10/12

Thursday, October 12, 2017 9:33 AM

Standard Enthalpy change of combustion $\Delta H_c^\ominus$

1 mol substance + O_2 $\xrightarrow[\text{completely burn}]{\text{excess}}$ product $\Delta H_c^\ominus$

$\Delta H^\ominus_{c(H_2)}$ $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$

State symbol

$\Delta H_c^\ominus$(Diamond) $C_{diamond} + O_{2(g)} \rightarrow CO_{2(g)}$

$\Delta H_c^\ominus$(graphite) $C_{graphite} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_{c(graphite)}^\ominus = \Delta H_{f}^\ominus(CO_2)$

Some substance that you can not have $\Delta H_c^\ominus$

$\begin{cases} O_2 \\ H_2O \end{cases}$

Enthalpy change of atomisation ($\Delta H_{at}^\ominus$)

In its most stable form

Endothermic

$\Delta H_{at}^\ominus$ $\boxed{\text{elements}} \longrightarrow$ 1 mol atoms $_{(g)}$

Bond energy: gas state covalent Bond

$\Delta H^\ominus_{at(Cl_2)}$ $\frac{1}{2}Cl_{2(g)} \longrightarrow Cl_{(g)}$ ← Use bond energy for Cl−Cl

Cl−Cl 242 kJ/mol $\Longrightarrow$ $\Delta H_{at}^\ominus(Cl_{2(g)}) = 121$ kJ/mol

$\Delta H^\ominus_{at}(Br_2)$ $\frac{1}{2}Br_{2(g)} \longrightarrow Br_{(g)}$

$\Delta H_{at}^\ominus(Na)$ $Na_{(s)} \longrightarrow Na_{(g)}$ $= \Delta H^\ominus_{fusion} + \Delta H^\ominus_{vapourization}$

Standard Enthalpy change of Neutralisation ($\Delta H_n^\ominus$)

$\Delta H_n^\ominus$: $acid_{(aq)} + alkaline_{(aq)} \longrightarrow salt_{(aq)} + \underline{1\ mol\ H_2O_{(l)}}$

or $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ ← Because of this, $\Delta H_n^\ominus < 0$

$\Delta H_n^\ominus = -57$ kJ/mol ← This was made HCl + NaOH

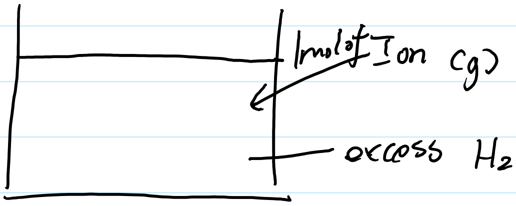
$\underbrace{CH_3COOH}_{weak} + \underbrace{NaOH}_{strong}$ < 57

$\underbrace{HCl}_{strong} + \underbrace{NH_3}_{weak}$ < 57

$\underbrace{CH_3COOH}_{weak} + \underbrace{NH_3}_{weak}$ < 57

not completely ionized → some energy needed to release

Standard Enthalpy Change of hydration $\Delta H^{\ominus}_{hyd}$



$\Delta H^{\ominus}_{h}$ $Na^{+}_{(g)} + aq \rightarrow Na^{+}_{(aq)}$ — hydrated — ion-dipole force

$Cl^{-}_{(g)} + aq \rightarrow Cl^{-}_{(aq)}$

Standard enthalpy change of Solution $\Delta H^{\ominus}_{Sol}$

1 mol of any substance dissolves in large excess of water

$\Delta H^{\ominus}_{sol}$ $1 NaCl_{(s)} + aq \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

$\Delta H^{\ominus}_{Sol}$ is a mix of EXO and Endo.

if $\Delta H^{\ominus}_{sol} << 0$, then it means it could be soluble

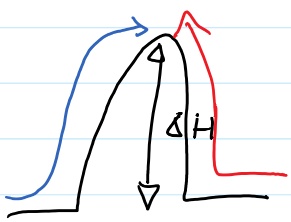
$NH_{3(g)} + aq \rightarrow NH_{3(aq)}$

Hess's law

$C_{(graphite)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{(g)}$ $\Delta H_f^{\ominus} = ?$

This is not possible by experiment

ΔH = state function



It doesn't change by the way you measure it → only related with initial and final state

We can do it in different way

$C_{(graphite)} + \frac{1}{2}O_{2(g)} \xrightarrow{\Delta H?} CO_{(g)}$

ΔH_1 ΔH_2

$+O_2$ $+O_2$

$\Delta H^{\ominus}_{f\,(CO)} = \Delta H_1 - \Delta H_2$

ΔH_1 ΔH_2

$+O_2$ CO_2 $+O_2$

$\Delta H_f^\ominus (CO) = \Delta H_1 - \Delta H_2$

Notice the direction! (if it's opposite it will mains $+\Delta H_2$).

$$\Delta H_{total} = \sum_{n}^{n} \Delta H_{intermidiate}$$ if the inital and final state are same.

$$A \xrightarrow{\Delta H_1} B \xrightarrow{\Delta H_2} C$$

$$A \xrightarrow{\Delta H} C$$

$\Delta H = \Delta H_1 + \Delta H_2$

make sure the direction is correct!

usually from $\Delta H_f^\ominus$ & $\Delta H_c^\ominus$ bond energy ✓

① $H_{2(g)} + Cl_{2(g)} \xrightarrow{\Delta H_r^\ominus} 2HCl_{(g)}$

$+$

$H_{2(g)} + Cl_{2(g)} \rightarrow 2H_{(g)} + 2Cl_{(g)}$ (atoms) $\rightarrow 2HCl_{(g)}$ $-2X$

② $A \xrightarrow{\Delta H_r} B$

$A \rightarrow$ element $\rightarrow B$ $\Leftarrow \Delta H_f^\ominus$

$\Delta H_r = -\Delta H_{f(A)} + \Delta H_{f(B)}$

$\Delta H_r = \sum \Delta H_{f P} - \sum \Delta H_{f R}$

③ $C_{(graphite)} + 2H_{2(g)} \xrightarrow{\Delta H_f^\ominus = ?} CH_{4(g)}$ 4 C−H bond

$C_{(graphite)} + 2H_{2(g)} \xrightarrow{\Delta H_{at}} C_{(g)} + 4H_{(g)} \leftarrow CH_{4(g)}$

$C_{(graphite)} + 2H_{2(g)} \rightarrow CO_2 + 2H_2O \leftarrow CH_{4(g)}$

Redox

Thursday, November 30, 2017 8:10 AM

10/23

Monday, October 23, 2017   8:11 AM

$2e^-$

$+2 \qquad\qquad\qquad\qquad 0$

$$3\,CuCl_2 + 2Al \longrightarrow 3Cu + 2AlCl_3$$

$0 \qquad\qquad\qquad\qquad +3$

$3e^-$

$5e^-$

$7+ \qquad\qquad\qquad\qquad 2+$

$$MnO_4^- \;\; 8H^+ + 5Fe^{2+} \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

$2+ \qquad\qquad\qquad\qquad 3+$

$1e^-$

half reaction:

$$5e^- + MnO_4^- + H^+ \longrightarrow Mn^{2+} + H_2O \quad \text{reducing}$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^- \quad \text{oxidizing}$$

Remember to add e^-

$2 \times 3e^- = 6e^-$

$6+ \qquad\qquad\qquad\qquad 3+$

$$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

$5e^- \qquad 1e^-$

$7+ \qquad -1 \qquad -2 \qquad 0$

$$2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

$2 \times 1e^- = 2e^-$

$3e^-$

$7+ \qquad +3 \qquad 4+ \qquad 4+$

$$8H^+ + 2MnO_4^- + 3C_2O_4^{2-} \longrightarrow 2MnO_2 + 6CO_2 + 4H_2O$$

$1e^- \times 2$

ethandioic acid (orgonic)

$8e^-$

$5+ \qquad\qquad\qquad\qquad 3-$

$$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

$+9 \qquad +8 \qquad H$

$0 \qquad 2e^- \qquad 2+$

Disproportionation Reactions 歧化反应

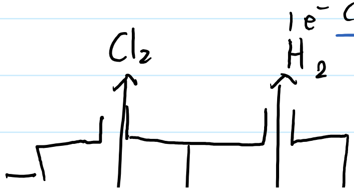
$1e^-$ (Reduction)

$-1 \qquad 2 \qquad 0$

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

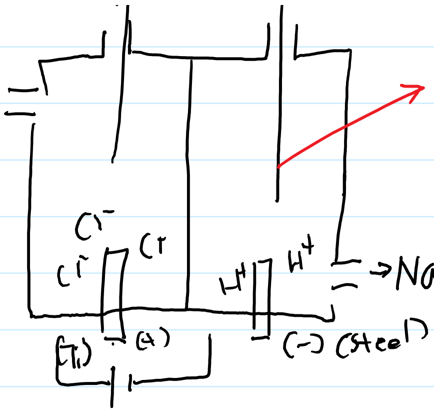
$1e^-$ (oxidation)

A redox reaction that for a single substance, it's reduce & oxidize at the same time



$\rightarrow H_2O + e^- \rightarrow H^+ + OH^- \rightarrow$ real reaction

c. NaCl



$H_2O + e^- \rightarrow H^+ + OH^-$ → real reaction

$H_2O \begin{cases} H^+ \\ OH^- \end{cases}$ (dissociation) → $2H^+ + 2e^- \rightarrow 2H_2$.
↳ low

oxidising $\underline{Cl_2}$ + $NaOH \rightarrow NaCl + H_2O + NaClO$ (cold) 20°C

alkaline + Halide → $Cl_2 + NaOH \rightarrow NaCl + H_2O + NaClO_3$ (hot) 70°C

1) $NaOH + Cl_2$

cold: $\overset{0}{1Cl_2} + 2NaOH \rightarrow 1Na\overset{-1}{Cl} + 1H_2O + 1\underline{Na\overset{+1}{Cl}O}$ chlorate(I)

$\frac{H1}{2} = 1$

1e⁻   1e⁻

chlorate

5e⁻

hot

$\underline{3}\overset{0}{Cl_2} + 6NaOH \rightarrow 5Na\overset{-1}{Cl} + 3H_2O + 1\underline{Na\overset{+5}{Cl}O_3}$ chlorate (V)

$\frac{H5}{2} = 3$

1e⁻

$SO_2 + NO_2 \rightarrow SO_3 + NO^-$

$NO^- + \frac{1}{2}O_2 \rightarrow NO_2$

$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

1e⁻

$2\overset{+4}{NO_2} + 1H_2O \rightarrow 1H\overset{+5}{N}O_3 + 1H\overset{+3}{N}O_2$

1e⁻

10/26

Thursday, October 26, 2017 10:00 AM

7. a) acidic (H^+/H_2O)

$$8H^+ + 2MnO_4^- + 3C_2O_4^{2-} \rightarrow 2MnO_4 + 6CO_2 + 4H_2O$$

b) alkaline (OH^-/H_2O)

$$2MnO_4^- + 3C_2O_4^- \rightarrow 2MnO_4 + 6CO_2 + 8OH^-$$

Reaction of Halide ions with concentrated sulfuric acid

- Concentrated sulfuric acid can be a strong acid and also an oxidising agent

$$H_2SO_4 + X^- \rightarrow \underset{-2}{H_2S} + \underset{+4}{SO_2} + \underset{0}{S}$$

