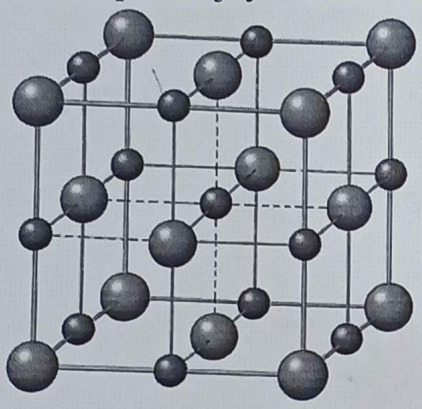
1-masala (5 ball).

Kobalt(II) oksidi CoO galit (NaCl) tuzilishida kristallanadigan ion birikma hisoblanadi ($a = 4{,}261$ Å). 16 K dan past haroratda u antiferromagnitga aylanadi, ammo xona haroratida u paramagnit. Kristall maydonning ajralish parametrlari (oksid ligandlari uchun): $\Delta_O = 9.1 \times 10^{-20}$ J; Juftlashish energiyasi $P = 2{,}5 \times 10^{-19}$ J (har bir elektron jufti uchun).

a) Bitta elementar yacehykada nechta kobalt oksidi joylashadi?
b) Co^{2+} hamda O^{2-} ionlari orasidagi eng yaqin masofani (Å) hisoblang.
c) Kobalt yuqori spin holatidami yoki quyi spin holatidami? Javobingizni izohlang.
d) Co^{2+} uchun CoO da qo‘zg‘almagan holatda elektron konfiguratsiyani ($t_{2g}^{m} e_g^{n}$) yozing va juftlashmagan elektronlar sonini ko‘rsating.
e) Ayni konfiguratsiya uchun effektiv magnit momentini hisoblang (BM).

Yechish:

a) Galit tuzilishda O^{2-} ionlari fcc tugunlarida, Co^{2+} ionlari oktaedrik bo‘shliqlarida joylashadi. Shuning uchun 4 ta CoO.



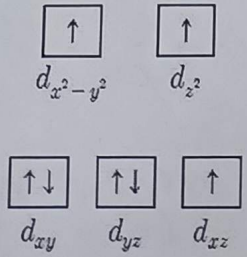
(1b)

b) Galit tuzilishda Co^{2+} (0,0,0) koordinataada, O^{2-} ($^1/_2$,0,0) koordinatada joylashadi. Shuning uchun masofa

$$a \times \sqrt{(0.5)^2 + 0^2 + 0^2} = a \times 0.5 = \frac{4.261}{2} = 2.1305 \text{ Å}.$$ (1b)

c) $\Delta_O = 9.1 \times 10^{-20}$ J < $P = 2{,}5 \times 10^{-19}$ J Co^{2+} yuqori spinli bo‘lishini ko‘rsatadi. (1b)

d) Yuqori spinli d^7 konfiguratsiya uchun $t_{2g}^5 e_g^2$

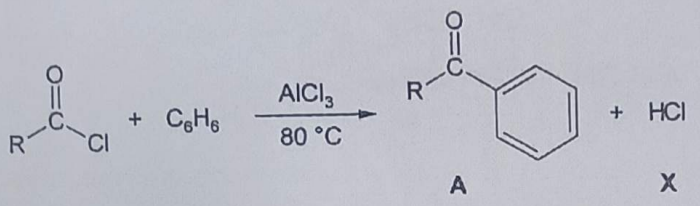


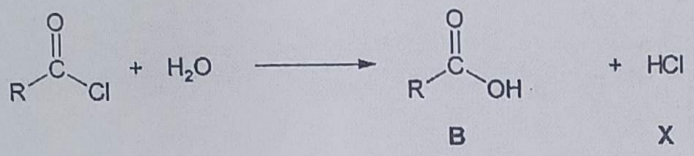
(1b)

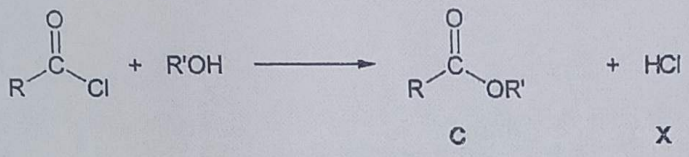
3 ta toq elektron.

