# INGURUGIRO TEKNOLOGIA

Luis M.Camarero Estela

Arritokieta Ortuzar Iragorri

Natalia Villota Salazar

OCW 2013

## 1. **ariketa**

a) 2000 mL $SO_2$/ $m^3$ gas ·1 L/1000 mL· 25000 $m^3$ gas/min · 1min /60 s=8333.33 L $SO_2$ /s

**P · V=N · R · T**

1.05 atm · 833.33 L= m/64.5 g $mol^{-1}$ ·0.082 atm L/mol K·733 K

m=931.68 g $SO_2$

b) 1200 mL $SO_2$/ $m^3$ gas ·1 L/1000 mL· 25000 $m^3$ gas/min · 1min /60 s=500 L $SO_2$ /s

**P · V=N · R · T**

1.05 atm · 500 L= m/64.5 g $mol^{-1}$ ·0.082 atm L/mol K·733 K

m=595.5 g $SO_2$

## 2. ariketa

$$a) 450 \frac{mL\ CO}{m^3\ ke} \frac{m^3\ CO}{10^6\ mL\ CO} 100\ m^3\ ke = 0{,}045\%$$

b)

$$P\ V = n\ R\ T$$

$$1{,}1\ \text{atm} \quad 450\ \text{mL CO} \frac{\text{L CO}}{1000\ \text{mL CO}} = \frac{\text{m}}{28}\ 0{,}082\ \frac{\text{atm L}}{\text{mol K}}\ 293\ \text{K}$$

$$\text{m} = 0{,}576\ \ \text{g CO}$$

## 3. ariketa

$$2{,}2\ \%\ \text{CO bolumena} = \frac{2{,}2\ m^3\ CO}{100\ m^3\ aire}\ \frac{1000\ L\ CO}{m^3\ CO} = 22\ \frac{L\ CO}{m^3\ aire}$$

$$P\ V = n\ R\ T$$

$$1{,}02\ atm\quad 22\ L\ CO = \frac{m}{28\ \frac{g\ CO}{mol\ CO}}\quad 0{,}082\ \frac{atm\ L}{mol\ K}\quad 293\ K$$

$$m = 26{,}15\ g\ CO$$

$$26{,}15\ g\ CO\ \frac{1000\ mg\ CO}{g\ CO}\ \frac{1}{m^3\ gas} = 2{,}61 \bullet 10^4\ \frac{mg\ CO}{m^3\ gas}$$

**4. ariketa**

Garajea:

$V = 4 \cdot 4 \cdot 3 = 48\ m^3$

CO muga = 1500 ppm = 1500 mL CO/ $m^3$ aire

Ihes hodia:

Q gasak=2.4 $m^3$ gas/ordu

CO: 8.7 g CO/ $m^3$ gas

P= 1 atm eta T=273 K

1500 mL CO/ $m^3$ aire $\cdot$48 $m^3$ aire = 72000 mL CO =72 L CO

$P \cdot V = N \cdot R \cdot T$

$1\ atm \cdot 72L = m/28\ g\ mol^{-1} \cdot 0.082\ atm\ L/mol\ K \cdot 273\ K$

m= 90.09 g CO

2.4 $m^3$ gas/ordu $\cdot$ 8.7 g CO/ $m^3$ gas=20.88 g CO/ ordu

90.09 g CO $\cdot$ ordu/20.88 g CO= <u>4.3 ordu</u>

## 5. Ariketa I

$O_2$ Laborategia

$$\text{Laborategia} = 10 \text{ x } 5 \text{ x } 3 = 150 \text{ m}^3 \text{ AIRE}$$

$$\text{AIRE} \begin{cases} 21\% \ O_2 \\ 79\% \ N_2 \end{cases}$$

$$150 \text{ m}^3 \text{ AIRE} \frac{21 \text{ m}^3 \text{ O}_2}{100 \text{ m}^3 \text{ AIRE}} = 31{,}5 \text{ x } 10^3 \text{ L O}_2$$

$$P \ V = n \ R \ T$$

$$1 \text{ atm } 31{,}5 \text{ x } 10^3 \text{ L} = n \ 0{,}082 \frac{\text{atm L}}{\text{mol K}} 298\text{K} \quad \rightarrow \quad n = 1.289 \text{ mol } O_2$$

