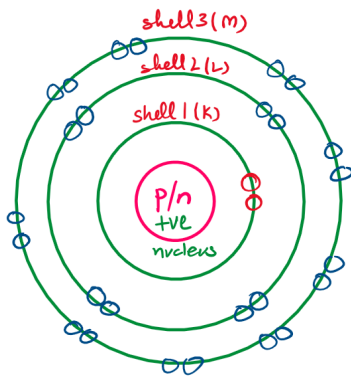
Atomic Structure

		<u>relative mass</u>	<u>relative charge</u>
Atom	p	1 (1.67×10^{-27} kg)	+1 ($+1.6 \times 10^{-19}$ C)
	n	1 "	0
	e	$1/1836$ (9.1×10^{-31} kg)	-1 (-1.6×10^{-19} C)

electrostatic force

ionic bond, covalent bond
metallic bond, intermolecular forces

like charges repel
unlike charges attract.



shell 1	2e	$2n^2$ $n = \text{shell no.}$
shell 2	8e	
shell 3	18e	
shell 4	32e	
shell 5	50e	

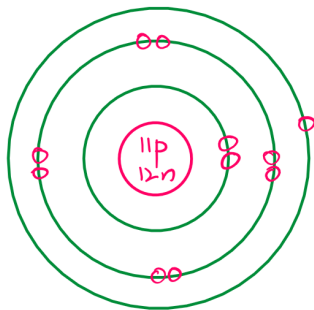
23 → bigger no → relative atomic mass
 average mass of an atom compared to $1/12$ the mass of ^{12}C atom. (mostly in decimals or rounded value)

11 Na

→ smaller no. → proton no. (atomic no.)

$11p$ (whole number)

(*proton = # electrons for neutral atom)



$$\begin{array}{r}
 11p \quad 12n \quad 11e \\
 \hline
 11 + 12 + \frac{11}{1836} \approx 23
 \end{array}$$

→ always a whole no

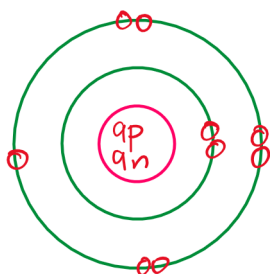
nucleon no = "p+n"

= 23 nucleons

(p+n)
19
9 p
= 10 n
p/e

9p, 9e
neutrons
 $n = 19 - 9 = 10e$

How to fill e^- in a shell
first 20 elements
shells, 2e, 8e, 8e, ...



Electronic configuration of first 20 elements

Element Z - SYMBOL	Electronic configuration	Element Z - SYMBOL	Electronic configuration
1 - H	1	11 - Na	2.8.1
2 - He	2	12 - Mg	2.8.2
3 - Li	2.1	13 - Al	2.8.3
4 - Be	2.2	14 - Si	2.8.4
5 - B	2.3	15 - P	2.8.5
6 - C	2.4	16 - S	2.8.6
7 - N	2.5	17 - Cl	2.8.7
8 - O	2.6	18 - Ar	2.8.8
9 - F	2.7	19 - K*	2.8.8.1
10 - Ne	2.8	20 - Ca*	2.8.8.2

Periodic Table

arranged according to proton no.
atom/elements are identified by proton no (determines its properties)

Groups

same no. of valence shell e⁻
similar chemical properties

Periods

total no of shells

1	2																	3	4	5	6	7	0						
+1	+2																	+3		-3	-2	-1	4						
																		1 H hydrogen 1				4 He helium 2							
																		Key											
																		relative atomic mass											
																		atomic symbol											
																		name											
																		atomic (proton) number											
7	9																	11	12	14	16	19	20						
Li	Be																	B	C	N	O	F	Ne						
lithium	beryllium																	boron	carbon	nitrogen	oxygen	fluorine	neon						
3	4																	5	6	7	8	9	10						
23	24																	27	28	31	32	35.5	40						
Na	Mg																	Al	Si	P	S	Cl	Ar						
sodium	magnesium																	aluminum	silicon	phosphorus	sulfur	chlorine	argon						
11	12																	13	14	15	16	17	18						
																		Metals											
39	40	45	48	51	52	55	56	59	59	63.5	65	70	73	75	79	80	84												
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr												
potassium	calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton												
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36												
85	88	89	91	93	96	[98]	101	103	106	108	112	115	119	122	128	127	131												
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe												
rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon												
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54												
133	137	139	178	181	184	186	190	192	195	197	201	204	207	209	[209]	[210]	[222]												
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn												
caesium	barium	lanthanum	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	silver	mercury	thallium	lead	bismuth	polonium	astatine	radon												
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86												
[223]	[226]	[227]	[261]	[262]	[266]	[269]	[277]	[286]	[271]	[272]	[285]	[286]	[289]	[289]	[293]	[294]	[294]												
Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt	Lv	Rg	Cn	Nh	Fl	Mc	Lr	Og	Og												
francium	radium	actinium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	livermorium	tennessine	copernicium	nihonium	flerovium	moscovium	livermorium	tennessine	oganeson												
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118												