H_2SO_4: +6, oxidising agent

X^-: Reducing agent

depend on: K×, Mn×; F^- × too strong F_2; Cl^-, Br^-, I^- avaliabe

Strongest Oxidising agent | Reducing agent

$F_2 + 2e^- \rightleftharpoons 2F^-$

$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$

$Br_2 + 2e^- \rightleftharpoons 2Br^-$

$I_2 + 2e^- \rightleftharpoons 2I^-$ Strongest

In redox reaction with halide salts

$H_2SO_4 + Cl^-$	acid-base reaction $\underset{\text{acid I}}{H_2SO_4} + \underset{\text{base II}}{NaCl} \rightarrow \underset{\text{base I}}{NaHSO_4} + \underset{\text{acid II}}{HCl}$ No Redox → Cl^- weak	steamy fumes (of HCl)
$H_2SO_4 + Br^-$	$\underset{\text{acid I}}{H_2SO_4} + \underset{\text{acid II}}{NaBr} \rightarrow \underset{\text{base I}}{NaHSO_4} + \underset{\text{base II}}{HBr}$ $2H\underset{-1}{Br} + \underset{+6}{H_2SO_4} \rightarrow \underset{0}{Br_2} + \underset{+4}{SO_2} + 2H_2O$ Redox $3H_2SO_4 + 2NaBr \rightarrow 2NaHSO_4 + Br_2 + SO_2 + 2H_2O$ overall	Steamy fumes (of HBr) orange-brown vapour
$H_2SO_4 + I^-$	$H_2SO_4 + NaI \rightarrow NaHSO_4 + HI$ $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$ Redox $9H_2SO_4 + 8NaI \rightarrow 8NaH_2SO_4 + 4I_2 + H_2S + 4H_2O$ Overall Reaction $H_2SO_4 + NaI \rightarrow NaHSO_4 + HI$ $6HI + H_2SO_4 \rightarrow 3I_2 + S + 4H_2O$ Redox $7H_2SO_4 + 6NaI \rightarrow 6NaHSO_4 + 3I_2 + S + 4H_2O$ Overall Reaction	1. purple vapour 2. Foul smell (rotten egg smell) (H_2S) 3. yellow solid (S) (1, 2) (1, 3)

acidic white fumes

Conjugate acid-base

therotically they should be all used up, but the HBr leaks as H_2SO_4 is weak

→ Halide gas + redox product + water

Reduced oxidised by product

$$7H_2SO_4 + \underset{\text{reduced}}{8HI} \rightarrow 4I_2 + H_2S + 4H_2O$$

stronger oxidising weaker oxidising

compare with H_3PO_4 this can not happen

Equillibria

Thursday, November 30, 2017 8:11 AM

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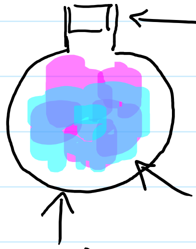
Thursday, November 2, 2017 9:33 AM

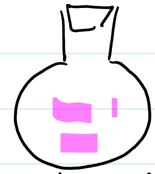
Equillibrium Constant



closed system (no in, no out)

$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

1mol 1mol 0mol



1dm^3 container

purple color (macroscopy properties)

purple color faded (unchange)

the same as long as T equillibrium

$H_2 + I_2 \rightleftharpoons 2HI$

remain the same

	H_2	I_2	$2HI$
inital	1	1	0
change	-0.86	-0.86	+1.72
final concentration	0.14	0.14	1.72

$C = \frac{n}{V} = \frac{1.72}{1} = 1.72 \text{ mol/dm}^3$

1.72 → concentration at equillibrium

[substance]

number of substance

Ratio $= \frac{[HI]^2}{[H_2][I_2]} = K_c \rightarrow \frac{1.72^2}{0.14 \times 0.14}$ → equillibrium constant

K_c the remain number of substance remain unchanged

This is called dynamic equillibrium (substance might change number of it)

$K_c >> 1 \rightarrow$ position of equillibrium to the right

$K_c << 1 \rightarrow$ position of equillibrium to the left

measure of equillibrium.

- expression of K_c.
- unit

- concentration of solid is constant, but is omitted in expressions for equillibrium constant

$A_{(aq)} + B_{(aq)} \rightarrow C_{(aq)} + H_2O_{(l)}$

$K_c = \frac{[C]}{[A][B]}$

Solvent → change omitted

$Zn_{(s)} + CuSO_{4(aq)} \rightleftharpoons ZnSO_4 + Cu_{(s)}$

$K_c = \frac{[ZnSO_4]}{[CuSO_4]}$

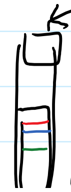
Solid → change omitted

$CH_3COOH + CH_2CH_2OH \rightleftharpoons CH_3C(=O)-O-CH_2CH_3 + H_2O$

add into reaction system

$K_c = \frac{[-C(=O)-O][H_2O]}{[COOH][OH]}$

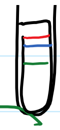
get it



all product will formed

K_c = (... / [COOH] [OH] ...)

find each of mass → n



} all product will formed

they are in total volume

$H_2 + I_2 \rightleftharpoons 2HI$ $\quad K_c = \frac{[HI]^2}{[H_2][I_2]} = x$

$\frac{1}{2}H_2 + \frac{1}{2}I_2 \rightleftharpoons HI$ $\quad K_c = \frac{[HI]}{[H_2]^{\frac{1}{2}}[I_2]^{\frac{1}{2}}} = \sqrt{x}$

K_c expression specify with the equation given

$2HI \rightleftharpoons H_2 + I_2$ $\quad K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{1}{x}$ ← also depends on the direction

* write down the equation then write expression for K_c

The equillibrium constant is a constant in a given temperature. It's unaffected by changes in concentration, pressure or catalyst

only change in T, no P, [C] or catalyst

expression for K_c: $aA + bB \rightleftharpoons cC + dD$

$$\boxed{K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}}$$

associated with this equation

Equillibrium constant in gaseous system (K_p)

It's easier to express substance involving gas phase with K_p

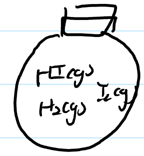
$HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ $K_c = \dfrac{[H_2][I_2]}{[HI]^2}$

partial pressure

$P = \left(\dfrac{n}{V}\right)RT = C\,RT \Rightarrow K_p = \dfrac{P_{H_2} P_{I_2}}{(P_{HI})^2} \propto K_c = \dfrac{[H_2][I_2]}{[HI]^2}$

concentration

constant in given temperature



$P \propto C$ (in constant temperature)

$P_{total} = \sum P_{partial} = P_{H_2} + P_{I_2} + P_{HI}$

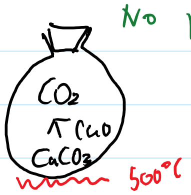
$$\boxed{A + 3C \rightleftharpoons 2B + 4D \qquad K_p = \dfrac{(pB)^2 (pD)^4}{(pA)(pC)^3}}$$

the partial pressure of a gas is the pressure that the gas would exert if it alone occupied the avaliable volume

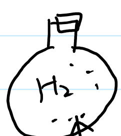
But what if we have some solid?

$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ ← Do we have K_p here?

No partial pressure   have partial pressure



$\boxed{K_p = P_{CO_2}}$ → As long as you have one of reactant/product in gas phase → you have K_p



constant T, constant V

$P \propto n$

$P_{total} \propto n_{total}$

measurable

$P_{H_2} \propto n_{H_2}$

not measurable

mole fraction of a gas (x)

$P_{H_2} = \dfrac{P_{total}\, n_{H_2}}{n_{total}} \Rightarrow \boxed{P_{partial} = \dfrac{P_{total}\, n_{partial}}{n_{total}} = \dfrac{n_{partial}}{n_{total}} P_{total}}$

$\boxed{P_A = X_A P_{total}}$

Units for K_p : Pa^n / kPa^n / atm^n

depends on the equation

$A_{(g)} \rightleftharpoons 2B_{(g)}$ $K_p = \dfrac{(P_B)^2}{(P_A)}$ if $2\times P_{total} \Rightarrow K_p$?

equillibrium will change position to restore the equillibrium

K_p doesn't change with p, K_p only change with C

$K_p = \dfrac{P_B{}^2}{P_A}$ ← change back position to restore the equillibrium

$$K_p = \frac{P_B^{\,2}}{P_A}$$

change back

$$P_{total} = P_A + P_B$$

$$P_{total} \times 2 \Rightarrow P_A \times 2 + P_B \times 2 \rightarrow K_p = \frac{(2P_B)^2}{2P_A} = \frac{4P_B^{\,2}}{2P_A} = 2\left(\frac{P_B^2}{P_A}\right)$$

new ratio

so $P_B \downarrow$ $P_A \uparrow$ $\leftarrow$ shift to left

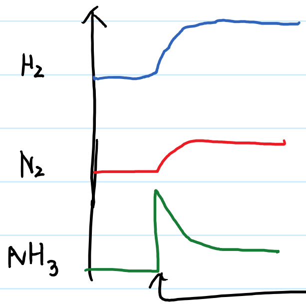
La Chatellier's Principle

> If a system in equilibrium is subjected to a chango, process will occur which tend to remove the change imposed

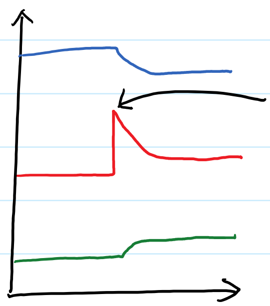
change is made $\rightarrow$ system try to opposed it

push to left

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$



add NH_3



added N_2

Conjugate acid-base-1

Acid — a proton (H^+ ion) donor

$[H]^+ : \ddot{Cl}:^-$

$HCl + H_2\ddot{O} \longrightarrow H_3O^+ + Cl^-$ (pair-2)

acid-1 base-2 acid-2 base-1

donating H^+ accepting H^+

Conjugate acid base pair: the difference between acid and base is H^+

Base — a proton (H^+ ion) acceptor

$OH^- + H_2O \rightleftharpoons H_2O + OH^-$

base-1 acid-2 acid-1 base-2

This require two molecules to collide

$H_2O \rightleftharpoons H^+ + OH^-$

self ionisation → autoionisation

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

acid-1 base2 acid-2 base-1

Whenever there is acid-base reaction there is always a base form (this might be ignored because it's too weak)

$\ddot{N}H_3 + H_2O \rightleftharpoons NH_4 + OH^-$

base-1 acid-2 acid-1 base-2

$HCl + H_2O \longrightarrow H_3O^+ + Cl^- \Rightarrow HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

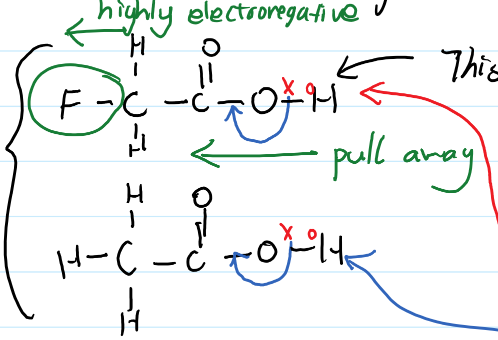
Strong acid

bond are strong to break.

$CH_3C(=O)-O-H + H_2O \rightleftharpoons CH_3C(=O)-O^- + H_3O^+ \Rightarrow CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^- + H^+$

Organic weak acid

Which one is stronger?



This will break quicker (pulled by F away from H)

the effect called electron withdrawing

this will break the bond easier

Stronger acid

weaker acid

Reaction Kinetics

Thursday, November 30, 2017 8:11 AM

$PCl_5 \rightleftharpoons PCl_3 + Cl_2$ $\qquad K_c = \dfrac{[PCl_3][Cl_2]\downarrow}{[PCl_5]\downarrow}$

$\downarrow$

$2V\uparrow$

$[C]\downarrow$

rate of reaction:

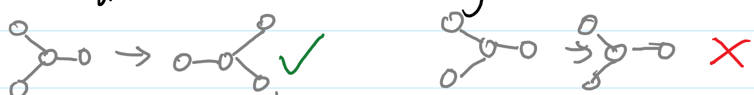
the change in the amount / concentration of a substance in a given time

Unit: $mol/dm^3/s$

can not practical measure: explosion.

Chemical reaction take only place by

- particles collide → collision theory
- collision need sufficient energy } successive collision
- orentation



$\underbrace{\text{Concentration, pressure (liquid) size}}_{\text{Collision frequency}}$ (solid)

$[C]\uparrow \Rightarrow$ more particles in given volume $\Rightarrow$ increase C.f.

