

ANALITIČKA KEMIJA - SEMINAR

- osnove statistike
- **kemija vodenih otopina**

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akademska godina: 2026./27.

1. Koliko grama $\text{SnCl}_2 \cdot 6\text{H}_2\text{O}$ je potrebno za pripravu 500,0 mL otopine koncentracije $0,275 \text{ mol L}^{-1}$?

$$V(\text{otopina}) = 500,0 \text{ mL} = 0,5000 \text{ L}$$

$$c(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) = 0,275 \text{ mol L}^{-1}$$

$$c(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) = \frac{n(\text{SnCl}_2 \cdot 6\text{H}_2\text{O})}{V(\text{otopina})} \quad n(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) = \frac{m(\text{SnCl}_2 \cdot 6\text{H}_2\text{O})}{M(\text{SnCl}_2 \cdot 6\text{H}_2\text{O})}$$

$$c(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) = \frac{m(\text{SnCl}_2 \cdot 6\text{H}_2\text{O})}{M(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) V(\text{otopina})}$$

$$m(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) = c(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) M(\text{SnCl}_2 \cdot 6\text{H}_2\text{O}) V(\text{otopina}) = 40,935 \text{ g}$$

2. U kojem volumenu treba otopiti 20,3540 g kalijeva bromata da bi dobili otopinu koncentracije $c(\text{KBrO}_3) = 0,1500 \text{ mol L}^{-1}$?

$$m(\text{KBrO}_3) = 20,3540 \text{ g}$$

$$c(\text{KBrO}_3) = 0,1500 \text{ mol L}^{-1}$$

$$n(\text{KBrO}_3) = \frac{m(\text{KBrO}_3)}{M(\text{KBrO}_3)} = 0,1219 \text{ mol}$$

$$V(\text{otopina}) = \frac{n(\text{KBrO}_3)}{c(\text{KBrO}_3)} = 0,8125 \text{ L} = 812,5 \text{ mL}$$

3. Koliko se grama NaOH nalazi u 100 mL otopine ako je maseni udio NaOH 10%? Gustoća otopine je $1,109 \text{ g mL}^{-1}$.

$$V(\text{otopina}) = 100 \text{ mL} \quad \rho(\text{otopina}) = 1,109 \text{ g mL}^{-1} \quad w(\text{NaOH}) = 10\% = 0,10$$

$$\gamma(\text{NaOH}) = \rho(\text{otopina}) w(\text{NaOH}) = 0,111 \text{ g mL}^{-1}$$

$$\gamma(\text{NaOH}) = \frac{m(\text{NaOH})}{V(\text{otopina})}$$

$$m(\text{NaOH}) = \gamma(\text{NaOH}) V(\text{otopina}) = 11,100 \text{ g}$$

4. Otopina kloridne (solne) kiseline ima gustoću $1,12 \text{ g mL}^{-1}$ i $w(\text{HCl}) = 23,81\%$. Koju masu, odnosno količinu HCl sadrži jedan mililitar ove kiseline (izraženo u miligramima i milimolima)?

$$\rho(\text{otopina}) = 1,12 \text{ g mL}^{-1} = 1120 \text{ g L}^{-1} \qquad w(\text{HCl}) = 23,81\% = 0,2381$$

$$\gamma(\text{HCl}) = \rho(\text{otopina}) w(\text{HCl}) = 266,672 \text{ g L}^{-1} = 266,672 \text{ mg mL}^{-1}$$

$$c(\text{HCl}) = \frac{\gamma(\text{HCl})}{M(\text{HCl})} = 7,31 \text{ mol L}^{-1} = 7,31 \text{ mmol mL}^{-1}$$

5. Koliki treba biti volumen vodene otopine, da bi otapanjem 1,60 g NaOH nastala otopina koncentracije 0,080 mol dm⁻³?

$$m(\text{NaOH}) = 1,60 \text{ g}$$

$$c(\text{NaOH}) = 0,080 \text{ mol dm}^{-3}$$

$$c(\text{NaOH}) = \frac{n(\text{NaOH})}{V(\text{otopina})}$$

$$c(\text{NaOH}) = \frac{m(\text{NaOH})}{M(\text{NaOH}) V(\text{otopina})}$$

$$V(\text{otopina}) = \frac{m(\text{NaOH})}{M(\text{NaOH})c(\text{NaOH})} = 0,5000 \text{ dm}^3 = 500,0 \text{ cm}^3$$

6. Kolika je masena koncentracija otopine, ako se 2,50 g neke tvari nalazi u 80,0 mL otopine?

$$m(\text{tvar}) = 2,50 \text{ g}$$

$$V(\text{otopina}) = 80,0 \text{ mL}$$

$$\gamma(\text{tvar}) = \frac{m(\text{tvar})}{V(\text{otopina})} = 31,25 \text{ g L}^{-1}$$

7. Tvar mase 13,50 g otopljena je u 450 cm³ otapala gustoće 1,00 g cm⁻³. Koji je sastav otopine izražen masenim udjelom?

$$m(\text{tvar}) = 13,50 \text{ g} \quad V(\text{otapalo}) = 450 \text{ cm}^3 \quad \rho(\text{otapalo}) = 1,00 \text{ g cm}^{-3}$$

$$w(\text{tvar}) = \frac{m(\text{tvar})}{m(\text{tvar}) + m(\text{otapalo})} = \frac{m(\text{tvar})}{m(\text{tvar}) + \rho(\text{otapalo})V(\text{otapalo})} = 2,91\%$$