Metals

NonMetals

Group 6
Period 3
Valence 6e
total shells = 3



Group 3
Period 6
3 Valence e⁻
6 x shells

Isotopes : Atoms of the same element have the same atomic no or proton no but different neutron/nucleon no. (p+n)

→ normally atoms have few stable isotopes

protium
 ^1_1H
stable

1p, 1e, 0n

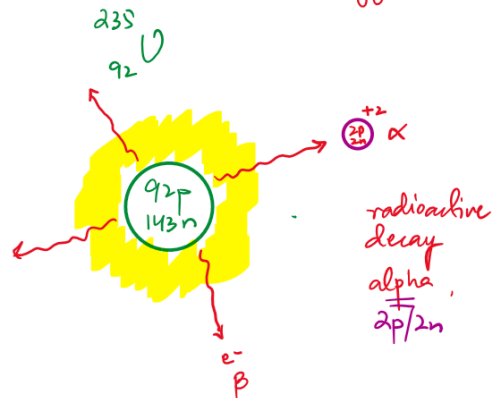
deuterium
 ^2_1H

1p, 1e, 1n

tritium
 ^3_1H

1p, 1e, 2n

unstable isotopes tend to be radioactive (bigger atoms)



Nuclear Energy
Uses : Medical Imaging
Industrial imaging / thickness of metal sheets

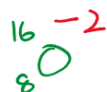
Ions

neutral atom

no. of protons _{+ve} = no. of electrons _{-ve}

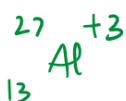
atoms gain / lose e^- in chemical reactions

gains $e^- \longrightarrow$ -ve ion / anion

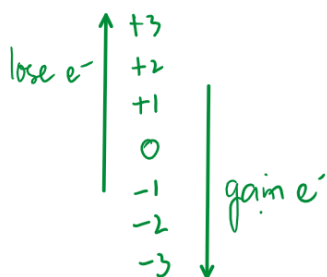


8p, 8e, 8n.
+2e

loses $e^- \longrightarrow$ +ve ion / cation



13p, 13e, 14n.
10e



Element: Atoms of the same type, having the same number of protons and electrons (neutrons can be different, they can be isotopes). These atoms will have the same electronic configuration and exactly the same chemical properties. E.g. Carbon is an element, Charcoal is an example of the element carbon.

Mixtures: When substances are only physically mixed together and not chemically combined. E.g. Sand + Water, Oil + Water.

Some examples of Mixtures

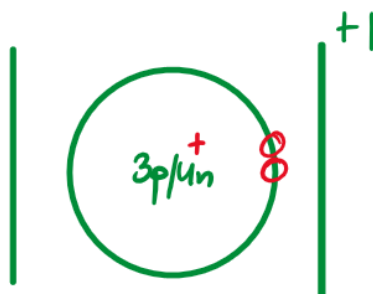
- 1 - Air $\rightarrow$ 78% Nitrogen, 21% Oxygen, Argon, Carbon Dioxide, Water Vapours
- 2 - Petroleum $\rightarrow$ Gasoline, Diesel, Bitumen, Kerosene
- 3 - Alloys are mixtures of metals e.g. Steel is Iron+Carbon, Brass is Copper + Zinc, Bronze is Copper +Tin, Stainless Steel is Iron + Carbon + Chromium & Nickel.

Compounds: When two or more atoms of different elements are chemical combined together. Compounds can be ionic or covalent. The new substance has different physical and chemical properties.