## 5. Ariketa II

$N_2$ LABORATEGIA:

$$150\ m^3\ AIRE\ \frac{79\ m^3\ N_2}{100\ m^3\ AIRE} = 118{,}5\ x\ 10^3\ L\ N_2$$

$$P\ V = n\ R\ T$$

$$1\ atm\ 118{,}5\ x\ 10^3\ L = n\ 0{,}082\ \frac{atm\ L}{mol\ K}\ 298K \qquad \rightarrow \qquad n=4.849\ \ mol\ N_2$$

$N_2$ IHESA:

$$N_2\ Botilak \qquad = 7\ x\ 25\ L = 175\ L\ N_2$$

$$P\ V = n\ R\ T$$

$$200\ atm\ 175\ L = n\ 0{,}082\ \frac{atm\ L}{mol\ K}\ 298K \qquad \rightarrow \qquad n=1.432\ \ mol\ N_2$$

$$O_2\ \% = \frac{O_2\ mol}{mol\ total} = \frac{1.289\ \ mol\ O_2}{1.289 + 4.849 + 1.432}\ x\ 100 = 17{,}02\%\ O_2 < 18\% \rightarrow \text{KONTUZ}$$

## 6. Ariketa

Erregaia:

$Q_{erregai}$= 2000 $m^3$ erregai/ egun

$\rho_{erregai}$= 0.75 g gas/ L erregai

200 $m^3$/egun ·0.75 g/L · 1000 L/$m^3$ =1.5 $10^7$ g/egun

Tximinia:

$Q_{gas}$= 930 $m^3$ gas/ ordu

$N_{ox}$= 3 kg $N_{ox}$ / gas ton

T= 273 K eta P= 1 atm

1.5 $10^7$ g/egun ·1 ton/ $10^6$ g ·3000 g/1 ton · 1 egun /24 ordu ·1 ordu/930 $m^3$= 2.016 g/ton

$NO_x$: %90 NO eta %10 $NO_2$

NO: 2.016 g/$m^3$ 90 g NO/100 g $NO_x$ = 1.814 g NO/ $m^3$

P · V=n · R · T

1 atm · V=1.814 g NO/ 30 g/mol · 0.082 atm L/mol K · 273 K

V=1.35 L NO $\Rightarrow$ 1350 ppm

$NO_2$: 2.016 g/$m^3$ 10 g $NO_2$/100 g $NO_x$ = 0.201 g $NO_2$/ $m^3$

P · V=n · R · T

1 atm · V= 0.201 g $NO_2$ / 46 g/mol · 0.082 atm L/mol K · 273 K

V=0.098 L NO $\Rightarrow$ 98 ppm

## 7. Ariketa

a) $$3000\,\frac{Ton\ IKATZ}{egun}\,\frac{365\,egun}{urte}\,\frac{1{,}2\,Ton\ S}{100\,Ton\ IKATZ}\,\frac{64\,Ton\ SO_2}{32\,Ton\ S}=26.280\,\frac{Ton\ SO_2}{urte}$$

b) 26280 ton $SO_2$/ urte·1 egun/3 · $10^7$ $m^3$ gas· 1 urte/365 egun · $10^9$ mg $SO_2$ / ton $SO_2$=2400 mg $SO_2$ / $m^3$

P · V=n · R · T

1 atm · V=2.4 g NO/ 64 g/mol · 0.082 atm L/mol K · 273 K

V=0.84 L $SO_2$ $\Rightarrow$ 840 ppm

c) $$CaCO_3 + SO_2 + \frac{1}{2}\,O_2 = CaSO_4 + CO_2$$

26280 ton $SO_2$/ urte·80 ton murriztuak/ ton $SO_2$· 1 urte/365 egun · $10^6$ g $SO_2$ / ton $SO_2$· 1 mol $SO_2$ / 64 g $SO_2$· 1 mol $CaCO_3$/ 1 mol $SO_2$· 100 g $CaCO_3$/ 1 mol $CaCO_3$· 1 ton $CaCO_3$/ $10^6$ g $SO_2$ =90 ton $CaCO_3$ / egun

## 8. **Ariketa I**

a) 7.2 kg partikula/ ton ikatz·1 kg ikatz/6.8 $m^3$ gas· 1 ton ikatz/1000 kg ikatz · $10^6$ mg partikula / kg partikula=1058.82 ppm

b)Atxikitutako partikulak= ekoiztutako partikulak-igorritako partikulak=1058.82-200= 858.82 ppm

