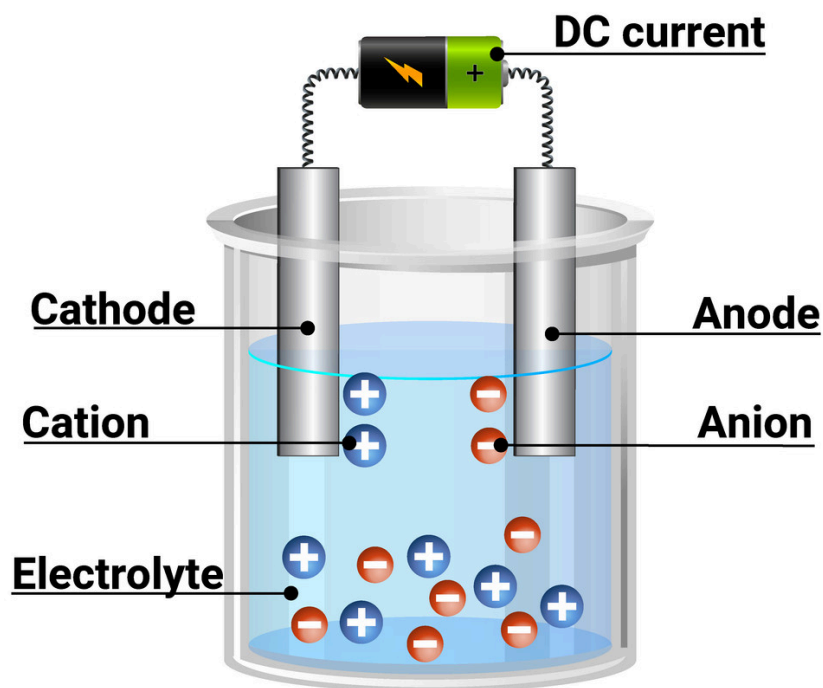


ELECTROCHEMISTRY

FOR

O Levels, GCE, iGCSE

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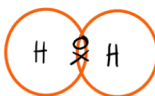
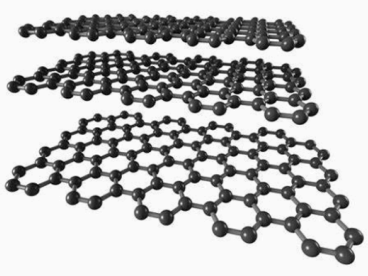
Chemical Compounds and Electricity

Electrochemistry

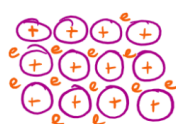
oxidation: loss of e^- } redox
 reduction: gain of e^- }

Electricity Conduction

movement of charged particles (ions or free moving e^-)

- simple covalent molecules: no electricity conduction (no ions or free electrons) 
- macromolecular / giant covalent - only **graphite** has free electrons and conducts electricity. 
- ionic compounds: conduct electricity in molten / aqueous state due to free moving ions Na^+, Cl^-

- metals:



conduct electricity due to free moving electrons

→ +ve ions don't move and don't conduct

Giant Metallic Lattice

regular arrangement of +ve metal ions in a sea of free moving electrons

* atoms / metal with more delocalized e^- are better conductors / Al high voltage transmission (Al atom loses $3e^-$)

