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

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

$H_3O^+ + OH^- \rightleftharpoons 2\,H_2O$

In any situation $[H_3O^+] \times [OH^-] = 1 \times 10^{-14}$

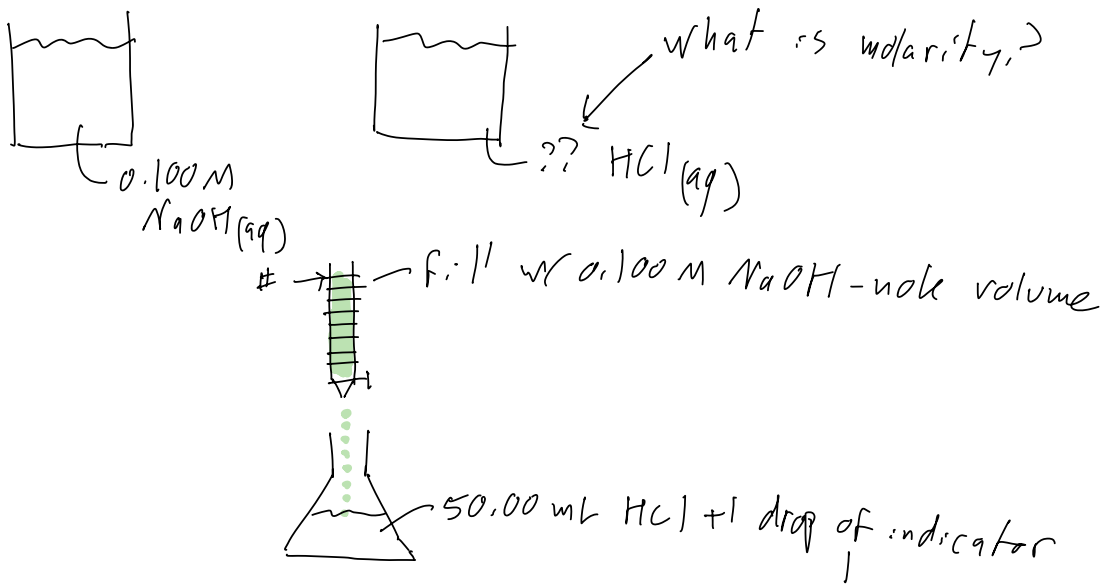
pH	$[H_3O^+]$	$[OH^-]$
4	1×10^{-4} M	1×10^{-10} M
7	1×10^{-7} M	1×10^{-7} M
9	1×10^{-9} M	1×10^{-5} M

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

$pH = 7 \rightarrow$ equal amt H_3O^+ / OH^- $\quad pH = -\log_{10}[H_3O^+]$

$pH < 7 \rightarrow$ more H_3O^+ (acidic)

$pH > 7 \rightarrow$ more OH^- (basic)



Add NaOH until indicator turns pink

moles OH^- added = moles H_3O^+ originally present at equivalence point

We added 27.65 mL 0.100 M NaOH to get to equiv point

$$0.02765\ L \times \frac{0.1\ mol\ OH^-}{1\ L} \times \frac{1\ mol\ H_3O^+}{1\ mol\ OH^-} = 0.002765\ moles\ H_3O^+\ initially$$

$$[H_3O^+] = \frac{0.002765\ mol}{0.05\ L} = 0.0553\ M$$

$$pH_{init} = -(\log_{10} 0.0553) \rightarrow 1.26$$

0.1 M NaOH $\rightarrow [OH^-] = 0.1\ M$

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

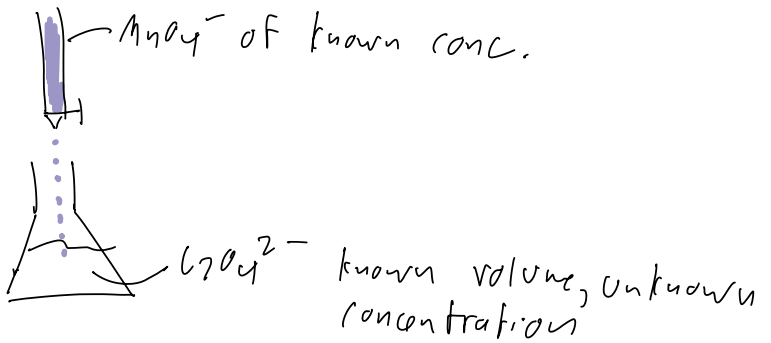
$$[H_3O^+] = \frac{1 \times 10^{-14}}{.1} = 1 \times 10^{-13}$$