η= araztutako partikulak/ ekoiztutako partikulak· 100 =858.82/1058.82·100=% 81.1

Mahuka iragazkia edo jaulkitzaile elektrostatikoa

c)

$$P\,V = n\,R\,T$$

$$1\,\text{atm}\;V = \frac{3{,}0\ \text{gr}\ SO_2}{64\ \frac{\text{mol}}{\text{gr}\ SO_2}}\ 0{,}082\ \frac{\text{atm L}}{\text{mol K}}\ 273\text{K}$$

$$V = 1{,}049\ \text{L}\ SO_2 = 1049\ \text{mL}\ SO_2$$

$$SO_2 = 1049\ \text{ppm}$$

300 mg $SO_2$/ $m^3$ gas ·6.8 $m^3$ gas / kg erregai· 1 g $SO_2$/1000 mg $SO_2$=20.4 g $SO_2$/kg erregai

## 8. **Ariketa II**

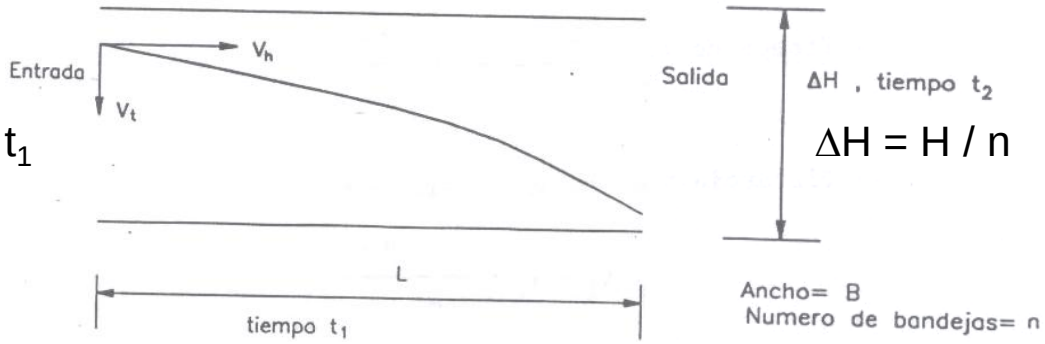
d) 20.4 g $SO_2$/ kg erregai·32 g S/ 64 g $SO_2$· 1 kg erregai/1000 g erregai=0.01021 kg S/kg erregai

%S (erregaian= 0.01021 kgS/kg erregai ·100=%1.02 S erregaian

# 9. Ariketa I

$$V_h = L / t_1$$

$$Q = H\ B\ L / t_1$$




$$V_t = y / t_1$$

$$\Delta H = H / n$$

$$V_t = 29.609\ \rho_p\ (d_p)^2$$

- $V_t$ = Airean partikulen erortze abiadura (m/s)
- $\rho_p$ = Partikulen dentsitatea (kg/m$^3$)
- $d_p$ = Partikulen diametroa (m)

Distantzia bertikala

$$y = V_t\ t_1 = V_t\ \frac{L\ B\ \Delta H\ n}{Q}$$

Igarotze denbora

$$t_1 = \frac{L}{V_h} = \frac{L\ B\ \Delta H\ n}{Q}$$

$$\Delta H = \frac{H}{n} = 0{,}2\ \text{m}$$

$$\eta = \frac{y}{\Delta H} = V_t\ \frac{L\ B\ n}{Q} = V_t\ \frac{6\ \text{m}\ 1{,}5\ \text{m}\ 10\ \text{m}}{10\ \frac{\text{m}^3}{\text{s}}} = 9\ V_t$$

$$V_t = 29609\ \rho_p\ \left(d_p\right)^2 = 29609 \quad 2000\ \frac{\text{Kg}}{\text{m}^3}\left(50\ 10^{-6}\ \text{m}\right)^2 = 0{,}148\ \frac{\text{m}}{\text{s}}$$

$$\eta = 9 \quad 0{,}148\ \frac{\text{m}}{\text{s}} = 1{,}33$$

# 9. **Ariketa II**

Etekina 1,0 baino handiago izateak dimentsioak gehiegizkoak direla eta eraginkortasun maximoarekin tamaina txikiagoko partikulak jaso zitezkeela adieraz zezakeen. Tamaina limite honako hau litzatekeelarik:

$$\eta = 1{,}0 = 9\ V_t = 9\ 29609\ 2000\ \frac{Kg}{m^3}\ (d_p)^2$$

$$d_p = 43\,10^{-6}\ m = 43\ \mu m$$

# 9. **Ariketa III**

b.) Etekin hau gertatzen da mugimendu nagusiak izaera laminarra duenean, hau da, Reynolds-en zkia.<3000 denean.