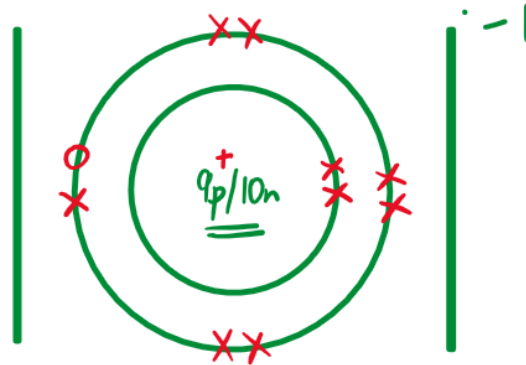
Ionic Bonding

ending fewer protons / less attraction
like to lose e^- / the ions for e^-

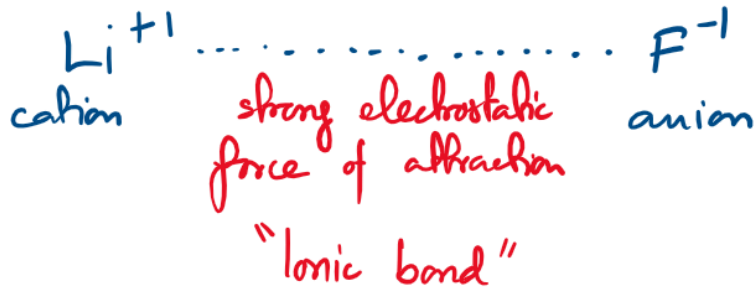
more protons / more attraction for e^-
like to gain e^- / -ve ions

[illegible]

metal / loses e^-

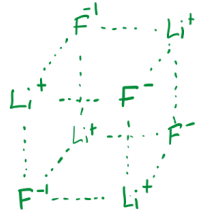
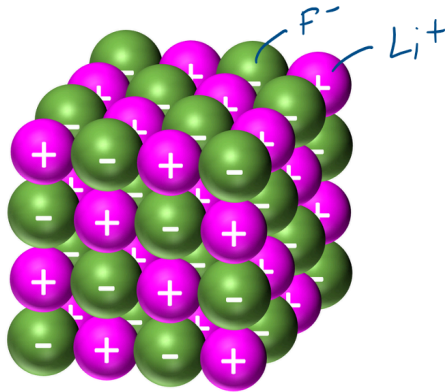


nonmetal/gains e^-



Structure and Properties

(a) Structure : Giant Ionic Lattice : regular arrangement of +ve and -ve ions with strong ionic bonds between them.



LiF
Lithium fluoride

* two +ve or two -ve ions should not be together

(b) high MP / BP / Strong

↳ very strong ionic bonds between +ve and -ve ions in the giant ionic lattice

NaCl(s) → table salt

Concrete / Cement → $\text{Ca}^{2+}\text{CO}_3^{2-}$

Tiles / Ceramics

↳ substances that are extremely strong.

MgO → furnaces / heat shields

Al_2O_3 → electrical appliances / high voltage transmission

Strength of the Ionic Lattice

strength $\propto$ change on ion
size of ion

→ greater +ve and -ve charge
more attraction

$\text{Na}^+\text{Cl}^- < \text{Mg}^{2+}\text{O}^{2-}$
stronger

→ smaller ions will be
more packed together
closer → more attraction

(c) Ionic lattices are brittle

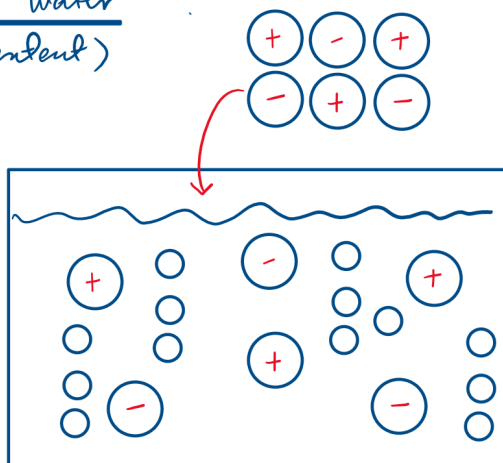


(d) Conduct electricity when molten or aqueous due to free moving ions.

electricity
movement of
charged particles

ions can move freely
(but not in solid state)