8. Maseni udio koncentrirane HNO_3 je 69,8%, a otopina ima gustoću 1,42 g/mL. Izračunajte: a) masu čiste HNO_3 u 1 mL koncentrirane kiseline; b) volumen koncentrirane kiseline koji sadrži 60,0 g HNO_3 .

a) $w(\text{HNO}_3) = 69,8\%$

$$\rho(\text{otopina}) = 1,42 \text{ g / mL}$$

$$\gamma(\text{HNO}_3) = \rho(\text{otopina}) w(\text{HNO}_3) = 0,99 \text{ g / mL}$$

b) $m(\text{HNO}_3) = 60,0 \text{ g}$

$$\gamma(\text{HNO}_3) = \frac{m(\text{HNO}_3)}{V(\text{otopina})}$$

$$V(\text{otopina}) = \frac{m(\text{HNO}_3)}{\gamma(\text{HNO}_3)} = 60,5 \text{ mL}$$

9. 50,0 cm³ otopine NaOH razrijeđeno je vodom na volumen od 250,0 cm³. Ako je koncentracija razrijeđene otopine 0,5510 mol dm⁻³, kolika je bila koncentracija prvobitne otopine?

$$V_1(\text{NaOH}) = 50,0 \text{ cm}^3$$

$$c_2(\text{NaOH}) = 0,5510 \text{ mol dm}^{-3}$$

$$V_2(\text{NaOH}) = 250,0 \text{ cm}^3$$

$$c_1(\text{NaOH}) = \frac{c_2(\text{NaOH})V_2(\text{NaOH})}{V_1(\text{NaOH})} = 2,7550 \text{ mol dm}^{-3}$$

10. Izračunajte molalnost perklorne kiseline koja sadrži 24,4 g HClO₄ u 198 g vode.

$$m(\text{HClO}_4) = 24,4 \text{ g}$$

$$m(\text{H}_2\text{O}) = 198 \text{ g} = 0,198 \text{ kg}$$

$$b(\text{HClO}_4) = \frac{n(\text{HClO}_4)}{m(\text{H}_2\text{O})} = \frac{m(\text{HClO}_4)}{M(\text{HClO}_4)m(\text{H}_2\text{O})} = 1,2 \text{ mol kg}^{-1}$$

11. Izračunajte molalnost vodene otopine octene kiseline masenog udjela 45,4%.

$$w(\text{CH}_3\text{COOH}) = 45,4\% = 0,454$$

$$b(\text{CH}_3\text{COOH}) = \frac{n(\text{CH}_3\text{COOH})}{m(\text{H}_2\text{O})} = \frac{m(\text{CH}_3\text{COOH})}{M(\text{CH}_3\text{COOH}) m(\text{H}_2\text{O})}$$

$$m(\text{CH}_3\text{COOH}) = b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) m(\text{H}_2\text{O})$$

$$w(\text{CH}_3\text{COOH}) = \frac{m(\text{CH}_3\text{COOH})}{m(\text{CH}_3\text{COOH}) + m(\text{H}_2\text{O})}$$

$$w(\text{CH}_3\text{COOH}) = \frac{b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) m(\text{H}_2\text{O})}{b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) m(\text{H}_2\text{O}) + m(\text{H}_2\text{O})}$$

$$w(\text{CH}_3\text{COOH}) = \frac{b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) m(\text{H}_2\text{O})}{(b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) + 1) m(\text{H}_2\text{O})}$$

$$w(\text{CH}_3\text{COOH}) b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) + w(\text{CH}_3\text{COOH}) = \\ = b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH})$$

$$b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) - w(\text{CH}_3\text{COOH}) b(\text{CH}_3\text{COOH}) M(\text{CH}_3\text{COOH}) = \\ = w(\text{CH}_3\text{COOH})$$

$$b(\text{CH}_3\text{COOH}) = \frac{w(\text{CH}_3\text{COOH})}{M(\text{CH}_3\text{COOH})(1 - w(\text{CH}_3\text{COOH}))} = \\ = 0,0138 \text{ mol g}^{-1} = 13,8 \text{ mol kg}^{-1}$$

Općenito vrijedi:

$$b(A) = \frac{w(A)}{M(A)(1 - w(A))}$$

12. Izračunajte množinsku koncentraciju otopine fruktoze ($\text{C}_6\text{H}_{12}\text{O}_6$) molalnosti $0,555 \text{ mol kg}^{-1}$. Gustoća otapala iznosi $1,16 \text{ g cm}^{-3}$.

$$b(\text{C}_6\text{H}_{12}\text{O}_6) = 0,555 \text{ mol kg}^{-1}$$

$$\rho(\text{otapalo}) = 1,16 \text{ g cm}^{-3}$$

$$b(\text{C}_6\text{H}_{12}\text{O}_6) = \frac{n(\text{C}_6\text{H}_{12}\text{O}_6)}{m(\text{otapalo})} = \frac{n(\text{C}_6\text{H}_{12}\text{O}_6)}{\rho(\text{otapalo}) V(\text{otopina})} = \frac{c(\text{C}_6\text{H}_{12}\text{O}_6)}{\rho(\text{otapalo})}$$

$$c(\text{C}_6\text{H}_{12}\text{O}_6) = b(\text{C}_6\text{H}_{12}\text{O}_6) \rho(\text{otapalo}) = 0,644 \text{ mol dm}^{-3}$$

13. Analizom sadnice lana nađeno je da je u $2,6 \text{ g}$ uzorka prisutno $4,0 \text{ }\mu\text{g}$ bakra. Izračunajte maseni udio bakra u uzorku izrazivši rezultat u ppm i ppb.

