$HA + H_2O \rightleftharpoons H_3O^+_{(aq)} + A^-$ ⟶

$B + H_2O \rightleftharpoons BH^+_{(aq)} + OH^-_{(aq)}$ ⟶

$H_3O^+_{(aq)} + OH^-_{(aq)} \rightleftharpoons 2\,H_2O$

$[H_3O^+]$ is useful metric in acid/base situation

$[H_3O^+] \times [OH^-] = \text{constant} = 1\times10^{-14}$

IF $[H_3O^+] = 1\times10^{-4}\,M$ then $[OH^-]$ must be $1\times10^{-10}\,M$

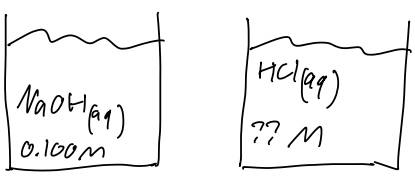
$pH = -\log_{10}([H_3O^+])$

$[H_3O^+]$	$[OH^-]$	pH
1×10^{-4}	1×10^{-10}	4
1×10^{-6}	1×10^{-8}	6
1×10^{-10}	1×10^{-4}	10
1×10^{-7}	1×10^{-7}	7

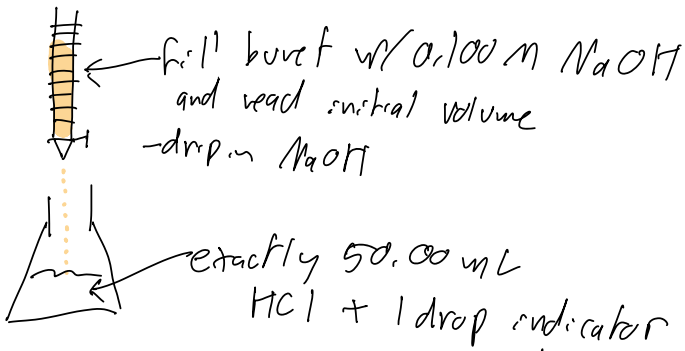
10X change in molarity ↓ 1 unit change in pH

pH < 7 means more H_3O^+ than OH^- → acidic

pH > 7 means less H_3O^+ than OH^- → basic



How to find $[HCl]$?
- with a titration



-eventually the next drop of NaOH causes indicator to turn pink

→ # moles OH^- added = # of moles H_3O^+ originally present

Ex: 27.65 mL of 0.100 M NaOH needed to get solution to turn pink ("equivalence point")

$0.02765\,L \times \frac{0.1\ mol}{L} = 0.002765$ moles OH^- added to flask

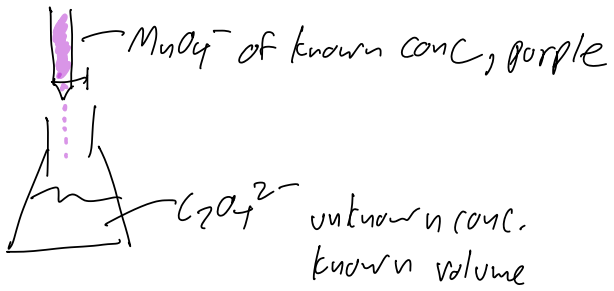
So there must have been 0.002765 moles H_3O^+ present initially

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

pH of original HCl $= -\log_{10}(0.0553) = 1.26$

Redox titration MnO_4^- (+7) is a strong oxidizing agent

can oxidize all sorts of stuff - including $C_2O_4^{2-}$



Add MnO_4^- until purple persists - b/c that is when we've added enough moles MnO_4^- to react w/ all $C_2O_4^{2-}$

We need balanced rxn for this process

* it takes place in acidic solution
  H_3O^+ gets added as reactant
  H_2O gets added as product

* $MnO_4^- \rightarrow Mn^{2+}$ (+7 → +2)
  $C_2O_4^{2-} \rightarrow CO_2$ (+3 → +4)

$$2\,MnO_4^-{}_{(aq)} + 5\,C_2O_4^{2-}{}_{(aq)} + 16\,H_3O^+{}_{(aq)} \rightarrow 2\,Mn^{2+}{}_{(aq)} + 10\,CO_{2\,(g)} + 24\,H_2O_{(\ell)}$$

need 5 C : 1 Mn

L → 28 O + # H_3O^+ R → 20 + # H_2O

and $H_2O : H_3O^+ = 1.5 : 1$

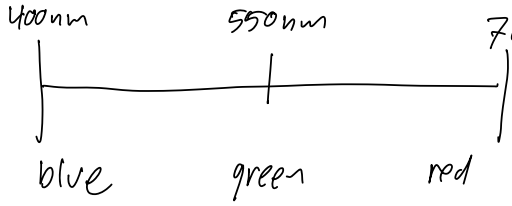
Last topic on CH 4

Spectrophotometry

~~light~~ Some colors of light are absorbed when light passes thru a sample of material ~~transmitted~~