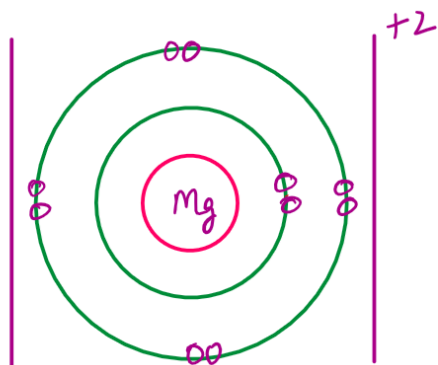
(e) Soluble in water
(varying extent)



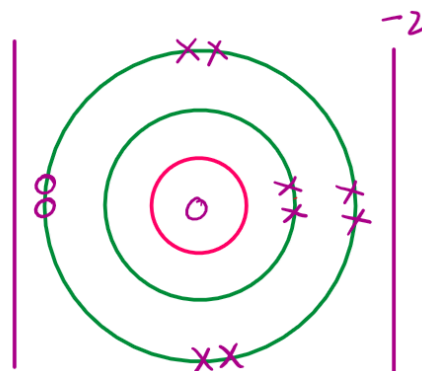
stronger ionic lattice
will be less soluble

dot and cross diagram

(a) $_{12}\text{Mg}$ and $_{8}\text{O}$



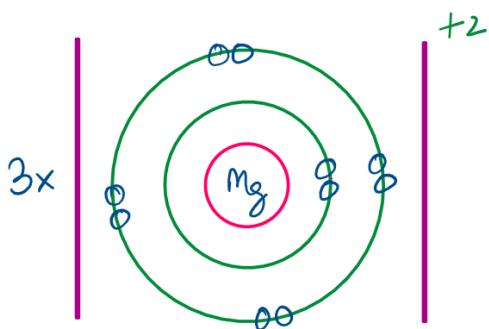
2, 8, 2
loses 2e



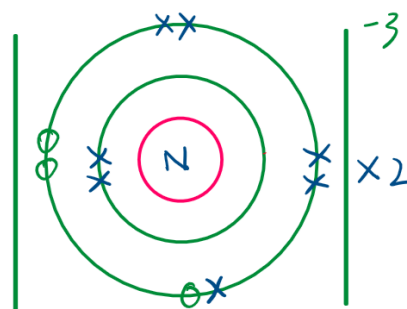
2, 6, 2
gains 2e

Mg Loses 2e and O Gains 2e

(b) $_{12}\text{Mg}$ and $_{7}\text{N}$



2, 8, 2
loses 2e
 $\times 3$
 $= 6e$



2, 5
gain 3e
 $\times 2$
 $= 6e$

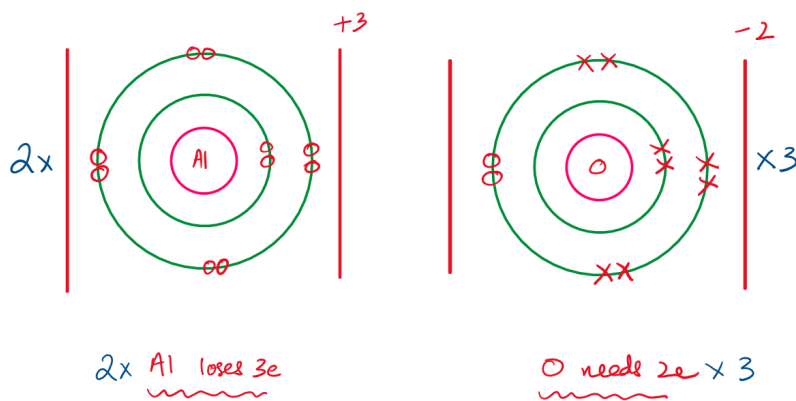
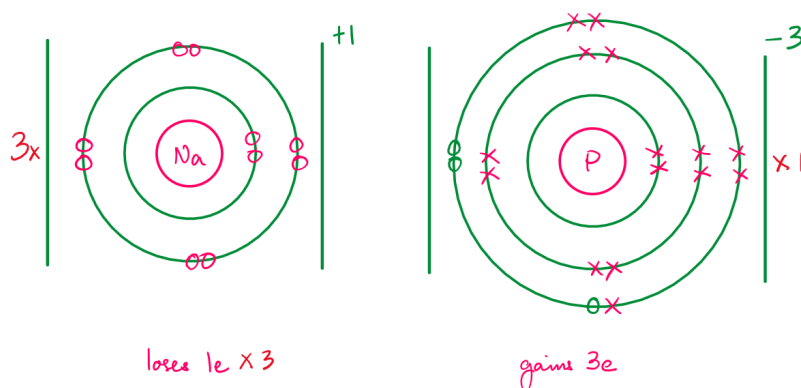
Mg loses 2e and N gains 3e. To balance electrons therefore we should have $3x\text{Mg}$ and $2x\text{O}$