$$m(\text{uzorak}) = 2,6 \text{ g}$$

$$m(\text{Cu}) = 4,0 \text{ }\mu\text{g} = 4,0 \cdot 10^{-6} \text{ g}$$

$$w(\text{Cu})_{\text{ppm}} = \frac{m(\text{Cu})}{m(\text{uzorak})} \cdot 10^6 \text{ ppm} = 1,5 \text{ ppm}$$

$$w(\text{Cu})_{\text{ppb}} = \frac{m(\text{Cu})}{m(\text{uzorak})} \cdot 10^9 \text{ ppb} = 1500 \text{ ppb}$$

14. Analizom 25,0 μL uzorka seruma nađeno je da sadrži 35,6 μg glukoze ($\text{C}_6\text{H}_{12}\text{O}_6$).
Izračunajte masenu koncentraciju i maseni udio $\text{C}_6\text{H}_{12}\text{O}_6$ u mg dm^{-3} odnosno ppm.

$$V(\text{uzorak}) = 25,0 \mu\text{L} = 25,0 \cdot 10^{-3} \text{ cm}^3 = 25,0 \cdot 10^{-6} \text{ dm}^3$$

$$m(\text{C}_6\text{H}_{12}\text{O}_6) = 35,6 \mu\text{g} = 35,6 \cdot 10^{-3} \text{ mg} = 35,6 \cdot 10^{-6} \text{ g}$$

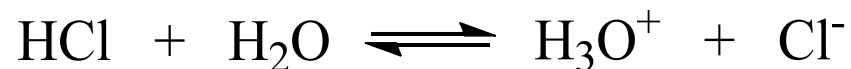
$$\gamma(\text{C}_6\text{H}_{12}\text{O}_6) = \frac{m(\text{C}_6\text{H}_{12}\text{O}_6)}{V(\text{uzorak})} = 1424 \mu\text{g cm}^{-3} = 1424 \text{ mg dm}^{-3}$$

S obzirom da je $\rho(\text{razrijeđene vodene otopine}) \approx 1 \text{ g cm}^{-3}$, maseni udio glukoze iznosi:

$$w(\text{A}) = \frac{m(\text{A})}{m(\text{uzorak})} \cdot 10^6 \text{ ppm} = \frac{m(\text{A})}{V(\text{uzorak}) \cdot 1 \text{ g cm}^{-3}} \cdot 10^6 \text{ ppm} = 1424 \text{ ppm}$$

15. Kolika je pH vrijednost otopine solne kiseline koncentracije $0,010 \text{ mol dm}^{-3}$?

$$c(\text{HCl}) = 0,010 \text{ mol dm}^{-3}$$

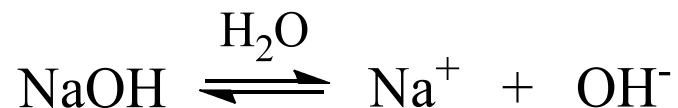


$$[\text{H}_3\text{O}^+] = c(\text{HCl}) = 0,010 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,010 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,00$$

16. Kolika je pH vrijednost otopine NaOH koncentracije $0,050 \text{ mol dm}^{-3}$?

$$c(\text{NaOH}) = 0,050 \text{ mol dm}^{-3}$$



$$[\text{OH}^-] = c(\text{NaOH}) = 0,050 \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,050 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 1,30$$

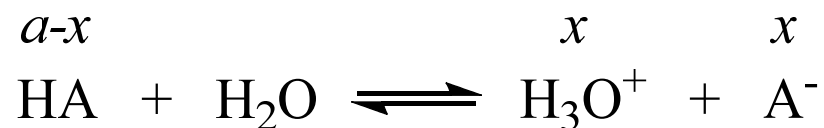
$$\text{pH} + \text{pOH} = \text{p}K_{\text{w}}$$

$$\text{pH} = \text{p}K_{\text{w}} - \text{pOH} = 14,00 - 1,30 = 12,70$$

17. Kolika je pH vrijednost otopine slabe kiseline, konstante $K_{\text{a}} = 2,0 \cdot 10^{-4} \text{ mol L}^{-1}$ i koncentracije $0,150 \text{ mol L}^{-1}$?

$$c_{\text{HA}} = 0,150 \text{ mol L}^{-1}$$

$$K_{\text{a}} = 2,0 \cdot 10^{-4} \text{ mol L}^{-1}$$



$$K_{\text{a}} = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

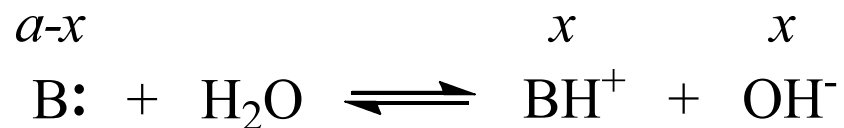
$$x = [\text{H}_3\text{O}^+] = \sqrt{a K_a} = \sqrt{c_{\text{HA}} K_a} = 5,5 \cdot 10^{-3} \text{ mol L}^{-1}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol L}^{-1}}\right) = -\log\left(\frac{5,5 \cdot 10^{-3} \text{ mol L}^{-1}}{\text{mol L}^{-1}}\right) = 2,26$$

18. Kolika je pH vrijednost otopine slabe baze, konstante $K_b = 1,0 \cdot 10^{-5} \text{ mol L}^{-1}$, ako je koncentracija baze u otopini $0,120 \text{ mol L}^{-1}$?

