Exam 3 Review Notes (Watch the video!!)

1. The chemical system and state functions
   - The state functions in the Ideal gas law. They are system variables measured to determine change: $\Delta n, \Delta P, \Delta T, \Delta V$
   - The chemical system and state functions: $n, P, V, T$

2. Famous gas laws (Easy)
   - Graham
   - Dalton
   - Charles
   - Boyle
   - Avagadro
   - Guy Lussac

   Be able to explain each of these laws in a single sentence. You will have to sort through a collection of T/F statements on the question.

3. Partial pressure (Dalton's Law) calculation (Easy)

   Isn't the Ideal gas law great? It says that

   $\uparrow \uparrow \uparrow$
   He N$_2$ SF$_6$

   are all the same simple countable hard spheres. So

   $5\text{He} + 6\text{N}_2 + 3\text{SF}_6 = 14$ gas molecules. And by extension

   $P_A + P_B + P_c = P_{\text{Total}}$
4 Combined gas law calculation

\[ \frac{P_1V_1}{T_1} = nR = \frac{P_2V_2}{T_2} \]

\[ P_2 = \frac{P_1V_1T_2}{T_1V_2} \]

This is classic Plug + Chug. You will be given 5 of 6 variables and will solve for unknown.

Steps

- Rewrite to solve for unknown first
- Plop in known values (change °C \to K)
- Perform simple math estimates to get answer without any actual calculations

5 Using PV = nRT to calculate MW

Need to derive MW relationship

\[ PV = nRT \]

\[ n = \frac{g}{MW} \]

\[ PV = \frac{g}{MW}RT \]

\[ MW = \frac{gRT}{PV} \]

So why is this hard?

- lots of exponents. Example: 3.48 mL = 3.48 \times 10^{-3} \text{ L}
- need to get everything into R units
- If the MW isn’t a gas MW, it is wrong

6 Relating number density to pressure

\[ PV = nRT \]

\[ \rho V = \frac{g}{MW}RT \]

\[ \rho = \frac{g}{MW}RT \]

\[ P = \rho \frac{RT}{MW} \]

The derivation on left isn’t needed because equation is on cover sheet, but it is instructive.

Note

- As mass density goes up, P goes up
- As MW goes up, P goes down
- As T goes up, P goes up
- There is no V in equation (it is in P already)
7 Gas reaction stoichiometry - combining volumes

You will be given a balanced gas reaction:

\[ \text{mole react} \rightarrow \text{mole product} \rightarrow \text{Volume of gas} \]

Guy Lussac lets us avoid a lot of PV=nRT calculations.

So once the \( \Delta n \) (difference in mole gas) is found, the volume of gases is easy to find. For example, at STP, \( \Delta n = 3 \) mole gas = v 67.2 L

8 Gas reaction stoichiometry - partial pressures

\[ \text{mole react} \rightarrow \text{mole product} \rightarrow \text{P} \text{ of gases} \]

Convert to moles:

\[ \text{fraction out total} \ \Delta n \text{gas} \rightarrow \text{P} = \frac{nRT}{V} \]

9 Kinetic Molecular Theory

*Know the facts*

- Small hard spheres
- \( V_{\text{gas}} \ll V_{\text{container}} \)
- Elastic collisions
- \( T \propto \text{KE} \)
- \( \text{KE} \propto m v^2 \)

Given various T/F statements, identify the correct answer.
10 Maxwell distributions - graph interpretation

Be able to explain how these distributions happen. If you can't explain from first principles, you can't answer question given a collection of T/F statements, find the correct answer.