Magnesium nitride^{ide}



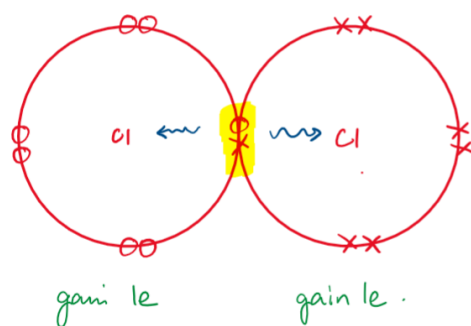
formula unit
simplest ratio of ions
in the ionic lattice

ions.



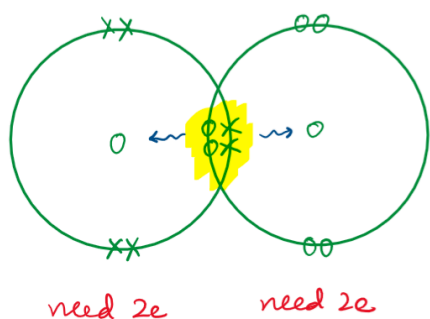
Covalent Compounds / Molecules

two different elements joined together (covalent or ionic)
 only nonmetals are present
 any simple covalent molecule where two or more atoms are covalently bonded



single covalent bond

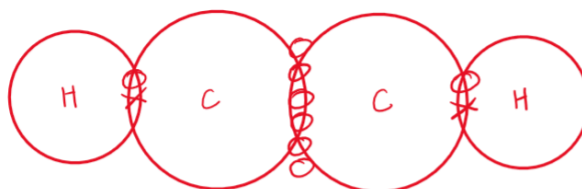
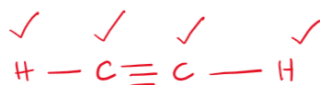
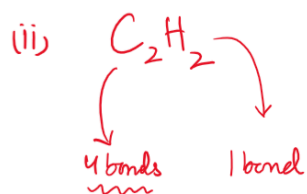
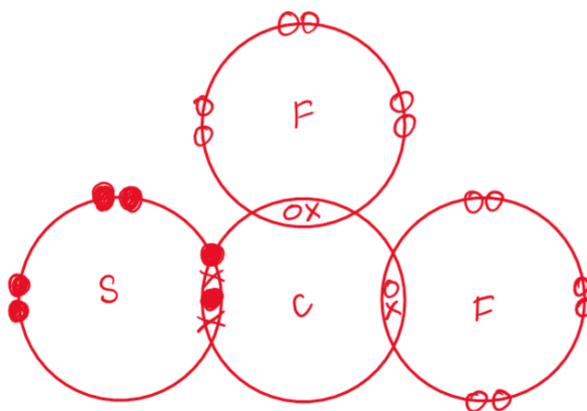
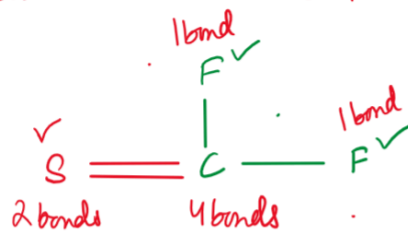
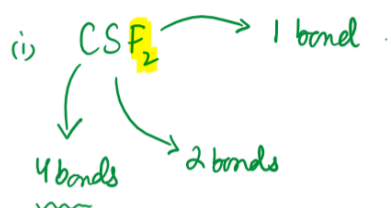
sharing of e^- between two atoms
shared electrons attract the nucleus of both atoms keeping them together