$$c_B = 0,120 \text{ mol L}^{-1}$$

$$K_b = 1 \cdot 10^{-5} \text{ mol L}^{-1}$$



$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B:}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

$$x = [\text{OH}^-] = \sqrt{a K_b} = \sqrt{c_B K_b} = 1,1 \cdot 10^{-3} \text{ mol L}^{-1}$$

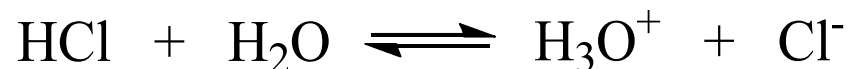
$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol L}^{-1}}\right) = -\log\left(\frac{1,1 \cdot 10^{-3} \text{ mol L}^{-1}}{\text{mol L}^{-1}}\right) = 2,96$$

$$\text{pH} + \text{pOH} = \text{p}K_{\text{w}}$$

$$\text{pH} = \text{p}K_{\text{w}} - \text{pOH} = 14,00 - 2,96 = 11,04$$

19. Izračunajte pH vrijednosti otopina sljedećih kiselina: a) klorovodične kiseline ($c(\text{HCl}) = 0,050 \text{ mol dm}^{-3}$); b) octene kiseline ($c(\text{CH}_3\text{COOH}) = 0,100 \text{ mol dm}^{-3}$, $K_{\text{a}} = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$); c) mravlje kiseline, ($c(\text{HCOOH}) = 0,200 \text{ mol dm}^{-3}$, $K_{\text{a}} = 1,70 \cdot 10^{-4} \text{ mol dm}^{-3}$); d) bromovodične kiseline, ($c(\text{HBr}) = 0,700 \text{ mol dm}^{-3}$); e) benzojeve kiseline, ($c(\text{C}_6\text{H}_5\text{COOH}) = 0,150 \text{ mol dm}^{-3}$, $K_{\text{a}} = 6,14 \cdot 10^{-5} \text{ mol dm}^{-3}$).

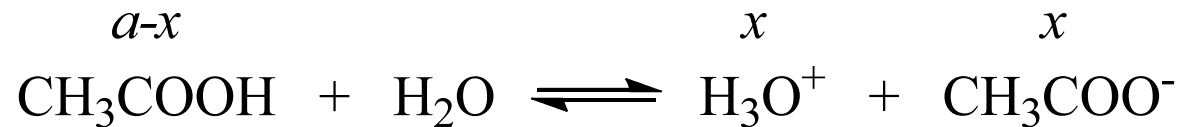
a) $c(\text{HCl}) = 0,050 \text{ mol dm}^{-3}$



$$[\text{H}_3\text{O}^+] = c(\text{HCl}) = 0,050 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,050 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 1,30$$

$$\text{b) } c(\text{CH}_3\text{COOH}) = 0,100 \text{ mol dm}^{-3} \qquad K_a = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$$

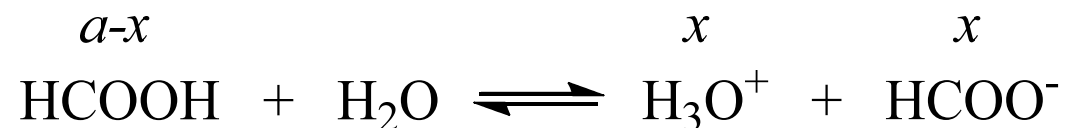


$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

$$x = [\text{H}_3\text{O}^+] = \sqrt{a K_a} = \sqrt{c(\text{CH}_3\text{COOH}) K_a} = 1,35 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{1,35 \cdot 10^{-3} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,87$$

$$\text{c) } c(\text{HCOOH}) = 0,200 \text{ mol dm}^{-3} \qquad K_a = 1,70 \cdot 10^{-4} \text{ mol dm}^{-3}$$



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HCOO}^-]}{[\text{HCOOH}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

$$x = [\text{H}_3\text{O}^+] = \sqrt{a K_a} = \sqrt{c(\text{HCOOH}) K_a} = 5,83 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{5,83 \cdot 10^{-3} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,23$$

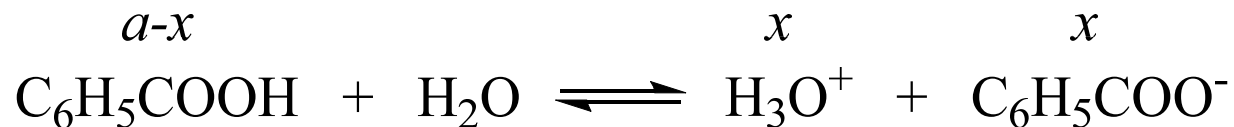
d) $c(\text{HBr}) = 0,700 \text{ mol dm}^{-3}$



$$[\text{H}_3\text{O}^+] = c(\text{HBr}) = 0,700 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,700 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 0,15$$

e) $c(\text{C}_6\text{H}_5\text{COOH}) = 0,150 \text{ mol dm}^{-3}$ $K_a = 6,14 \cdot 10^{-5} \text{ mol dm}^{-3}$



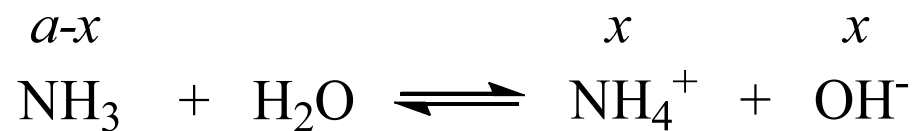
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{C}_6\text{H}_5\text{COO}^-]}{[\text{C}_6\text{H}_5\text{COOH}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

$$x = [\text{H}_3\text{O}^+] = \sqrt{a K_a} = \sqrt{c(\text{C}_6\text{H}_5\text{COOH}) K_a} = 3,04 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{3,04 \cdot 10^{-3} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,52$$