$p\uparrow$

size $\Rightarrow$ powder $\Rightarrow$ more surface area

k.e. a measure of T

Temperature $\Rightarrow$ C.f. (10 K → 20 K, rate ≈ 2x)

more significant

$\Rightarrow$ k.e. $\uparrow \Rightarrow$ higher C.f.

$T_1 = 300K$ $\qquad T_2 = 310K$

$k.e. \propto T_1$ $\qquad k.e. \propto T_2$.

$\Downarrow$ $\qquad \Downarrow$

$\frac{1}{2}mV^2$ $\qquad \frac{1}{2}mV^2$

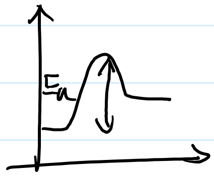
$V_1^2 = \frac{310}{}$ $\quad 7 \quad \sqrt{310}$

$$\frac{V_1^2}{V_2^2} = \frac{310}{310} \Rightarrow V_2 = \sqrt{\frac{310}{300}}\, V_1$$

$V_2 = 1.017\, V_1 \simeq \underline{16\%} \Rightarrow$ there is other factor

energy factor

- Activation energy E_A

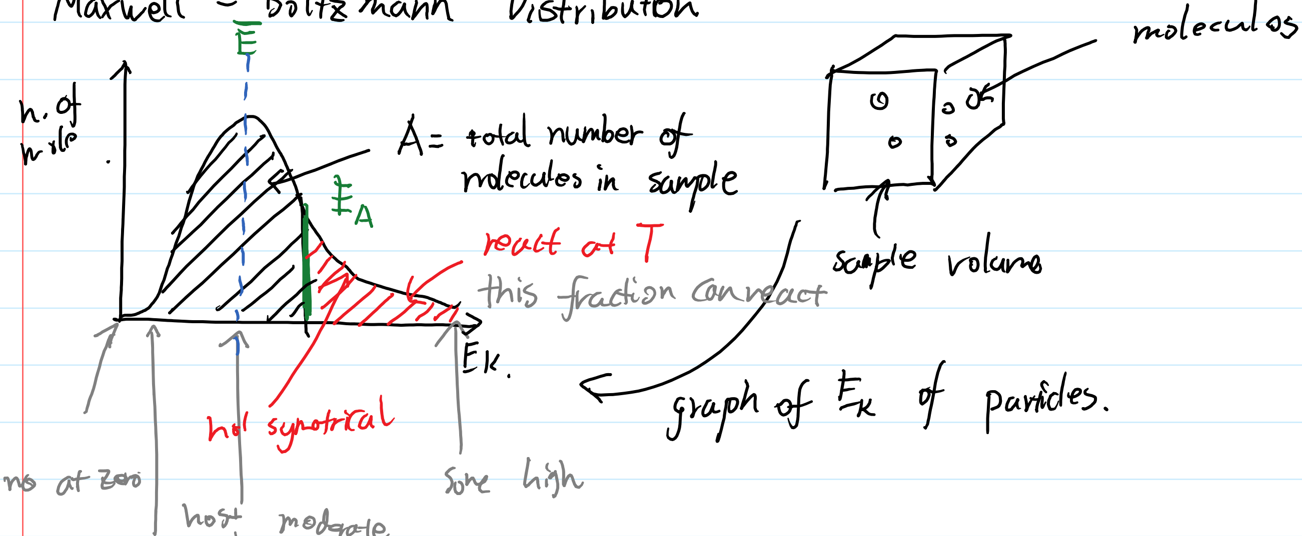


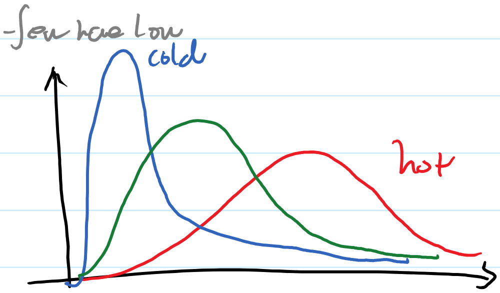
$\Rightarrow$ may not always react when they collide

if $E_A \gg$, small amount

if $E_A \ll$, large amount.

Maxwell - Boltzmann Distribution





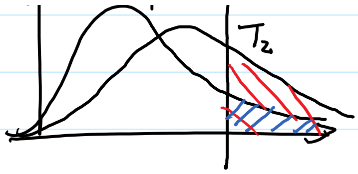
$\xrightarrow[\Delta]{\text{heat}}$ push to right ($\bar{E}\uparrow$)

total area = constant $\Rightarrow$ peak reduce

Back to T_2 and T_1

$T_2 = T_1 + 10$

T_1 fraction E_A < T_2 fraction E_A $\Rightarrow$ more successive collision



fraction E_A < fraction E_A => more succossive collision

Periocity

Thursday, November 30, 2017 8:12 AM

11/27

Monday, November 27, 2017 8:02 AM

Periocity – the properties repeat at the periodic table

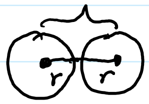
Physical properties

- Atomic radius & ionic radius [covered]
- ionisation energy [covered]
- melting point
- electrical conductivity

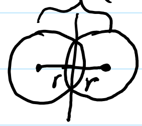
l ← x-ray crystography

l ← bond length

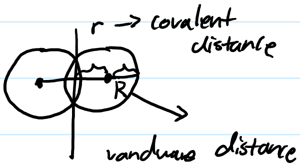
metal



non-metals (covalent)



vanduare radius ↑ distance between nucleus & e^-



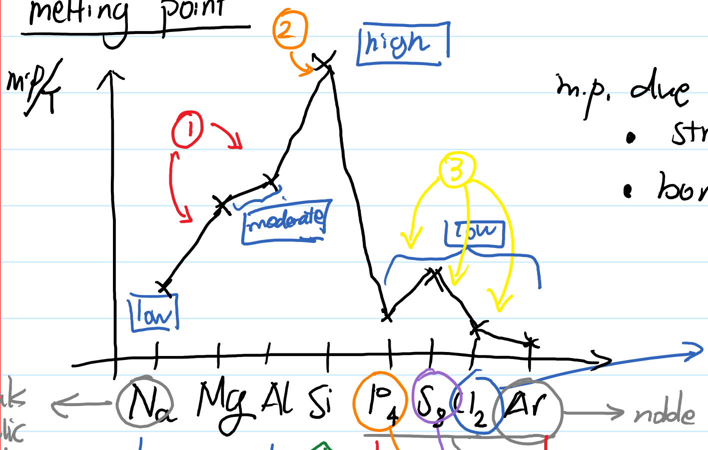
atomic radius: half of bond length l

not a straight line because e^- crowded → repulsion

ionic radius

- cation smaller (loss e^-)
- neutral atom
- anion larger (more e^-)

melting point



m.p. due to
- structure ← most important
- bonding

weak metallic bond ← Na

diatomic

Ar → noble gas.

→ natural form

Bonding: metallic | covalent | covalent

Structure: Giant metallic | Giant covalent (diamond-like) | simple molecule

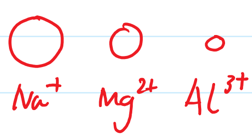
metals | metalloid / semi-metal | non-metal

→ tetraatomic simple molecule

→ Octaiveatomic

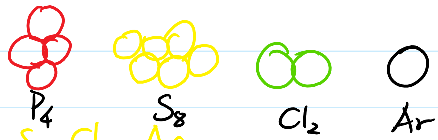
① Na – Al ↑
- structure – giant metallic
- bonding – metallic

stronger metallic bond { - higher charge density, - more e^-



metals ~~metalloid~~ non-metal

semi-metal



② Si highest

- structure — giant covalent (strong)
- bond — covalent

- many strong covalent bond to be broken in the lattice (melt → brake all the bond)

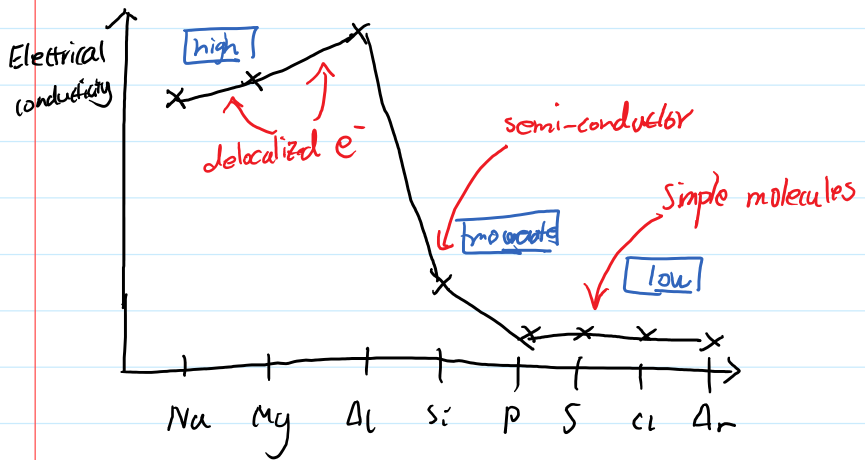
③ P, S, Cl, Ar

- Structure — Simple covalent
- bond — covalent

- IMF → Vd. force

$S_8 > P_4 > Cl_2 > Ar$

Electrical Conductivity



Chemical Properties

observation [1]
color [1]

	△ (burn) O_2	(dry) (powder) △ Cl_2	H_2O
Na	yellow Frame $4Na_{(s)} + O_{2(g)} \rightarrow 2Na_2O_{(s)}$ white solid/smoke (Na_2O)	yellow Flame $2Na + Cl_2 \rightarrow NaCl_{(s)}$ green gas disappear	Float, move, melt, violent, fizz $2Na + 2H_2O \rightarrow H_2$ $\underline{\cancel{2NaOH}}$ Alkaline
Mg	Bright Flame $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$ white solid/smoke (MgO)	white Flame $Mg + Cl_2 \rightarrow MgCl_{2(s)}$ white smoke	slow, bubbles (few) → cold $Mg + H_2O \rightarrow \underline{Mg(OH)_2} + H_2$ → weak alkaline fast, no bubbles → steam $Mg + H_2O \rightarrow \underline{MgO} + H_2$ → white solid
Al	white Flame $2Al + 3O_2 \rightarrow Al_2O_3$ white solid/smoke (Al_2O_3)	white smoke sublime $2Al + 3Cl_2 \rightarrow \underline{Al_2Cl_{6(s)}}$ crystal → hydration → acidic solution	
Si	Slow $Si + O_2 \rightarrow SiO_2$ white flame	Slow $Si + 2Cl_2 \rightarrow \underline{SiCl_{4(l)}}$ → colorless	
P	white flame → sublime $P_4 + 5O_2 \rightarrow \underline{P_4O_{10}}$	$\underline{PCl_{3(l)}}$ & $\underline{PCl_{5(s)}}$ → white solid colorless $2P + 3Cl_2 \rightarrow PCl_{3(l)}$	

P	White flame $P_4 + 5O_2 \rightarrow P_4O_{10}$ (sublime / fuse) white smoke	$PCl_{3(l)}$ & $PCl_{5(s)}$ colorless → white solid $2P + 3Cl_2 \rightarrow PCl_{3(l)}$ $2P + 5Cl_2 \rightarrow PCl_{5(s)}$	
S	Blue Flame $S + O_2 \rightarrow SO_2$ (pungent smell)		

Variation in Oxidation number

1. of oxides (Na → S)

ionic compound: No. of e^- lost in reaction

electron used during bonding

+1	+2	+3	+4	+5	+4
Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2

P_2O_5 is only empirical

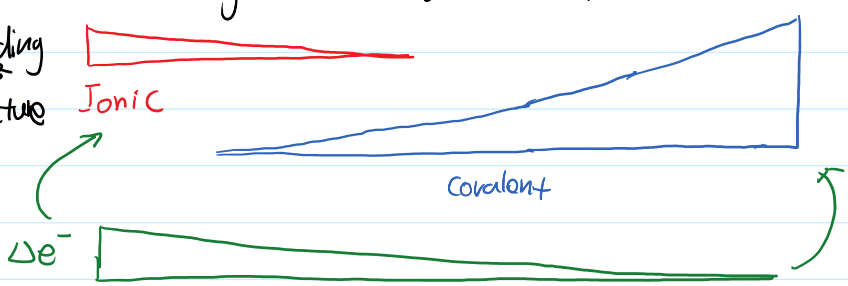
Do not Use it

Bonding structure: giant ionic (Na_2O, MgO, Al_2O_3); giant covalent (SiO_2); simple molecules (P_4O_{10}, SO_2)

2. oxidation number of Chlorides (Na → P)

+1	+2	+3	+4	+3 / +5
$NaCl$	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3 / PCl_5

Bonding & Structure



causing this different

Reactions of Oxides with water [Na → S]

- are their ionic? / Covalent?
- What is the resultant pH?
- are their basic? / Amphoteric? / acidic?

