CHM1311 Midterm 1

05/10/19

Stoichiometry

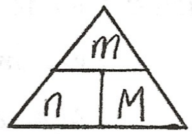
1 mol = 6.022×10^{23} things

N = avogadro's constant = 1 mole

m = mass (g)

n = # of moles (mol)

M = molar mass (g/mol)



# of atoms = nN

# of molecules = $N\left(\frac{m}{M}\right)$ or Nn

# of formula units (i.e. 'ionic molecules') = $N\left(\frac{m}{M}\right)$ or Nn

mass % = $\frac{(\text{\# atoms X})(\text{atomic mass X})}{\text{molecular mass compound}} \times 100$ = $\frac{(\text{moles of X in formula})(\text{molar mass X})}{\text{molar mass of compound}} \times 100$

mass of an element = (mass compound) $\left(\frac{\text{mass of element in 1 mol of compound}}{\text{molar mass of compound}}\right)$

empirical formula: lowest whole number ratio of atoms of each element in compound
'ionic formula for molecules'

molecular formula: shows actual number of atoms of each element in a compound

emirical formula from moles of elements: make preliminary formula using #moles as subscripts
multiply / divide to get whole numbers (lowest possible)

empirical formula from masses of elements: find # moles of each element → $\frac{m}{M}$
preliminary formula using #moles as subscripts
multiply / divide to get whole numbers (lowest possible)

molecular formula from empirical formula: $\frac{\text{molar mass (g/mol)}}{\text{empirical formula mass (g/mol)}}$
(make sure to have whole numbers)

Balancing chemical equations: law of conservation of matter
balance with coefficients

Stoichiometric calculations: coefficients in equation represent the relative number of moles
moles are proportional to mass
mole ratios of balanced equations used as conversion factors

calculating quantities of reactants / products: write and balance reaction equation
use mole ratio as conversion factor
equivalent ratios for calculating mass a molar m

Reactions in sequence: a product of a reaction will usually become a reactant in another
overall reactions are written by combining the reactions
substances formed in one reaction and reacted in the next are eliminated

writing overall reactions: write the individual balanced equations
adjust coefficients so equal product / reactants can be cancelled out
combine equations

Limiting reactants: in a perfect world, there is exactly enough of each reactant
in reality, one reactant can limit the amount of product produced
other reactants will be in excess and there will be leftover

limiting reactant problems: determine limiting reagent
calculate using equivalent ratios based on limiting reactant

Reaction yields: theoretical yield is the amount of product calculated using molar ratios
actual yield is the amount of product actually produced

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Solution stoichiometry: a solution has solutes dissolved in a solvent
concentration of a solution is the amount of solute in solution

Molarity is synonymous with concentration

$$\text{concentration / molarity (C/M)} = \frac{\text{moles solute (mol)}}{\text{volume of solution (L)}}$$

calculating mass of solute in a volume of solution = (volume solution)(moles of solute)(molar mass)
diluting a concentrated solution: adding solvent, ∴ moles of solute is constant

determining amount (mol) of ions in a solution: write dissociation equation for each compound
calculate number of moles of each amount
per 1 mole of solution

Redox reactions involve movement of electrons between reactants
from lower electron affinity to higher electron affinity

oxidation: loss of e^-

reduction: gain of e^-

Oxidation	Reduction
Is	Is
Losing e^-	Gaining e^-

oxidation numbers: the charge an atom has when e^- transferred completely (not shared)

- atoms in elemental form: 0
- monatomic ion: same as ion charge
- Group 1: +1 always
- Group 2: +2 always
- hydrogen: +1 w non-metals
  - -1 w metals or boron
- fluorine: -1 always
- oxygen: -2 usually
  - could be +2 or -1 when w Group 1/2 metal or fluorine
- Group 17: -1 except when w oxygen

neutral polyatomic molecules or formula units have net oxidation number zero

Poly atomic ions have net oxidation number equal to charge of the ion

Balancing redox reactions: give all atoms their oxidation and find what is being reduced/oxidized
break into half reactions (oxidation and reduction)
balance stoichiometrically by adding H_2O, H^+/H_3O^+ (acidic), OH^- (basic)
balance electronically by adding electrons to the deficient side
multiply each reaction by a scalar so the electron transfer is equal
recombine the half-reactions
cancel out the electrons

Quantum chemistry

electromagnetic radiation includes visible light, radio waves, gamma rays, X-rays

f or v = frequency - cycles per second
λ = wavelength - distance between crests
c = speed of light = 3.00×10^8 m/s

higher amplitude gives higher intensity, brighter light compared to lower amplitude which gives lower intensity, dimmer light
colour is determined by wavelength
blackbody radiation: when a solid object emits light if it has high enough energy

$E = nhv$	E = energy	h = Planck's constant = 6.626×10^{-34} $m^2 \cdot kg/s$
	n = positive integer	v = frequency

Quantum theory: energy is quantized (stepwise, not continuous)
atoms change their energy states by emitting/absorbing quanta of energy
$\Delta E = nhv$

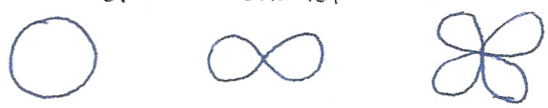
energy of one photon: $\Delta E = hv$
Bohr's model of the hydrogen atom: has certain energy levels (shells, states, etc.)
each level has a circular orbit of e^- around the nucleus
when the H e^- is in the first orbit, it is the ground state
the atom does not radiate energy while in a stationary state
the atom changes stationary states by absorbing/emitting a photon
when the e^- is not in ground state, the atom is in excited state

$E = mc^2$

Louis de Broglie said that all matter has a wavelength
de Broglie wavelength = $\lambda = \frac{h}{mv}$
m = mass
h = Planck's constant
v = speed (m/s)

Heisenberg's uncertainty principle: it is not possible to know both the position and momentum (velocity) of a moving particle at the same time. In other words, you could know where it is but not where it is going and vice versa, but not both simultaneously.

s-orbital p-orbital d-orbital



Quantum numbers

n = principal quantum number = size of orbital = energy level = any positive integer

l = angular momentum number = shape of orbital = $0 \leq l \leq n-1$

m_l = magnetic quantum number = orientation of orbital = $-l \leq m_l \leq l$

m_s = spin quantum number = direction of electron spin = $\pm\frac{1}{2}$

Pauli exclusion principle: each electron in an atom has a unique set of quantum numbers
one orbital can have maximum $2e^-$ and they must have opposing spins

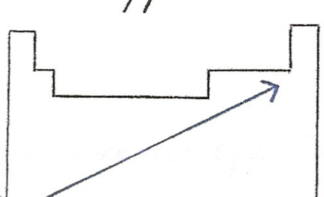
Aufbau principle: electrons always go in the lowest energy sublevel available

Hund's rule: when orbitals of equal energy are available ($n=n$), there will be the maximum number of unpaired electrons possible with parallel spins

1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p → 5s → 4d → 5p → 6s → 4f → 5d → 6p → 7s → 5f → 6d → 7p

Ionization energy is the energy required to remove 1 mol of e^- from 1 mol of an atom / ion in the gaseous state

ionization energy trend:



also: electron affinity trend
also: electronegativity trend

atomic size