SOLUTIONS

Chem B REVIEW SHEET
Unit 8: Chapters 13 & 14

Unit 8 Objectives:

CHAPTER 13

1. Be able to describe the three assumptions of the kinetic theory
2. Explain how kinetic theory explains gas pressure
3. Convert between units of pressure
4. Explain the relationship between the temperature in kelvins and the average kinetic energy of particles
5. Identify the factors that determine the physical properties of solids.
6. Explain the relationship between evaporation and kinetic energy
7. Explain the relationship between a liquid's vapor pressure and boiling point
8. Compare and contrast the structural organization of crystal systems and non-crystalline solids
9. Identify the states of matter, the triple point, the normal boiling point and normal freezing point when given a phase diagram of a substance
10. Determine what state(s) of matter a substance will be in when given a specific temperature and pressure.

CHAPTER 14

1. Explain why gases are easier to compress than solids or liquids are.
2. Describe the three factors that affect gas pressure.
3. Describe the relationships among the temperature, pressure and volume of a gas.
4. Depict the relationship between volume and temperature, between temperature and pressure and between volume and pressure of a gas graphically.
5. Be able to use the three gas laws to determine mathematically how the volume, pressure and/or temperature of a gas is changed when a change to the system is made.
6. Calculate the amount of a contained gas when the pressure, volume and temperature are specified.
7. Determine the conditions under which real gases are most likely to differ from real gases.
8. Relate the total pressure of a mixture of gases to the partial pressures of the component gases.
9. Explain how the molar mass of a gas affects the rate at which the gas diffuses.

Part I: Kinetic Theory and Gases

- Read 13.1, HW: 1, 2, 4, 8, 31, 32, 37, 38

1) What are the three assumptions that kinetic theory makes about the properties of gases?
   - ~~Move randomly~~
   - Gas molecules have insignificant volume
   - Gas molecules are constantly moving and colliding w/ each other and the walls.
   - Gas molecules have elastic collisions.
   - Temp depends on ave. KE of molecules.

2) Convert 892 mmHg to atm and to kPa:

$$\frac{892 \text{ mmHg}}{} \Big| \frac{1 \text{ atm}}{760 \text{ mmHg}} = \boxed{1.17 \text{ atm}}$$

$$\frac{892 \text{ mmHg}}{} \Big| \frac{101.3 \text{ kPa}}{760 \text{ mmHg}} = \boxed{119 \text{ kPa}}$$

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Standard pressure : 1 atm = 101.3 kPa
Standard temp : 0°c = 273 K

3) List the various units used to measure pressure and temperature.
   a. Pressure units: atm, kPa, mmHg
   b. Temperature units: °F, °c, K
   c. Some equations/laws require us to use particular units. For example, we have to use Kelvins when working with the gas laws. Why is this?

When working with Gay Lussac's law, we need to have a way to measure temperature without using (–) numbers. This is needed because the is no such thing as (–) pressure. So if $T_1 = 10°c = 283\ K$, $P_1 = 1\ atm$, $T_2 = -10°c = 27?$, $P_2 = ?$

w/ °c
(1) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $P_2 = \frac{T_2 P_1}{T_1} = \frac{10(1)}{-10} = -1\ atm$

(2) w/ K $P_2 = \frac{283(1)}{273} \approx 1.05\ atm$

Part II: The Nature of Liquids and Solids

- Read 13.2-13.3, HW: Figure 13.9, 22, 24

4) A. Compare the average kinetic energy of a glass water bottle and the average kinetic energy of the liquid water *in* the bottle. (i.e. Do they have the same ave KE or are they different?)

They are the same if the substances are at the same temperature b/c ave KE ∝ T.

B. Why do we see a difference in phases if they are at the same temperature? What factor dictates the phase of a substance?

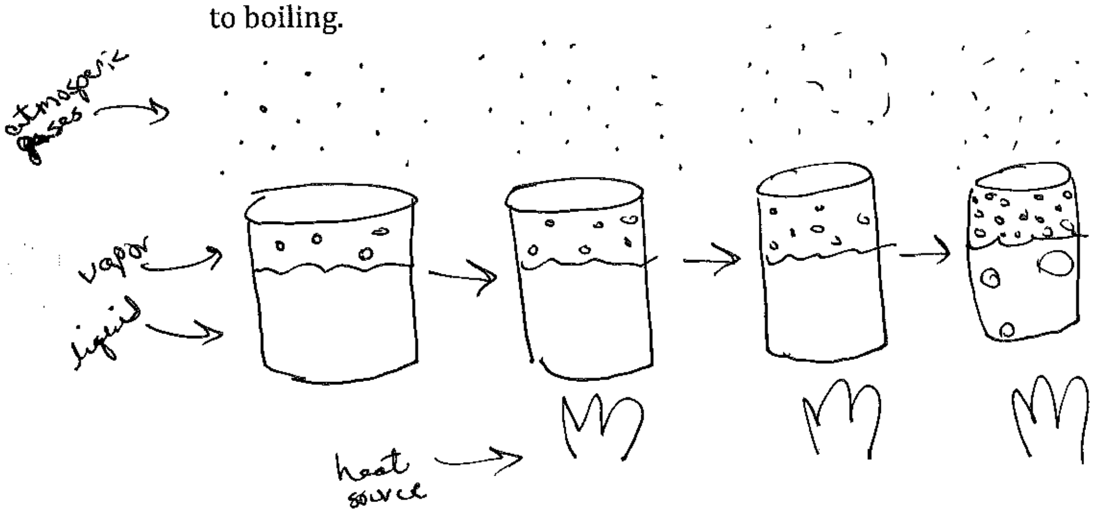
IMFs and types of bonding of the substance.