} should be answered

1. Na_2O [Ionic] reacts ready with water to give an [alkaline] solution (pH=14)

$Na_2O + H_2O \rightarrow NaOH_{(aq)}$

2. MgO [Ionic] reacts with water to give an [weakly alkaline] solution (pH = 9-11)

$MgO + H_2O \rightarrow Mg(OH)_{2\,(aq)}$ ← slightly soluble so weakly acidic

$Mg(OH)_2 \rightleftharpoons Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$

– basic

$MgO + H_2O \rightarrow Mg(OH)_{2\,(aq)}$ ← $Mg(OH)_2 \rightleftharpoons Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$

basic

3. Al_2O_3 [insoluble] in water because of [giant ionic structure with covalent character] [pH = 7]

amphoteric   acidic

$Al_2O_3 + HCl \longrightarrow AlCl_3 + H_2O$

base

$Al_2O_3 + NaOH \longrightarrow Na^+ + Al(OH_4)^- \Rightarrow Na \cdot Al(OH)_4$

acid

hot & concentrated

H_2O (for balanced)

12/4

Monday, December 4, 2017 8:06 AM

4. SiO_2 is [insoluble] because it's [Giant covalent Structure], so [pH = 7]
it's [acidic]

insoluble → no interaction

$$SiO_2 + 2\underbrace{NaOH_{(aq)}}_{\text{hot \& concentrated}} \longrightarrow \underbrace{Na_2SiO_3}_{\text{sodium silicate}} + H_2O$$

5. P_4O_{10} and SO_2/SO_3 have [simple molecules] and all are [acidic, pH = 1-2]

$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ phosphric acid pH=2

$SO_2 + H_2O \longrightarrow H_2SO_3$ solfurous pH=2

$SO_3 + H_2O \longrightarrow H_2SO_4$ solfuric pH=1

Chlorides of P3

	Na	Mg	Al	Si	P
formula	NaCl	$MgCl_2$	$AlCl_3$ / Al_2Cl_6	$SiCl_4$	PCl_3 / PCl_5
structure	Giant ionic	Giant ionic / covalent	simple molecule / ionic	simple molecule	simple molecule
M.P.	801	710	184	—	—
effect of H_2O	dissolve	dissolve	react (Hydrolysis)	react	react

$\underbrace{AlCl_{3(s)}}_{\text{hydrated crystal (ionic)}} \xrightarrow{\Delta} \underbrace{Al_2Cl_{6(s)}}_{\text{dimer (covalent)}} \longrightarrow \underbrace{AlCl_{3(g)}}_{\text{decomposition}}$

react (Al, Si, P): white steamy fuse → limiting H_2O

	NaCl	$MgCl_2$	$AlCl_3$	others
pH	7	6.5	3	1 – 2

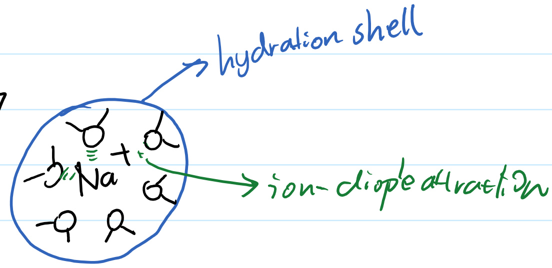
Reactions of chlorides with water

Reactions of chlorides with water

1. an ionic chloride dissolves in H_2O:

$NaCl_{(s)} + aq \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$ pH = 7

ion-dipole force

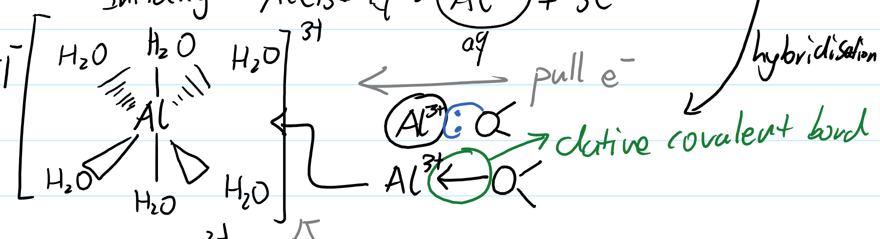


$MgCl_{2(s)} + aq \longrightarrow Mg^{2+}_{(aq)} + 2Cl^-_{(aq)}$ pH = 6.5 (why?)

(Al^{3+} → high charge density → highly polarizing) ← drag pair of e^-

Initially: $AlCl_3 + aq \rightarrow Al^{3+}_{aq} + 3Cl^-$ → 3d unused → hybridisation → dative covalent bond

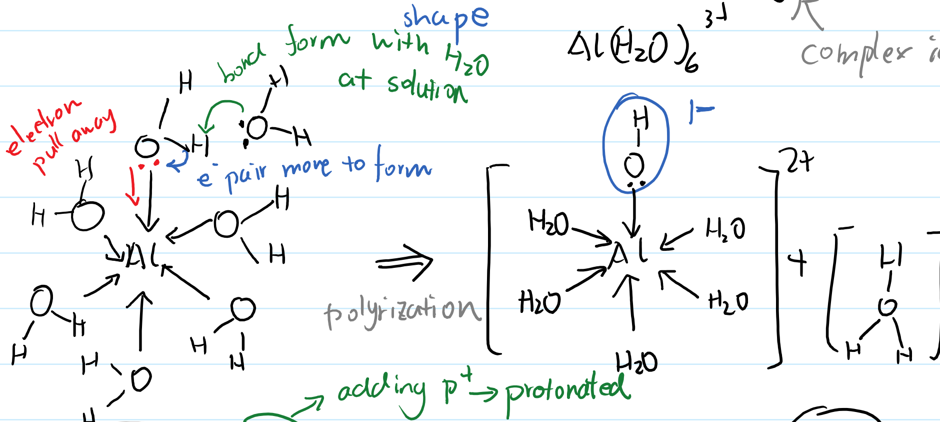
[EXO] → $AlCl_{3(s)} + 6H_2O \longrightarrow Al(H_2O)_6^{3+} + 3Cl^-$



pH = 3 (why?)

octahedral shape

$Al(H_2O)_6^{3+}$



⇒ pH ↓ (3)

$Al(H_2O)_6^{3+} + H_2O \rightleftharpoons Al(H_2O)_5OH^{2+} + H_3O^+$ equillibrium → right

adding p^+ → protonated

donating H^+ acid — losing p^+ → deprotonation

accepting H^+ base

large amount of water

limiting water:

$[\,AlCl_{3(s)} + \overset{\text{drops}}{H_2O} \longrightarrow \underline{AlCl_2OH_{(s)}} + HCl_{(g)}\,]$ → steamy fume

for $MgCl_2$

Na^+ Mg^{2+} Al^{3+}

highly polarised

$[Mg(H_2O)_6]^{2+} \rightleftharpoons [Mg(H_2O)_5OH]^+ + H^+$ (left) pH≈6.5

$[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(H_2O)_5OH]^{2+} + H^+$ pH=3

Na$^+$ Mg^{2+} Al^{3+} → highly polarising

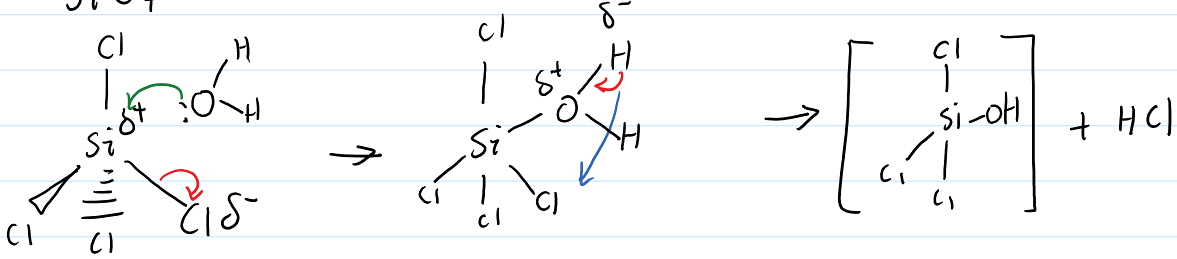
$[Mg(H_2O)_6] \rightleftharpoons [Mg(H_2O)_5OH] + H^+$ pH≈6.5

$[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(H_2O)_5OH]^{2+} + H^+$ pH=3

more polarising → right

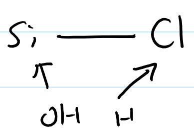
2. Covalent chorides + H_2O → Acidic (steamy fume)

$SiCl_4$



→ $SiCl_3OH$
$SiCl_2(OH)_2$
$SiCl(OH)_3$
$Si(OH)_4$
form

hydrolysis:

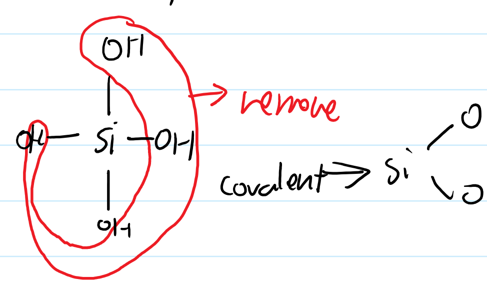


→ SiOH HCl

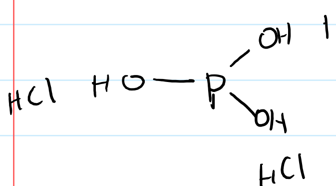
$SiCl_{4(l)} + 4H_2O \rightarrow Si(OH)_{4(s)} + 4HCl_{(g)}$

$SiCl_4 + 2H_2O \rightarrow SiO_{2(s)} + 4HCl_{(g)}$

white solid, steamy fume

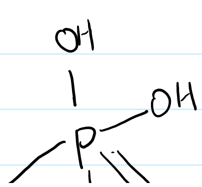


$PCl_3 + 3H_2O \rightarrow H_3PO_3$

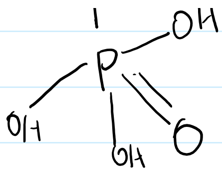


⇒ $P(OH)_3 \rightarrow H_3PO_3$

$PCl_5 + 4H_2O \rightarrow H_3PO_4$



⇒ $P(OH)_4O \rightarrow H_3PO_4$



$\Rightarrow P(OH)_4O \rightarrow H_3PO_4$

12/7

Thursday, December 7, 2017 9:36 AM

Period II

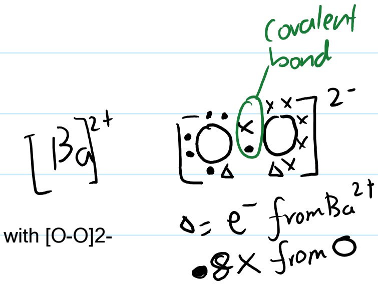
Chemical Properties[Mg to Ba]

- Reactive metals
- Outer shell electron configuration ns2
- Only one oxidation state of +2
- Strong reducer
- Trend down the group

Reaction with Oxygen[Mg to Ba]

All group II elements burn in oxygen with a bright flame to form monoxides which are

- White ionic solids
- Basic



- Mg burns with a bright white flame
- Ca and Sr burn with red flames
- Ba burns with apple green flame
    - In burning with excess of oxygen, Ba form BaO2(Barium Preroxide)[ionic] with [O-O]2-

NaO2	MgO	Al2O3
Basic Alkaline	Basic Weak alkaline	amphoteric

Reactions with water[Mg to Ba]

Group II metals react with water to form metal hydroxides and hydrogen gas, the solubility of hydroxides increase down the group.