$$R_E \geq 3000 \geq \frac{V_h\ D_h}{\nu} = \frac{:\frac{5}{B}\ \frac{4\,\Delta H\ B}{(2\,\Delta H + B)}}{1{,}5\,10^{-5}\ \frac{m^2}{s}} = 140082 \text{ FLUJO TURBULENTO}$$

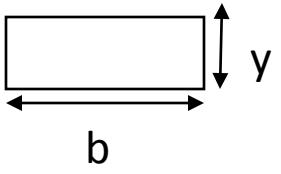
$D =$ Kondukzioaren diametroa (m)

$\nu =$ Airearen biskositate zinematikoa (m/s)

$V_h =$ Abiadura horizontala (m/s)

$$V_h = \frac{Q}{n\ B\ \Delta H} = \frac{5}{B}$$

Orokorrean, jaulkitzaile mekanikoek sekzio errektangeluarra dute, ondorioz, erradio hidrauliko kontzeptura jo behar dugu :

| Sekzio mota | Azalera A ($m^2$) | Bustitako perimetroa P (m) | Erradio hidraulikoa Rh (m) |
|---|---|---|---|
|   | by | b+2y | by/(b+2y) |

$$R_h = \frac{Bustitako azalera}{Bustitako\ perimetroa} = \frac{\Delta H\quad B}{(2\,\Delta H + B)}$$

$$R_h = \frac{Azalera}{Perimetroa} = \frac{\frac{\Pi\ D_h^{\ 2}}{4}}{\Pi\ D_h} = \frac{D_h}{4}$$

# 9. **Ariketa III**

4 µm-rainoko partikulak eliminatzeko behar den B zabalera:

$$R_E = 3000 = \frac{\frac{5}{B}\,\frac{4\,(0{,}2\,B)}{(0{,}4 + B)}}{1{,}5\,10^{-5}\left(\frac{m^2}{s}\right)} \rightarrow B = 88{,}88\ m$$ Bideraezina

# 10. Ariketa I

## OEK

**Etilenglikola $C_2H_6O_2$, 150 mg/L**: $C_2H_6O_2 + 5/2\ O_2 \rightarrow 2\ CO_2 + \cdot H_2O$

OEK= 2.5 mol $O_2$/1 mol etilenglikol · 32 g $O_2$/1 mol $O_2$ · 1 mol etilenglikol/62 g etilenglikol · 150 mg etilenglikol/L·1g etilenglikol/1000 mg etilenglikol ·1000 mg $O_2$/ 1 g $O_2$= 194 mg $O_2$/L

**Fenol $C_6H_6O$, 100 mg/L**: $C_6H_6O + 7\ O_2 \rightarrow 6\ CO_2 + \cdot 3H_2O$

OEK= 7 mol $O_2$/1 mol fenol · 32 g $O_2$/1 mol $O_2$ · 1 mol fenol/94 g fenol · 100 mg fenol/L·1g fenol/1000 mg fenol ·1000 mg $O_2$/ 1 g $O_2$= 238 mg $O_2$/L

**Sulfuro $S^{2-}$, 40 mg/L:** $S^{2-} + 2\ O_2 \rightarrow SO_4^{2-}$

OEK= 2 mol $O_2$/1 mol $S^{2-}$ · 32 g $O_2$/1 mol $O_2$ · 1 mol $S^{2-}$/32 g $S^{2-}$ · 40 mg $S^{2-}$/L·1g $S^{2-}$/1000 mg $S^{2-}$ ·1000 mg $O_2$/ 1 g $O_2$= 80 mg $O_2$/L

**Hidratatatutako etilendiamina $C_2H_{10}N_2O$, 125 mg/L** : $C_2H_{10}N_2O + 5/2\ O_2 \rightarrow 2CO_2 + \cdot 2H_2O + 2NH_3$

OEK= 2.5 mol $O_2$/1 mol $C_2H_{10}N_2O$ · 32 g $O_2$/1 mol $O_2$ · 1 mol $C_2H_{10}N_2O$ /78 g $C_2H_{10}N_2O$ · 125 mg $C_2H_{10}N_2O^-$/L·1g $C_2H_{10}N_2O$ /1000 mg $C_2H_{10}N_2O^-$ ·1000 mg $O_2$/ 1 g $O_2$= 128 mg $O_2$/L