11 Graham's law - ratio of gas speeds

diffusion, effusion, speed all follow equation 27 cover sheet

\[ \frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}} \]

Note inverse square root relationship

Example: \( \frac{\text{H}_2}{\text{O}_2} \) is 4 times slower than \( \text{O}_2 \), \( \sqrt{2} \approx 1.414 \), \( \sqrt{8} \approx 2.828 \), \( \sqrt{32} \approx 5.66 

12 Gas non-ideality - theory - failing conditions of the IGL

Non-ideality happens
- gases have volume
- gases have IMF

This non-ideality occurs
- when \( P \) increases
- when \( T \) decreases

You will be given a collection of T/F statements and must find the correct answer.
13 Gas non-ideality – van der Waals' coefficients - meaning and use

The van der Waals equation (on core sheet) corrects non-ideality with a + b coefficients

Be able to assign a and b to gases

Example: if a = 1, 2 it is He while 4 = NH₃
       if b = 0.01 it is H₂ while 0.06 = SF₆

b = corrects size
a = corrects P term

Be able to do relative rankings

14 Distinguishing intra and Intermolecular forces

There are 5 kinds of forces built on Coulomb's law in matter:

Intermolecular IMF

Dispersion, dipole-dipole, H-bond
Non-polar, polar
~1 KJ/mole, ~20 KJ/mole

I onic, Covalent

~N-H, ~F-H

Explain dispersion forces (instantaneous forces or London forces)

- Created by induced dipoles in the electron cloud
- Happen in all molecules and get larger as molecules get larger
- Only IMF in non-polar compounds
- Get so large that bigger molecules \( \rightarrow l \rightarrow s \)

You will be given several T/F statements and need to find correct one
16 Intermolecular force theory (H bonding)

Be able to draw simple compounds with H-bonding and distinguish different types of bonds (covalent vs H-bond)

17 Assigning Intermolecular force in molecules

You will be given a bunch of compounds and asked the dominant EMF in each.

Example:
- CaH6 = dispersion
- CH3OH = H bond
- O3 = dipoles-dipoles
- NaCl = ionic

18 Assigning Intermolecular force in molecules

You will be given a compound and asked what IMF forces exist in it.

Remember that dispersion is found in all molecules.
- dipoles-dipoles in polar compounds
- H-bonding in polar compounds with H-F, O-H, N-H
19 Theory behind ranking of properties of liquids (dispersive forces) medium
You will be given a collection of T/F statements that describe dispersive (instantaneous dipole = London = dispersion) forces.

Be able to explain the origin and application of this most ubiquitous (everything has dispersion force) T/F

20 Theory behind ranking of properties of liquids (H bonding) medium

H2O

H20

HF

NH3

CH4

MW

This is a very famous plot of H bonding that shows how special the OH, FH, NH is period 2 are.
Be able to explain the trends.

21 Physical property definitions medium

Just like the 6-3 laws, be able to write a sentence explaining

boiling point
surface tension
viscosity
evaporation
vapor pressure
capillary action

be able to sort through a collection of T/F statements on the question
22. Ranking properties of liquids (direct relationship with IMF)

Most liquid properties increase with increasing IMF:
- b.p.
- s.t.
- c.a.
- Visc
- ΔHvap, etc

So to rank them, first need to rank IMF: The bucket method

nonpolar dispersive rank by MW

< polar perm. dipole

< H bond rank by NHClO4

< ionic rank by charge density

Note of course size matters and dispersive wins as molecules get bigger, but not some thing to bear in mind

23. Ranking properties of liquids (inverse relationship with IMF)

Evaporation and vapor pressure are inversely related to IMF.

so do what you did for 22 above in reverse

V.P. dispersive evap

> dipole dipole

> H bond

Hint: is CH₃F

H-bond? Draw it

H - F No! F is no attached to H

24. Types of solids

There are 4 types of solids:
- metallic
- ionic
- molecular
- network covalent

These will be mixed and matched with examples:
- metals = to left on table
- ionic = salts = left + right (cation + anion)
- molecular = molecules you can draw that have IMF
- covalent = elements to right on table too large to draw
Ionic solids have properties easily ranked based on charge density. So in some way from Exam 2, charge density & lattice energy, have charge density & melting points of salts. Example, $\text{Al}_2\text{O}_3$ melts much much higher than $\text{NaCl}$.

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**Gracious Ranking Hint:** Get the boundaries right in multiple choice and you don’t have to waste time on rest of problem.

Example, Rank boiling $\text{He}$, random $\text{N}_2$, that, $\text{H}_2\text{O}$, whatever... $\text{H}_2\text{O}$ must be right because the two and $\text{H}_2\text{O}$ are on boundaries.