Electrolysis of Molten Electrolytes

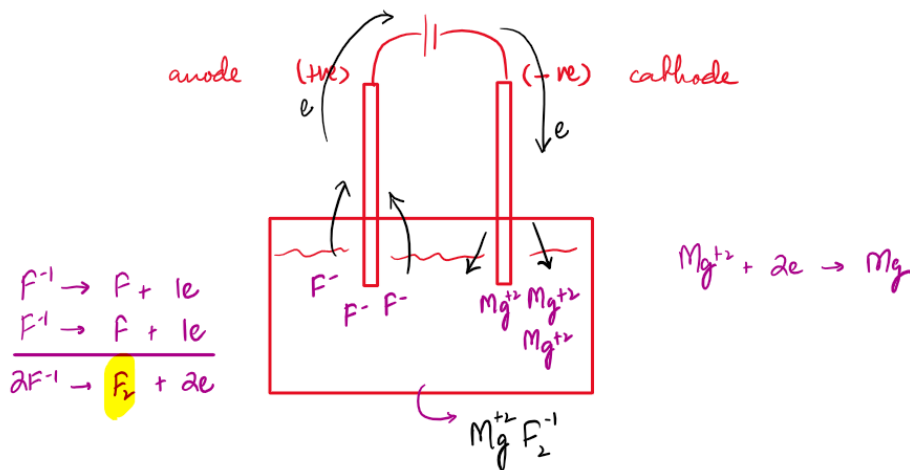
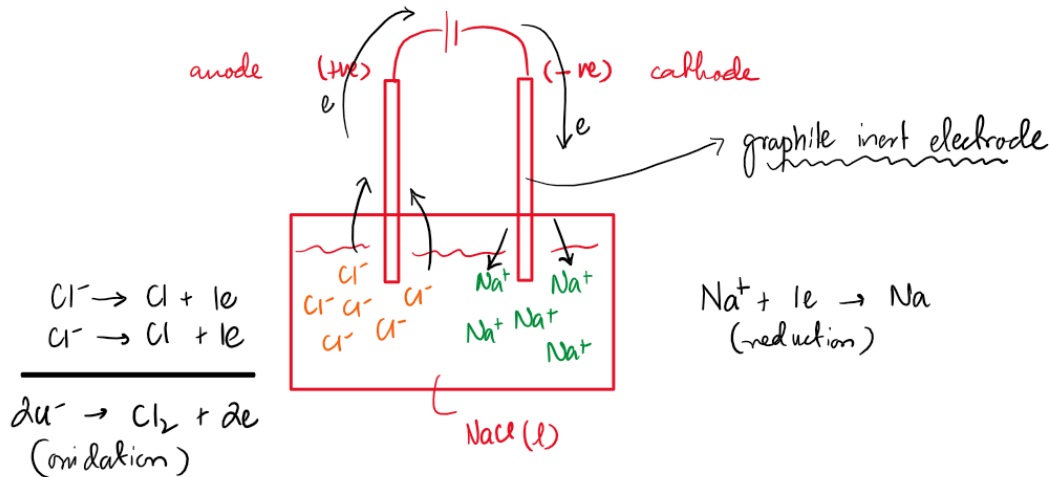
Electrolysis decomposition of an electrolyte by passing current.

free moving ions
acids, bases, salts
(aqueous / molten)

Electrolysis of Molten Electrolytes

Inert electrodes (graphite or platinum)

some atoms are always diatomic
* note: $H_2, O_2, N_2, Ar?$
(F_2, Cl_2, Br_2, I_2)

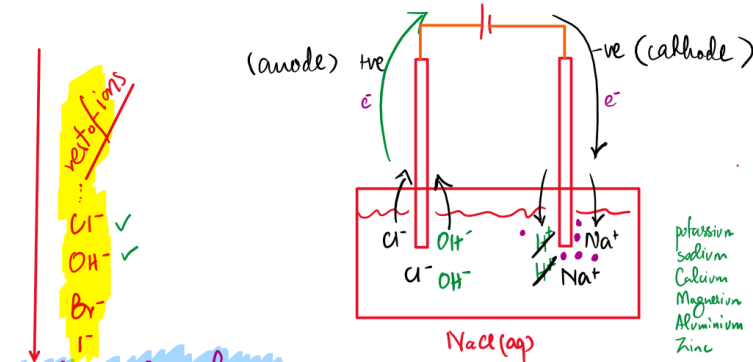


HOME WORK

- | | | |
|-------|------------------------------|---------------------------------|
| (i) | $\text{CaCl}_2 (\ell)$ | $\text{Ca}^{+2}, \text{Cl}^-$ |
| (ii) | $\text{Na}_2\text{O} (\ell)$ | $\text{Na}^+, \text{O}^{-2}$ |
| (iii) | $\text{CuS} (\ell)$ | $\text{Cu}^{+2}, \text{S}^{-2}$ |
| (iv) | $\text{AlBr}_3 (\ell)$ | $\text{Al}^{+3}, \text{Br}^-$ |
| (v) | K_3N | $\text{K}^+, \text{N}^{3-}$ |