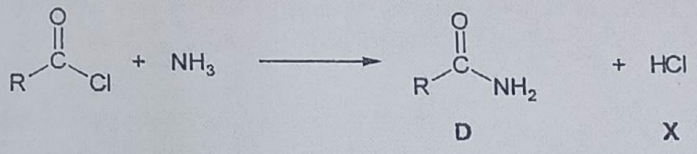
e) Effektiv magnit momenti: $\mu_{\text{eff}} = \sqrt{n(n+2)} = \sqrt{3(3+2)} = 3{,}87$ BM (1b)

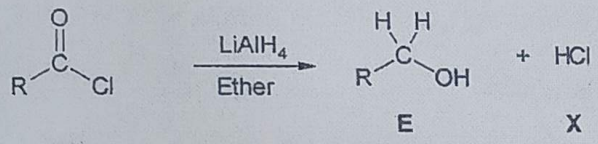
2-masala

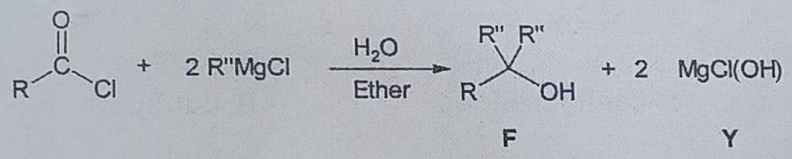


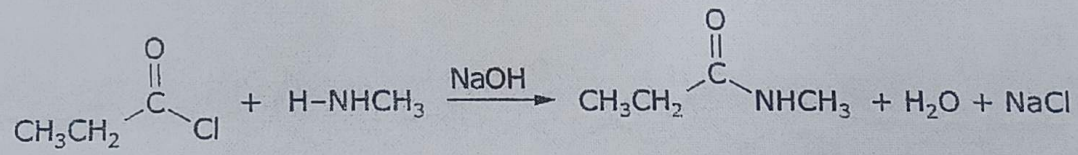


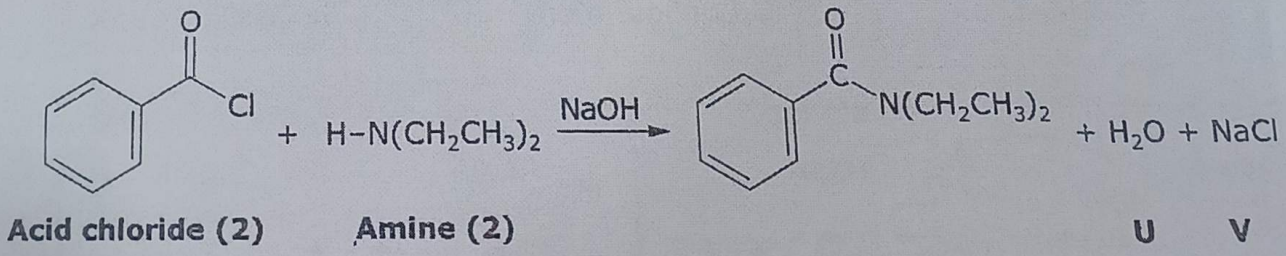










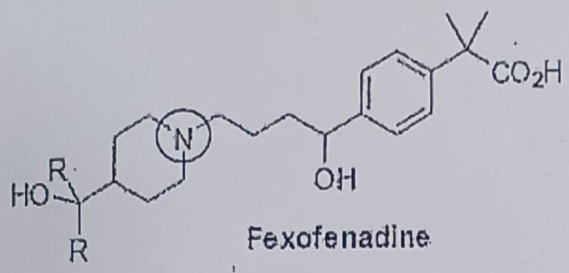


Amid (1) – *N*-metilpropanamid; Amid (2) – *N,N*-dietilbenzamid.
Har bir modda uchun 0.3 balldan, to'g'ri nomlanish uchun 0.4 balldan.

Jami – 14 x 0.3 + 2 x 0.4 = 5 ball

3-masala

1.