- The solubility of group II sulphates decrease down the group
- The solubility of group II carbonates are insoluble

- Mg react very slowly with cold water/few bubbles
    - Mg(OH)2 - only slightly soluble in water[9-11]
- Ca reacts steadily with cold water. The solution goes cloudy/cloudy suspension [pH=11]
    - Ca(OH)2 - slightly soluble(More soluble than Mg(OH)2)
- Sr & Ba react vigorously with water, Ba even more vigorously than Sr[pH = 13/14]
    - Sr(OH)2 & Ba(OH)2

Thermal decomposition

The thermal stability of nitrates and carbonates increase down the group II because the polarization of metal anion decrease because metal anion becomes bigger with less charge density

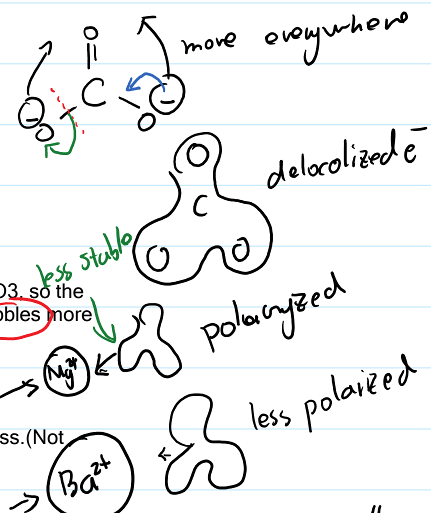
$O=C=O + O^{2-}$

Group II metal nitrates [Mg to Ba]

Group II metal nitrates decompose under heating produce metal oxide, brown nitrogen dioxide gas and oxygen gas

Mg(NO3)2 -> MgO + NO2 + O2 (less energy)

Ba(NO3)2 ->BaO + NO2 + O2(more energy)



Group II metal carbonates[Mg to Ba]

Group II metal carbonates decompose under heating produce metal oxide and carbon dioxide

MgCO3 ->MgO + CO2(less energy)

BaCO3 -> BaO + CO2(more energy)

When heating at a constant temperature, MgCO3 will be much easier to decmopose than the BaCO3, so the BaCO3 will remain some carbonate, therefore when adding acid afterward, BaCO3 will likely to bubbles more compare with MgCO3

Some Uses of Group II compounds:

1. Magnesium oxide, MgO
- Used to made the blast furnace linning(refractory furnace linning) because it prevents heat loss.(Not choosing ceramics because must not be acidic)
    - High mp
    - Thermal insulator
2. Calcium oxides CaO or powdered limestone or Ca(OH)2 = neutralise acidic soil
3. Calcium carbonate,limestone, CaCO3 is also used to make cement which is used as building material
4. Mg(OH)2 to treat acid indigestion
5. Ca(OH)2 used in agriculture to neutralise acid soils Ca(OH)2 + 2H+ -> Ca 2+ +2 H2O
6. Mg(OH)2 used in toothpate and indigestion tablets as anti acid Mg(OH)2 + 2H+ -> Mg2+ + 2H2O

- smaller ions → higher charge density
- higher density → polarizing effect

Group VII

oxidizing agent   reducing agent

Strong ← $F_2 + 2e^- \rightleftharpoons 2F^-$

- Halogens - diatomic molecules
- Outer shell electron configuration = ns2p5

Group VII

- Halogens - diatomic molecules
- Outer shell electron configuration = ns2p5
- Appearance and color->color intensity increase down the group
Chlorine	Pale-Green gas
Bromine	Red-brown liquid
Iodine	Dark Grey solid/purple vapor
- Volatility of Group VII elements
  - Simple molecules[1]
  - IMF[1]
  - Stronger down the group[1]
  - Molecuels size increase&electron number increase[1]

Redox Properties

- Halogens -oxidizing agents
- Halide ions -reducing agents
- Displacement reaction between halogens and halide ions
  - A more reactive halogen will displace a less reactive one from its compounds
  - Cl2 + KBr(colorless) -> KCl + Br2(Orange)

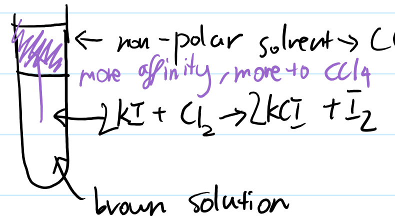
Strong ← $F_2 + 2e^- \rightleftharpoons 2F^-$

$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$

$Br_2 + 2e^- \rightleftharpoons 2Br^-$

$I_2 + 2e^- \rightleftharpoons 2I^-$ → strong

- higher density → polarizing effect
- strong polarizing effect breaks the bond in carbonates/nitrates ⇒ less stability



12/11

Monday, December 11, 2017 8:01 AM

$F_2 + H_2 \rightarrow 2HF_{(g)}$ explode under all condition → −200°C (E_a low)

$Cl_2 + H_2 \rightarrow 2HCl_{(g)}$ explode under sunlight (bright light) → (E_a high)

$Br_2 + H_2 \rightarrow 2HBr$ slow reaction, only happen on heating around 200°C

$I_2 + H_2 \rightleftharpoons 2HI$ Incomplete reaction under heating (800°C)

extent of reaction decrease

reversible because incomplete

$X-X + H-H \rightarrow 2HX$

small ← (+) $\;\; 2X + 2H \;\;$ (−) → big

① E_a quit low

F-F short but bond energy low

o o → F atom too short, repulsion help break

② H-F bond energy highest makes the reaction most exothermic because bond length shortest → release more energy to form

F − F (should be strongest)	HF
I —— I	H —— I

bond length increase (↓)

bond strength increase

short → higher

$Cl_2 + H_2 \rightarrow 2H-Cl \quad \Delta H = -92$ EXO

(+) $2Cl + 2H$ − more

insignificant compare with question

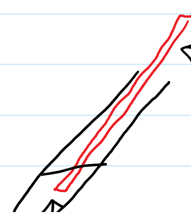
long → lower

$I_2 + H_2 \rightleftharpoons 2H—I \quad \Delta H = +26.$ ENDO

(+) $2I + 2H$ − less

relative thermal stability

	HF	HCl	HBr	HI
Bond energy	562	431	366	299



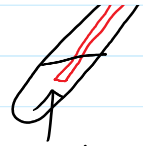
← red hot glass rod

HF / HCl → nothing

HBr → brownish vapour

Bond energy	562	431	366	299

more stable



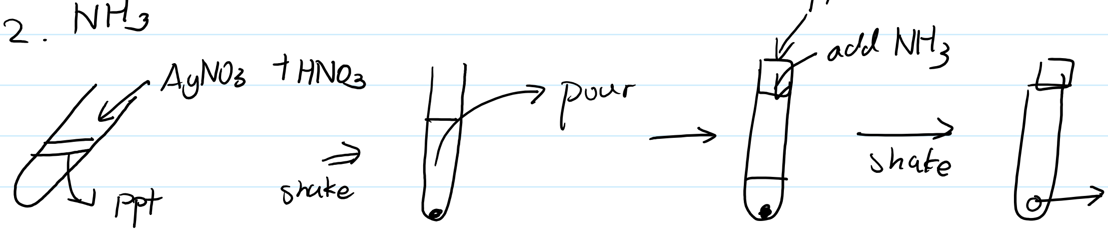
HF / HCl ~~→~~ nothing
HBr → brownish vapor
HI → purple gas
immediately

Reaction ~~with halide ions of concentrated sulfuric acid~~

Con either reduced to SO_2 to S or H_2S → see Redox notes

Test for halide ions

1. $AgNO_3$ [HNO_3] → acidified. → In case if it contaminated with CO_3^{2-} ⇒ $Ag_2CO_3^{2-}$ (white)
2. NH_3



- dissolve Cl^-
- partially dissolve Br^-
- not dissolve I^-

Halide ion	Color of ppt.	solubility of precipitate in dilute NH_3	Concentrated NH_3
Cl^-	white	soluble	soluble
Br^-	Cream	insoluble	soluble
I^-	yellow	insoluble	insoluble

- central metal ions
- number of particles → with lp (ligand)
- connect by dative covalent bond.

complex ion

pull lp

increase concentration → right

$$AgCl + NH_3 \rightleftharpoons [Ag(NH_3)_2]^+_{(aq)} + Cl^-$$

lattice broken

bond to Ag^+

$$[H_3N \rightarrow Ag^+ \leftarrow NH_3]^+$$

high charge density

linear

- dative covalent bond
- ligand

NH_3 { base, nucleophi, ligand.

- NH_3 → act as nucleophi
  attract nucleus

increase [C] ⇒ right

$$\underset{\text{ionic}}{AgBr} + NH_3 \underset{\text{left}}{\rightleftharpoons} \underset{\text{covalent}}{[Ag(NH_3)_2]^+} + Br^- \;/\; [Ag(NH_3)_2]Br$$

AgI $\not\rightarrow$

~~Disproportion reaction of Chlorine~~ 歧化

redox reaction which one substance both oxidised & reduced

- a reaction of Cl with cold [NaOH] at $\underline{15^\circ C}$

$$\overset{0}{Cl_2} + NaOH \rightarrow \overset{-1}{NaCl} + \underbrace{\overset{+1}{NaClO}}_{} + H_2O$$ bleach

- a reaction of hot [NaOH] at $70^\circ C$

$$3\overset{0}{Cl_2} + 6NaOH \rightarrow 5\overset{-1}{NaCl} + \overset{+5}{NaClO_3} + 3H_2O$$ weed killer

Reaction of Cl_2 with H_2O (purification)

HClO is Choric (I) acid ⇒ mild oxidising agent → kill bacteria (not harm to human) low concentration

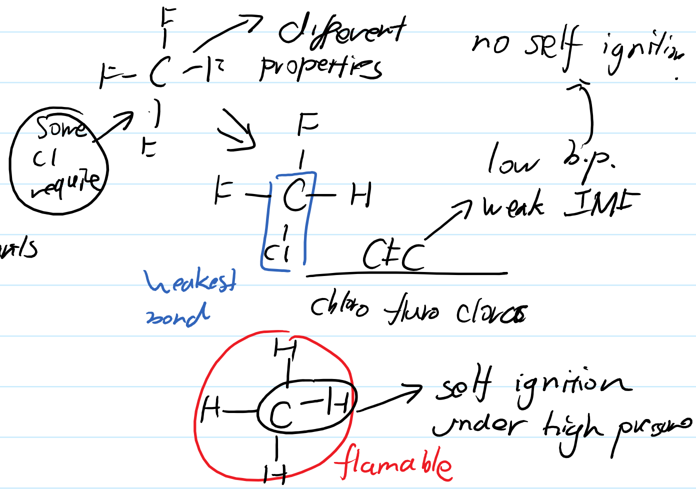
$$Cl_2 + H_2O \rightleftharpoons HCl + HClO$$ weak oxidising agent   minimum amount of Cl_2

Cl_2 dissolve in water in small amount

Application

F_2

- make CFCs → useful { refrigerators, aerosol propellants }



- make PTFE for non-stick pans.
- florides in toothpaste

Cl_2

- make PVC
- make bleaches
- disinfectant to purify water

Br_2

- As AgBr in photography
- As fire extinguishers, $CClBrF_2$

I_2

- as mild antiseptic [solution of iodine in alcohol]

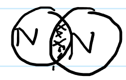
12/12

Tuesday, December 12, 2017 1:34 PM

Nitrogen

nitrogen is diatomic and <u>unreactive</u> (Ea is quit high)