Electrolysis of aqueous electrolytes (inert electrodes, graphite or Pt)

→ dissolved in water



greater tendency for ion to lose e-



remember this → bubbles/effervescence

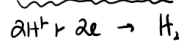
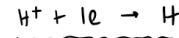
exception: if solution is concentrated and Cl- are at anode always select Cl-



→ greenish-yellow gas

Reactivity Series

potassium
sodium
calcium
magnesium
aluminium
zinc
iron
tin
lead
hydrogen
copper
mercury
silver
gold
platinum

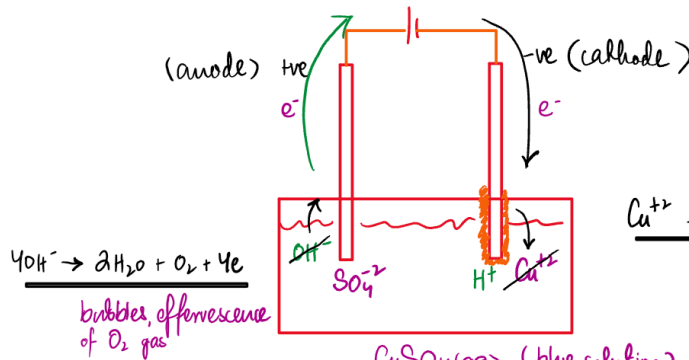


bubbles/effervescence seen

greater tendency for ions to gain e-

- * Cl₂(g) greenish-yellow gas
- * Br₂(l) red/brown liquid
- * I₂(s) blue, black solid
(I₂(aq) brown, yellow solution
I₂(g) purple vapor)

CuSO₄(aq)



brown/pink shiny metallic deposit

CuSO₄(aq) (blue solution)

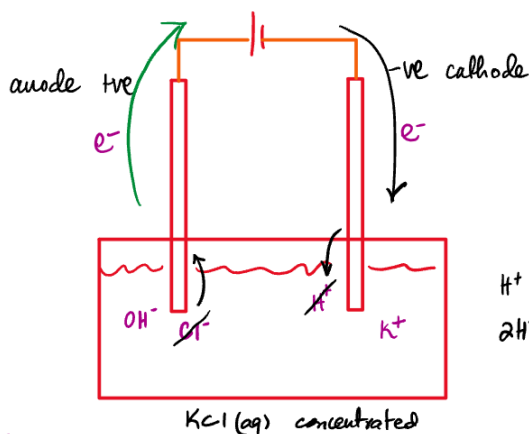
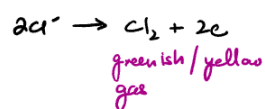
↓ changes to



* color of solution: blue to colorless and solution becomes more acidic

KCl(aq) concentrated

always Cl^- is oxidized when solution is concentrated

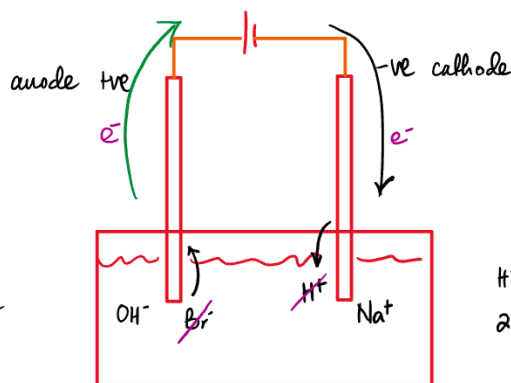
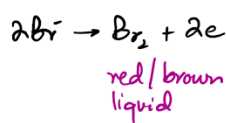


H^+ is lower in the reactivity series
 $2\text{H}^+ + 2e^- \rightarrow \text{H}_2$
 bubbles / effervescence

KCl(aq) concentrated
 ↓ changes to
 K^+OH^- solution becomes basic

NaBr(aq)

Br^- is lower in the series



H^+ is lower in the reactivity series
 $2\text{H}^+ + 2e^- \rightarrow \text{H}_2$
 bubbles / effervescence