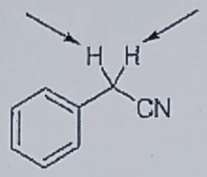
Fexofenadine

(0.75 ball)

2. $(0.12014 - 0.11200) / 36.45 = 2.233 \cdot 10^{-4}$ mol (HCl va Feksofenadin) →
$M = 0.11200 / 2.233 \cdot 10^{-4} = 501.5$ g/mol. **(0.75 ball)**

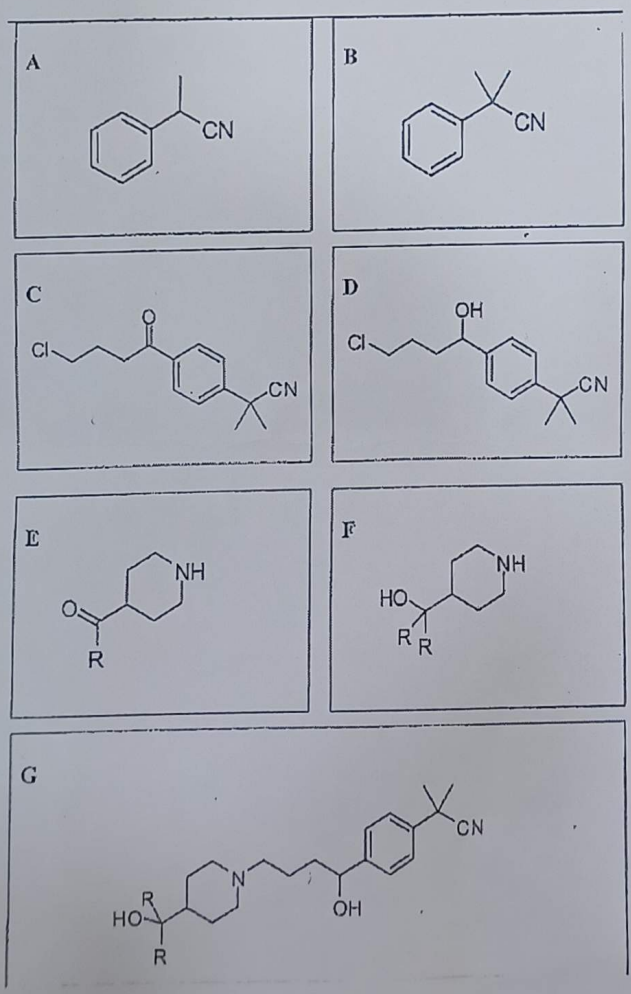
3. $501.5 = 347.4 + 2R \rightarrow R = 77.1$ g/mol. Bu $-C_6H_5$ (fenil) guruhiga mos keladi. **(0.5 ball)**

4.



(0.75 ball)

5.



(7 x 0.75 = 5.25 ball)

Jami – 8 ball

$$k = \frac{mol \cdot l^{-1} \cdot s^{-1}}{(mol \cdot l^{-1}) \cdot (mol \cdot s^{-1})^2} = \frac{mol \cdot l^{-1} \cdot s^{-1}}{mol^3 \cdot l^{-3}} \Rightarrow l^2 \cdot mol^{-2} \cdot s^{-1} \; yoki \; \frac{l^2}{mol^2 \cdot s}$$

2. Noma'lum namunada natriy karbonat (Na_2CO_3) va natriy bikarbonat ($NaHCO_3$) aralashmasi mavjud. 1,000 g namuna suvda eritilib, 250,0 ml hajmli o'lchov kolbasiga to'ldiriladi. Shu eritmaning barchasi (250,0 ml) quyidagi tartibda titrlanadi:

1) Fenolftalein indikatori ishtirokida 0,1000 M HCl eritmasi bilan titrlanadi. Rangsizlanish nuqtasida sarflangan hajm $V_1 = 12{,}50\ ml$.

2) Shundan so'ng eritmaga metiloranj indikatori qo'shiladi va titrlash davom ettiriladi. Rang qizildan sariqqa o'zgarganda qo'shimcha sarflangan hajm $V_2 = 18{,}00\ ml$.