20. Izračunajte pH vrijednosti otopina sljedećih baza: a) amonijaka ($c(\text{NH}_3) = 0,250 \text{ mol dm}^{-3}$, $K_b = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$); b) etilamina, ($c(\text{C}_2\text{H}_5\text{NH}_2) = 0,500 \text{ mol dm}^{-3}$, $K_b = 5,62 \cdot 10^{-4} \text{ mol dm}^{-3}$); c) piridina ($c(\text{C}_5\text{H}_5\text{N}) = 0,400 \text{ mol dm}^{-3}$, $K_b = 2,29 \cdot 10^{-9} \text{ mol dm}^{-3}$); d) amonijaka ($c(\text{NH}_3) = 0,080 \text{ mol dm}^{-3}$, $K_b = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$); e) kalijeva hidroksida ($c(\text{KOH}) = 0,080 \text{ mol dm}^{-3}$).

$$\text{a) } c(\text{NH}_3) = 0,250 \text{ mol dm}^{-3} \qquad K_b = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$$



$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

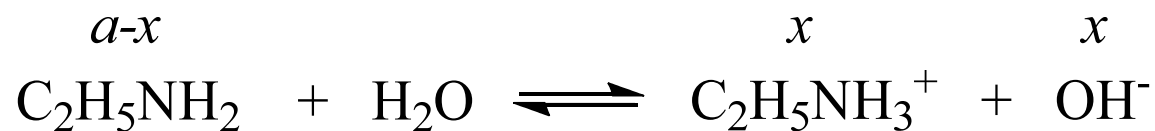
$$x = [\text{OH}^-] = \sqrt{a K_b} = \sqrt{c(\text{NH}_3) K_b} = 2,13 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{2,13 \cdot 10^{-3} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,67$$

$$\text{pH} + \text{pOH} = \text{p}K_w$$

$$\text{pH} = \text{p}K_w - \text{pOH} = 14,00 - 2,67 = 11,33$$

$$\text{b)} \quad c(\text{C}_2\text{H}_5\text{NH}_2) = 0,500 \text{ mol dm}^{-3} \qquad K_b = 5,62 \cdot 10^{-4} \text{ mol dm}^{-3}$$



$$K_b = \frac{[\text{C}_2\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_2\text{H}_5\text{NH}_2]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

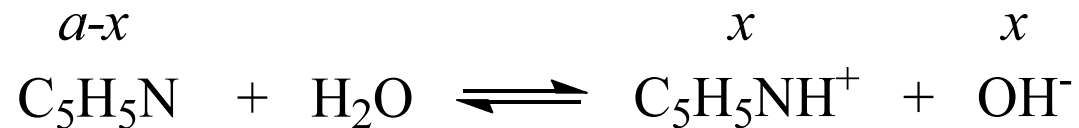
$$x = [\text{OH}^-] = \sqrt{a K_b} = \sqrt{c(\text{C}_2\text{H}_5\text{NH}_2) K_b} = 0,0168 \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,0168 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 1,78$$

$$\text{pH} + \text{pOH} = \text{p}K_w$$

$$\text{pH} = \text{p}K_w - \text{pOH} = 14,00 - 1,78 = 12,22$$

$$\text{c) } c(\text{C}_5\text{H}_5\text{N}) = 0,400 \text{ mol dm}^{-3} \qquad K_b = 2,29 \cdot 10^{-9} \text{ mol dm}^{-3}$$



$$K_b = \frac{[\text{C}_5\text{H}_5\text{NH}^+][\text{OH}^-]}{[\text{C}_5\text{H}_5\text{N}]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

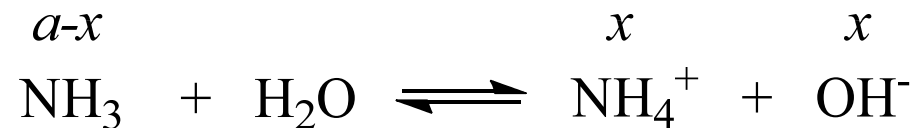
$$x = [\text{OH}^-] = \sqrt{a K_b} = \sqrt{c(\text{C}_5\text{H}_5\text{N}) K_b} = 3,03 \cdot 10^{-5} \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{3,03 \cdot 10^{-5} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 4,52$$

$$\text{pH} + \text{pOH} = \text{p}K_w$$

$$\text{pH} = \text{p}K_w - \text{pOH} = 14,00 - 4,52 = 9,48$$

$$\text{d) } c(\text{NH}_3) = 0,080 \text{ mol dm}^{-3} \qquad K_b = 1,82 \cdot 10^{-5} \text{ mol dm}^{-3}$$



$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = \frac{x^2}{a-x} \approx \frac{x^2}{a}$$

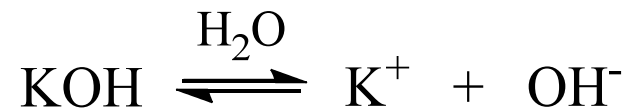
$$x = [\text{OH}^-] = \sqrt{a K_b} = \sqrt{c(\text{NH}_3) K_b} = 1,21 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{1,21 \cdot 10^{-3} \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 2,92$$

$$\text{pH} + \text{pOH} = \text{p}K_w$$

$$\text{pH} = \text{p}K_w - \text{pOH} = 14,00 - 2,92 = 11,08$$

e) $c(\text{KOH}) = 0,080 \text{ mol dm}^{-3}$



$$[\text{OH}^-] = c(\text{KOH}) = 0,080 \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right) = -\log\left(\frac{0,080 \text{ mol dm}^{-3}}{\text{mol dm}^{-3}}\right) = 1,10$$