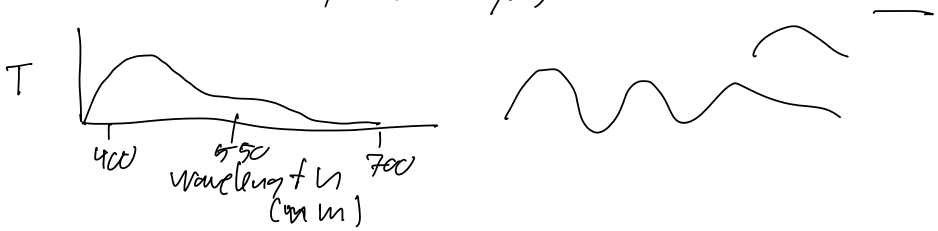
transmitted light ~~was~~ passes thru and gets to your eyes

absorbed light gets "caught" by the sample



← wavelengths that correspond to colors

$T = \text{transmission} = \frac{\text{amount of light that comes out}}{\text{amount of light that goes in}}$



$Abs = -\log_{10} T$

Ex: 90% light transmitted

$T = \frac{90}{100} = 0.9$

$Abs = -\log(0.9) = 0.045$

Beer's Law

$Abs = \varepsilon \times l \times c$

- ε: extinction coefficient → units of $M^{-1}cm^{-1}$ — specific to given substance
- l: "pathlength" — distance light travels thru sample (in cm)
- c: molarity

Ch 5- Energy, Heat and Work

↳ ability to do work or transfer heat

* Energy is conserved
* We can convert energy from one form to another

Chemical bonds are good venue for concentrating energy

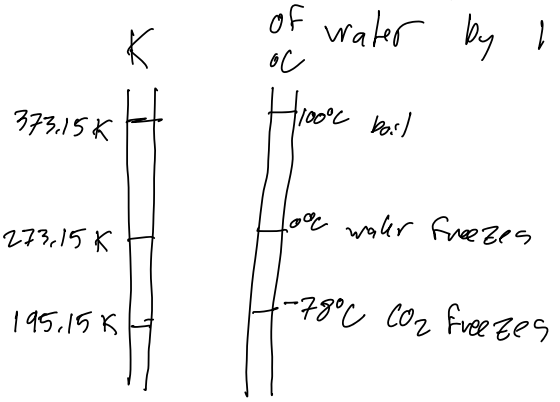
Temperature - indicates direction of heat flow
heat flows from higher temp → lower temp
when temperature of 2 objects becomes equal, there will be no more heat flow

system - what we are studying
surroundings - rest of universe

heat transferred from system → surroundings exothermic
heat transferred from surroundings → system endothermic

Units

Joule → 4.184 J is the amount of heat energy needed to raise temp of 1 gram of water by 1 Kelvin or 1 degree Celsius



Change of 1 K is same as change of 1°C

Calorie = 4.184 J

Specific heat capacity - property of a given material (C)

- describes how much energy required to change temp of that material
- in units of $\frac{J}{g \cdot K}$

$q = mC\Delta T$ $\quad \Delta T = T_f - T_i$

(amount of heat energy) (mass) (change in temp)

$C_{H_2O} = 4.184 \frac{J}{gK}$

$T(K) = T(°C) + 273.15$

How much energy is needed to warm 1 kg H_2O from 25°C to 80°C

$m = 1\,kg = 1000\,g$

$\Delta T \rightarrow T_f = 80°C + 273.15 = 353.15\,K$

$T_i = 25°C + 273.15 = 298.15\,K$

$T_f - T_i = 55\,K$

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

How much energy needs to be removed from 1 kg H_2O at 80°C to get it to 25°C

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

230120 J must be removed

Sometimes heat in/out but no ΔT

during phase change T is constant but energy is moving

s → liq liq → gas endothermic gas → liq liq → solid exothermic

Heat of fusion = amt of energy sol → liq 333 J/g for water
Heat of evap = amt of energy liq → gas 2256 J/g for water

1g liquid H_2O @ 100°C
↓ requires 2256 J
1g gaseous H_2O @ 100°C

liquid water @ 25°C → gaseous water @ 100°C
↓ $q = mc\Delta T$
liquid water @ 100°C ——— 2256 J/g ———

Heat transfer q: transfer- combine 2 items at diff temps
- At what temp are they when they equilibrate

$q_1 = m_1 C_1 \Delta T_1$
$q_2 = m_2 C_2 \Delta T_2$
$q_1 + q_2 = 0$

usually trying to find T_f and both objects have same T_f

$q_1 = m_1 C_1 (T_f - T_{i,1})$
$q_2 = m_2 C_2 (T_f - T_{i,2})$