O‘zbekiston Respublikasi Sog‘liqni saqlash vazirligi
TOSHKENT FARMATSEVTIKA INSTITUTI
NOORGANIK, FIZIK VA KOLLOID KIMYO KAFEDRASI

5-MA’RUZA:

OKSIDALANISH-QAYTARILISH REAKSIYALARI

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TOSHKENT-2022

REJA:

Mavzuning ma’ruza davomida yoritiladigan qismlari:

1. Gidrolizlanish konstantasi;
2. Gidrolizlanish darajasi;
3. Eng muhim oksidlovchi va qaytaruvchilar;
4. Oksidlanish-qaytarilish reaksiyalari turlari;
5. OQR tenglash usullari.

Mavzuning talaba mustaqil o’zlashtirishi lozim bo’lgan qismlari:

1. **Elektron balans usuli;**
2. **Elektrod potensial;**
3. **Latimer va Frost diagrammalari;**
4. **Gidroliz va uning turlari;**
5. **Gidroliz hamda OQR ning farmatsiyadagi ahamiyati;**

ASOSIY ADABIYOTLAR:

1. X.R.Tuxtayev, A.T.Sharipov, S.N.Aminov. Noorganik kimyo. Darslik. – Toshkent.: “Fan va texnologiya”,2018, 560 bet.

2. Shriver and Atkins, Inorganic Chemisrty, Fifth Edition, 2010/ P.W.Atkins, T.L.Owerton, J.P. Rourke, M.T. Weller and F.A. Armstrong, W.H. Freeman and Company, New York. 2010. P. 825.

3. Э.Т.Оганесян, В.А.Попков, Л.И.Щербакова, А. К. Брель; под ред. Э. Т. Оганесяна. — М. : Юрайт, 2019. — 447 с. — Серия: Специалист.

4. Общая и неорганическая химия для фармацевтов: учебник и и практикум для СПО/ под общ.ред. В.В.Негребецкого, И.Ю.Белавина, В.П.Сергеевой.-Издательство Юрайт, 2019.-357 с.-Серия: профессиональное образование.

5. Шрайвер Д., Эткинс П. Неорганическая химия. В 2-х т. Т 1/ Перевод с англ. М.Г.Розовой, С.Я. Истомина, М.Е.Тамм-Мир, 2004.-679 с.

6. Шрайвер Д., Эткинс П.. Неорганическая химия. В 2-х т. Т 2/ Перевод с англ. А.И.Жирова, Д.О.Чаркина, С.Я. Истомина, М.Е.Тамм-Мир, 2004.-486 с.

7. Thomas R. Gilbert - Chemistry_ The Science in Context-Norton (2017)

Tuzlar eritmalarining gidrolizi

- **Tuz ionlarining suv bilan o‘zaro ta’sirida kuchsiz elektrolitlar hosil bo‘lishi gidroliz deyiladi.**

1. Kuchli asoslar va kuchli kislotalardan hosil bo'lgan tuzlar gidrolizga uchramaydi.

2. Kuchsiz asos va kuchli kislotadan hosil bo'lgan tuzlar kation bo’yicha gidrolizlanadi, muhit kislotali bo'ladi.

$$NH_4Cl + H_2O = NH_4OH + HCl$$

$$NH_4^+ + Cl^- + H_2O = NH_4OH + H^+ + Cl^-$$

$$NH_4^+ + 2H_2O = NH_4OH + H_3O^+;$$ **kislotali muhit, pH < 7.**

1-bosqich. $AlCl_3 + H_2O = AlOHCl_2 + HCl$

$$Al^{3+} + 3Cl^- + H_2O = AlOH^{2+} + 2Cl^- + H^+ + Cl^-$$

$$Al^{3+} + 2H_2O = AlOH^{2+} + H_3O^+ \qquad pH < 7$$

2- bosqich. $AlOHCl_2 + H_2O = Al(OH)_2Cl + HCl$

$$AlOH^{2+} + 2Cl^- + H_2O = Al(OH)_2^{1+} + Cl^- + H^+ + Cl^-$$

$$AlOH^{2+} + 2H_2O = Al(OH)_2^+ + H_3O^+$$

3- bosqich. $Al(OH)_2Cl + H_2O = Al(OH)_3 + HCl$

$$Al(OH)_2^+ + Cl^- + H_2O = Al(OH)_3 + H^+ + Cl^-$$

$$Al(OH)_2^+ + 2H_2O = Al(OH)_3 + H_3O^+$$

$Al_2(SO_4)_3$

1- bosqich. $Al_2(SO_4)_3 + 2H_2O = 2AlOHSO_4 + H_2SO_4$

$Al^{3+} + 2H_2O = AlOH^{2+} + H_3O^+$

2- bosqich. $2AlOHSO_4 + 2H_2O = [Al(OH)_2]_2SO_4 + H_2SO_4$

$AlOH^{2+} + 2H_2O = 2[Al(OH)_2]^+ + H_3O^+$

3- bosqich. $[Al(OH)_2]_2SO_4 + 2H_2O = 2Al(OH)_3 + H_2SO_4$

$Al(OH)_2^+ + 2H_2O = Al(OH)_3 + H_3O^+$

3). Kuchli asos va kuchsiz kislotadan hosil bo‘lgan tuzlar anion bo’yicha gidrolizlanadi va muhit ishqoriy bo‘ladi.

$CH_3COONa + H_2O = CH_3COOH + NaOH$

$CH_3COO^- + Na^+ + H_2O = CH_3COOH + Na^+ + OH^-$

$CH_3COO^- + H_2O = CH_3COOH + OH^-$ **ishqoriy muhit, pH > 7**

1-bosqich. $Na_2CO_3 + H_2O = NaOH + NaHCO_3$

$2Na^+ + CO_3^{2-} + H_2O = Na^+ + OH^- + Na^+ + HCO_3^-$

$CO_3^{2-} + H_2O = OH^- + HCO_3^-$ pH > 7

2-bosqich. $NaHCO_3 + H_2O = NaOH + H_2CO_3$

$Na^+ + HCO_3^- + H_2O = Na^+ + OH^- + H_2CO_3$

$HCO_3^- + H_2O = OH^- + H_2CO_3$

1-bosqich. $K_3PO_4 + H_2O = K_2HPO_4 + KOH$

$3K^+ + PO_4^{3-} + H_2O = K^+ + OH^- + 2K^+ + HPO_4^{2-}$

$PO_4^{3-} + H_2O = OH^- + HPO_4^{2-}$

2-bosqich. $K_2HPO_4 + H_2O = KH_2PO_4 + KOH$

$2K^+ + HPO_4^{2-} + H_2O = K^+ + H_2PO_4^- + K^+ + OH^-$

$HPO_4^{2-} + H_2O = H_2PO_4^- + OH^-$

3-bosqich. $KH_2PO_4 + H_2O = H_3PO_4 + KOH$

$K^+ + H_2PO_4^- + H_2O = H_3PO_4 + K^+ + OH^-$

$H_2PO_4^- + H_2O = H_3PO_4 + OH^-$

4). Kuchsiz asos va kuchsiz kislotadan hosil bo‘lgan tuzlar ham kation bo’yicha, ham anion bo’yicha gidrolizga uchraydi.

$CH_3COONH_4 + H_2O = CH_3COOH + NH_4OH$

$CH_3COO^- + NH_4^+ + H_2O = CH_3COOH + NH_4OH$

$Al_2S_3 + 6H_2O = Al(OH)_3\downarrow + 3H_2S\uparrow$

$Al_2(CO_3)_3 + 6H_2O = 2Al(OH)_3\downarrow + 3H_2CO_3$

Al_2S_3 va $Al_2(CO_3)_3$ eritmada beqaror moddalardir.

Birgalikdagi gidroliz

$$2AlCl_3 + 3Na_2CO_3 + 3H_2O = 2Al(OH)_3\downarrow + 6NaCl + 3CO_2\uparrow$$

$$2Al^{3+} + 3CO_3^{2-} + 3H_2O = 2Al(OH)_3 + 3CO_2\uparrow$$

$AlCl_3$ o'rniga – $Al_2(SO_4)_3$; $CrCl_3$; $Fe(NO_3)_3$; $BiCl_3$; $Fe_2(SO_4)_3$.

Na_2CO_3 o'rniga – K_2CO_3, Li_2CO_3.

$$2CuSO_4 + 2K_2CO_3 + H_2O = (CuOH)_2CO_3\downarrow + 2K_2SO_4 + CO_2\uparrow$$

$$2Cu^{2+} + 2CO_3^{2-} + H_2O = (CuOH)_2CO_3\downarrow + CO_2\uparrow$$

$CuSO_4$ o'rniga – $MgSO_4$, $BeSO_4$.

Karbonatlar, atsetatlar, sulfitlar, sulfidlar o'rniga:

$$2FeCl_3 + 3Na_2S + 6H_2O = 2Fe(OH)_3\downarrow + 6NaCl + 3H_2S\uparrow$$

$$2Fe^{3+} + 3S^{2-} + 6H_2O = 2Fe(OH)_3\downarrow + 3H_2S\uparrow$$

$$2Al(NO_3)_3 + 6CH_3COONa + 6H_2O = 2Al(OH)_3\downarrow + 6CH_3COOH + 6NaNO_3$$

$$3K_2CO_3 + Al_2(SO_4)_3 + 3H_2O = 2Al(OH)_3\downarrow + 3K_2SO_4 + 3CO_2$$

$$3CO_3^{2-} + 2Al^{3+} + 3H_2O = 2Al(OH)_3\downarrow + 3CO_2$$

Gidrolizdagi alohida holatlar:

I -b. $BiCl_3 + H_2O \leftrightarrow BiOHCl_2 + HCl$

$Bi^{3+} + H_2O \leftrightarrow BiOH^{2+} + H^+$

II -b. $BiOHCl_2 + H_2O \leftrightarrow Bi(OH)_2Cl + HCl$

$BiOH^{2+} + H_2O \leftrightarrow Bi(OH)_2^+ + H^+$

$Bi(OH)_2Cl = BiOCl\downarrow + H_2O$

I -b. $Na_2SiO_3 + H_2O \leftrightarrow NaHSiO_3 + NaOH$

$SiO_3^{2-} + H_2O \leftrightarrow HSiO_3^- + OH^-$

II -b. $2NaHSiO_3 \leftrightarrow Na_2Si_2O_5 + H_2O$

$2HSiO_3^{2-} \leftrightarrow Si_2O_5^{2-} + H_2O$

KOVALENT BOG'LANISHGA EGA BIRIKMALAR GIDROLIZI:

$KH + H_2O = KOH + H_2$

$Ca_3N_2 + 6H_2O = 3Ca(OH)_2 + 2NH_3$

$Na_3P + 3H_2O = 3NaOH + PH_3$

$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$

$PCl_5 + H_2O = POCl_3 + 2HCl$

$SiCl_4 + 3H_2O = H_2SiO_3 + 4HCl$

$SO_2Cl_2 + H_2O = H_2SO_4 + HCl$

$Mg_2Si + 2H_2O = 2Mg(OH)_2 + SiH_4$

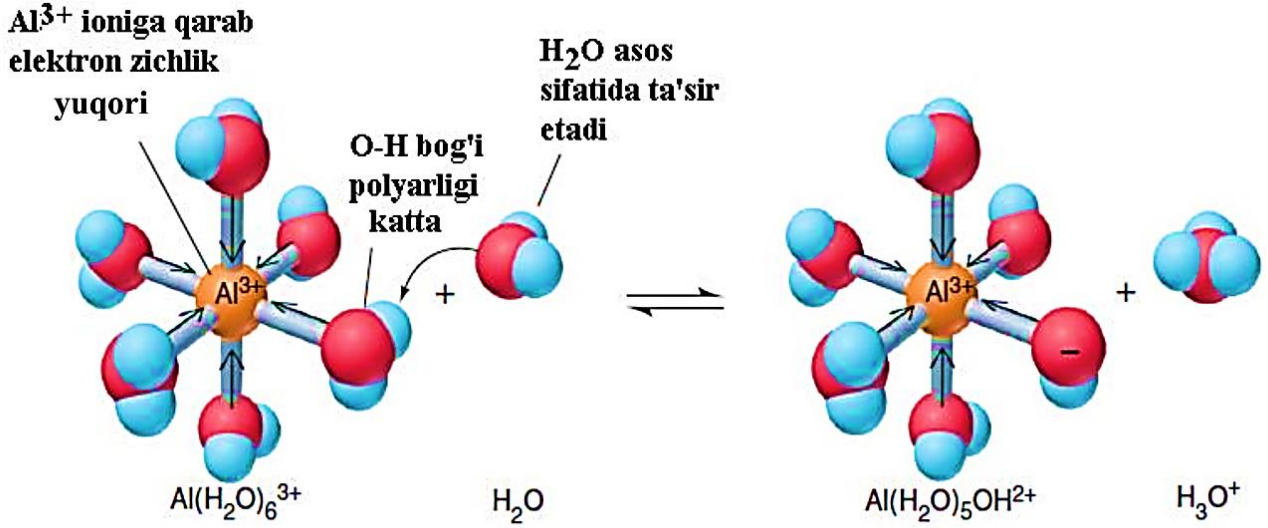
Akvakation hosil bo’lish bilan boradigan gidroliz

$$Al(NO_3)_3(aq) + 6H_2O(s) \leftrightarrow Al(H_2O)_6](NO_3)_3(aq)$$

$$Al^{3+}(aq) + +6H_2O(s) \leftrightarrow [Al(H_2O)_6]^{3+}(aq)$$

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(s) \leftrightarrow [Al(H_2O)_5OH]^{2+} + H_3O^+(aq)$$

$$[Al(H_2O)_5OH]^{2+}(aq) + H_2O(s) \leftrightarrow [Al(H_2O)_4(OH)_2]^+(aq) + H_3O^+(aq)$$



Gidrolizlanish konstantasi

- **Gidroliz qaytar jarayondir. Kuchli asos va kuchsiz kislotadan hosil bo'lgan tuzlar uchun:**

$$CH_3COO^- + H_2O \leftrightarrow CH_3COOH + OH^-$$

$$K = \frac{[CH_3COOH]\cdot[OH^-]}{[CH_3COO^-]\cdot[H_2O]};$$

$$K_g = K\cdot[H_2O] = \frac{[CH_3COOH]\cdot[OH^-]}{[CH_3COO^-]}.$$

- **Sur'at hamda mahrajni $[H^+]$ ga ko'paytirganda:**

$$Kg = \frac{[CH_3COOH]\cdot[OH^-]\cdot[H^+]}{[CH_3COO^-]\cdot[H^+]} = \frac{[OH^-]\cdot[H^+]}{K_{kis}}; \quad \frac{1}{K_{kis}} = \frac{[CH_3COOH]}{[CH_3COO^-]\cdot[H^+]}$$

- **$[OH^-]_*[H^+]=K_w$ suvning ion ko'paytmasi:**

$$K_g = \frac{K_w}{K_{kis}}.$$

Kuchsiz asos va kuchli kislotadan hosil bo'lgan tuzlar uchun:

$$NH_4Cl + H_2O \leftrightarrow NH_4OH + HCl$$

$$NH_4^+ + H_2O \leftrightarrow NH_4OH + H^+$$

$$Kg = \frac{[NH_4OH]\cdot[H^+]}{[NH_4^+]};$$

Sur'at hamda mahrajni [OH$^-$] ga ko'paytirganda:

$$K_г = \frac{[NH_4OH]\cdot[H^+]\cdot[OH^-]}{[NH_4^+]\cdot[OH^-]} = \frac{[H^+]\cdot[OH^-]}{K_{основа}};$$

$$K_{основа} = \frac{[NH_4OH]}{[NH_4^+]\cdot[OH^-]}. \quad Kг = \frac{K_w}{K_{основа}}$$

- **Kuchsiz asos va kuchsiz kislotadan hosil bo’lgan tuzlar uchun:**

$$CH_3COO^- + NH_4^+ + H_2O \leftrightarrow CH_3COOH + NH_4OH$$

$$K = \frac{[CH_3COOH] \cdot [NH_4OH]}{[CH_3COO^-] \cdot [NH_4^+]};$$

- **Sur’at hamda mahrajni $[H^+]_*[OH^-]$ ga ko’paytirganda:**

$$K = \frac{[CH_3COOH] \cdot [NH_4OH] \cdot [H^+] \cdot [OH^-]}{[CH_3COO^-] \cdot [NH_4^+] \cdot [H^+] \cdot [OH^-]} = \frac{[H^+] \cdot [OH^-]}{K_{кис} \cdot K_{осн}};$$

$$K_W = [H^+] \cdot][OH^-]$$

$$K_g = \frac{K_w}{K_{кис} \cdot K_{осн}}.$$

Gidrolizlanish darajasi

- **Gidrolizlangan ionlar sonining molekulalarning umumiy soniga nisbati:**

$$\beta = \frac{n}{N} \quad \text{èëè} \quad \beta = \frac{n}{N} \cdot 100$$

- **Gidroliz darajasi tuzning tabiatiga, konsentratsiyasiga, haroratiga bog'liq.**

$$CH_3COONa + H_2O \leftrightarrow CH_3COOH + NaOH$$

$$(1-\beta)\cdot C \qquad \beta \cdot C \qquad \beta \cdot C$$

$$CH_3COO^- + H_2O \leftrightarrow CH_3COOH + OH^-$$

$$K_g = \frac{[CH_3COOH]\cdot[OH^-]}{[CH_3COO^-]} = \frac{\beta \cdot C \cdot \beta \cdot C}{(1-\beta)\cdot C} = \frac{\beta^2 \cdot C}{1-\beta}; \qquad K_g = \frac{\beta^2 \cdot C}{1-\beta}$$

- **Agar, 1 - β = 1:**

$$K_g = \beta^2 \cdot C; \qquad \beta^2 = \frac{Kg}{C}; \qquad \beta = \sqrt{Kg / C} \qquad \beta = \sqrt{\frac{K_w}{K_{кис} \cdot C}}.$$

- Kuchsiz asos va kuchli kislotadan hosil bo'lgan tuzlar:

$$NH_4Cl + H_2O \leftrightarrow NH_4OH + HCl$$

$$(1-\beta)\cdot C \qquad \beta\cdot C \qquad \beta\cdot C$$

$$NH_4^+ + H_2O \leftrightarrow NH_4OH + H^+$$

$$Kg = \frac{[NH_4OH]\cdot[H^+]}{[NH_4^+]} = \frac{\beta\cdot C\cdot\beta\cdot C}{(1-\beta)\cdot C} = \frac{\beta^2\cdot C}{(1-\beta)}; \quad Kg = \frac{\beta^2\cdot C}{1-\beta}.$$

$$\beta^2 = \frac{K_g}{C}; \qquad \beta = \sqrt{K_g / C.} \quad \beta = \sqrt{\frac{K_w}{K_{основ}\cdot C}}.$$

- Kuchsiz asos va kuchsiz kislotadan hosil bo'lgan tuzlar (CH_3COONH_4):

$$CH_3COONH_4 + H_2O \leftrightarrow CH_3COOH + NH_4OH$$

$$CH_3COO^- + NH_4^+ + H_2O \leftrightarrow CH_3COOH + NH_4OH$$

$$(1-\beta)\cdot C \quad (1-\beta)\cdot C \qquad \beta\cdot C \qquad \beta\cdot C$$

$$K_g = \frac{\beta\cdot C\cdot\beta\cdot C}{(1-\beta)\cdot C\cdot(1-\beta)\cdot C} = \frac{\beta^2}{(1-\beta)^2}; \quad K_g = \frac{\beta^2}{(1-\beta)^2};$$

$$\frac{\beta^2}{(1-\beta)^2} = K_г; \qquad \frac{\beta^2}{(1-\beta)^2} = \frac{K_w}{K_{кис}\cdot K_{основа}}; \frac{\beta}{1-\beta} = \sqrt{\frac{K_w}{K_{кис}\cdot K_{основа}}}$$

Gidroliz eritmaning konsentratsiyasiga bog'liq emas. Gidrolizning farmatsiyadagi ahamiyati

- **$Pb(NO_3)_2$** - bitmas yaralarni davolash maqsadida ishlatiladi. Biroq ta’sir qiluvchi modda - **$PbOHNO_3$**
- Qon hamda biologik eritmalar tarkibida **Na_2HPO_4, NaH_2PO_4, H_2CO_3, $NaHCO_3$** eritmalari bo’ladi, shuning hisobiga organizmda pH doimiydir.
- Asosiy energiya manbai yog'lar, oqsillar, uglevodlar, glyukozidlar va boshqalarning gidrolizidir.