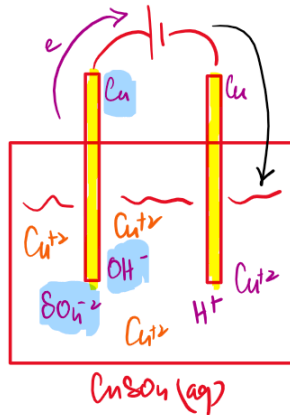
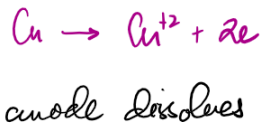
NaBr(aq)
 ↓ changes to
 NaOH(aq)
 solution changes basic / alkaline

Electrolysis Using Active Electrodes (Made out of Metals e.g. Cu, Ag etc)

Electrolysis of Aqueous Solutions using Active (reactive metal) Electrodes

Anode

OH^- , SO_4^{2-} don't lose e^-
but Cu metal itself
loses e^-



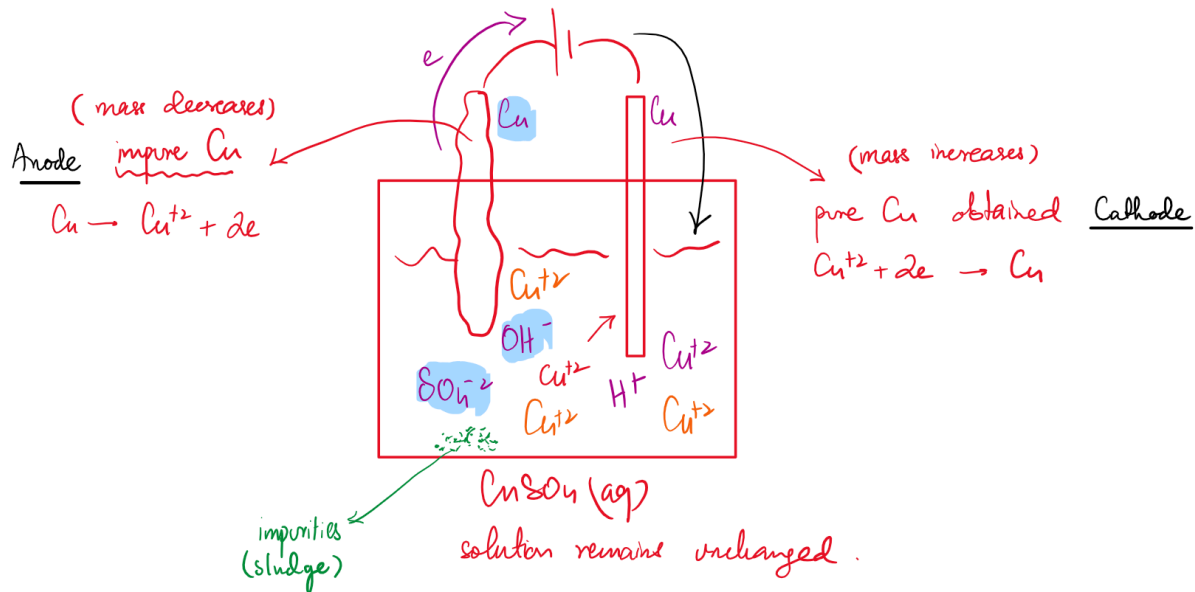
cathode (same as before)

Cu^{2+} , H^+ ?



solution remains unchanged (remains blue)
as anode produces Cu^{2+}
while cathode removes Cu^{2+}