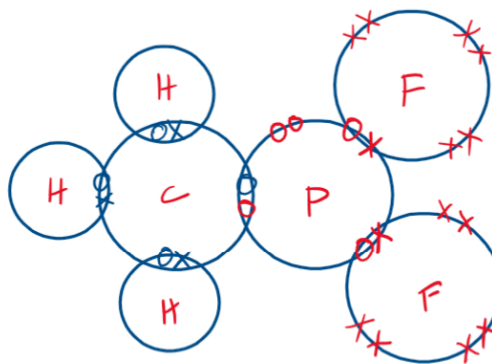
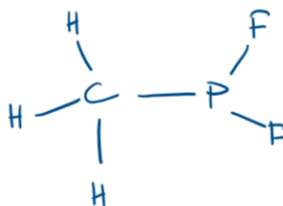
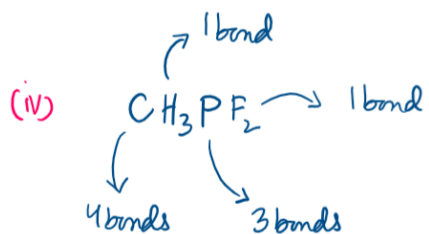
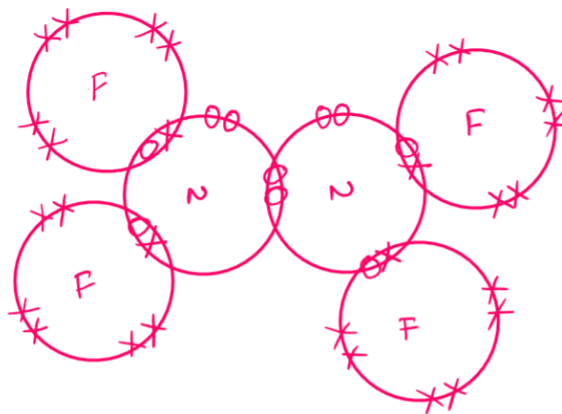
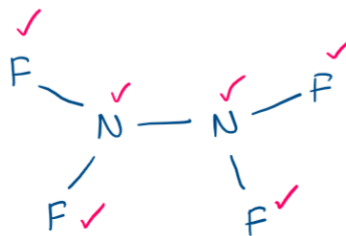
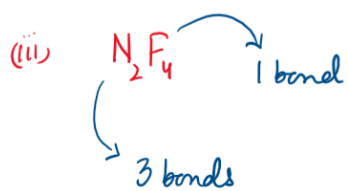


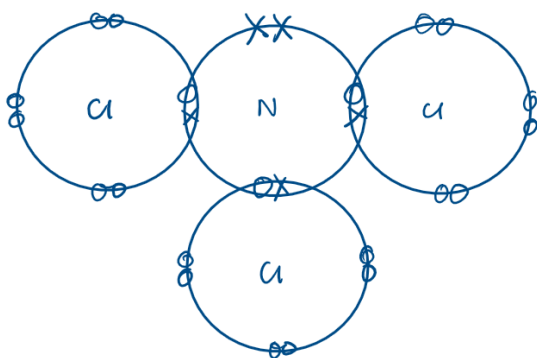
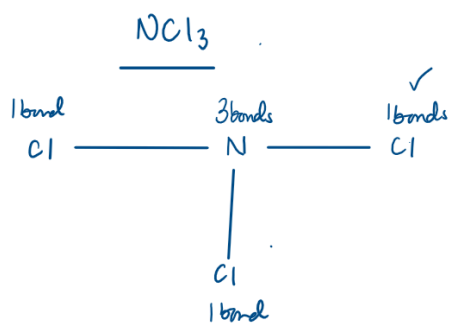
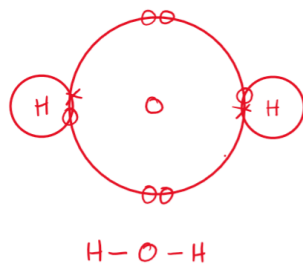
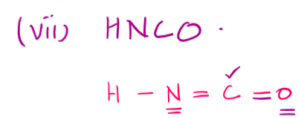
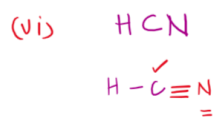
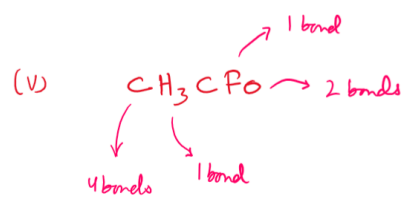
double covalent bond