Ea high



$N \equiv N$ (nitrogen molecules)

nitrogen and oxygen react in the upper atomsphere during thunderstorm

$N_2 + O_2 \xrightarrow[\Delta T \text{ high}]{} NO$ Ea high {natural: thunderstorm; man made: car engine

both of the reactants comes from air

H − F weakiest $HF \rightleftharpoons H^+ + F^-$

H − Cl
H − I } strongest acid → $H\text{-}Cl \rightarrow H^+ + Cl^-$
H − Br

Ammonia and Ammonium compounds

① NH_3 is a base, accept $H^+ \rightarrow NH_4^+$ $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$

conjugate acid-base pair

Usage of nitrogen

① Nitrogen used to make ammonia in haber process

② making UREA and salts and fertilizers

③ make nitric acid

④ nitrogen is used as inert atmosphere for food storage and metal works

{ • soluble to absorbed

H₂N−C(=O)−NH₂ contained NPK

Problem with fertilizer

highly soluble

$NH_3 + 2O_2 \xrightarrow{\text{catalyst}} HNO_3 + H_2O$ 900°C

⑤ Nitrogen oxides in atmosphere and acid rain

make explosive s (TNT)

at high T the $N_2 + O_2 \rightarrow$ nitrogen oxides

① Eutrophication (Alage growth due to excess use of fertilisor and take over O_2 of water)

all compound of nitrate

② nitrate ions in drinking water could be carcinogenic 致癌

cleaning: car : catalyst; factory : thax gas

exhaust in car engine $\rightarrow SO_2 + NO + NO_2 + CO + CO_2$

disulphurcation

removing acidic acid (Pass through $CaO/CaCO_3$)

$CaSO_3$

SO_2 & NO_2 contribute to acid Rain

N_2 $\xrightarrow{\text{Exhaust}}$

CO_2 — Car

CO — catalyst: Pt, Pd, Rh

NO_x

SO_2

C_xH_y

O_2

H_2O

$CO + \frac{1}{2}O_2 \rightarrow CO_2$

$CO + NO \rightarrow CO_2 + N_2$

SO_2 — acid rain

CO_2 — global warming

(Pb) lead poisoing ⇒ lead stick on it and not work

Organic

Thursday, January 4, 2018 9:31 AM

Homologous Series

compounds of molecules with same general formula and chemical formula

Same general formula but different functional group

aldehyde

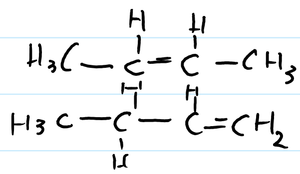
ketone

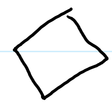
or C_nH_{2n} { alkene, cycloalkane }

Isomers

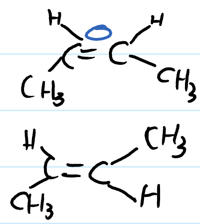
Isomers are compounds with same molecular formula but having different structure

- Structural isomers — different formula. C_4H_8





- Stereoisomers — different arrangement in space [3D] → $CH_3CHCHCH_3$



can not rotate around π

rotate to change to this

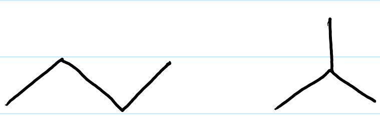
so they are slightly different

- Structure isomers
  - chain isomers
  - positional isomers
  - functional group isomers
- stereoisomers
  - geometrical isomers [cis-trans isomers]
  - optical isomers

chain isomers

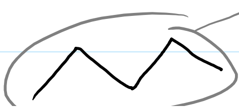
same molecular formula but different carbon skeleton → different branches

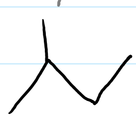
C_4H_{10}



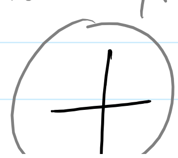
C_5H_{12}

highest m.p.





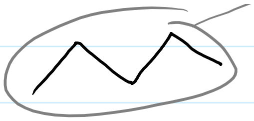
lowest m.p.



different in physical properties
- longest
- least branches

} highest m.p.

C_5H_{12}



① branch

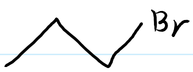
② branch

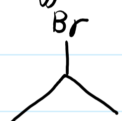
- longest
- least branches

} highest m.p.

position isomers

Position due to the different position of the functional group on same carbon skeleton

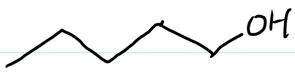


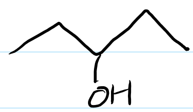


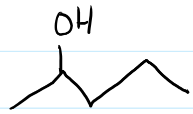
} different physical properties

similar (not exactly same) chemical properties — due to mechanism

$C_5H_{11}OH$





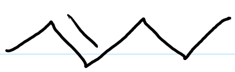


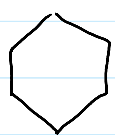
functional isomers

Compounds with same molecular but with atoms arranges to give different functional group

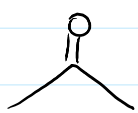
different chemical properties

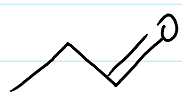
$C_6H_{12} \rightarrow C_nH_{2n}$





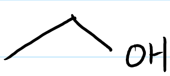
C_3H_6O { Ketone, aldehyde.



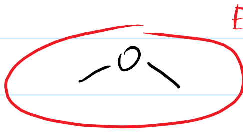


a not stable alcohol

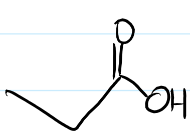
C_2H_6O

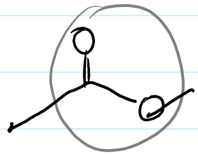


Ether



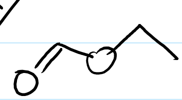
$C_3H_6O_2$



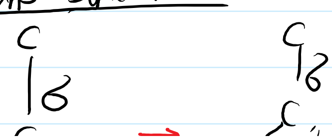


ester

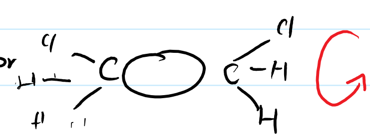
OR

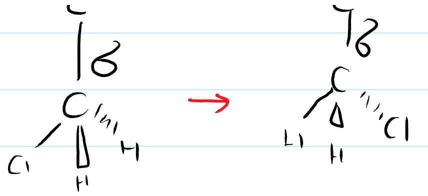


Cis-trans isomerism

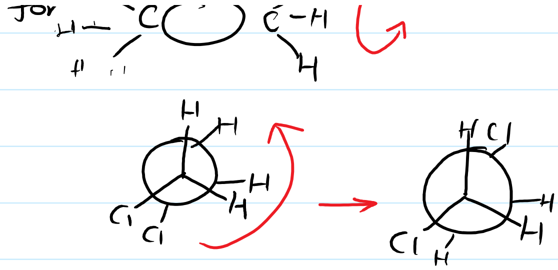


for

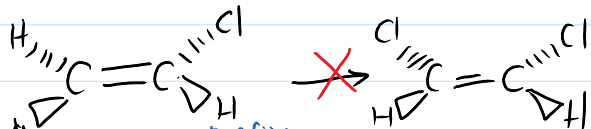




σ bond-free rotation make no cis-trans isomer



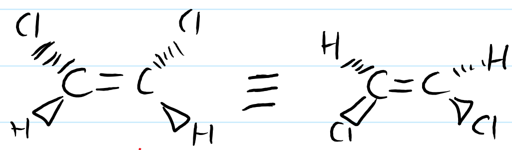
no free rotation for double bond



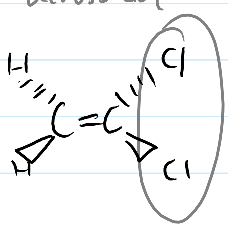
prefix

trans (across) → two similar group on across side

cis (on the same side) → two similar group on same side.

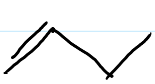


both cis.

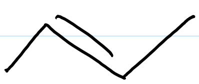


no cis-trans ⇒ functional group on same carbon

E/Z configuration?

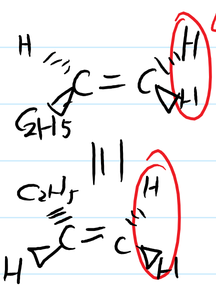


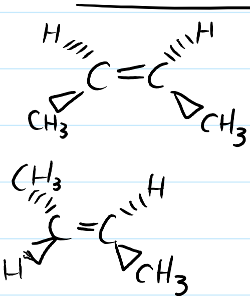
not cis-trans



at least one different group on both Carbon.

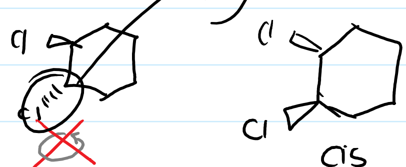
→ on both side of C=C have 2 different group.





cis

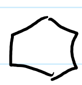
trans



going back.

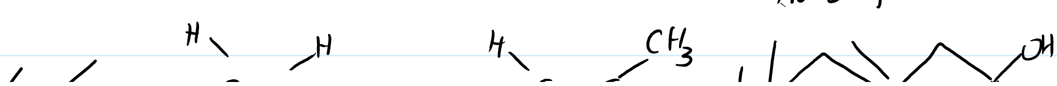
trans

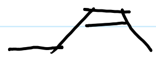
cis

Geometrical isomerism { C=C double bond. /  ring structure

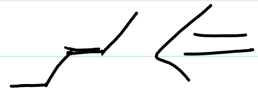
Pent-2-ene

trans-fat

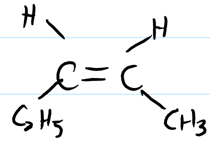




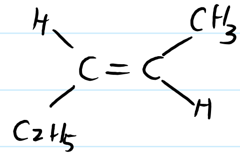
cis



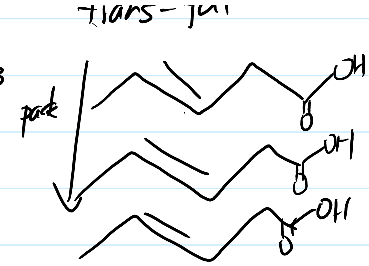
trans

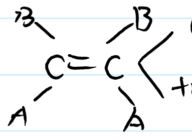


cis



trans

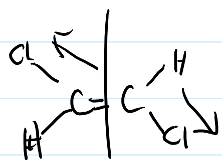


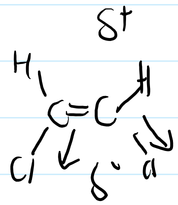


cis
trans.

$2^n \Rightarrow n$ = number of double bond

Similar chemical properties / different physical properties





Van der waar

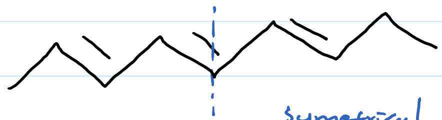
dipole (higher m.p.)

1/11

Monday, January 8, 2018 9:20 AM

Non-Symetrical Cis-Trans

$2^n = 2^3 = 8$



symetrical

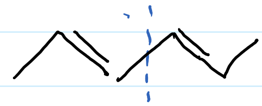
don't panic, this will not appear on the test

Use the marking way to identify

T	T	T
C	C	T
T	C	C
C	C	C
C	T	C
T	C	T
T	T	C
C	T	T

same (T, C in third column); same (C, T in third column)

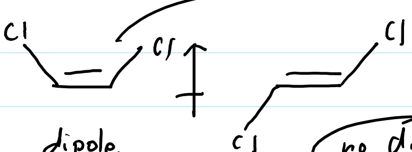
total 6.