Quyidagilarni toping:

a) Fenolftalein va metiloranj nuqtalarida sodir bo'ladigan reaksiyalarning molekulyar va ionli tenglamalarini yozing. Qaysi kislota-asos juftlari bu nuqtalarda rol o'ynaydi?

b) 250,0 ml eritmadagi Na_2CO_3 va $NaHCO_3$ ning mmol miqdorlarini hisoblang.

c) Dastlabki 1,000 g namunadagi Na_2CO_3 va $NaHCO_3$ ning massa ulushlarini (%) toping.

d) Faraz qiling, HCl eritmasining haqiqiy konsentratsiyasi 0,09850 M ga teng (boshqa barcha hajmlar aniq). U holda (c) qismdagi natijalar qanday o'zgaradi? Yangi massa ulushlarini hisoblang.

e) Agar alikvot tarkibida faqat Na_2CO_3 bo'lganda, fenolftalein va metiloranj nuqtalarida sarflanadigan HCl hajmlari nisbati V_1/V_2 qanday bo'lar edi? Agar faqat $NaHCO_3$ bo'lganda-chi? Javobingizni qisqacha izohlang.

Yechim:

a) Reaksiyalar

Fenolftalein nuqtasi (pH ~ 8,3):

Ionli tenglama:

$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$

Molekulyar tenglama:

$Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$

1-bosqichda karbonat-ioni (zaif asos) gidrokarbonat-ga (amfoter) aylanadi. Bu kislota-asos jufti: CO_3^{2-}/HCO_3^-.

Metiloranj nuqtasi (pH ~3,7):

Ionli tenglama:

$$HCO_3^- + H^+ \longrightarrow H_2O + CO_2\uparrow$$

Molekulyar tenglama:

$$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$$

Bu bosqichda gidrokarbonat (amfoter, bu erda asos vazifasida) karbonat kislotaga (so'ngra CO_2 va H_2O ga) aylanadi. Kislota-asos jufti: HCO_3^-/H_2CO_3 (yoki HCO_3^-/CO_2).

b) 250,0 ml eritmadagi miqdorlar (mmol)

Sarflangan HCl ning modda miqdori:

$$n_{HCl}(V_1) = C_{HCl} \cdot V_1 = 0{,}1000\frac{mol}{l} \cdot 0{,}01250\ l = 0{,}001250\ mol = 1{,}250\ mmol$$

Bu butun eritmadagi CO_3^{2-} ni HCO_3^- ga aylantirish uchun ketgan kislota. Shuning uchun:

$$n_{Na_2CO_3} = 1{,}250\ mmol$$

Metiloranj bosqichida sarflangan kislota dastlab mavjud HCO_3^- va birinchi bosqichda hosil bo'lgan HCO_3^- ni neytrallaydi:

$$n_{HCl}(V_2) = C_{HCl} \cdot V_2 = 0{,}1000 \cdot 0{,}01800 = 0{,}001800\ mol = 1{,}800\ mmol$$

Hosil bo'lgan HCO_3^- miqdori $n_{Na_2CO_3}$ ga teng (1,250 mmol). Shuning uchun dastlab mavjud $NaHCO_3$ miqdori:

$$n_{NaHCO_3} = 1{,}800 - 1{,}250 = 0{,}550\ mmol$$

Javob:
$n_{Na_2CO_3} = 1{,}250\ mmol$, $n_{NaHCO_3} = 0{,}550\ mmol$ (250,0 ml eritmada).

c) Massa ulushlari (0,1000 M HCl)

Molyar massalar: $M_{Na_2CO_3} = 105{,}99\ g/mol$, $M_{NaHCO_3} = 84{,}01\ g/mol$

Massalar:

$$m_{Na_2CO_3} = 0{,}001250\ mol \cdot 105{,}99\frac{g}{mol} = 0{,}1325\ g$$

$$m_{NaHCO_3} = 0{,}000550\ mol \cdot 84{,}01\frac{g}{mol} = 0{,}0462\ g$$

Massa ulushlari (namuna 1,000 g)

$$\omega_{Na_2CO_3} = \frac{0{,}1325}{1{,}000} \cdot 100\% = 13{,}25\%$$

$$\omega_{NaHCO_3} = \frac{0{,}0462}{1{,}000} \cdot 100\% = 4{,}62\%$$

Javob: $Na_2CO_3 = 13{,}25\%$, $NaHCO_3 = 4{,}62\%$

d) HCl konsentratsiyasi **0,09850 M bo‘lganda**

Yangi konsentratsitya bilan:

$$n_{Na_2CO_3} = 0{,}09850 \cdot 0{,}01250 = 0{,}00123125\ mol$$

$$m_{Na_2CO_3} = 0{,}00123125 \cdot 105{,}99 = 0{,}1305\ g$$

$$n_{NaHCO_3} = 0{,}09850 \cdot 0{,}00550 = 0{,}00054175\ mol$$

$$m_{NaHCO_3} = 0{,}00054175 \cdot 84{,}01 = 0{,}0455\ g$$

$$\omega_{Na_2CO_3} = \frac{0{,}1305}{1{,}000} \cdot 100\% = 13{,}05\%$$

$$\omega_{NaHCO_3} = \frac{0{,}0455}{1{,}000} \cdot 100\% = 4{,}55\%$$

Javob: $Na_2CO_3 = 13{,}05\%,\ NaHCO_3 = 4{,}55\%$

e) Alikvotda faqat bitta modda bo‘lgandagi V_1/V_2 nisbatan izohi

Faqat Na_2CO_3 bo‘lsa:

Birinchi bosqichda karbonat gidrokarbonatga o‘tadi (V_1). Ikkinchi bosqichda hosil bo‘lgan shu gidrokarbonat to‘liq titrlanadi (V_1). Ikkala bosqichga ham teng miqdorda HCl sarflanadi.

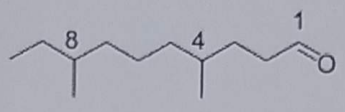
Nisbat: $\frac{V_1}{V_2} = 1$ (chunki$V_1 = V_2$).

Faqat $NaHCO_3$ bo‘lsa:

Fenolftalein muhitida gidrokarbonat HCl bilan reaksiyaga kirishmaydi ($V_1 = 0$). Titrlash faqat metiloranj qo‘shilgandan keyin boshlanadi ($V_2 > 0$).

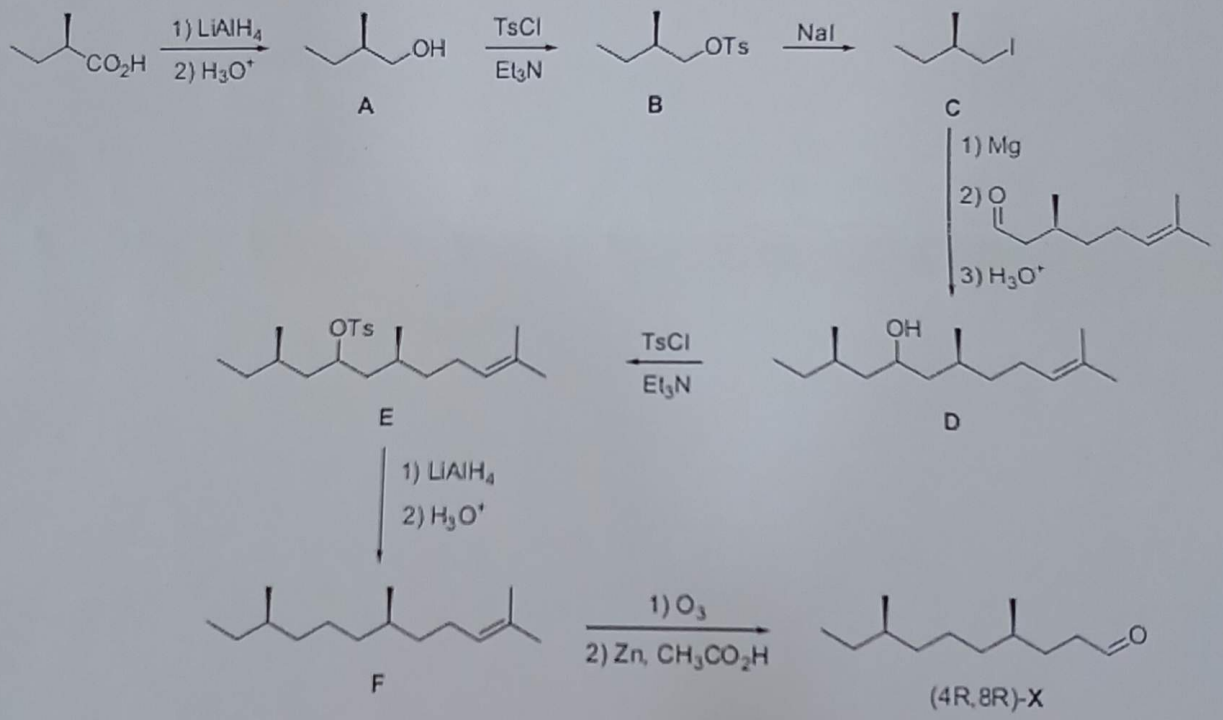
Nisbat: ($\frac{V_1}{V_2} = 0$).