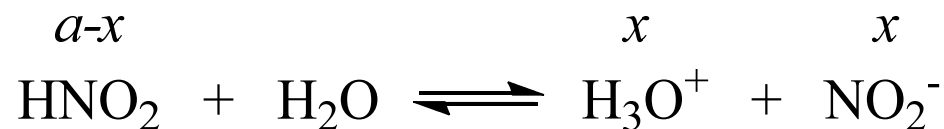
$$\text{pH} + \text{pOH} = \text{p}K_{\text{w}}$$

$$\text{pH} = \text{p}K_{\text{w}} - \text{pOH} = 14,00 - 1,10 = 12,90$$

21. Otopina nitritne kiseline množinske koncentracije $0,0495 \text{ mol dm}^{-3}$ ima pH 2,34. Izračunajte konstantu disocijacije kiseline.

$$c(\text{HNO}_2) = 0,0495 \text{ mol dm}^{-3}$$

$$\text{pH} = 2,34$$



$$\text{pH} = -\log\left(\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}}\right)$$

$$\frac{[\text{H}_3\text{O}^+]}{\text{mol dm}^{-3}} = 10^{-\text{pH}} = 10^{-2,34}$$

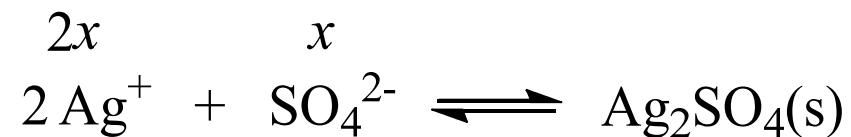
$$[\text{H}_3\text{O}^+] = [\text{NO}_2^-] = x = 0,0046 \text{ mol dm}^{-3} \quad c(\text{HNO}_2) = a = 0,0495 \text{ mol dm}^{-3}$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]} = \frac{x^2}{a - x} = 4,65 \cdot 10^{-4} \text{ mol dm}^{-3}$$

22. Topljivost Ag_2SO_4 je $5,7 \cdot 10^{-3} \text{ g cm}^{-3}$. Kolika je konstanta produkta topljivosti?

$$\gamma(\text{Ag}_2\text{SO}_4) = 5,7 \cdot 10^{-3} \text{ g cm}^{-3} = 5,7 \text{ g dm}^{-3}$$

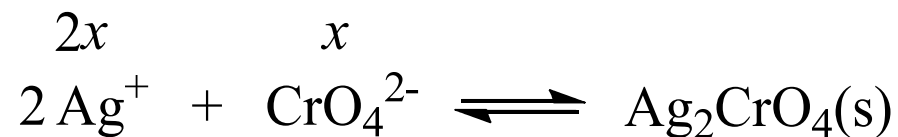
$$c(\text{Ag}_2\text{SO}_4) = \frac{\gamma(\text{Ag}_2\text{SO}_4)}{M(\text{Ag}_2\text{SO}_4)} = 1,83 \cdot 10^{-2} \text{ mol dm}^{-3}$$



$$x = c(\text{Ag}_2\text{SO}_4) = 1,83 \cdot 10^{-2} \text{ mol dm}^{-3}$$

$$K_{\text{sp}} = [\text{Ag}^+]^2[\text{SO}_4^{2-}] = (2x)^2 x = 4x^3 = 2,45 \cdot 10^{-5} \text{ mol}^3 \text{ dm}^{-9}$$

23. Konstanta produkta topljivosti Ag_2CrO_4 je $1,3 \cdot 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$. Kolika je topljivost srebrova kromata izražena u mol dm^{-3} i g cm^{-3} ?



$$K_{\text{sp}} = [\text{Ag}^+]^2[\text{CrO}_4^{2-}] = (2x)^2 x = 4x^3 = 1,3 \cdot 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$$

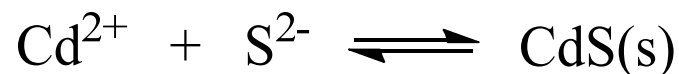
$$c(\text{Ag}_2\text{CrO}_4) = x = \sqrt[3]{\frac{K_{\text{sp}}}{4}} = 6,9 \cdot 10^{-5} \text{ mol dm}^{-3}$$

$$\gamma(\text{Ag}_2\text{CrO}_4) = c(\text{Ag}_2\text{CrO}_4)M(\text{Ag}_2\text{CrO}_4) = 2,29 \cdot 10^{-5} \text{ g cm}^{-3}$$

24. Koja je koncentracija sulfidnih iona potrebna za početak taloženja kadmijevog sulfida, ako otopina sadrži 50 mg Cd^{2+} iona u 100 cm^3 ($K_{\text{sp}} = 7,1 \cdot 10^{-27} \text{ mol}^2 \text{ dm}^{-6}$)?

$$m(\text{Cd}^{2+}) = 50 \text{ mg} = 0,050 \text{ g}$$

$$V(\text{otopina}) = 100 \text{ cm}^3 = 0,100 \text{ dm}^3$$



$$K_{\text{sp}} = [\text{Cd}^{2+}][\text{S}^{2-}] = 7,1 \cdot 10^{-27} \text{ mol}^2 \text{ dm}^{-6}$$

$$[\text{Cd}^{2+}] = \frac{m(\text{Cd}^{2+})}{M(\text{Cd}^{2+})V(\text{otopina})} = 4,45 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$[\text{S}^{2-}] = \frac{K_{\text{sp}}}{[\text{Cd}^{2+}]} = 1,59 \cdot 10^{-24} \text{ mol dm}^{-3}$$