C	C
T	T
C	T
T	C

total 3

B.p. and M.p. of Cis-trans



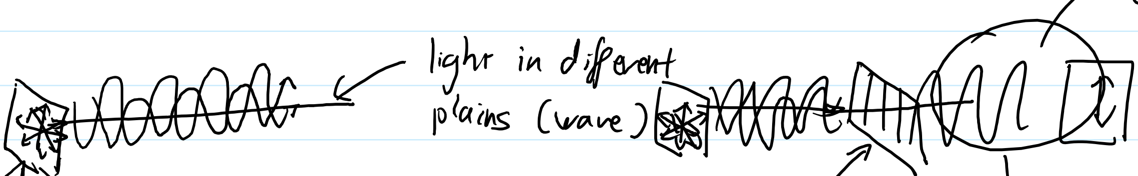
dipole

no dipole → van deer vaals

dipole-dipole

higher m.p./b.p. of cis

Obtical isomerism



plain polarized light

light in diferent plains (wave)

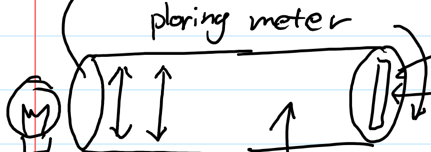
unpolarized light

polarized

Vibrate in single plain

filter (polarizer)

ploring meter



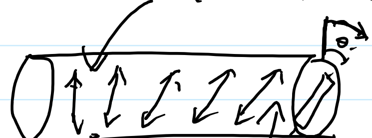
see the light if same direction

slit the same direction

sodium light

OI_1 / OI_2 solution

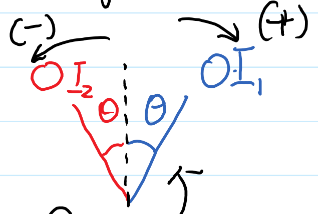
OI_1 solution



optical isomer

polarized light rotated

sodium light — OI_1/OI_2 solution — polarized light rotated

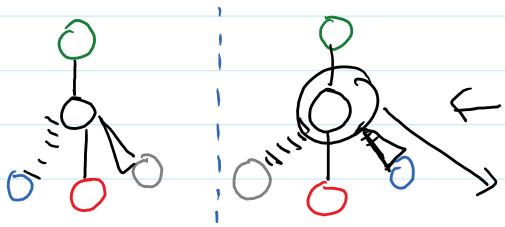


$\theta_1 = \theta_2$

optical activities: to rate plane polarized light into the specific site.

asymetric (chiral) → no plain of symetric

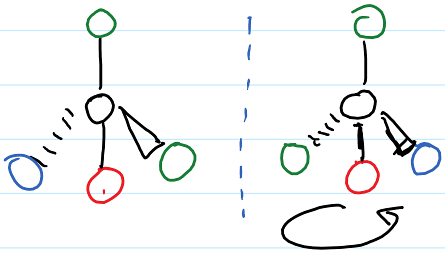
optical isomes are identical to one another, except in optical activity (they have mirror image which are not superimpossable



← they are not superimpossiable

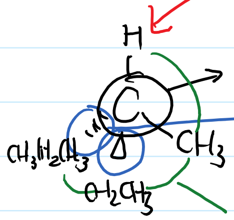
chairal center → one where its connected to 4 different groups

mirror image



← they are ~~super imposiable~~

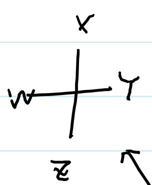
not super imposible



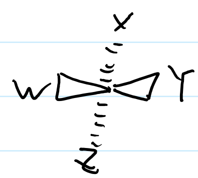
chiral carbon

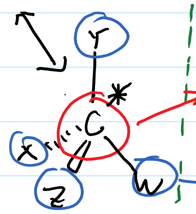
3D structure

four different group



Fisher projection →



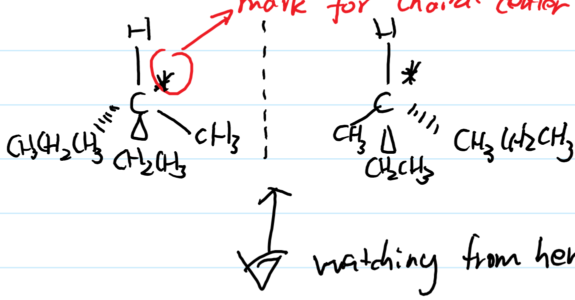


① Carbon to 4 group

② 4 group are different

③ mirror image not super imposible.

mark for chairal center



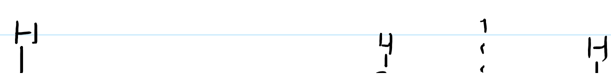
watching from here

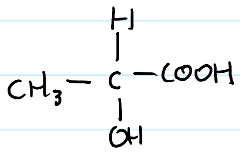
Optical isomers / enantiomers

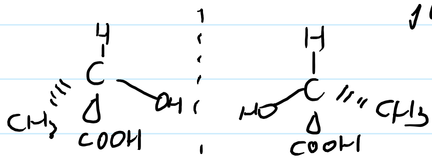
= two non superimposable mirror images of a chiral molecule

In natural reaction we get the mixture of both optical isomers ① useful ② useless / side effect

just get one stereoisomer → use for drug







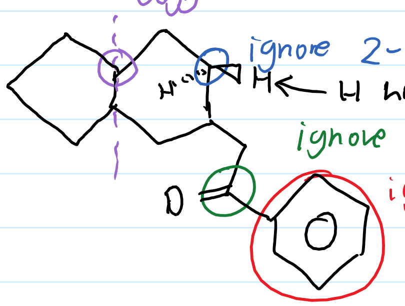
mirror plane

just get one stereoisomer → use for drug

← draw this on the test paper.

how to count chairal center in complex compound?

asymmetric C ✓



ignore 2-H

H ← H hidden

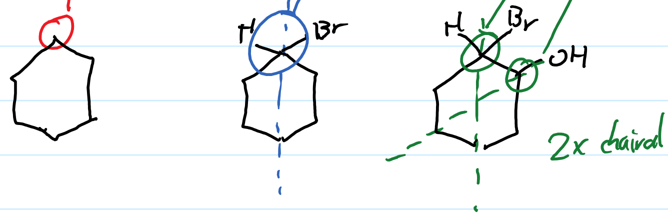
ignore double bond

ignore benzene

2-H not chairal

still no chairal

asymmetrical



2x chairal

Degree of Rotation

- nature of molecule
- concentration of solution.

rotation 'cancel out'

racemate mixture

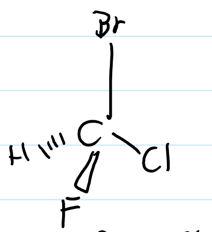
solution/substance

OI_1

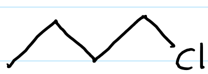
OI

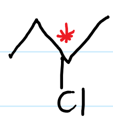
equal amount

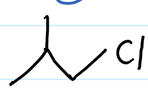
enzyme → stereospecific → one orientation only

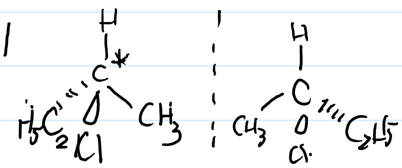


C_4H_9Cl

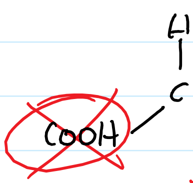
① 

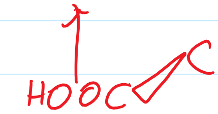
② 

① 



This is correct





wrong → C connect to carbon

if a compound have more than 1 chairal center, it is possible that these two compound's mirror image are superimpossible

Introduction to Organic reactions

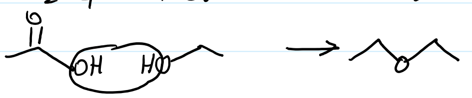
- subsitution → an atom/group replace by another
- addition → two or more molecules react together to form a single molecule
- Elimination → a small molecule is removed from a larger one [usually from C=C]

Sub − $CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$ two product

add − $C_2H_4 + HCl \longrightarrow CH_3CH_2Cl$ one product → unsaturated reactant.

Eli − $C_2H_5Br \longrightarrow C_2H_4 + HBr$ unsaturated product

condensation: Add & Eli



$+ H_2O$

Reaction Mechanism → the sequence of small steps in a reaction

two particles collision happened → Intermediate creates

one particle → Intermediate C–X → C⊕ + X⊖ } both are mechanism.

bond breaking → rearrange

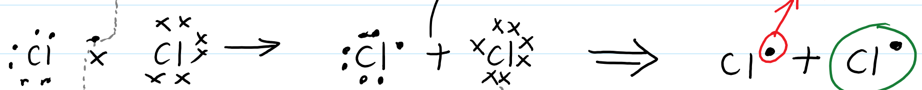
Ways of breaking bond

Homolytic → breaking of covalent bond such that each atom get one e^-

non-polar forming free radicals

mostly same / similar e^- negativity

Cl — Cl



free radicals.

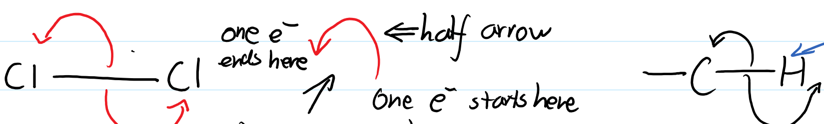
un pair extra e^-

reactive to form octaive

bond breaking equally

no overall charge

this could happen to C−H



one e^- ends here

⇐ half arrow

one e^- starts here

how arrow shows

not very polar (similar e^- negativity)

free radicals → an atom/group with an unpaired e^- formed from homolytic fission

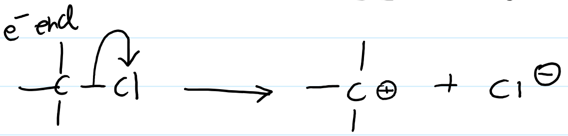
Hetelyic → breaking of covalent bond such that both e^- goes to one atom, forming postive and negative ions

polar bond

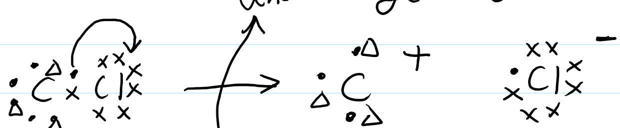
full arrow

2e^- end

2e^- start



when charge on C



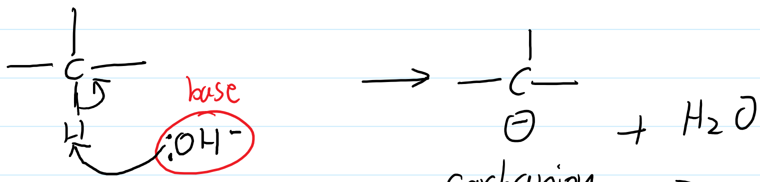
carbocation

anion

carbocation is a species that carries a postive charge on a carbon atom

→ two hane

carbocation is a species that carries a postive charge on a carbon atom



proton acceptor

$C = C - C = C$
① ② ③ ④

the name
show clearly

~~but-1,3-diene~~
buta-1,3-diene

Carbanion → removal of hydrogen atom in a C-H bond results in an anion

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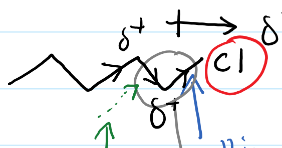
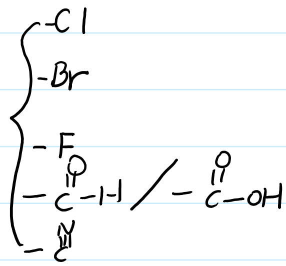
Inductive effect

pull e^- away from other atom.