**OEK Totala**= 194+238+80+128=640 mg $O_2$/L

# 10. Ariketa II

**$OEB_5$**

$OEB_5 = OEK_{TOTALA} - OEK_{BIODEGRADAEZINA} = 640 - 128 = 512$ mg $O_2$/L

$OEB_{eguna} = OEB_{\infty}\,[1-\exp(-k \cdot t)] = 512\,\,[1-\exp(-0.2\ egun^{-1} \cdot 5\ egun)] = 323.6$ mg $O_2$/L

# 10. Ariketa III

## KOT

**Etilenglikola $C_2H_6O_2$, 150 mg/L**: $C_2H_6O_2 + 5/2\ O_2 \rightarrow 2\ CO_2 + \cdot H_2O$

KOT= 2 mol $CO_2$/1 mol etilenglikol · 12 g C/1 mol $CO_2$ · 1 mol etilenglikol/62 g etilenglikol · 150 mg etilenglikol/L·1g etilenglikol/1000 mg etilenglikol ·1000 mg C/ 1 g C= 58 mg C/L

**Fenol $C_6H_6O$, 100 mg/L**: $C_6H_6O + 7\ O_2 \rightarrow 6\ CO_2 + \cdot 3H_2O$

KOT= 6 mol $CO_2$/1 mol fenol · 12 g C/1 mol $CO_2$ · 1 mol fenol/94 g fenol · 100 mg fenol/L·1g fenol/1000 mg fenol ·1000 mg C/ 1 g C= 76.6 mg C/L

**Sulfuro $S^{2-}$, 40 mg/L:** $S^{2-} + 2\ O_2 \rightarrow SO_4^{2-}$

KOT= 0 mg C/L

**Hidratatatutako etilendiamina $C_2H_{10}N_2O$, 125 mg/L** : $C_2H_{10}N_2O + 5/2\ O_2 \rightarrow 2CO_2 + \cdot 2H_2O + 2NH_3$

OEK= 2 mol $CO_2$/1 mol $C_2H_{10}N_2O$ · 12 g C/1 mol $CO_2$ · 1 mol $C_2H_{10}N_2O$ /78 g $C_2H_{10}N_2O$ · 125 mg $C_2H_{10}N_2O^-$/L·1g $C_2H_{10}N_2O$ /1000 mg $C_2H_{10}N_2O^-$ ·1000 mg C/ 1 g C= 38.5 mg $O_2$/L

**KOT**= 58+76.6+0+38.5=173.1 mg $O_2$/L

## 11. Ariketa I

a) $Ca^{2+}$ (ur gorgorra)$+Na_2CO_3 \rightarrow CaCO_3 \downarrow +2\ Na^+$

2.8 $10^{-4}$ mol $Ca^{2+}$/L ur gogorra $\cdot$1 mol $Na_2CO_3$/1 mol $Ca^{2+}\cdot 10^3$ L/1$m^3$=0.28 mol $Na_2CO_3/m^3$ ur

# 11. Ariketa II

b)

$$Ca^{2+}\,(\text{ur gorgorra}) + 2\,HCO_3^-\,(\text{ur gorgorra}) + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2\,H_2O$$

$$4.6\ 10^{-4}\ \text{mol}\ HCO_3^-/\text{L ur gogorra} \cdot 1\ \text{mol}\ Ca(OH)_2/2\ \text{mol}\ HCO_3^- \cdot 10^3\ \text{L}/1\text{m}^3 = 0.23\ \text{mol}\ Ca(OH)_2/\text{m}^3\ \text{ur}$$

| | **$Ca^{2+}$ ur gogorra** | **$HCO_3^-$ ur gogorra** | **$Ca(OH)_2$ erreaktiboa** | **Hauspeatutako $CaCO_3$** |
|---|---|---|---|---|
| **Hasierako kontzentrazioa** | $2.8\ 10^{-4}$ mol/L | $4.6\ 10^{-4}$ mol/L | | |
| **Gehitutako kararria** | | | $2.3\ 10^{-4}$ mol/L | |
| **Hauspeatzegatik aldaketa** | $-2.3\ 10^{-4}$ mol/L | $-4.6\ 10^{-4}$ mol/L | $-2.3\ 10^{-4}$ mol/L | $4.6\ 10^{-4}$ mol/L |
| **Hauspeaketa eta gero** | $0.5\ 10^{-4}$ mol/L | 0 | 0 | $4.6\ 10^{-4}$ mol/L |

# 11. Ariketa III

$$Ca^{2+}\,(\text{ur gorgorra}) + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2\ Na^{+}$$