Oksidlanish-qaytarilish reaksiyalari

Oxidation and reduction

$\overset{0}{Zn} + 2H\overset{+1}{Cl} \overset{-1}{} = \overset{+2}{Zn}\overset{-1}{Cl_2} + \overset{0}{H_2}$

$\overset{0}{Cu} + H_2\overset{+6}{S}O_4 = \overset{+2}{Cu}\overset{+6}{S}O_4 + \overset{+4}{S}O_2 + H_2O$

$$2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$$

$$2\,C_4H_{10}(g) + 13\,O_2(g) \rightarrow 8\,CO_2(g) + 10\,H_2O(g)$$

$$Fe^{3+}(aq) + Cr^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cr^{3+}(aq)$$

$$3\,CH_3CH_2OH(aq) + 2\,CrO_4^{2-}(aq) + 10\,H^+(aq) \rightarrow 3\,CH_3CHO(aq) + 2\,Cr^{3+}(aq) + 8\,H_2O(l)$$

$$LiCO_{2(s)} + C_{(s)} = LiC_{(s)} + CO_{2(s)}$$

Elektron qabul qilish jarayoni qaytarilish, elektron berish jarayoni oksidlanish, hamda butun bu ikki jarayon oksidlanish-qaytarilish reaksiyasi deb nomlanadi.

OQR nazariyasi

1. Agar atom, molekula yoki ion elektronlar bersa, bunday reaksiyalar oksidlanish deb ataladi. Bunday holda, oksidlanish darajasi oshadi va zarrachaning o'zi qaytaruvchi deb ataladi.

$$Al^{o} - 3e \rightarrow Al^{+3}$$

$$N^{-3} - 8e \rightarrow N^{+5}$$

$$2Cl^{-1} - 2e \rightarrow Cl_2{}^{o}$$

$$H_2 - 2e \rightarrow 2H^{+1}$$

$$Mn^{+2e} \rightarrow Mn^{+7}$$

$$Fe^{+2} - 1e \rightarrow Fe^{+3}$$

$$Cr^{+3} - 3e \rightarrow Cr^{+6}$$

$$S^{-2} - 8e \rightarrow S^{+6}$$

2. **Agar atom, molekula yoki ion elektronlarni qabul qilsa, bu jarayon qaytarilish deb ataladi va oksidlanish darajasi pasayadi. Zarrachaning o'zi oksidlovchi deb ataladi.**

$$Cl_2^{\,o} + 2e \rightarrow 2Cl^{-1} \qquad 2H^{+1} + 2e \rightarrow H_2^{\,o}$$

$$Mn^{+7} + 5e \rightarrow Mn^{+2} \quad \vdots \quad Fe^{+3} + 1e \rightarrow Fe^{+2}$$

$$Cr^{+6} + 6e \rightarrow Cr^{+3} \qquad S^{+6} + 8e \rightarrow S^{-2}$$

$$S^{o} + 2e \rightarrow S^{-2} \qquad N^{+5} + 8e \rightarrow N^{-3}$$

3. **Oksidlanish va qaytarilish reaksiyalari bir vaqtning o'zida sodir bo'ladi.**

1- jadval. Eng muhim oksidlovchi va qaytaruvchi moddalar

Qaytaruvchilar	Oksidlovchilar
Na, K, Ca, Zn, Fe, Mg, Al, C, Si, H_2, CO, H_2S, Na_2S, SO_2 Sulfit kislota va uning tuzlari Na_2SO_3; $Na_2S_2O_3$; HCl, HBr, HI; $FeSO_4$; $MnSO_4$; H_2O_2; HNO_2 va uning tuzlari; NH_3; N_2H_4, NH_2OH, NO; H_3PO_3, H_3AsO_3, aldegidlar, spirtlar, chumoli kislota shavel kislota aldegidlari; katoddagi elektr toki.	Galogenlar F_2,Cl_2,Br_2,J_2, Mn_2O_7, MnO_2; $KMnO_4$, K_2MnO_4 CrO_3, K_2CrO_4, K_2CrO_7; HNO_3 va uning tuzlari; O_2, O_3, H_2O_2 va tuzlar; H_2SO_4 (kons). CuO, Ag_2O; PbO_2; $AuCl_3$, AgCl; $(NH_4)_2S_2O_8$ KClO; $KClO_3$; $KClO_4$; Shox arog'i ($3HCl+HNO_3$); HNO_3 va HF aralashmasi; anoddagi elektr toki.

Gazlar orasidagi:

$$3H_2 + N_2 = 2NH_3$$
$$4NH_3 + 5O_2 = 4NO + 6H_2O$$
$$2SO_2 + O_2 = 2SO_3$$

Qattiq moddalar va gazlar orasidagi OQR:

$$2Mg_{(q)} + O_{2\,(g)} = 2MgO_{(q)}$$
$$2Sb_{(q)} + 3CI_{2\,(g)} = 2SbCI_{3\,(q)}$$

Qattiq moddalar va eritmalar orasidagi OQR:

$$4HCI\,(s) + MnO_2\,(q) = CI_2\,(g) + MnCI_2\,(s) + 2H_2O\,(s)$$
$$16HCI(s) + 2KMnO_4(s) = 5CI_2(s) + 2MnCI_2(s) + 8H_2O(s) + 2KCI(s)$$

Faqat qattiq moddalar orasidagi OQR:

$$2Al_{(q)} + Fe_2O_{3\,(q)} = Al_2O_{3\,(q)} + 2Fe_{(q)}$$
$$C_{(q)} + 2PbO_{(q)} = 2Pb_{(q)} + CO_{2\,(g)}$$

OQR eritmada:

$$3Na_3AsO_3 + K_2Cr_2O_7 + 4H_2SO_4 = 3Na_3AsO_4 + Cr_2(SO_4)_3 + 4H_2O + K_2SO_4$$

$$2NaCrO_2 + 3H_2O_2 + 2NaOH = 2Na_2CrO_4 + 4H_2O$$

Turli xil o.d. ga ega bir xil elementlar o'rtasida:

$$2H_2S + H_2SO_3 = 3S + 3H_2O$$
$$5HCl + HClO_3 = 3Cl_2 + 3H_2O$$

OQR 4 turga bo’linadi:

1) Molekulalararo;
2) Ichki molekulyar;
3) Disproporsiya reaksiyasi;
4) Murakkab OQR.

Molekulalararo OQR

$$CuSO_4 + Zn = ZnSO_4 + Cu$$

$$\overset{0}{Cu} + 2\overset{+6}{H_2S}O_4 = \overset{+2}{Cu}SO_4 + \overset{+4}{S}O_2 + 2H_2O$$

Ichki molekulyar OQR – bunda ayni bir molekula tarkibida ham oksidlovchi, ham qaytaruvchi atomlari bo’lishi mumkin:

$$2KNO_3 = 2KNO_2 + O_2$$
$$4HNO_3 = 4NO_2 + 2H_2O + O_2$$
$$2\,Ba(NO_3)_2 = 2BaO + 4NO_2 + O_2$$
$$(NH_4)_2Cr_2O_7 = Cr_2O_3 + N_2 + 4H_2O$$
$$2HgO = 2Hg + O_2$$
$$2KClO_3 = 2KCl + 3O_2$$

Disproporsiya reaksiyasi – bunda ayni bir element reaksiya davomida ham oksidlanadi, ham qaytariladi:

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + MnO_2 + 4KOH$$

$$3KClO = 2KCl + KClO_3$$

$$3HNO_2 = HNO_3 + 2NO + H_2O$$

$$4\ Na_2SO_3 = 3Na_2SO_4 + Na_2S$$

$$6NaOH + 3S = 2Na_2S + Na_2SO_3 + 3H_2O$$

$$2KOH + Cl_2 = KCl + KOCl + H_2O$$

$$6KOH + 3Cl_2 \rightarrow 5KCl + KClO_3 + 3H_2O$$

Murakkab OQR:

$$As_2S_3 + HNO_3 + H_2O \rightarrow H_3AsO_4 + H_2SO_4 + NO$$

$$2As^{+3} - 4e \rightarrow 2As^{+5} \qquad 3$$

$$3S^{-2} - 24e \rightarrow 3S^{+6}$$

$$N^{+5} + 3e \rightarrow N^{+2} \qquad 28$$

$$3As_2S_3 + 28HNO_3 + 4H_2O \rightarrow 6H_3AsO_4 + 9H_2SO_4 + 28NO$$

OQR 2 xil tenglashtirish usullari mavjud:

1). Elektron balans usuli;

2). Ion-elektron (yarim reaksiya) usuli.

+7 +1 -1 +2 0 -1

$$2KMnO_4 + 16HCl = 2MnCl_2 + 5Cl_2 + 2KCl + 8H_2O$$

$$Mn^{+7} + 5e \rightarrow Mn^{+2}$$

$$2Cl^{-1} - 2e \rightarrow Cl_2^{\circ}$$

0 +5 +2 +2

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO + 4H_2O$$

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

Eritmalar tarkibiga quyidagi ionlar uchramaydi:

$$Mn^{+7};\quad Cr^{+6};\quad S^{+6};\quad N^{+5};\quad Cl^{+7}$$

Eritmalar tarkibiga quyidagi ionlar uchraydi:

Mn^{2+}, Cr^{3+}, MnO_4^-, CO_3^{2-}, ClO_4^-, $Cr_2O_7^{2-}$, SO_4^{2-}

Ion-elektron (yarim reaksiya) usuli.