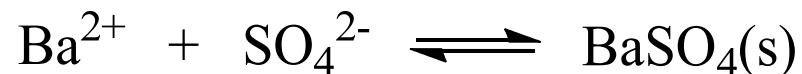
25. Ako u litru otopine stavimo 0,0010 mol Ba^{2+} iona i 0,00010 mol SO_4^{2-} iona, hoće li istaložiti BaSO_4 ($K_{\text{sp}} = 1,0 \cdot 10^{-10} \text{ mol}^2 \text{ L}^{-2}$)?

$$n(\text{Ba}^{2+}) = 0,0010 \text{ mol}$$

$$n(\text{SO}_4^{2-}) = 0,00010 \text{ mol}$$

$$K_{\text{sp}} = 1,0 \cdot 10^{-10} \text{ mol}^2 \text{ L}^{-2}$$

$$V(\text{otopina}) = 1 \text{ L}$$



$$[\text{Ba}^{2+}] = \frac{n(\text{Ba}^{2+})}{V(\text{otopina})} = 1 \cdot 10^{-3} \text{ mol L}^{-1}$$

$$[\text{SO}_4^{2-}] = \frac{n(\text{SO}_4^{2-})}{V(\text{otopina})} = 1 \cdot 10^{-4} \text{ mol L}^{-1}$$

$$[\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1,0 \cdot 10^{-7} \text{ mol}^2 \text{ L}^{-2} > K_{\text{sp}}$$

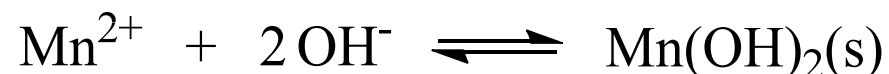
BaSO₄ će se taložiti.

26. Ako je pH vrijednost otopine 8,6, koliko miligrama Mn²⁺ iona zaostaje u 100 mL otopine nakon što se istaložio Mn(OH)₂ ($K_{\text{sp}} = 1,9 \cdot 10^{-13} \text{ mol}^3 \text{ L}^{-3}$)?

$$\text{pH} = 8,6$$

$$V(\text{otopina}) = 100 \text{ mL} = 0,100 \text{ L}$$

$$K_{\text{sp}} = 1,9 \cdot 10^{-13} \text{ mol}^3 \text{ L}^{-3}$$



$$K_{\text{sp}} = [\text{Mn}^{2+}][\text{OH}^-]^2 = 1,9 \cdot 10^{-13} \text{ mol}^3 \text{ L}^{-3}$$

$$\text{pH} + \text{pOH} = \text{p}K_{\text{w}}$$

$$\text{pOH} = \text{p}K_{\text{w}} - \text{pH} = 14,00 - 8,60 = 5,40$$

$$\text{pOH} = -\log\left(\frac{[\text{OH}^-]}{\text{mol dm}^{-3}}\right)$$

$$\frac{[\text{OH}^-]}{\text{mol dm}^{-3}} = 10^{-\text{pOH}} = 10^{-5,40}$$

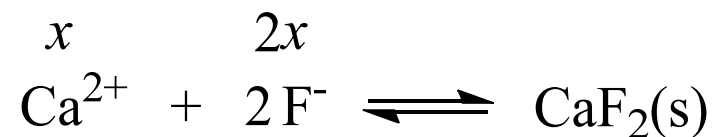
$$[\text{Mn}^{2+}] = \frac{K_{\text{sp}}}{[\text{OH}^-]^2} = 1,19 \cdot 10^{-2} \text{ mol L}^{-1}$$

$$m(\text{Mn}^{2+}) = [\text{Mn}^{2+}] V(\text{otopina}) M(\text{Mn}^{2+}) = 6,54 \cdot 10^{-2} \text{ g} = 65,4 \text{ mg}$$

27. Vrijednost $\text{p}K_{\text{sp}}$ za CaF_2 je 10,40. Kolika je topljivost CaF_2 izražena u mol L^{-1} ?

$$\text{p}K_{\text{sp}} = -\log K_{\text{sp}} = 10,40$$

$$K_{\text{sp}} = 10^{-\text{p}K_{\text{sp}}} = 10^{-10,40}$$



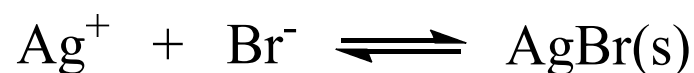
$$K_{\text{sp}} = [\text{Ca}^{2+}][\text{F}^{-}]^2 = x(2x)^2 = 4x^3 = 10^{-10,40} = 3,98 \cdot 10^{-11} \text{ mol}^3 \text{ L}^{-3}$$

$$c(\text{CaF}_2) = x = \sqrt[3]{\frac{K_{\text{sp}}}{4}} = 2,15 \cdot 10^{-4} \text{ mol L}^{-1}$$

28. Koliko miligrama KBr je potrebno za početak taloženja AgBr, ako 100 cm³ otopine sadrži 50 mg Ag⁺ iona ($K_{\text{sp}} = 5,0 \cdot 10^{-13} \text{ mol}^2 \text{ dm}^{-6}$)?