$0.5\ 10^{-4}$ mol $Ca^{2+}$ /L ur gogorra $\cdot 1$ mol $Na_2CO_3$ /1mol $Ca^{2+} \cdot 10^3$ L/1$m^3$=0.05 mol $Na_2CO_3$ /$m^3$ ur

| | Ca $^{2+}$ ur gogorra | $Na_2CO_3$ erreaktiboa | Hauspeatutako $CaCO_3$ | Hauspeatutako Na+ |
|---|---|---|---|---|
| Hasierako kontzentrazioa | $0.5\ 10^{-4}$ mol/L | | | |
| Gehitutako kararria | | $0.5\ 10^{-4}$ mol/L | | |
| Hauspeatzegatik aldaketa | $-0.5\ 10^{-4}$ mol/L | $-0.5\ 10^{-4}$ mol/L | $0.5\ 10^{-4}$ mol/L | $10^{-4}$ mol/L |
| Hauspeaketa eta gero | 0 | 0 | $0.5\ 10^{-4}$ mol/L | $10^{-4}$ mol/L |

# 11. Ariketa III

c)

$$Ca^{2+} + 2HCO_3^- \text{ (ur gorgorra)} + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2\ H_2O$$

$5.6\ 10^{-4}$ mol $Ca^{2+}$ /L ur gogorra $\cdot 1$ mol $Ca(OH)_2$ /2 mol $HCO_3^- \cdot 10^3$ L/1$m^3$=0.28 mol $Ca(OH)_2$ /$m^3$ ur

| | $Ca^{2+}$ ur gogorra | $HCO_3^-$ ur gogorra | $Ca(OH)_2$ ereaktiboa | Hauspeatutako $CaCO_3$ |
|---|---|---|---|---|
| Hasierako kontzentrazioa | $2.8\ 10^{-4}$ mol/L | $5.6\ 10^{-4}$ mol/L | | |
| Gehitutako kararria | | | $2.8\ 10^{-4}$ mol/L | |
| Hauspeatzegatik aldaketa | $-2.8\ 10^{-4}$ mol/L | $-4.6\ 10^{-4}$ mol/L | $-2.8\ 10^{-4}$ mol/L | $5.6\ 10^{-4}$ mol/L |
| Hauspeaketa eta gero | 0 | 0 | 0 | $5.6\ 10^{-4}$ mol/L |

# 12. Ariketa

c)

| KATIOIA | KONTZENTRAZIOA mg/L | MASA BALIOKIDEA Baliokide gramoa |
|---|---|---|
| $Na^{+}$ | 35 | 23 |
| $Mg^{2+}$ | 9 | 12.2 |
| $Ca^{2+}$ | 48 | 20 |
| $K^{+}$ | 1 | 3 |

Gogortasuna Mg 2+ eta Ca2+ kontzentrazioaren gainean kalkulatuko dugu:

9 mg $Mg^{2+}$/L ·50 baliokide gramo $CaCO_3$/12.2 baliokide gramo $Mg^{2+}$+
48 mg $Ca^{2+}$/L ·50 baliokide gramo $CaCO_3$/20 baliokide gramo $Mg^{2+}$=156.9 mg$CaCO_3$/L

## 13. Ariketa

a) $$pH = -\log[H_3O^+] = -\log(3{,}4\ 10^{-4}) = -\log 3{,}4 - \log 10^{-4} = 3{,}47$$

b) $$6{,}7 = -\log[H_3O^+] \rightarrow \quad 10^{-6{,}7} = [H_3O^+]$$

$$[H_3O^+] = 1{,}99\ 10^{-7}$$

## 14. Ariketa

$$Ca(OH)_2\,(s) \;\leftrightarrow\; Ca^{+2}\,(aq) + \;2\,OH^-\,(aq)$$

s=disolbagarritasuna izanik

-  s  2 s

$$Ks = [Ca^{+2}][OH^-]^2 = (s)(2s)^2 = 4\,s^3$$

$$s = \left[\frac{Ks}{4}\right]^{1/3} = 1{,}2546\;10^{-2} \quad \Rightarrow \quad [OH^-] = 2\,s = 2{,}509\;10^{-2}$$

$$Kw = [H_3O^+][OH^-]$$

$$[H_3O^+] = \frac{Kw}{[OH^-]} = \frac{10^{-14}}{2{,}509\;10^{-2}} = 3{,}986\;10^{-13}$$

$$pH = -\log\,[H_3O^+] = -\log\,[3{,}986\;10^{-13}] = 12{,}4$$