Acid: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$

Base: $B + H_2O \rightleftharpoons OH^- + BH^+$

$H_3O^+ + OH^- \rightleftharpoons 2\,H_2O$ ← this equilibrium always exists

Regardless of circumstance $[H_3O^+] \times [OH^-] = 1 \times 10^{-14}$

$[H_3O^+]$	$[OH^-]$	pH
1×10^{-2} M	1×10^{-12} M	2
1×10^{-7} M	1×10^{-7} M	7
1×10^{-9} M	1×10^{-5} M	9

We use $[H_3O^+]$ to describe acid/base situation

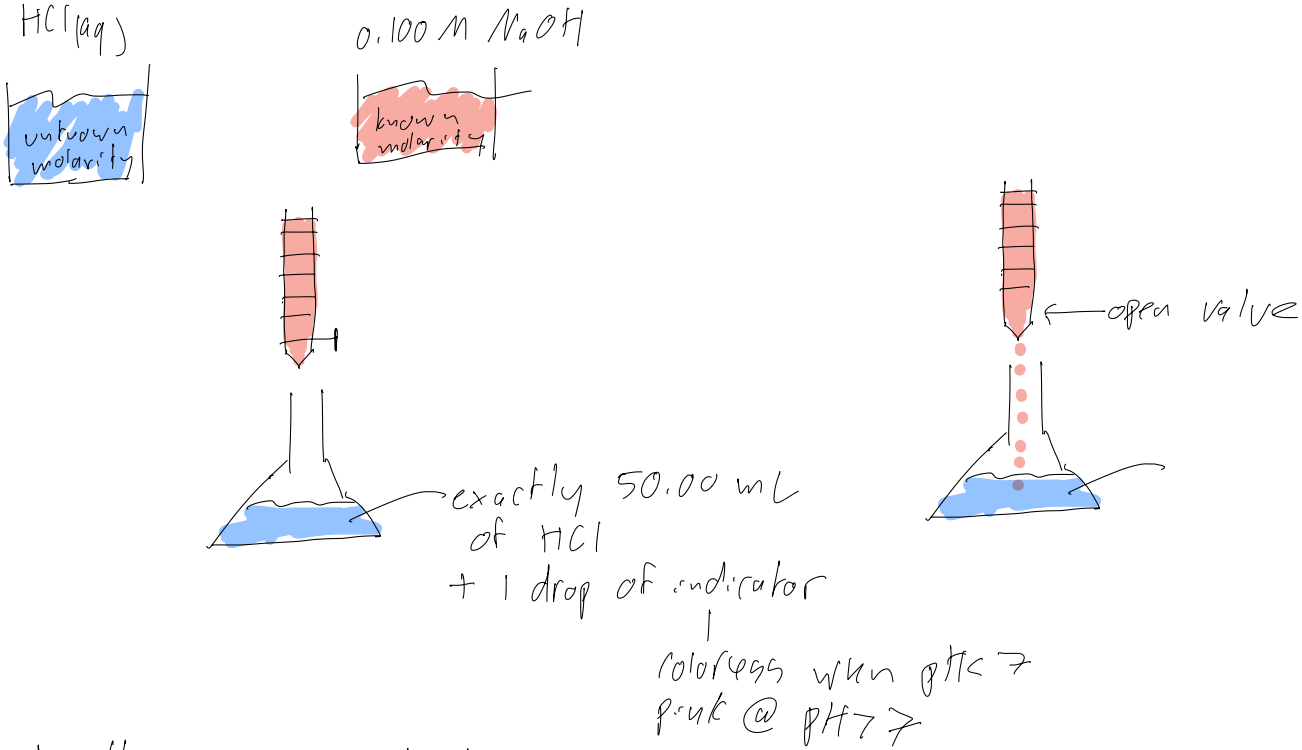
$pH = -\log_{10}[H_3O^+]$

pH = 7 equal amts of H_3O^+ and OH^- → neutral

pH < 7 more H_3O^+ than OH^- → acidic

pH > 7 more OH^- than H_3O^+ → basic

Titration



eventually we will have added enough OH^- to react with all H_3O^+ from HCl (neutral pH)

- Add 1 more drop NaOH → soln becomes basic → indicator changes color

equivalence point is when we've added exactly enough OH^- to react w/ all H_3O^+ moles OH^- added = moles H_3O^+ originally present