↑ IMFs will cause orderliness of substance to increase (more tightly held together).

5) Arrange the states of matter with respect to their orderliness:

Solids > liquids > gases
lowest KE — highest KE

6) Draw a series of pictures (from memory if possible!) to show the process of heating a liquid to boiling.



BP is the temperature at which the vapor pressure (pressure exerted by gas above the liquid) is equal to OR greater than the air pressure above the liquid... BUBBLES of substance's vapor escaping from solution! :)

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7) Is the boiling point of water at the top of Mount McKinley (the highest point in North America) higher or lower than it is in Death Valley (the lowest point in North America)? **(Lower… but why?)**

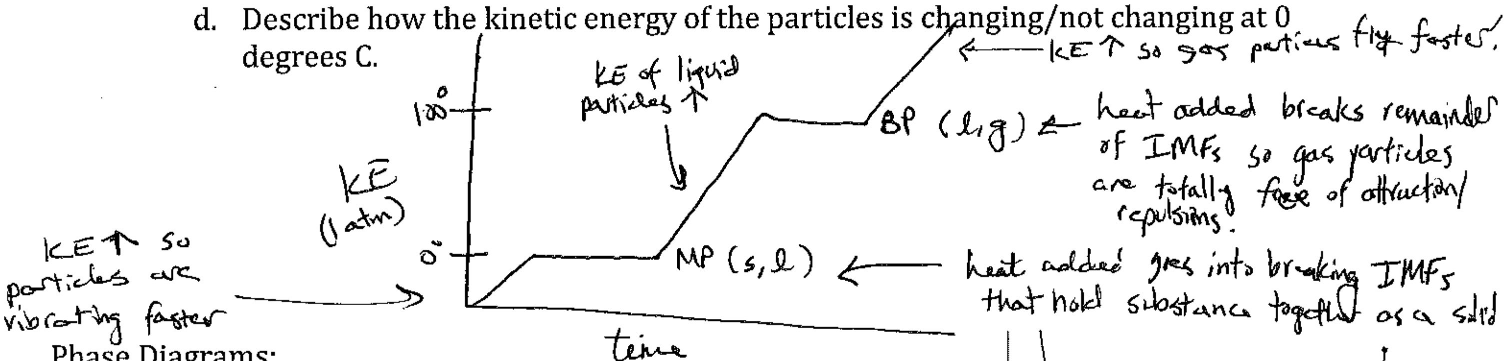
As altitude ↑, atmospheric pressure ↓ so less vapor pressure is needed for VP = AP and boiling to occur. Thus, the temp. at which water boils will be lower on top of a mountain than at/below sea level.

Part III: Changes of State

- Read 13.4, HW: Figure 13.18 (a, b, c and d), 28, 54

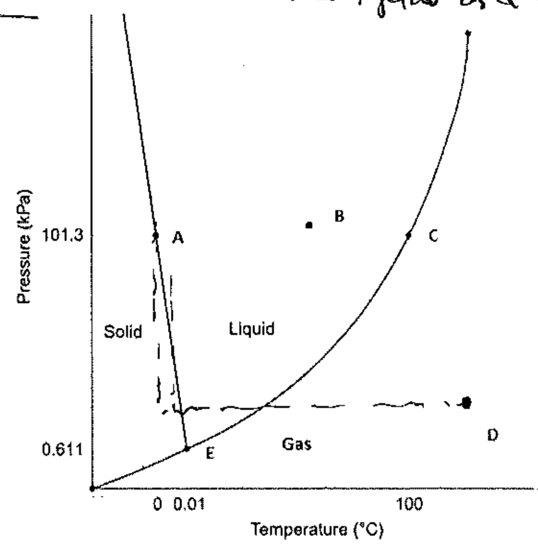
Heating Curves

8) Draw a heating curve for water and label the diagram with (Hint: axes should be labelled as Kinetic Energy vs. Time/heating):
   a. Melting point : 0°C at 1 atm
   b. Boiling point : 100°C at 1 atm
   c. Describe how the kinetic energy of the particles is changing/not changing from -50 degrees C to 0 degrees C.
   d. Describe how the kinetic energy of the particles is changing/not changing at 0 degrees C.