1) Kislotali muhitda oksidlovchi tarkibidagi ortiqcha kislorod vodorod ioni bilan bog'lanib suv molekulasini hosil qiladi va qaytariladi:

$$[O] + 2H^+ + 2e \rightarrow H_2O$$
$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$$

2) Neytral va ishqoriy sharoitda oksidlovchi tarkibidagi ortiqcha kislorod suv molekulasi bilan bog'lanib gidroksid ionini hosil qiladi va qaytariladi:

$$[O] + H_2O + 2e \rightarrow 2OH^-$$
$$MnO_4^- + 2H_2O + 3e \rightarrow MnO_2 + 4OH^-$$

3) Kislotali va neytral sharoitda qaytaruvchi tarkibidagi yetishmayotgan kislorodni suvdan olib vodorod ionini hosil qiladi:

$$H_2O - 2e \rightarrow [O] + 2H^+$$
$$SO_3^{2-} + H_2O - 2e \rightarrow SO_4^{2-} + 2H^+$$

4) Kuchli ishqoriy muhitda qaytaruvchi yetishmayotgan kislorodni gidroksid ionidan olib oksidlanadi va suv hosil qiladi:

$$2OH^- - 2e \rightarrow [O] + H_2O$$
$$SO_3^{2-} + 2OH^- - 2e \rightarrow SO_4^{2-} + H_2O$$
$$J^- + 6OH^- - 6e \rightarrow JO_3^- + 3H_2O$$

1-misol.

$$KNO_2 + KMnO_4 + H_2SO_4 = MnSO_4 + KNO_3 + K_2SO_4 + 2H_2O$$

$$NO_2^- + MnO_4^- + H^+ \rightarrow NO_3^- + Mn^{2+} + \ldots..$$

$$NO_2^- + H_2O - 2e \rightarrow NO_3^- + 2H^+ \quad 2 \mid 5$$

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O \quad 5 \mid 2$$

$$5NO_2^- + 2MnO_4^- + 6H^+ = 5NO_2^- + 2Mn^{2+} + 3H_2O$$

$$5K^+ + 2K^+ + 3SO_4^{2-} = 5K^+ + 2SO_4^{2-} + 2K^+ + SO_4^{2-}$$

$$5KNO_2 + 2KMnO_4 + 3H_2SO_4 = 5KNO_3 + 2MnSO_4 + K_2SO_4 + 3H_2O$$

2-misol.

$$2KMnO_4 + 3Na_2SO_3 + H_2O = 3Na_2SO_4 + 2MnO_2 + 2KOH$$

$$MnO_4^- + SO_3^{2-} + H_2O \rightarrow MnO_2 + SO_4^{2-} + \ldots\ldots$$

$$MnO_4^- + 2H_2O + 3e \rightarrow MnO_2 + 4OH^- \quad 3 \mid 2$$

$$SO_3^{2-} + H_2O - 2e \rightarrow SO_4^{2-} + 2H^+ \quad 2 \mid 3$$

$$2MnO_4^- + 3SO_3^{2-} + H_2O = 3SO_4^{2-} + 2MnO_2 + 2OH^-$$

$$2K^+ + 6Na^+ = 6Na^+ + 2K^+$$

$$2KMnO_4 + 3Na_2SO_3 + H_2O = 3Na_2SO_4 + 2MnO_2 + 2KOH$$

3-misol.

$$H_2O_2 + FeSO_4 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2O$$

$$Fe^{2+} - 2e \rightarrow Fe^{3+} \quad | \quad 1 \quad | \quad 1$$

$$H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O \quad | \quad 1 \quad | \quad 1$$

$$2Fe^{2+} + H_2O_2 + 2H^+ = 2Fe^{3+} + 2H_2O$$

$$H_2O_2 + 2FeSO_4 + H_2SO_4 = Fe_2(SO_4)_3 + 2H_2O$$

4-misol.

$$KI + H_2O_2 \rightarrow J_2 + KOH$$

$$2I^- - 2e \rightarrow J_2 \quad | \quad 1 \quad | \quad 1$$

$$H_2O_2 + 2e \rightarrow 2OH^- \quad | \quad 1 \quad | \quad 1$$

$$H_2O_2 + 2I^- = 2OH^- + I_2$$

$$2KI + H_2O_2 \rightarrow J_2 + 2KOH$$

5-misol.

$$NaCrO_2 + H_2O_2 + NaOH = Na_2CrO_4 + H_2O$$

$$CrO_2^- + 4OH^- - 3e \rightarrow CrO_4^{2-} + 2H_2O \quad 3 \mid 2$$

$$H_2O_2 + 2e \rightarrow 2OH^- \quad 2 \mid 3$$

$$2NaCrO_2 + 3H_2O_2 + 2NaOH = 2Na_2CrO_4 + 4H_2O$$

6-misol.

$$H_2O_2 + MnO_4^- + H^+ \rightarrow O_2 + Mn^{2+} \ldots\ldots$$

$$H_2O_2 - 2e \rightarrow O_2 + 2H^+ \quad 2 \mid 5$$

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O \quad 5 \mid 2$$

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

$$5H_2O_2 + 2KMnO_4 + 3H_2SO_4 = 5O_2 + 2MnSO_4 + H_2SO_4 + 8H_2O$$

7-misol.

$$H_2O_2 + [Fe(CN)_6]^{3-} + OH^- = O_2 + [Fe(CN)_6]^{4-} + \ldots\ldots\ldots$$

$$H_2O_2 + 2OH^- - 2e \rightarrow O_2 + 2H_2O \quad | \quad 2 \quad | \quad 1$$

$$[Fe(CN)_6]^{3-} + 1e \rightarrow [Fe(CN)_6]^{4-} \quad | \quad 1 \quad | \quad 2$$

$$H_2O_2 + 2OH^- + 2[Fe(CN)_6]^{3-} = O_2 + 2H_2O + 2[Fe(CN)_6]^{4-}$$

$$H_2O_2 + 2K_3[Fe(CN)_6] + 2KOH = O_2 + 2K_4[Fe(CN)_6] + 2H_2O$$

8-misol.

$$Fe^{2+} + Cr_2O_7^{2-} + H^+ \rightarrow Fe^{3+} + Cr^{3+} + \ldots\ldots$$

$$Fe^{2+} - 1e \rightarrow Fe^{3+} \quad | \quad 1 \quad | \quad 6$$

$$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O \quad | \quad 6 \quad | \quad 1$$

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

Oksidlovchi hamda qaytaruvchi ekvivalentini aniqlash

Oksidlovchi yoki qaytaruvchi moddaning ekvivalenti 1 mol elektronga grammdagi moddaning miqdoridir.

$$Fe^{2+}+Cr_2O_7^{2-}+H^+ \rightarrow Fe^{3+}+Cr^{3+}+\ldots\ldots$$

$$Fe^{2+} - 1e \rightarrow Fe^{3+} \qquad 1 \quad 6$$

$$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O \qquad 6 \quad 1$$

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

- **Molekulyar holda:**

$$6FeSO_4 + K_2Cr_2O_7 + 7H_2SO_4 = 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O$$

Oksidlovchi ekvivalenti:

$E\ K_2Cr_2O_7 = M/6 = 294/6 = 49 g/mol$

Qaytaruvchi ekvivalenti:

$E\ FeSO_4 = M/1 = 152\ g/mol.$

$$E = M/n$$

В кислой среде:

$$MnO_4^- + 8H^+ + 5\bar{e} = Mn^{2+} + 4H_2O \qquad E_{KMnO_4} = \frac{M}{5} =$$

$$= \frac{158}{5} = 31,6 \ g/mol$$

В нейтральной среде:

$$MnO_4^- + 2H_2O + 3\bar{e} = MnO_2 + 4OH^- \qquad E_{KMnO_4} = \frac{M}{3} =$$

$$= \frac{158}{3} = 52,7 \ g/mol$$

В щелочнойной среде:

$$MnO_4^- + 1\bar{e} = MnO_4^- \qquad E_{KMnO_4} = \frac{M}{1} = 158 g/mol.$$

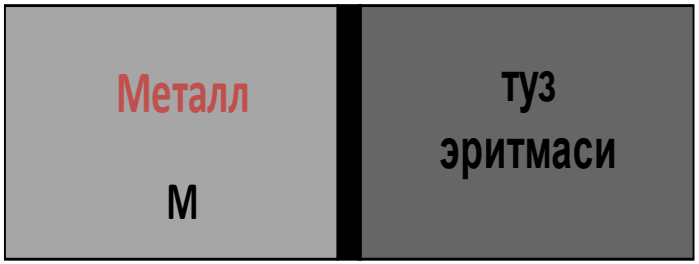
Oksidlovchilar	Qaytaruvchilar
$HClO \rightarrow HCl$; $KClO_3 \rightarrow KCl$	$HCl \rightarrow Cl_2$
$H_2SO_4 \rightarrow SO_2$ $H_2SO_4 \rightarrow H_2S$ $H_2SO_4 \rightarrow S$ $Na_2SO_3 \rightarrow S$	$H_2S \rightarrow S$ $SO_2 \rightarrow SO_3$ $S \rightarrow SO_2$
$HNO_3 \rightarrow NO_2$ $HNO_3 \rightarrow N_2O$ $HNO_3 \rightarrow NO$ $KNO_2 \rightarrow NO$ $HNO_3 \rightarrow NH_4NO_3$	$NH_3 \rightarrow N_2$ $NH_3 \rightarrow NO$ $NH_3 \rightarrow KNO_3$
$KMnO_4 \rightarrow MnSO_4$ (kislotali muhitda) $KMnO_4 \rightarrow MnO_2$ (neytral muhitda) $KMnO_4 \rightarrow K_2MnO_4$ (ishqoriy muhitda) $MnO_2 \rightarrow MnSO_4$	$MnSO_4 \rightarrow MnO_2$; $MnSO_4 \rightarrow K_2MnO_4$ $MnSO_4 \rightarrow KMnO_4$ $MnO_2 \rightarrow KMnO_4$ (kislotali) $MnO_2 \rightarrow K_2MnO_4$ (neytral) $K_2MnO_4 \rightarrow KMnO_4$
$K_2Cr_2O_7 \rightarrow Cr_2(SO_4)_3$ Kuchli kislotali (H_2SO_4)	Cr^{3+} birikmalari $CrCI_3$ (ishqoriy) $\rightarrow K_2CrO_4$

ELEKTROD POTENSIALLAR

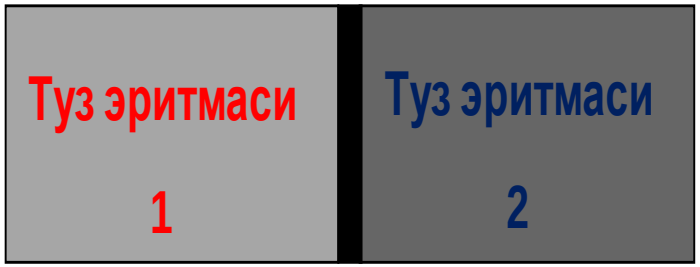
- Kimyoviy energiyaning elektr energiyaga aylanish hodisasi – **galvanik elementlarda** yuz beradi. (Aksincha, elektr energiyasining kimyoviy energiyaga aylanish hodisasi **elektroliz** vaqtida yuz beradi).
- Galvanik elementlar **2 ta elektroddan tashkil topgan zanjirdan iborat.**
- **Elektrod** («elektro…» so’zidan ὁδός — «yo’l, yo’nalish») — bir-biriga tegib turgan 2 tur o’tkazgich-metal va elektrolitdan tashkil topgan sistemadir.