50.00 mL of HCl(aq) of unknown conc
Added 27.65 mL of 0.100 M NaOH to get to equivalence point

$$0.02765\ L\ NaOH \times \frac{0.1\ moles\ OH^-}{1\ L} = 0.002765\ moles\ OH^-$$

so there must have been 0.002765 moles H_3O^+ originally in the 50.00 mL of HCl(aq) that we used

$$[HCl(aq)] = \frac{0.002765\ mol}{0.05\ L} = 0.0553\ M$$

pH of orig HCl solution → $-\log_{10}(0.0553) = 1.26$

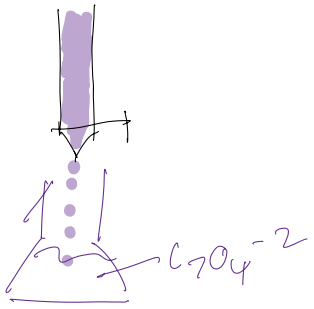
Redox titration will involve ox/red chemistry instead of acid/base chemistry

permanganate ion (MnO_4^-) is good at oxidizing things including $C_2O_4^{-2}$ ion

MnO_4^- is reduced to Mn^{2+}
Mn: +7 → +2

$C_2O_4^{-2}$ gets oxidized to CO_2
C: +3 → +4
O: −2 → −2

MnO_4^- solution of known concentration in buret
└purple



when purple persists, no more $C_2O_4^{-2}$ remaining

Reaction takes place in acidic solution so H_3O^+ is on reactant side and H_2O is on product side

$$MnO_4^-(aq) + \frac{5}{2}C_2O_4^{-2}(aq) + {}^{8}H_3O^+(aq) \longrightarrow Mn^{2+}(aq) + {}^{5}CO_2(g) + {}^{12}H_2O(\ell)$$

* each Mn will oxidize 5 C
* always 1.5x as many H_2O as H_3O^+

14 + 0 from H_3O^+ on left
10 + 0 from H_2O on right

$$2\,MnO_4^-(aq) + 5\,C_2O_4^{-2}(aq) + 16\,H_3O^+(aq) \rightarrow 2\,Mn^{2+}(aq) + 10\,CO_2(g) + 24\,H_2O(\ell)$$

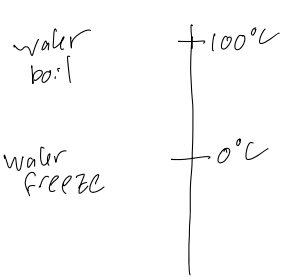
IF we added 0.05 moles MnO_4^-
then must have taken $0.05\ mol\ MnO_4^- \times \frac{5\ mol\ C_2O_4^{-2}}{2\ mol\ MnO_4^-} = 0.125\ mol\ C_2O_4^-$

Chapter 5 – energy – ability to do work
– ability to transfer heat

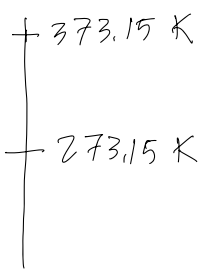
* energy is conserved
* energy can be converted from one form to another

Temperature – tells the direction of heat flow
heat flows from higher temp → lower temp

Celsius



Kelvin



°C + 273.15 → Kelvin temp

Joule is our energy unit

system vs surroundings

system: what we are "looking at"

surroundings: everything else

energy from system → surroundings: exothermic

energy from surroundings → system: endothermic

Specific heat capacity (C)

- specific to a material/substance
- describes how much energy required to change temperature of 1 gram of that material → $\frac{J}{g\ K}$

Δ = final − initial

$q = m C \Delta T$ (m: mass; ΔT: change in temp)

q: amount of heat energy involved in process

Ex: How much heat needed to warm 1 kg H_2O from 75°C to 80°C

C for water = $4.184 \frac{J}{g\ K}$

mass = 1000 g

$T_f = 80°C = 353.15\ K$

$T_i = 75°C = 298.15\ K$

$\Delta T = 55\ K$

$q = (1000\ g)\left(4.184 \frac{J}{g\ K}\right)(55\ K) = 230120\ J$ q > 0 for endothermic

If that water cools back down to 75°C

$q = (1000\ g)\left(4.184 \frac{J}{g\ K}\right)(-55\ K) = -230120\ J$ q < 0 for exothermic

During phase changes, energy is moving but temp is not changing

sol → liq, liq → gas } endothermic

gas → liquid, liquid → solid } exothermic

$q = mC\Delta T$ does <u>not</u> apply to phase changes

Water solid → liq @ 273.15 K $\frac{333\ J}{g}$ "heat of fusion"

liq → gas @ 373.15 K $\frac{2256\ J}{g}$ "heat of evaporation"

Ice cube @ 273.15 K
↓ 333 J/g
Liquid water @ 273.15 K
↓ $q = mc\Delta T$
Liquid water @ 373.15 K
↓ 2256 J/g
Gaseous water @ 373.15

heat transfer – when heat goes from substance at higher temp to substance at lower temp until thermal equilibrium is reached

$q_1 = m_1 c_1 \Delta T_1$

$q_2 = m_2 c_2 \Delta T_2$

$q_1 + q_2 = 0$

$T_{f,1} = T_{f,2}$