6-masala

1.  **(1 ball)**

2. Xiral markazlar soni 2 ta. Demak, stereoizomerlar soni = $2^2 = 4$ ta. **(2 ball)**

3. Moddalarda stereokimyoni ko'rsatish shart emas:



A dan F gacha moddalarga 1.5 balldan – 6 x 1.5 = **9 ball**

Jami – 12 ball

Berilgan:
T_1=350K
P_1=5 atm
n=3 mol
C_V = 3,0 kal·mol^{-1}·K^{-1}
Bosim qaytar va adiabatik ravishda 5 atm dan 1 atmgacha kengayganda
T_2–?
V_2–?
A–?
ΔU–?
ΔH–?
ΔF–?
ΔG–?

Yechish:

Qaytar adiabatik jarayonda T_2 ni Puassonning quyidagi tenglamasi bo'yicha topamiz:

$$T_1^{\gamma} \cdot P_1^{1-\gamma} = T_2^{\gamma} \cdot P_2^{1-\gamma} \quad (1)$$

yoki

$$T_1 \cdot P_1^{1-\gamma/\gamma} = T_2 \cdot P_2^{1-\gamma/\gamma} \quad (1a)$$

$$T_2 = T_1 \cdot \left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} \quad (2)$$

$$C_P = C_V + R = 3 + 1{,}987 \quad (3)$$

Adiabatik konstantaning qiymati:

$$\gamma = \frac{C_P}{C_V} = \frac{4{,}987}{3} = 1{,}662 \quad (4)$$

Endi (4) dagi qiymatni (2) ga qo'yamiz:

$$T_2 = T_1 \cdot \left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} = 350 \cdot \left(\frac{1}{5}\right)^{1.662-1/1{,}662} = 184.32K$$

Mendeleev-Klapeyron tenglamasidan V_1 ni aniqlaymiz:

$$V_1 = \frac{nRT_1}{P_1} = \frac{3 \cdot 0{,}082 \cdot 350}{5} = 17{,}23 \text{ litr}$$

V_2 ni aniqlaymiz:

$$V_2 = \frac{nRT_2}{P_2} = \frac{3 \cdot 0{,}082 \cdot 184{,}32}{1} = 45{,}25 \text{ litr}$$

yoki

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$V_2 = V_1 \left(\frac{P_1}{P_2}\right)^{5/3} = 17{,}23 \cdot 5^{\frac{5}{3}} = 45{,}25 \text{ litr}$$

$$\Delta U = nC_V(T_2 - T_1) = 3 \cdot 3(184{,}32 - 350) = -1491{,}12 \ kal$$

(yoki -6247,79 Joul)

Endi ishni topamiz. Adiabatik jarayonda Q=0 va A= –ΔU ekanligidan:

A= + 1491,12 kal

(yoki +6247,79 Joul)

Endi entalpiyani topamiz:

$Q_P = \Delta H = n \cdot C_P \cdot (T_2 - T_1) = 3 \cdot 4{,}987 \cdot (184{,}32 - 350) = -2478{,}73$ kal

(yoki – 10385,91 Joul)

Qaytar adiabatik jarayonda sistema entropiyasi o'zgarmaydi: (ΔS=0)

Gelmgols va Gibbs energiyalarini aniqlash tenglamalari quyidagicha:

$$\Delta F = \Delta U - T\Delta S$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta S = 0$$