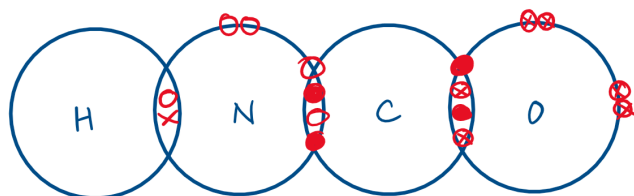
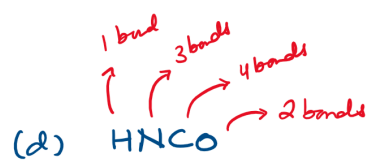
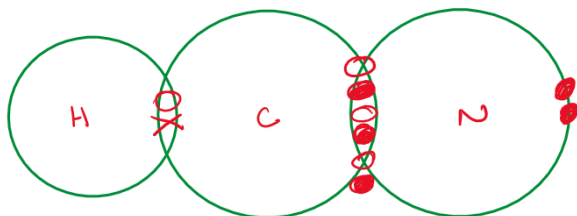
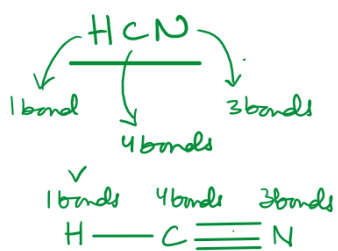
gp 4	gp 5	gp 6	gp 7	H
share 4e	share 3e	share 2e	share 1e	share 1e
4 bonds	3 bonds	2 bonds	1 bond	1 bond

Draw Structural Formula (and then draw dot and cross)









Properties

- 1- Structure : simple molecular arrangement / lattice with very weak intermolecular forces



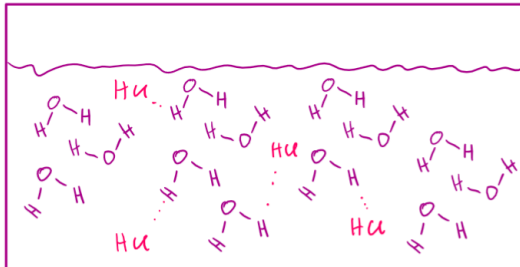
- 2- Low MP/BP mostly gases or low boiling point liquids/solids

↳ less energy need to break weak intermolecular forces.
 $\text{CH}_4, \text{CO}_2, \text{HCl}, \text{O}_2, \text{N}_2$, mostly gases

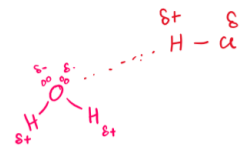
- 3- Don't Conduct Electricity (except graphite)
no free moving charged particles (ions or electrons)

- 4- Solubility varies

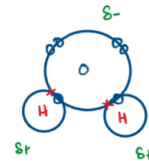
$\text{O}_2, \text{N}_2, \text{H}_2$, etc insoluble
 CO_2 weakly soluble
 HCl, NH_3 very soluble.



H_2O polar molecules and dissolves other polar substances



soluble - polar
insoluble - nonpolar



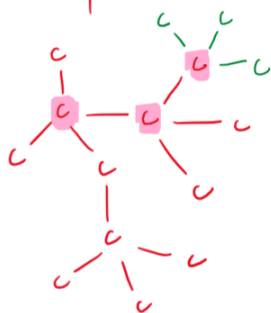
Giant Covalent Structures

(a) Allotropes of Carbon

→ same element having two or more different structures in the same physical state

(i) Diamond

C - sp^3 makes 4 bonds



3 dimensional network
of many strong covalent bonds

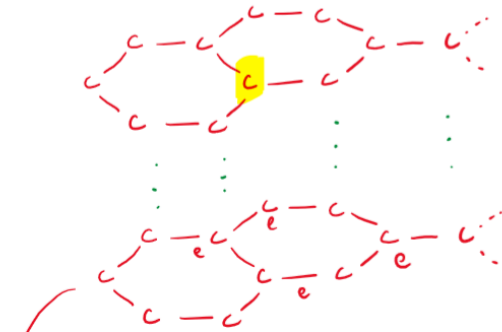
* tetrahedral arrangement, angles 109.5°

* Very Strong with Very high MP
large energy needed to break
many strong covalent bonds

* abrasive, drilling, cutting.