Ma’lumki, kimyiviy jihatdan yoki fizikaviy holatlari bilan faqr qiladigan 2 o’tkazgich bir-biriga tekkizilsa, ular orasida potensiallar farqi vujudga keladi. Chunonchi, turli metallar, metall va metall tuzi eritmasi hamda ikki xil elektrolit eritmalarida bu hol kuzatiladi

Контакт потенциал

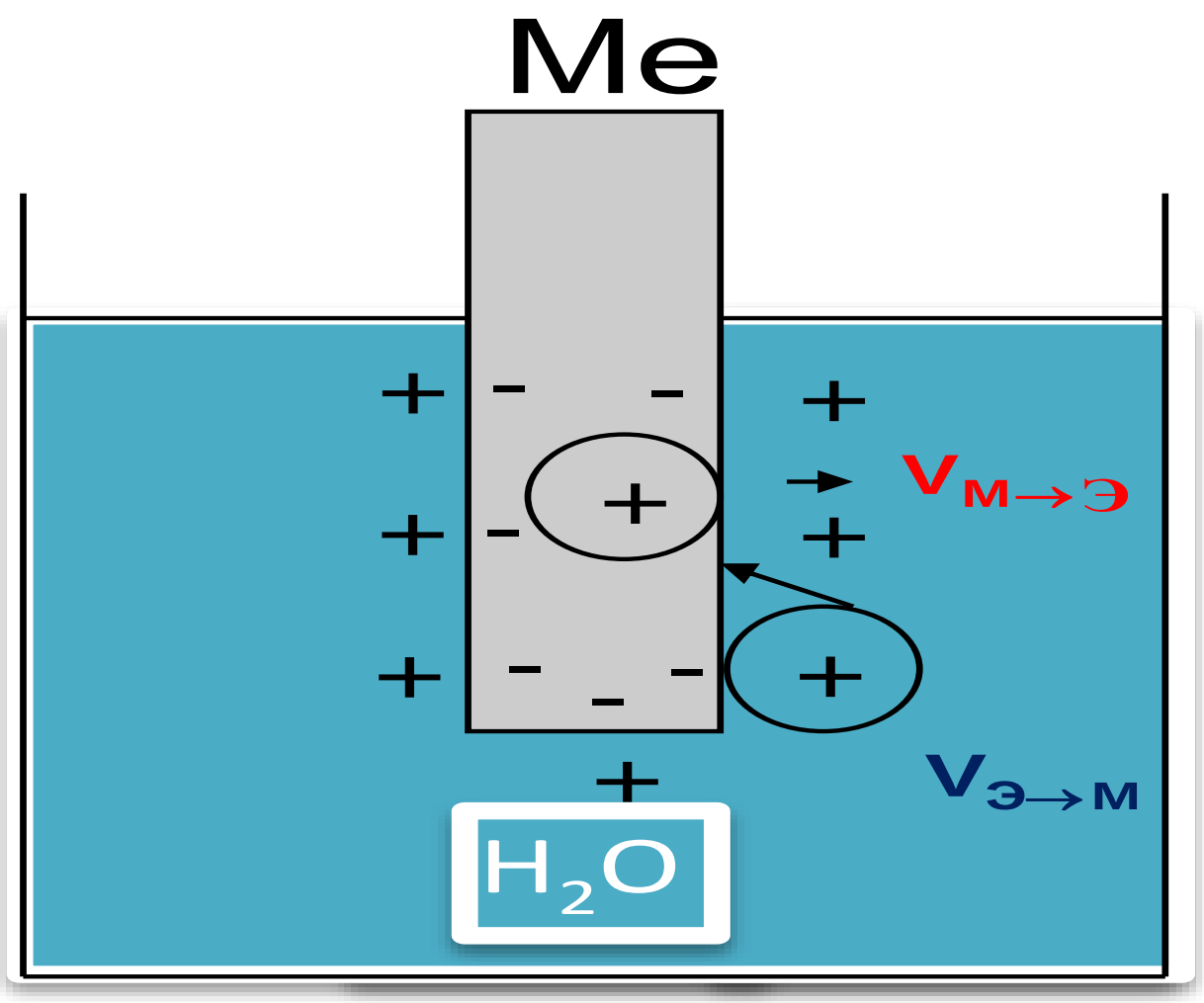


Электрод потенциал



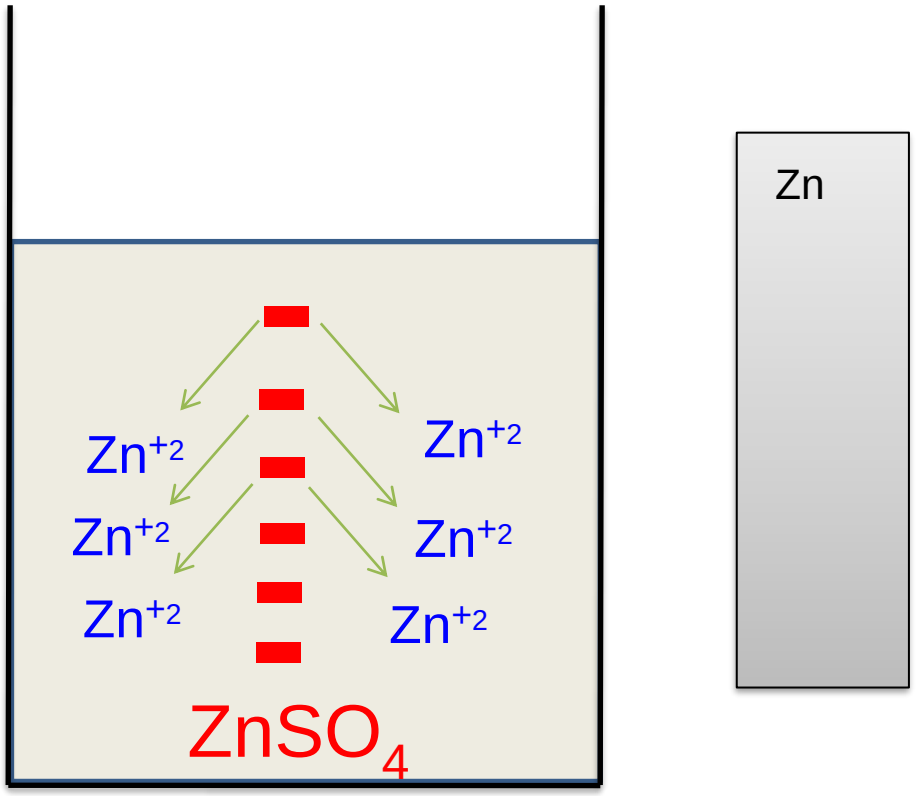
Диффузион потенциал

Bu potensiallarning qiymati – o’tkazgichlarning shakli, o’lchami, tegib turgan yuzlarining kattaligiga bog’liq bo’lmasdan, faqta ularning **kimyoviy tabiatiga va fizikaviy holatiga bog’liq.**



Bu **potensiallar farqi – elektrod potensiali deyiladi, φ – bilan belgilanadi.** Potensiallar farqi metallning bundan keying erishiga to’sqinlik qiladi va **sistemada muvozanat yuzaga keladi.** Muvozanat vaqtida metalldan eritmaga o’tayotgan ionlar soni bilan eritmadan plastinka yuzasiga cho’kayotgan ionlar soni tenglashadi.

$Me^0 \rightarrow Me^+ + e^-$



Agar metall suvga emas, **o'zining tuzi eritmasiga tushirilgan bo'lsa**, elektrod potensialini vujudga kelishi kationlarni metalldan uning tuzi eritmasiga va aksincha eritmadan metallga qayta tortilishi bilan tushuntiriladi.

Oksidlanish-qaytarilish potentsiallari

Oksidlanish-qaytarilish reaksiyalarini miqdoriy baholash uchun oksidlanish-qaytarilish potensiallari va tizimning Gibbs energiyasining o'zgarishini aniqlash (bu reaksiyaning yo'nalishini aniqlash imkonini beradi) kabi xususiyatlar muhimdir:

$$\Delta G_r = -nF\varphi_o$$

n - OQR ishtirok etuvchi elektronlar soni; F - Faradey soni;
φ_o – elektrodning standart elektrod potensiali.

Elektrod potentsiali Nernst tenglamasi asosida aniqlanadi:

$$Cu^{2+} + Zn = Zn^{2+} + Cu \qquad K = \frac{[Zn^{2+}]\cdot[Cu]}{[Cu^{2+}]\cdot[Zn]} = \frac{[Zn^{2+}]}{[Cu^{2+}]};$$

Har qanday OQ reaksiyasi uchun elektrod potentsialini aniqlash tenglamasini quyidagicha yozishimiz mumkin:

$$a[oxi]_A + b\,\mathrm{Re}\,d_B = c[\mathrm{Re}\,d]_A + d[Oxi]_B \qquad K = \frac{[\mathrm{Re}\,d]^{\ c}{}_C[Oxi]^{d}{}_B}{[Oxi]^{a}{}_A\cdot[\mathrm{Re}\,d]^{b}{}_B}$$

$$\varphi = \varphi^o + RTLnK \qquad \varphi = \varphi^o + \frac{RT}{nF}\ln K$$

- **Oksidlanish-qaytarilish reaksiyalari potensiallari**

$Zn - 2e \rightarrow Zn^{2+}$ $\quad Cu^{2+} + 2e \rightarrow Cu$

$E\ Zn/Zn^{2+} = -0{,}763$ v ;