Used for purifying impure Cu

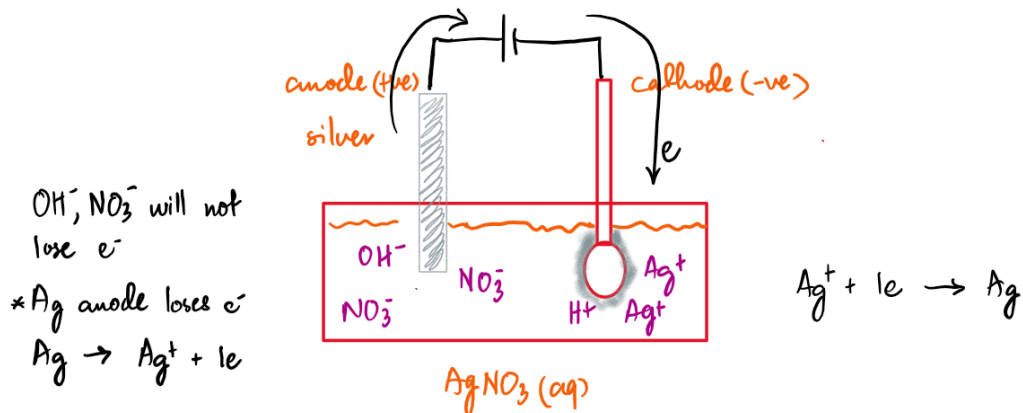


Electroplating

cover an object (metallic object with an unreactive shiny metal)
e.g gold plated watches, looks good and prevents rusting with water and air
↳ expensive

Electroplate a spoon with silver

1. object, spoon : cathode
2. electroplating metal : anode
3. solution should contain ions of electroplating metal



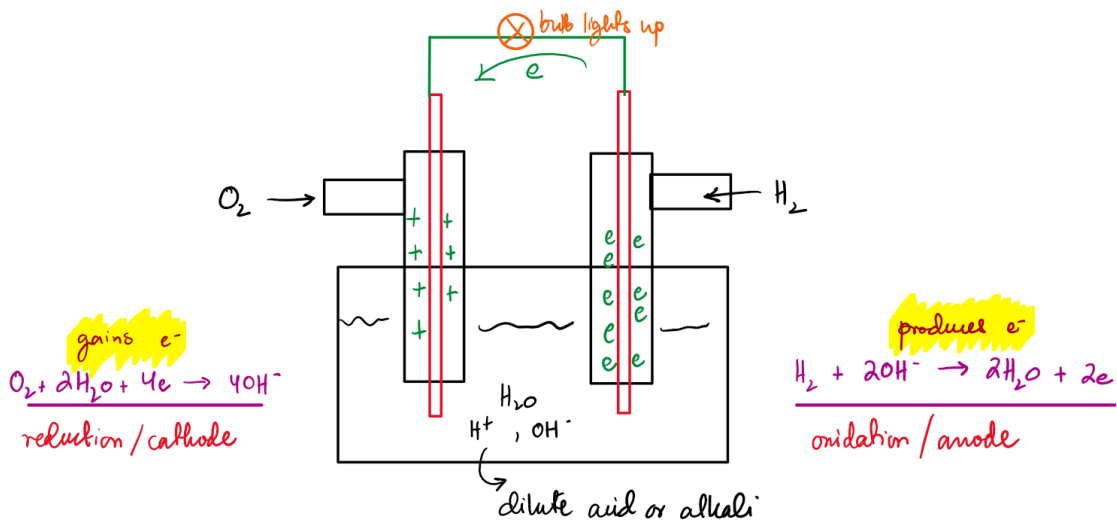
Hydrogen-Oxygen Fuel Cell

Fuel Cell

opposite of electrolysis

Electrolysis : electrical energy $\rightarrow$ chemical energy
(battery) (reactions at cathode/anode)

Cell : chemical energy $\rightarrow$ electrical energy
(reactions) (battery)