(ii) Graphite

C makes 3 bonds with 1 delocalized e^-



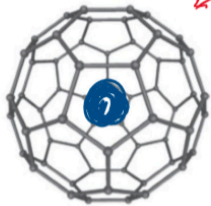
Graphene: single sheet of graphite

layered hexagonal
sheet like structure
* weak intermolecular
forces (Van der Waals)
between layers

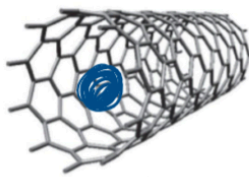
* very good conductor of electricity
because of delocalized e^-
(electrodes in batteries)

* Soft and slippery.
layer can slide easily
dry lubricant.

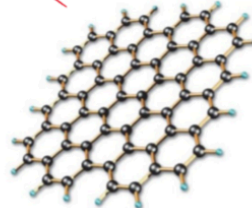
C60 buckyball



fullerene



nanotube



graphene

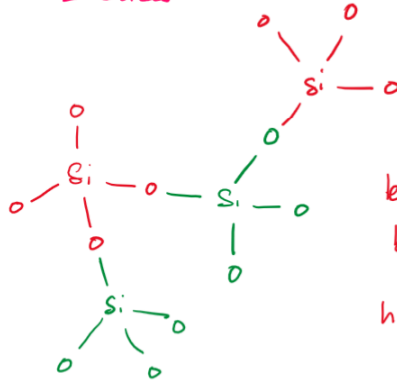
nanotechnology

Silicon dioxide / Silicon(IV) oxide / SiO_2

(sand, silica, glass, quartz)

Silicon (Group IV) - 4 bonds

Oxygen - 2 bonds



tetrahedral arrangement
bond angles 109.5°

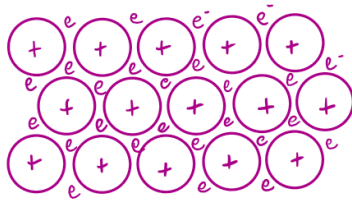
high MP / BP, very strong
- giant covalent structure with many strong covalent bonds.

- no electrical conduction
no free moving electrons, or ions

ceramic

Metals and Alloys

left side of the periodic table
like to lose e^- , form +ve ions



Giant Metallic Lattice

Regular arrangement of the metal ions in a sea of free moving delocalized e^-

Metallic Bond

attraction between delocalized e^- and +ve metal ions

more delocalized e^- , greater +ve charge on ion $\rightarrow$ stronger metallic bond.

Properties

1- Usually have high Melting Points (except mercury)

Group I metal $\rightarrow$ less than 100°C

transition metals $\rightarrow$ very high MP

2. conduct electricity and heat .

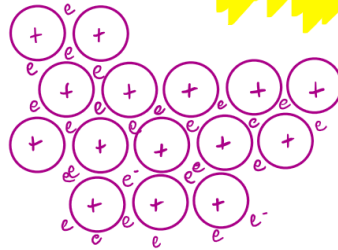
because of free moving mobile electrons

3. malleable and ductile (not brittle)

↳ reshape

↳ make wires

when the metal is hammered, the metal ions can slip and slide in the giant metallic lattice without breaking metallic bonds

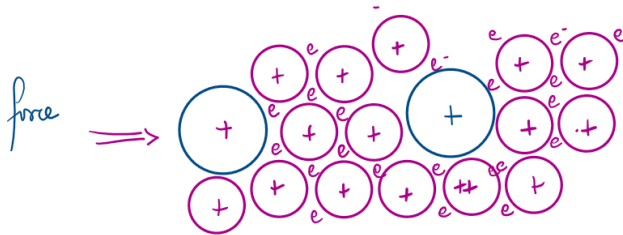


Group 1 metals are very malleable

Alloys

↳ very strong, not malleable or ductile, brittle

↳ alloy wheels, car bodies etc
pure metals not used in industry.



due to different sized metal ions, the layers can no longer easily slip and slide as an irregular metallic lattice is formed

Steel - Iron + Carbon

Bronze - Cu + Sn

Brass - Cu + Zn

Stainless Steel - Iron + Carbon + Cr

* greater impurity added

- stronger alloy,

- brittle