$E\ Cu/Cu^{2+} = +0{,}337$ v

$E\ Cu/Cu^{2+} - E\ Zn/Zn^{2+} = 0{,}337 - (-0{,}763) = 1{,}1$ v

$2FeCl_3 + SnCl_2 = 2FeCl_2 + SnCl_4$

$E\ Fe^{2+}/Fe^{3+} = +0{,}77$ v $\quad E\ Sn^{4+}/Sn^{2+} = +0{,}15$ v

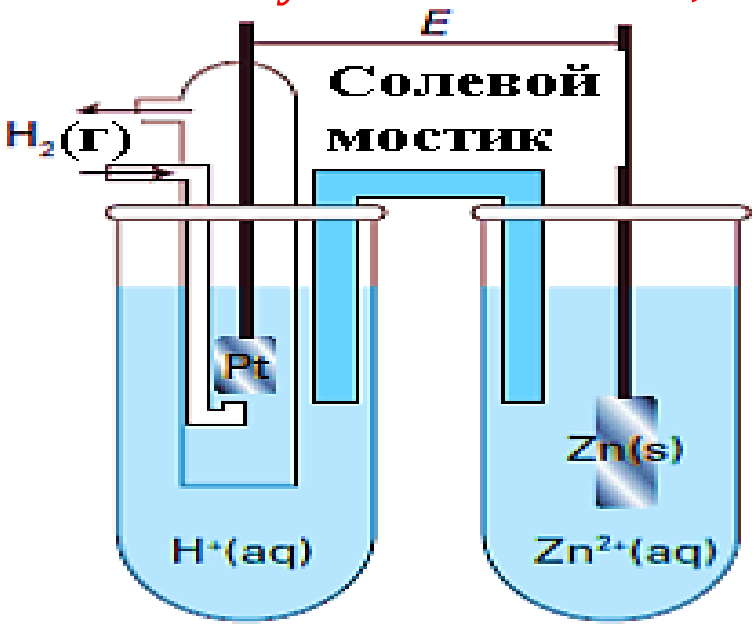
$2NaCl + Fe_2(SO_4)_3 = 2FeSO_4 + Cl_2 + Na_2SO_4$

$2Cl^- + Fe^{3+} = Cl_2 + Fe^{2+}$

$2Cl^-/Cl_2$ uchun $E = +1{,}36$ v; $\quad Fe^{3+}/Fe^{2+}$ uchun $E = +0{,}77$ v;

- **Oksidlovchi moddaning elektrod potentsiali qaytaruvchiga qaraganda kamroq.**
- **Reaksiya to'g'ri yo'nalishda ketmaydi.**

Oksidlanish yoki qaytarilish reaksiyasi davom etishini bilish uchun oksidlanish-qaytarilish potentsiali tushunchasini bilish muhim. Buning uchun OQ potentsiallarining elektrokimyoviy qatoridan foydalaniladi. (1-va 5.2-jadvallar). ***Elektrod potentsiali qanchalik past bo'lsa, metall shunchalik faol bo'lib, u shunchalik yaxshi oksidlanadi, tuzlari parchalanishi qiyinroq bo'ladi.***



Vodorod-rux elektrodining galvanik elementi

Barcha oksidlanish-qaytarilish reaktsiyalari juftlikda amalga oshiriladi va shuning uchun bu juftlikda vodorod-rux elektrodlari olinadi. Bunday holda, oddiy vodorod elektrodi uchun potentsial nolga teng.

$$H^+(aq) + e^- \rightarrow \tfrac{1}{2}H_2(g) \qquad E^{\circ}(H^+, H_2) = 0$$

Rux elektrod uchun potentsial:

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \qquad E^{\circ}(Zn^{2+}, Zn) = -0.76\,V$$

$$Pt, H_2 \,|^+\, [H^+] = 1 \,|\, KCl \,][Zn^{2+} = 1 \,|^-\, Zn$$

$$\varphi_{H_2} \qquad\qquad \varphi_{Zn}$$

$$2H^+(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + H_2(g) \qquad E_{cell}^{\circ} = +0.76V$$

$$E = \varphi_{H_2} - (-0.763\,V) = 0{,}763$$

1-jadval. 298 K da standart oksidlanish-qaytarilish (elektrod) potensiallari

Elektroddagi yarim reaksiya	$\varphi_{elektrod}$ V	Elektroddagi yarim reaksiya	$\varphi_{elektrod}$
$Li^+ + e \rightarrow Li^o$	-3,05	$F_2 - 2e \rightarrow 2F^-$	+2,87
$K^+ + e \rightarrow K^o$	-2,92	$H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O$	+1,78
$Ba^{2+} + 2e \rightarrow Ba^o$	-2,90	$PbO_2 + 4H^+ + SO_4^{2-} + 2e \rightarrow PbSO_4 + 2H_2O$	+1,69
$Ca^{2+} + 2e \rightarrow Ca^o$	-2,76	$MnO_4^- + 4H^+ + 3e \rightarrow MnO_2 + 2H_2O$	+1,68
$Na^+ + e \rightarrow Na^o$	-2,71	$MnO_4^- + 8H^+ + 3e \rightarrow MnO_2 + 2H_2O$	+1,51
$La^{3+} + 3e \rightarrow La^o$	-2,37	$PbO_2 + 4H^+ + 2e \rightarrow Pb^{2+} + 2H_2O$	+1,46
$Mg^{2+} + 2e \rightarrow Mg^o$	-2,37	$Ge^{4+} + e \rightarrow Ge^{3+}$	+1,44
$H_2 + 2e \rightarrow 2H^-$	-2,23	$Cl_2 + 2e \rightarrow 2Cl^-$	+1,36
$Al^{3+} + 3e \rightarrow Al^o$	-1,71	$Cr_20_7^{2-} + 14H^+ \rightarrow Cr^{3+} + 7H_2O$	+1,33
$Mn^{2+} + 2e \rightarrow Mn^o$	-1,03	$O_2 + 4H^+ + 4e \rightarrow 2H_2O$	+1,23
$Zn^{2+} + 2e \rightarrow Zn^o$	-1,71	$Br_{2(S)} + 2e \rightarrow 2Br^-$	+1,21
$Fe^{2+} + 2e \rightarrow Fe^o$	-0,76	$[AuCl_4^-] + 3e \rightarrow Au + 4Cl^-$	+1,09
$Cr^{3+} + e \rightarrow Cr^{2+}$	-0,41	$NO_3^- + 4H^+ + 3e \rightarrow NO + 2H_2O$	+0,99
$Co^{2+} + 2e \rightarrow Co^o$	-0,41	$2Hg^{2+} + 2e \rightarrow Hg^o_2$	+0,96
$PbSO_4 + 2e \rightarrow Pb + SO_4^{2-}$	-0,40	$Ag^+ + e \rightarrow Ag^o$	+0,91
$Ni^{2+} + 2e \rightarrow Ni^o$	-0,35	$Hg_2^{2+} + 2e \rightarrow 2Hg^o$	+0,80
$Sn^{2+} + 2e \rightarrow Sn^o$	-0,23	$Fe^{3+} + 3e \rightarrow Fe^{2+}$	+0,80
$Pb^{2+} + 2e \rightarrow Pb^o$	-0,14	$0_2 + 2H^+ + 2e \rightarrow H_2O_2$	+0,77
$2H^+ + 2e \rightarrow H_2^o$	-0,13	$MnO_4^- + 2H_2O + 3e \rightarrow MnO_2 + 4OH^-$	+0,68
$SO_4^{2-} + 4H^+ + 2e \rightarrow H_2SO_3 + H_2O$	0,00		+0,59
$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	+0,20		
$Cu^{2+} + 2e^- \rightarrow Cu^o$	+0,27		
$I_2 + 2e \rightarrow 2I^-$	+0,34		
	+0,56		

Table 5.2 Selected standard potentials at 298 K; further values are included in *Resource section 3*

Couple	$E^{\ominus}$/V
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq)$	+1.76
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$[IrCl_6]^{2-}(aq) + e^- \rightarrow [IrCl_6]^{3-}(aq)$	+0.87
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$[PtCl_4]^{2-}(aq) + 2e^- \rightarrow Pt(s) + 4Cl^-(aq)$	+0.60
$I_3^-(aq) + 2e^- \rightarrow 3I^-(aq)$	+0.54
$[Fe(CN)_6]^{3-}(aq) + e^- \rightarrow [Fe(CN)_6]^{4-}(aq)$	+0.36
$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$	+0.22
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0
$AgI(s) + e^- \rightarrow Ag(s) + I^-(aq)$	−0.15
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	−0.76
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	−1.68
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	−2.84
$Li^+(aq) + e^- \rightarrow Li(s)$	−3.04

Potensiallar diagrammalar ko’rinishida

Diagrammalar turli oksidlanish darajalariga ega bir element mavjud bo'lgan zarralar guruhlarining nisbiy termodinamik barqarorligi haqida ma'lumot beradi. Diagrammalarning ikki turi mavjud (Latimer va Frost).

Latimer diagrammasi **odatda ma'lum bir element uchun miqdoriy ma'lumotlarni tavsiflaydi va turli birikmalardagi bir element zarrachalarining oksidlanish darajasining o'zgarishini ko'rsatadi. Standart potensiallar diagrammada oksidlanish darajasi o'zgarishining o'tish chizig'i ustida yozilgan. Maksimal oksidlanish darajasi chap tomonda, eng kichik oksidlanish darajasi esa o'ngda:**

Ushbu diagrammada turli birikmalardagi elementning turli oksidlanish darajalari o'rtasidagi bog'liqlik haqida ma'lumot mavjud. Bunda elementning oksidlanish darajasi zarrachalar ostida yoziladi. O'tish kuchli kislotali muhitda pH = 0 degan ma'noni anglatadi:

$$ClO_4^- \xrightarrow{+1,20} ClO_3^-$$

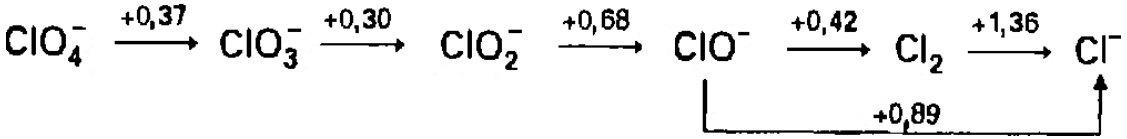
$$ClO_4^-(aq) + 4H^+(aq) + 4e \rightarrow ClO_3^-(aq) + H_2O(ж) \qquad \varphi = 1.67$$

O'tishni yozib, ma'lum yarim reaksiyalarga o'tish mumkin:

$$HClO \rightarrow Cl_2 \qquad \varphi = 1{,}63$$

$$2HClO(aq) + 2H^+(aq) \rightarrow Cl_2(г) + 2H_2O(ж) \qquad \varphi = 1{,}63V$$

Ishqoriy muhitda xlor birikmalarining Latimer diagrammasi quyidagicha:



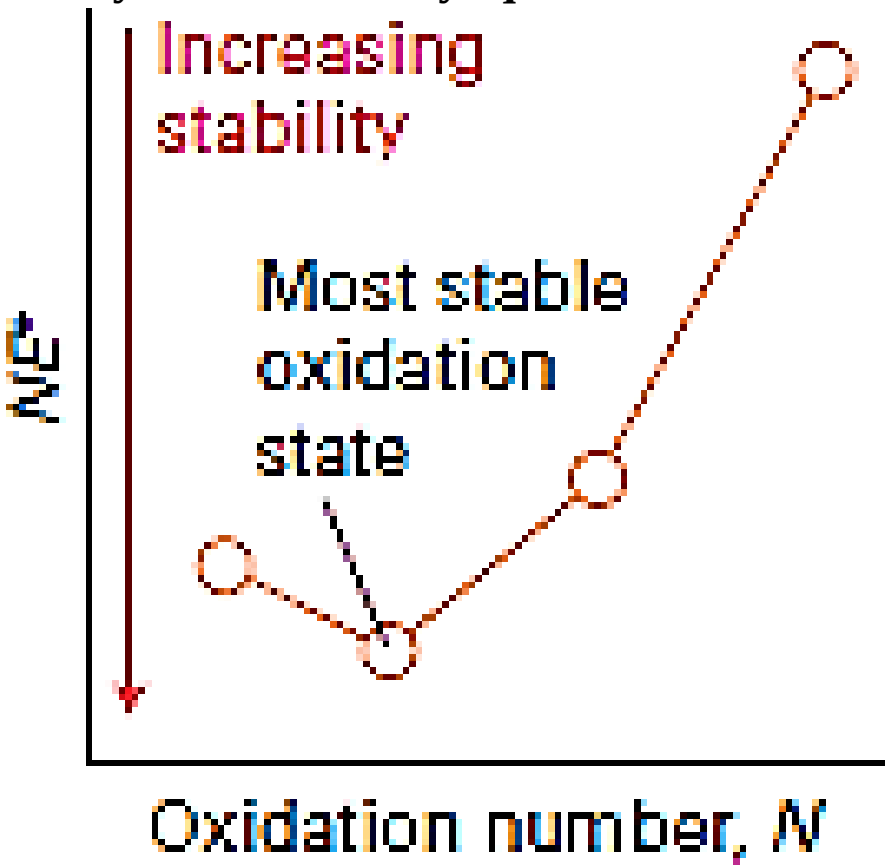
Bunday holda, reaksiyada suv va gidroksil guruhi ishtirok etadi:

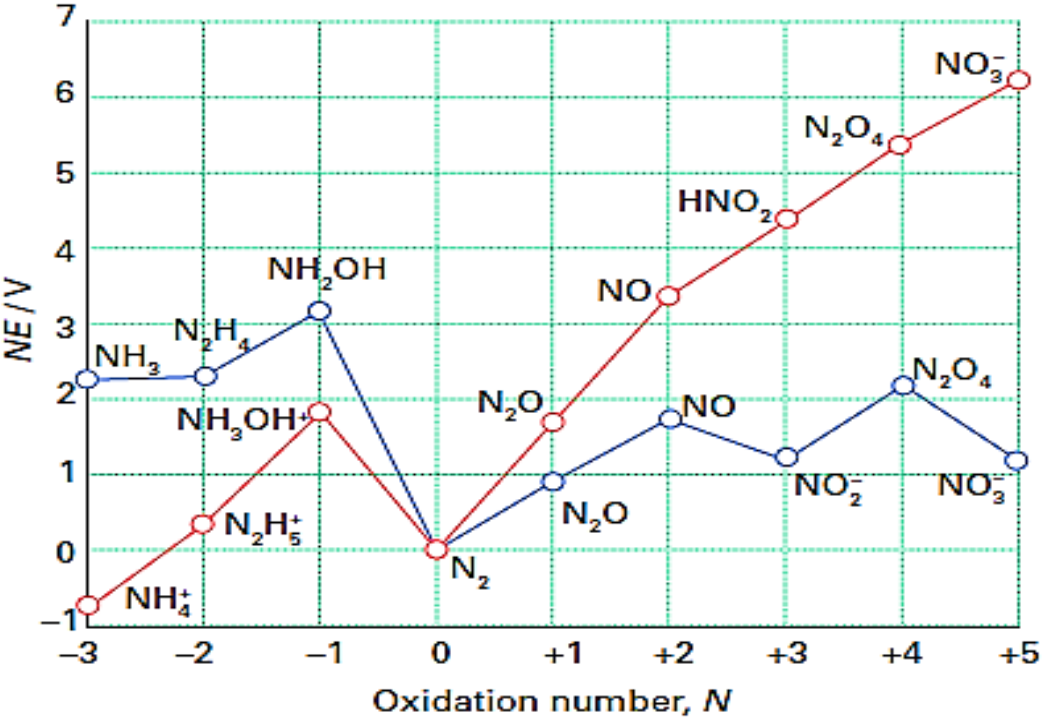
$$2ClO^-(aq) + 2H_2O(ж.) + 2e^- \rightarrow Cl_2(г.) + 4OH^-(aq) \qquad E^\circ = +0{,}42\ В$$

Frost diagrammasi **- elementning elektrod potensialining oksidlanish darajasiga bog'liqligi grafigившк. Frost diagrammasi quyidagi formula asosida Gibbs energiyasining oksidlanish darajasiga bog'liqligi sifatida qaraladi:**

$$n\varphi = -\frac{\Delta G_r^o}{F}$$, где ΔG_r^o .

Agar shunday bo'lsa, Frost diagrammasidagi eng barqaror zarra boshqa barcha zarralar ostida joylashgan zarradir. Chiziqning qiyaligi qanchalik katta bo'lsa, mos keladigan juftlikning salohiyati shunchalik yuqori bo'ladi.





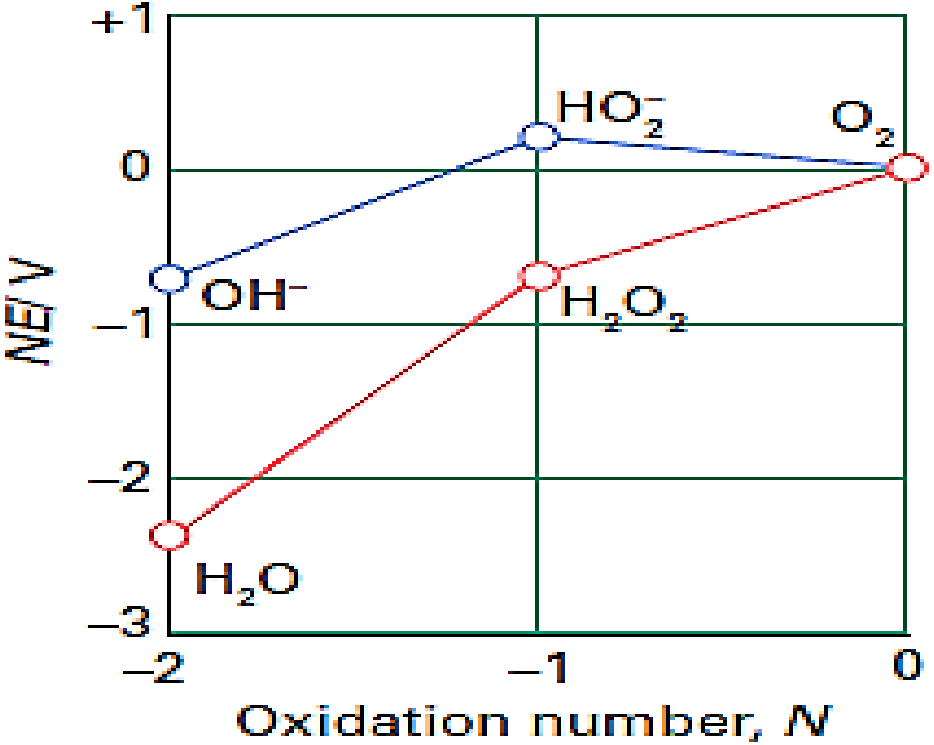
Azotli birikmalar uchun Frost diagrammasining tasviri. Qizil chiziq kislotali, ko'k chiziq esa ishqoriydir.

Birikmalarning eng barqaror holati N_2 ga to'g'ri keladi. Kuchli kislota HNO_3 kuchsiz asos NO_3^- ga mos keladi. Katta qiyaligi nitrat kislotaning standart sharoitlarda kuchli oksidlovchi vosita ekanligini ko'rsatadi. Shu bilan birga, gidroksilamin disproporsiyalanish reaksiyalariga nisbatan beqaror. NH_4NO_3 ning parchalanish reaksiyasi normal haroratda ingibit qilinadi. Qattiq fazada, qizdirilganda, u tez ketishi mumkin. Shuning uchun ammoniy nitrat tog' jinslarini buzish uchun dinamit sifatida ishlatiladi. Agar nuqtalar deyarli bir xil to'g'ri chiziqda joylashgan bo'lsa, Frost diagrammasida hech qanday zarracha reaksiyaning asosiy mahsuloti bo'lmaydi. Azotli birikmalarning uchta reaksiyasiga misol:

$$NO(г) + NO_2(г) + H_2O(ж) \rightarrow 2HNO_2(aq) \quad (1)$$

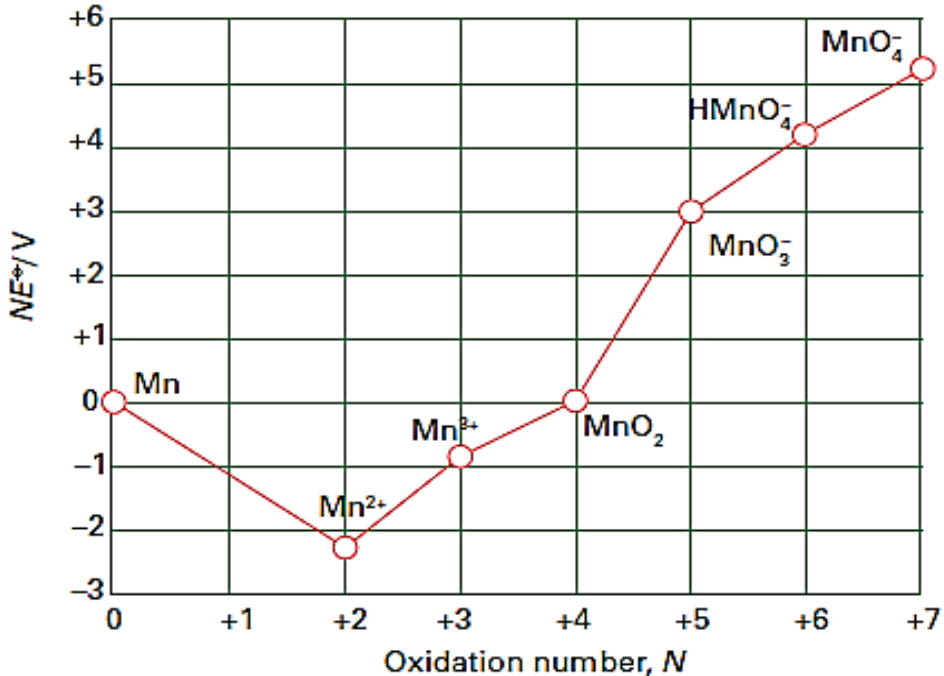
$$3HNO_2(aq) \rightarrow HNO_3(aq) + 2NO(г) + H_2O(ж) \quad (2)$$