$$m(\text{Ag}^{+}) = 50 \text{ mg} = 0,050 \text{ g}$$

$$V(\text{otopina}) = 100 \text{ cm}^3 = 0,100 \text{ dm}^3$$



$$[\text{Ag}^+] = \frac{m(\text{Ag}^+)}{M(\text{Ag}^+) V(\text{otopina})} = 4,64 \cdot 10^{-3} \text{ mol dm}^{-3}$$

$$[\text{Br}^-] = \frac{K_{\text{sp}}}{[\text{Ag}^+]} = 1,08 \cdot 10^{-10} \text{ mol dm}^{-3}$$

$$n(\text{Br}^-) = n(\text{KBr}) = [\text{Br}^-] V(\text{otopina}) = 1,08 \cdot 10^{-11} \text{ mol}$$

$$m(\text{KBr}) = n(\text{KBr}) M(\text{KBr}) = 1,28 \cdot 10^{-9} \text{ g} = 1,28 \cdot 10^{-6} \text{ mg}$$

Masa KBr treba biti veća od $1,28 \cdot 10^{-6} \text{ mg}$.

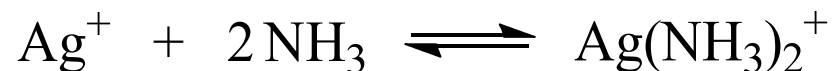
29. Ako je u otopinu, koja sadrži 2,1574 g Ag^+ iona, dodan NH_3 u suvišku, tako da je u konačnom volumenu otopine od 1 L koncentracija amonijaka $2,0 \text{ mol L}^{-1}$, a masena koncentracija Ag^+ iona $3,7 \cdot 10^{-8} \text{ g L}^{-1}$, kolika je vrijednost konstante nastajanja ovog kompleksa?

$$m(\text{Ag}^+) = 2,1574 \text{ g}$$

$$V(\text{otopina}) = 1 \text{ L}$$

$$[\text{NH}_3] = 2,0 \text{ mol L}^{-1}$$

$$\gamma(\text{Ag}^+)_{\text{kon}} = 3,7 \cdot 10^{-8} \text{ g L}^{-1}$$



$$c(\text{Ag}^+) = \frac{m(\text{Ag}^+)}{M(\text{Ag}^+)V(\text{otopina})} = 0,020 \text{ mol L}^{-1}$$

$$[\text{Ag}^+] = \frac{\gamma(\text{Ag}^+)_{\text{kon}}}{M(\text{Ag}^+)} = 3,4 \cdot 10^{-10} \text{ mol L}^{-1}$$

$$[\text{Ag}(\text{NH}_3)_2^+] = 0,020 - 3,4 \cdot 10^{-10} \approx 0,020 \text{ mol L}^{-1}$$

$$K_f = \frac{[\text{Ag}(\text{NH}_3)_2^+]}{[\text{Ag}^+][\text{NH}_3]^2} = \frac{0,020}{3,4 \cdot 10^{-10} \cdot (2,0)^2} = 1,47 \cdot 10^7 \text{ L}^2 \text{ mol}^{-2}$$

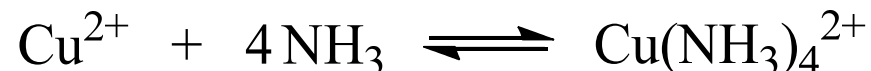
30. Ako pomiješamo 0,10 mol bakrova(II) sulfata i 0,60 mol amonijaka te otopinu razrijedimo na 1 L, kolika će biti koncentracija iona bakra(II) u otopini nakon reakcije stvaranja kompleksa ($K_f = 1,07 \cdot 10^{12} \text{ L}^4 \text{ mol}^{-4}$)?

$$n(\text{CuSO}_4) = 0,10 \text{ mol}$$

$$n(\text{NH}_3) = 0,60 \text{ mol}$$

$$V(\text{otopina}) = 1 \text{ L}$$

$$K_f = 1,07 \cdot 10^{12} \text{ L}^4 \text{ mol}^{-4}$$



$$n(\text{NH}_3) : n(\text{Cu}(\text{NH}_3)_4^{2+}) = 4 : 1$$

Ako se pretpostavi da svi Cu^{2+} ioni iz CuSO_4 sudjeluju u nastanku kompleksa i ako se zanemari njegova disocijacija, možemo pisati:

$$c(\text{Cu}(\text{NH}_3)_4^{2+}) = \frac{n(\text{Cu}(\text{NH}_3)_4^{2+})}{V(\text{otopina})} \approx [\text{Cu}(\text{NH}_3)_4^{2+}] = 0,10 \text{ mol L}^{-1}$$

$$n(\text{NH}_3)_{\text{vezani}} = 4 n(\text{Cu}(\text{NH}_3)_4^{2+}) \quad c(\text{NH}_3)_{\text{vezani}} = 4 c(\text{Cu}(\text{NH}_3)_4^{2+})$$

$$[\text{NH}_3] = c(\text{NH}_3) - 4 [\text{Cu}(\text{NH}_3)_4^{2+}] = 0,20 \text{ mol L}^{-1}$$

$$K_f = \frac{[\text{Cu}(\text{NH}_3)_4^{2+}]}{[\text{Cu}^{2+}][\text{NH}_3]^4}$$

$$[\text{Cu}^{2+}] = \frac{[\text{Cu}(\text{NH}_3)_4^{2+}]}{K_f [\text{NH}_3]^4} = \frac{0,10}{1,07 \cdot 10^{12} (0,20)^4} = 5,84 \cdot 10^{-11} \text{ mol L}^{-1}$$