FE Exam Review - Chemistry

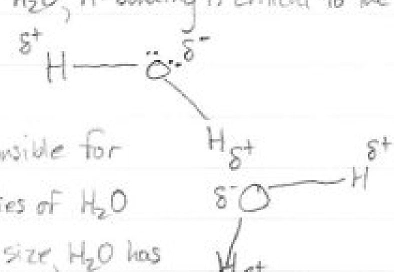
Intro - Points about taking this exam

- Don't expect to get everything right
- Harvest your points
- Don't spend time on problems you can't solve - look for cheap points
- Not possible to review "Chemistry" in one hour

States of Matter

Gas: Molecules are relatively far apart
little or no structure
molecules move relative to each other, frequent collisions (fluid)

condensed Liquid: molecules are more closely spaced
some motion among molecules (fluid)
weak bonds hold molecules together (London, van der Waal's, dipole interactions, H-bonding)
In the case of H_2O, H-bonding is critical to the properties of water:



H-bonding responsible for
unusual properties of H_2O

for a molecule of its size, H_2O has

- high boiling point
- high freezing point

} compare w/ NH_3, CH_4 → similar MW, exist as gas at room T, P, require very low T to liquify, freeze

Solid: molecules are organized, sometimes crystalline
not fluid, but will deform

Atomic Structure

basic components

H^+ proton: +1 charge
neutron: neutral charge
e^- electron: −1 charge

Proton and neutron have similar mass, much greater than e^- mass

- Atoms have neutral charge − ∴ atoms have same number of protons and electrons
- Nucleus of an atom includes protons + neutrons
- Name of an atom is defined by number of protons
- Isotopes are atoms that have same number of protons, different number of neutrons.

For example, chlorine has two common isotopes: ^{35}Cl and ^{37}Cl

mass number ← ^{35}Cl → 17 protons + 18 neutrons → atomic number

^{37}Cl → 17 protons + 20 neutrons

natural abundance of Cl isotops is ~ 3:1 for $^{35}Cl : ^{37}Cl$

$$\therefore \text{AW Chlorine} = \frac{3 \cdot 35 + 1 \cdot 37}{4} = 35.5$$

Ideal gas law

$PV = nRT$

R = gas constant = $0.08205 \frac{L \cdot atm}{K \cdot mole}$

recognize that this equation can be rearranged, interpreted many different ways

- if nRT are fixed (e.g., no info given about them in a problem), then PV = constant, or P, V are inversely related

$n = \frac{PV}{RT}$ = number of moles of gas at P, T in volume V

if we multiply by A = Avagadro's number = 6.02×10^{23} $\frac{\text{molecules/atoms/ions}}{\text{mole}}$,
we get the number of molecules/atoms/ions

Periodic Table

Rows = periods

Columns = groups

- in general, elements move from metallic → non-metallic as we go from L → R
- heavier elements tend to be more metallic
- atomic radius ↓ from L → R (greater nuclear charge) atomic radius ↑ from top → bottom
- ionization potential = energy req'd to remove e^- from gaseous atom or ion
  - 2^{nd} ionization potential > 1^{st} ionization potential (becomes increasingly harder to remove e^-)
  - ionization potential ↑ from L → R in a period (e^- held more tightly to nucleus)
  - ionization potential ↓ from top → bottom in a group (e^- further from nucleus in larger atoms)
- important groups in periodic table include:
  - Group IA – Alkali metals tend to be M^+ to gain noble gas e^- structure
  - Group IIA – Alkaline Earth metals tend to be M^{2+} " " " " " "
  - Group VIIA – Halogens tend to be X^- " " " " " "
  - Group VIIIA – Noble gases, inert gases, rare gases → very stable, ~ non-reactive

Reaction Stoichiometry/Equilibria/Kinetics

For a general rxn: $aA + bB \underset{k_r}{\overset{k_F}{\rightleftharpoons}} cC + dD$

a, b, c, d are stoichiometric coefficients, which describe the molar quantities of reactants and products.

For an elementary rxn (one that takes place exactly as written, no intermediates, etc.), the kinetics of the rxn can be written directly from the stoichiometric expression:

$r_{Forward} = k_F[A]^a[B]^b$ $\quad r_{reverse} = k_r[C]^c[D]^d$, where $[i]$ = molar conc (activity) of i

When the rates of the forward/reverse reactions are equal, then the system has reached a condition of chemical equilibrium: $k_F[A]^a[B]^b = k_r[C]^c[D]^d$

Formally, we defined the ratio of forward & reverse rate constants as an Equilibrium Constant (K_{eq})

$$K_{eq} = \frac{k_F}{k_r} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

any combination of [A], [B], [C], [D] that satisfies this equality is an equilibrium condition → ∴ there are an infinite number of equilibrium conditions, all of which satisfy this equation