$$2NO_2(г) + H_2O(ж) \rightarrow HNO_3(aq) + HNO_2(aq) \quad (3)$$

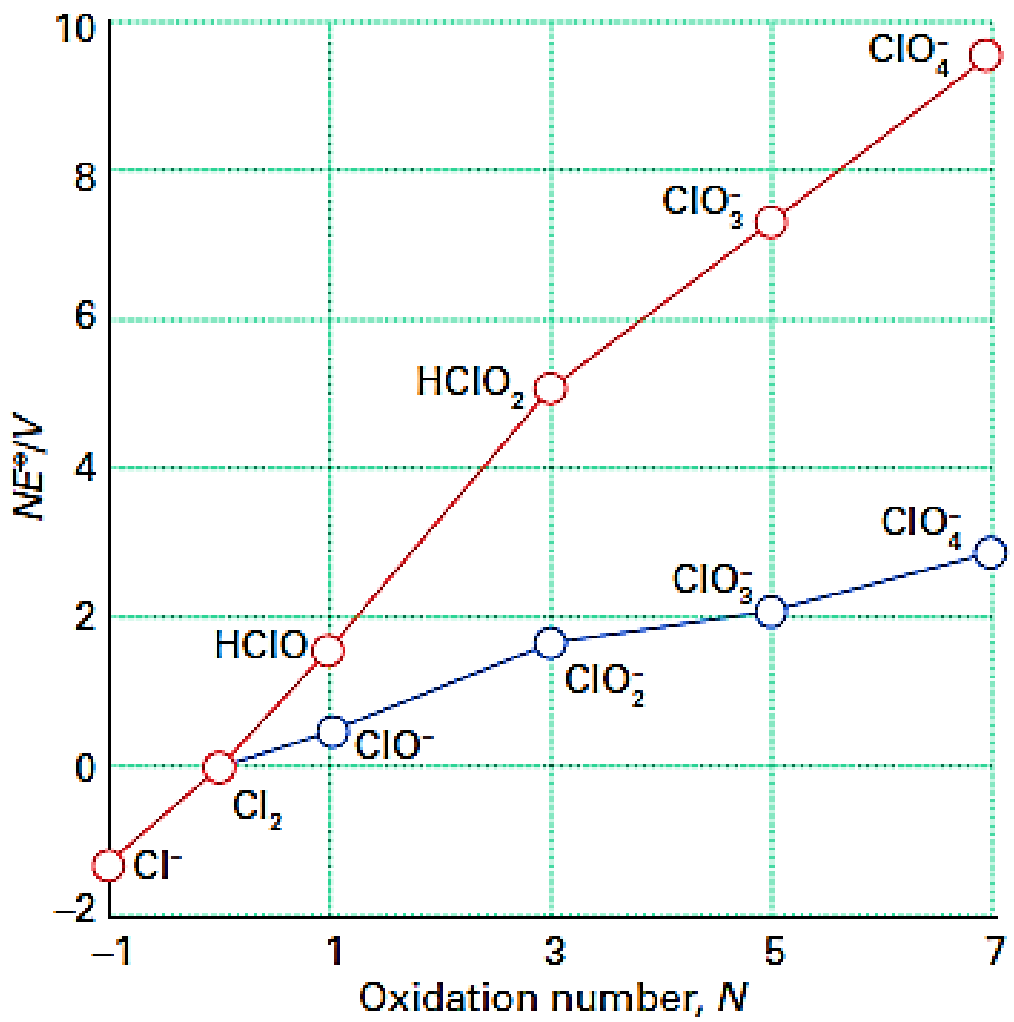


Kislotali va ishqoriy sharoitda eritmadagi kislorodning Frost diagrammasi.

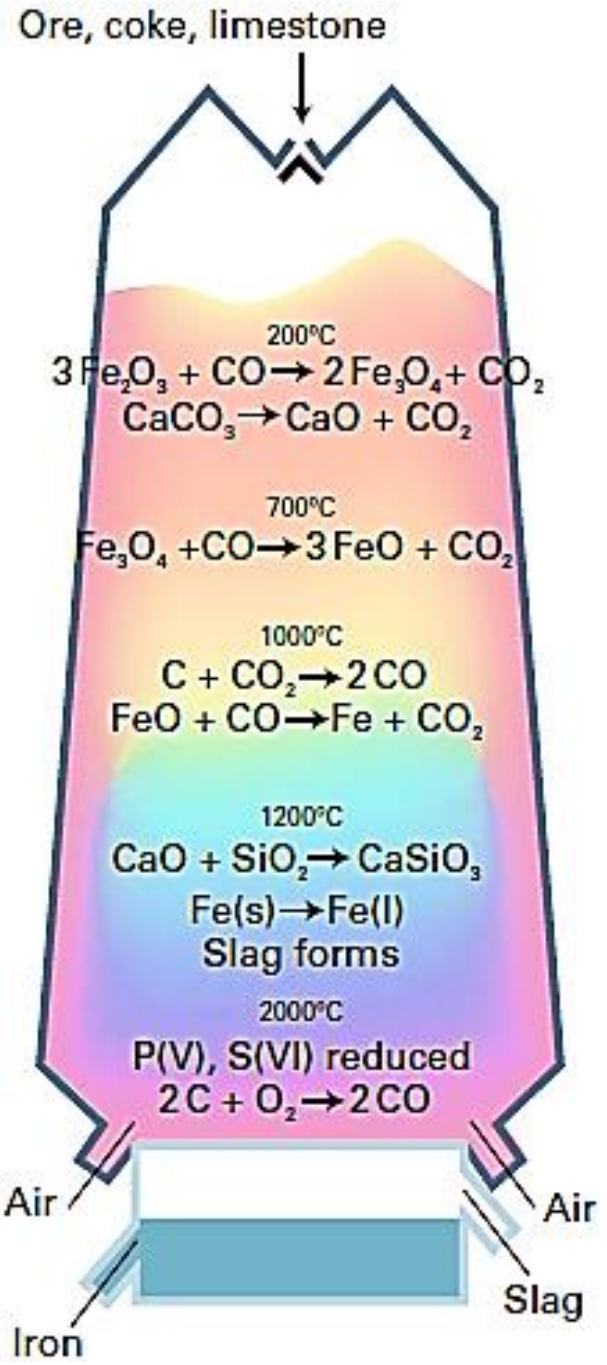
Kislotali va ishqoriy muhitda kislorodning Frost diagrammasi. Oksidlanish darajasi 0 dan -1 gacha bo'lgan kislorod va vodorod peroksid uchun $\varphi = 0{,}70$ *V*.



Kislotali eritmada marganes birikmalari uchun Frost diagrammasi. $HMnO_4$ va $HMnO_3$ kuchli kislotalardir.



Kislotali eritmada marganes birikmalari uchun Frost diagrammasi. $HClO_3$ va $HClO_4$ kuchli kislotalardir.



Mis, magniy, temir va kremniy tabiatdagi tabiiy birikmalardan ushbu metallarni qaytarib olinadi.

Fig. 5.17 A schematic diagram of a blast furnace showing the typical composition and temperature profile.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

$$SiO_2(l) + 2C(s) \xrightarrow{1700^\circ C} Si(l) + 2CO(g)$$

$$2SiC(s) + SiO_2(l) \rightarrow 3Si(l) + 2CO(g)$$

Electrochemical extraction

$$2Al_2O_3(s) + 3C(s) \rightarrow 4Al(s) + 3CO_2(g)$$

$$2Cl^-(aq) + 2H_2O(l) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g) \quad \Delta_r G^\ominus = +422 \text{ kJ mol}^{-1}$$

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g) \quad \Delta_r G^\ominus = +414 \text{ kJ mol}^{-1}$$

Chemical reduction

about 6000 years ago.

$$2\,Cu_2S(s) + 3\,O_2(g) \rightarrow 2\,Cu_2O(s) + 2\,SO_2(g)$$

$$2\,Cu_2O(s) + Cu_2S(s) \rightarrow 6\,Cu(s) + SO_2(g)$$

$$MgO(s) + C(s) \xrightarrow{\Delta} Mg(l) + CO(g)$$

Chemical oxidation

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(l)$$

$$2\,H_2S(g) + SO_2(g) \xrightarrow{\text{Oxide catalyst, 300°C}} 3\,S(s) + 2\,H_2O(l)$$

The catalyst is typically Fe_2O_3 or Al_2O_3.

$$Au(s) + 2\,CN^-(aq) \rightarrow [Au(CN)_2]^-(aq) + e^-$$

$$2[Au(CN)_2]^-(aq) + Zn(s) \rightarrow 2\,Au(s) + [Zn(CN)_4]^{2-}(aq)$$

$$2\,NaBr(aq) + Cl_2(g) \rightarrow 2\,NaCl(aq) + Br_2(l)$$

OQR ahamiyati

Nafas olish, ovqat hazm qilish, turli biokimyoviy sintezlar.

Mikroelementlar yetishmasligi OQR yo’nalishida o’zgarishlar ro’y berishi bilan bog’langan.

OQR qonning klinik analizida, qondagi kalsiyni aniqlashda, siydik kislotasi, katalaza va peroksidaza fermentlari, xlor, xlorli ohak, ichimlik suvlardagi qoldiq xlorni aniqlash va oksidimetriya usullarida qo’llaniladi.

E’tiboringiz uchun raxmat!