EWG – Electron withdrawn Group



this bond polarised

pull e^-

transfer of charge

last ≈ 3 bond

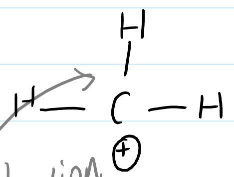
direction of e^- transfer — make the bond polared

pulling e^- effect get transmitted → Negative Inductive Effect

weak effect

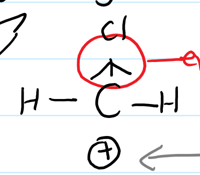
for carbocation:

unstability increase → not form



methyl cation

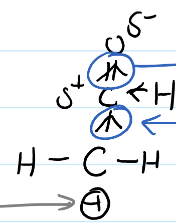
highly unstable



even withdraw more

more unstable

stronger charge



This bond polarised.

this pair is also attract and pull away from $C^{\oplus}$

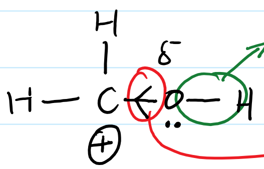
more unstabe

Electron donating Group

and reversely, there is postive inductive effect ⇒ associate with EDG

push e^- away

$-OH$ $-NH_2$ $-CH_{3(4)}$ $(-R)$

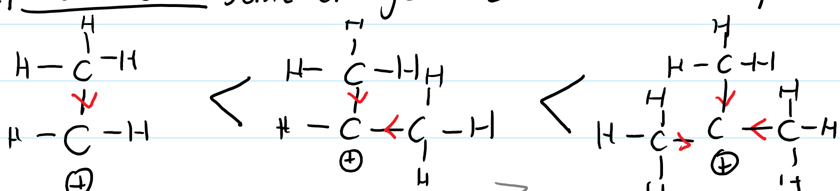


this bond already highly polar

the already negative $O^{\delta-}$ will attracted by $C^{\oplus}$ and even (··) on it

This effect is called postive inductive effect

EDG neutralized some charge on carbocation to help to stabalize it → more stabe



primary

least stable

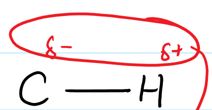
secondary

tertiary

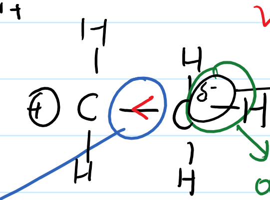
most stable

few S

prefer this at most



very small polarisation

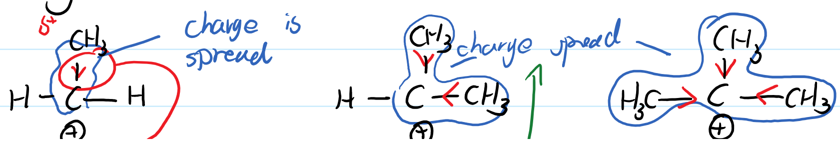


alreay negatively charge.

only behave in this sceario

postive inductive effect due to ⊕ pull C e^-

another way to explain:

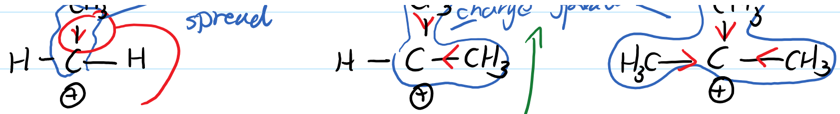


charge is spread

charge spread

more EDG alkyl group

more neutralise carbocation's

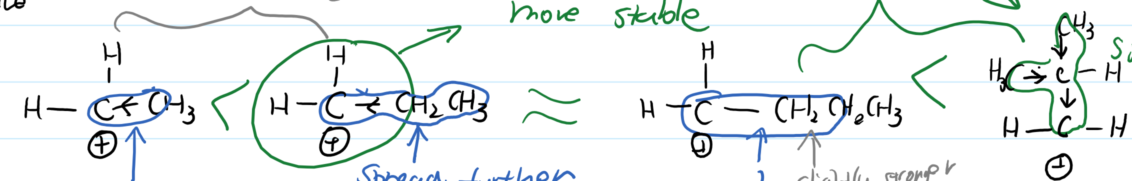


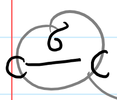
more e⁻ donating group more neutralise carbocation's postive charge. Easier to spread charge → more stable

postive charge attract $C^{\delta+}$ e^- towards $C^{\oplus}$
have $C^{\delta+}$ slightly polarised

charge density decrease by spreading across → make it more stable

compare





effect primarily on $C \overset{\sigma}{-} C$ not π

beyond 2-C bond is too weak

Nucleophiles && Electrophiles

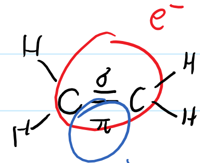
- Nucleophile

accept a pair of e⁻

attack by ⊕

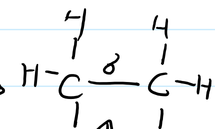
neutral { $H_2\ddot{O}$, $\ddot{N}H_3$ } → lone pair e⁻ (e⁻ rich) ↓ donate lone pair ↓ form dative covalent bond

anion { $\ddot{O}H^-$, $\ddot{C}\equiv N^-$, $\ddot{H}^-$ hydride }



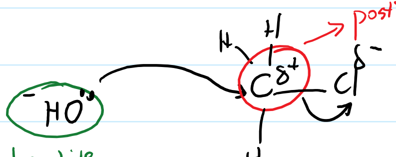
π bond weakest

C — C



broken π bond

a donar of lone pair e⁻ forming dative covalent bond (attracted to +ve center)



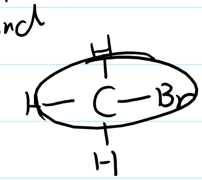
electron deficent → electrophilic

- Electrophile → donate a pair of e⁻

- acceptor of a lone pair of e⁻

$\{ Br^+, -\overset{\ominus}{N}O_2$

polar bond

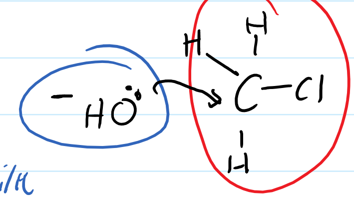


electrophile.

Mechanism to learn

- free radical substitution
- electrophilic addition
- electrophilic substitution.

- Nucleophilic substitution
- Nucleophilic addition



Alkanes

Physical properties

meth— but gases
othes — liquid
C-70 — solid

} von deer waals force increase. non-polar.

more branches → less contact surface → m.p. decrease.

von deer waals force formed — Stronger

solvent → organic (non-polar) solvent

CCl$_4$ hexane

dissolve in water → break H-bond — Stronger
so energy less → too small

alkanes → saturated / non polar → non-reactive

not enough

① non-polar → ② not reactive with electrophile / nucleophile / ions

Not attractive

③ however → can react with non-polar O_2 / Br_2 / Cl_2

① Combustion   ② subsitution   ③ Cracking

free radical subsitiution

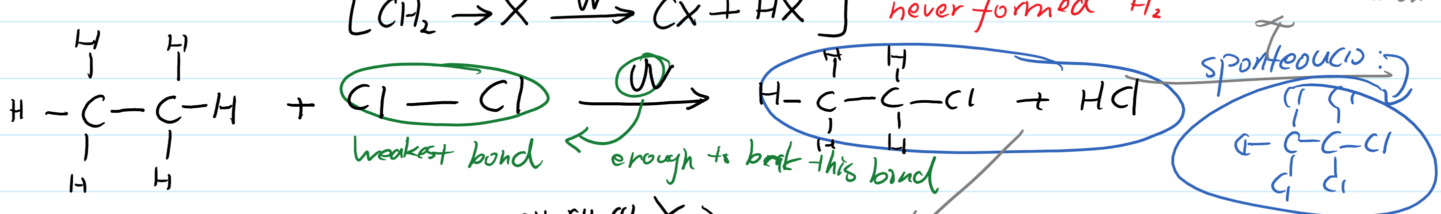
Cl_2 / Br_2 (F_2) → reactive   no I_2 → unreactive

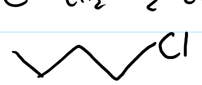
Condition: UV Light

Reagent: $Cl_2(g)$ / $Br_2(g)$ → Br water no reaction, must have gas phase

Product: $C_nH_{2n+2-m}X_m$

$[CH_2 \to X \xrightarrow{W} CX + HX]$ never formed H_2



$CH_3CH_2CH_3X$ ✗
$H_3C-CH_2-CH_2-CH_3$ ✓


} Strange product

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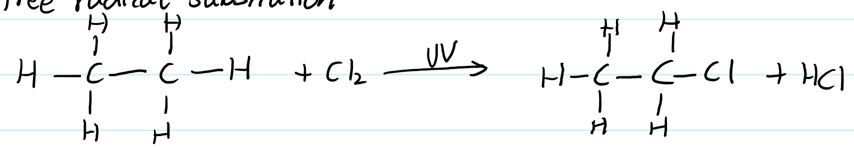
free radical subsitution



$\rightarrow$ CH_3CHCl_2 / CH_3CHCl_3 / CCl_3CCl_3 } mixture of compand

disubsituted

all are subsitutad

are we going to get { $CH_3CH_2CH_2CH_3$? ✓

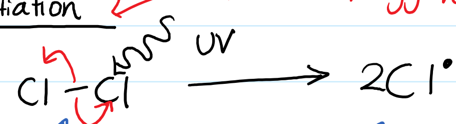
$CH_3CH_2CH_3$? ✗

$CH_3CH_2CH_2CH_2Cl$? ✓

Mechanism

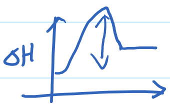
1. Initiation

← activation energy require ⇒ break the bond $\Delta H > 0$ → bond breaking



← initiation step → create free radicals

break bond → ΔH



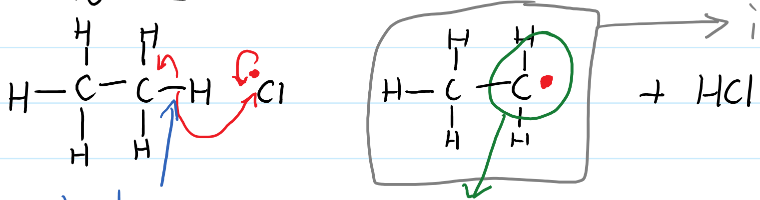
Ea high

2. Propigation

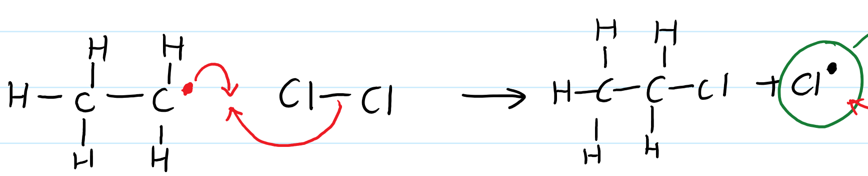
M + FR → M + FR

ΔH depende ⇒ one form, One break

intermediate

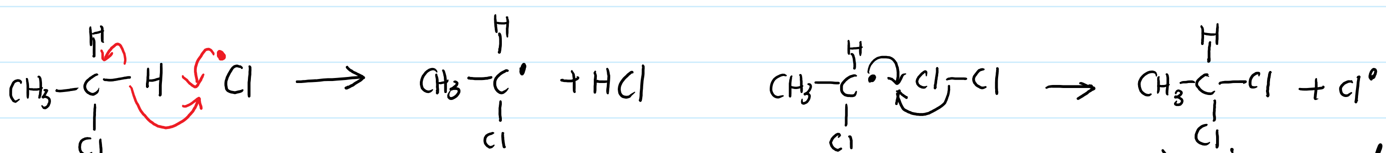


⇒ overall → $CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$



catalyst → helps reaction / regenerated

This is not going to stop here



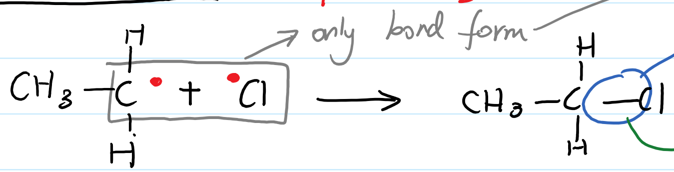
going on and on

3. Termination

$FR_1 + FR_2 \rightarrow M \rightarrow \Delta H < 0$ (C–Cl form), etc. → lowest Ea

only bond form

only bond forming ⇒ Ea low



→ remove FR → terminate reaction