Overall equation

make sure e^- gained/lost are equal

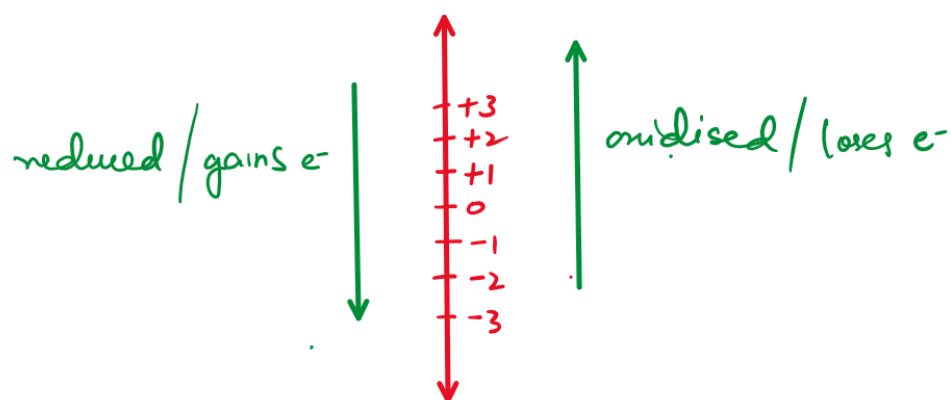


Redox Reactions

Redox Reactions

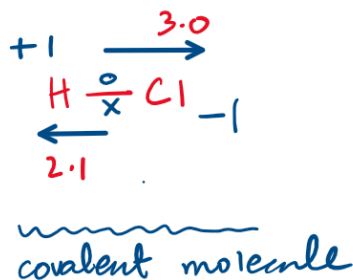
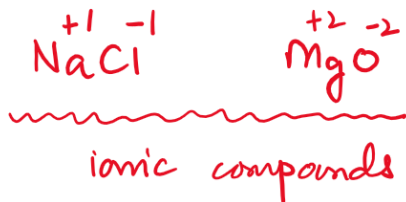
Reduction : gain of e^- $\longrightarrow$ charge/oxidation state decreases

Oxidation : loss of e^- $\longrightarrow$ charge/oxidation state increases



Oxidation State

Change on an element in a compound if the compound was ionic



Table

neutral element = '0'

compounds

Grp 1: +1

Grp 2: +2

Grp 3: +3

transition metals: variable

Oxygen: -2 (except in H_2O_2 , -1)

Hydrogen: +1 (except in metal hydrides)

(a) $\overset{+1}{\text{H}}_2\overset{+6}{\text{S}}\overset{-2}{\text{O}}_4$ individual charges add up to the total charge

$$\{+1 \times 2 + x - 2 \times 4\} = 0$$

$$x = +8 - 2$$

$$= +6$$

(b) Fe_2O_3

$$\{2x - 2 \times 3\} = 0$$

$$2x = +6$$

$$x = +3$$

(c) H_3PO_3

$$\{+1 \times 3 + x - 2 \times 3\} = 0$$

$$x = +6 - 3$$

$$= +3$$

(d) $\text{Cr}_2\text{O}_7^{2-}$

$$\{2x - 2 \times 7\} = -2$$

$$2x = +14 - 2$$

$$x = +6$$

(e) NH_4^{+1}

$$\{x + 1 \times 4\} = +1$$

$$x = 1 - 4$$

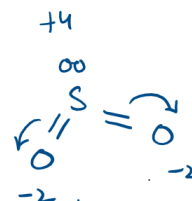
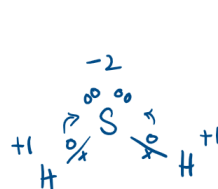
$$= -3$$