$pH = 13$

Redox titration

MnO_4^- strong oxidizer can oxidize $C_2O_4^{2-}$

purple



When MnO_4^- reacts it becomes colorless

When purple persists → equivalence point where all $C_2O_4^{2-}$ has reacted

we need a balanced rxn for this process

* This takes place in acidic solution (H_3O^+ on reactant side, H_2O on product side)
* $MnO_4^- \rightarrow Mn^{2+}$ ($+7$) $\quad C_2O_4^{2-} \rightarrow CO_2$ ($+3$, $+4$)

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

Mn:C ratio is 1:5 (from ox #)

1.5x H_2O as H_3O^+

2 moles MnO_4^- react w/ 5 moles $C_2O_4^{2-}$

on right, 20 O from CO_2, 10 per H_2O

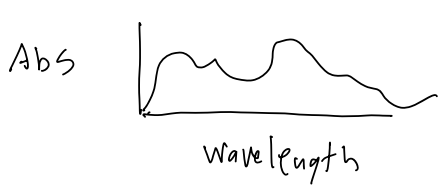
Spectrophotometry – when light passes through a material some colors of light pass through and some get absorbed

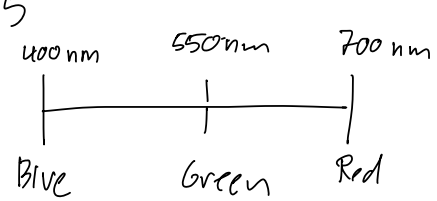
$$\text{Transmission} = \frac{\text{amount of light that came through}}{\text{amt of light that was put in}}$$

$$\text{Absorbance} = -\log_{10}(\text{Transmission})$$

$T = 0.9$ means 90% of light went thru

$Abs = -\log_{10}(0.9) = 0.045$





$Abs = \varepsilon \times l \times c$ (c: molarity)

- Abs → unitless
- ε → extinction coefficient
  - units of $M^{-1}cm^{-1}$
  - characteristic to material and wavelength
- l → pathlength → distance in cm that light is travelling thru sample

$$c = \frac{Abs}{\varepsilon \times l}$$

Energy — ability to do work
— ability to transfer heat

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

Temperature - metric that indicates direction of heat flow
- no heat flow if 2 objects are same temp

Celsius	Kelvin
water boil 100°C	373.15 K
water freeze 0°C	273.15 K

change of 10°C = change of 10 K
$10°C \neq 10\ K$
Keep it in Kelvin
$°C + 273.15 \rightarrow K$

Joule is unit of energy
4.184 J is the amount of energy needed to raise the temp of 1g of liquid water by 1 K

1 calorie = 4.184 J
1000 calories = 1 kcal = 1 dietary calorie = 4184 J

system and surroundings = universe

↓ what we are studying

↓ everything else

system → surroundings exothermic

surroundings → system endothermic

Specific heat capacity (C) – property specific to a material
- describes how much energy needed to change temp
- Units $\frac{J}{g\ K}$

$q = mC\Delta T$

m = mass

Δ means final − initial

$\Delta T = T_f - T_i$

q = amt of heat involved in a process

$C_{H_2O} = \frac{4.184\ J}{g\ K}$

How much energy to warm 1 kg of water from 25°C → 80°C

$m = 1000\ g$

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

$\Delta T = (80 + 273.15) - (25 + 273.15) = 55\ K$

$q = (1000\ g)(4.184\ \frac{J}{g\ K})(55\ K) = 230120\ J$ q70 is endothermic

How much energy given off when 1 kg H_2O at 80°C cools to 25°C

$\Delta T = (25+273.15)-(80+273.15) = -55\ K$

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

Sometimes heat moves into/out of system but temp doesn't change

During phase changes temp remains constant energy is used to accomplish phase change

Exo
gas → liq
liq → solid

Endo
sol → liq
liq → gas

*Can't use $q = mC\Delta T$ for phase changes

Heat of fusion (sol → liq) of water is $333\ \frac{J}{g}$

1g solid water at 0°C → 1g liquid water @ 0°C requires 333 J

Heat of evaporation (liq → gas) of water is 2256 J/g

liquid water @ 75°C
↓ $q = mC\Delta T$
liquid water @ 100°C
↓ 2256 J/g
gaseous water @ 100°C

1g 25 → 100°C ~300 J

Heat transfer — combine hot + cold thing. Heat moves from hot to cold until "thermal equilibrium" is reached

$q_1 = m_1 c_1 \Delta T_1$

$q_2 = m_2 c_2 \Delta T_2$

$q_1 + q_2 = 0$

$T_{1\,init} \neq T_{2\,init}$

$T_{1\,final} = T_{2\,final}$