(f) $\text{Al}(\text{NO}_3)_3$

$$\{+3 + 3x - 2 \times 9\} = 0$$

$$3x = +18 - 3$$

$$x = +5$$



(g) H_2CO_3

$$\{+1 \times 2 + x + -2 \times 3\} = 0$$

$$x = +6 - 2$$

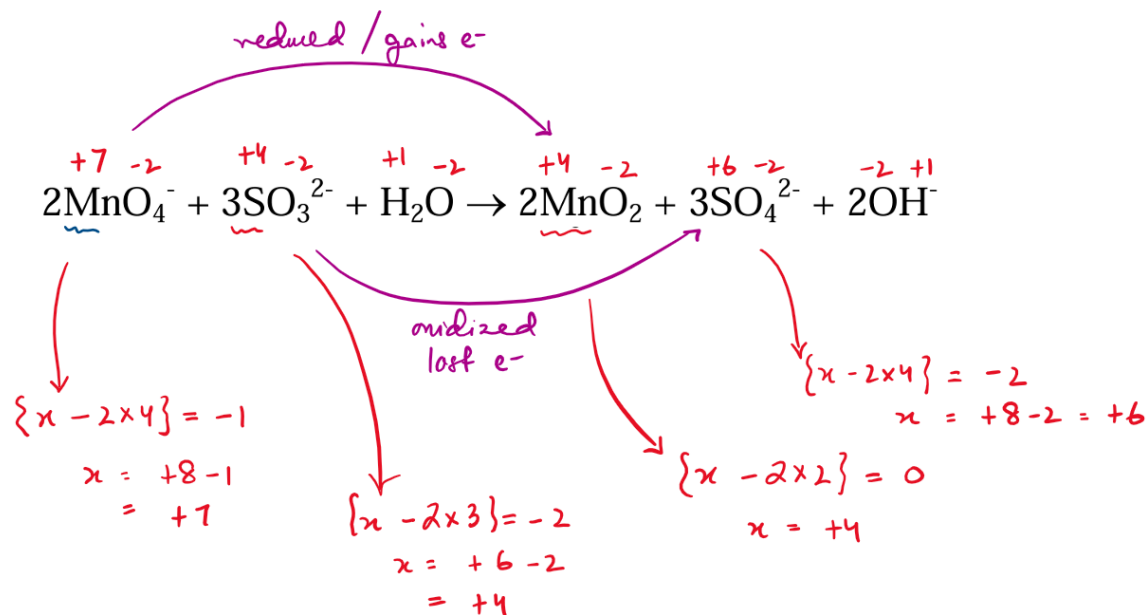
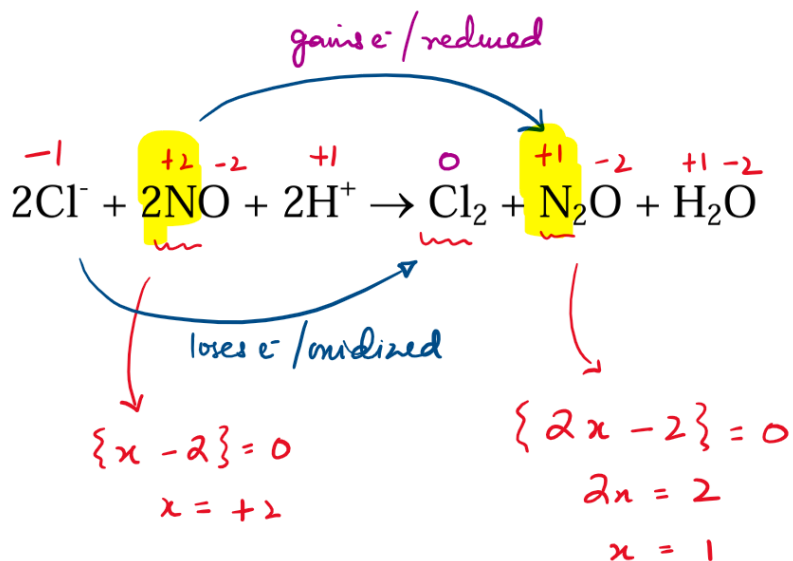
$$= +4$$

(h) PO_3^{-3}

$$\{x - 2 \times 3\} = -3$$

$$x = +6 - 3$$

$$= +3$$



Shortcut . oxidation : gains Oxygen, loses H
 Reduction loses Oxygen, gains H



* Naming

Oxidizing Agent is the substance reduced
Reducing Agent is the substance oxidized

K Na Ca Mg Al Zn Fe Sn Pb (H) Cu Hg Ag Au Pt

reactive metals like to lose e^-
oxidation / good reducing agents

unreactive metals
don't like to lose e^-
really bad reducing agents

* "ions" like to really gain e^- / reduced
very good oxidizing agents

oxidizing agent

1- $KMnO_4$ potassium manganate (VII)
purple to colorless

condition: acidified
heat with
reflux

2. $K_2Cr_2O_7$ potassium dichromate (VI)
orange to green

conditions: " "

Reducing Agent

1- KI potassium iodide
colorless $\longrightarrow$ brown
 $2I^- \longrightarrow I_2 + 2e^-$

2. SO_2

SO_2 bleaches wood pulp
food containers to kill bacteria.