Phase Diagrams:

9) What phases are present at:
   e. Point A: s, l
   f. Point B: l
   g. Point C: l, g
   h. Point D: g
   i. Point E: s, l, g



10) Given that your substance is under the conditions of Point D, what changes need to made to the system in order to bring that substance to:
   j. Point A: ↓T and ↑P
   k. Point B: ↓T and ↑P
   l. Point E: ↓T and ↓P

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Part IV: Properties of gases and gas laws

- Read: 14.1-14.2, HW: 2, 4, 9, 10, 12, 14-16

1) List the four variables that affect gas behavior and their units of measure. (hint-ideal gas equation)

P : atm, kPa
V : L, dm^3
T : K
n : mol

$R = 8.31 \frac{kPa \cdot L}{mol \cdot K} = 0.082 \frac{atm \cdot L}{mol \cdot K}$

2) For the following, indicate what change will happen to the 2nd variable given the change seen in the first: *(assuming the other two variables remain constant)*

P ↑, T ↑ (KE more ~~collisions~~ will lead to more collisions)

T ↓, V ↓ (less KE leads to fewer collisions leads to smaller size)

P ↓, V ↑ (fewer collisions leads to smaller size)

n ↑, V ↑ (think of blowing up a balloon. ↑ air in balloon ↑ size of balloon)

3) Describe what changes are occurring to the gas in the following scenarios using the gas laws we have talked about this week:

a. **Egg demo**: An hardboiled egg is set on top of a flask with cooling water vapor inside. Why does the egg end up *inside* the container?

b. **Marshmallow syringe demo**: A marshmallow in a depressed, capped syringe will decrease in size when the syringe piston is pulled back. Why does that happen?

c. **Flip a lid demo**: A piece of dry ice is put into a film canister and the lid is shut. Explain why the lid pops off violently soon after.

d. **Cartesian diver demo**: A diver is trying to catch the treasure at the bottom. To accomplish this, you squeeze the pop bottle and the diver goes down. The diver has an air bubble in it. What happens to the volume of the bubble as you apply pressure? Why does the diver go down as pressure is applied?

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4) A bag of potato chips is packaged at sea level (1.00 atm) and has a volume of 315 mL. If this bag of chips is transported to Denver (0.775 atm), what will the new volume of the bag be? **406 mL**

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$ ΔV; ΔP $V_2 = \frac{P_1V_1}{P_2} = \frac{(1\ atm)(0.315\ L)}{(0.775\ atm)} = 0.406\ L$

$P_1 = 1\ atm$ $P_2 = 0.775\ atm$
$V_1 = 0.315\ L$ $V_2 = ?$

$V_2 = 406\ mL$

5) A child has a toy balloon with a volume of 1.80 liters. The temperature of the balloon when it was filled was 20⁰ C and the pressure was 1.00 atm. If the child were to let go of the balloon and it rose 3 kilometers into the sky where the pressure is 0.667 atm and the temperature is -10⁰ C, what would the new volume of the balloon be? **2.42 L**

ΔP ΔT ΔV

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$

$P_1 = 1\ atm$
$V_1 = 1.8\ L$
$T_1 = 20+273\ K = 293\ K$
$P_2 = 0.667\ atm$
$T_2 = -10+273\ K = 263\ K$
$V_2 = ?$

$\frac{P_1V_1T_2}{T_1P_2} = V_2$

$V_2 = \frac{(1\ atm)(1.8\ L)(263\ K)}{(293\ K)(0.667\ atm)}$

$V_2 = 2.42\ L$

Part V: Ideal Gases

- Read: 14.3, HW: 26, 27, 28, 31

6) At 34°C, the pressure inside a nitrogen-filled tennis ball with a volume of 0.148 L is 212 kPa. How many moles of nitrogen gas are in the tennis ball? **0.00123 mol N_2** ← error

no Δ occuring - use Ideal Gas equation!

use R=8.31

$PV=nRT$ $n = \frac{PV}{RT} = \frac{(0.148\ L)(212\ kPa)}{(8.31\ \frac{kPa \cdot L}{mol \cdot K})(34+273\ K)} = 0.110\ mol\ N_2$

7) Calcium carbonate decomposes at high temperatures to form carbon dioxide and calcium oxide. The lab conditions are 99.5 kpa and 50 degrees C.

$$CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}$$

How many grams of calcium carbonate will I need to form 0.53 liters of carbon dioxide?

1) Use PV=nRT to determine # mols CO_2 at these conditions

$n = \frac{(99.5\ kPa)(0.53\ L)}{(8.31\ \frac{kPa \cdot L}{mol\ K})(50+273\ K)} = 0.0196\ mol\ CO_2$

2) Use stoichiometry to determine g_{CaCO_3} needed to make this # mols CO_2

$\frac{0.0196\ mol\ CO_2}{} \times \frac{1\ mol\ CaCO_3}{1\ mol\ CO_2} \times \frac{100.24\ g\ CaCO_3}{1\ mol\ CaCO_3} = 1.18\ g$

8) How is a real gas different from an ideal gas? Under what conditions do real gases tend to behave differently from the assumptions of the ideal gas law?

Real gases do experience:

1) attractions/repulsions: at low T, the molecules will stick together and become liquids!
2) Have volume: at high P, molecules do take up a lot of space!

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Part VI: Gases: Mixtures and Movements

- Read: 14.4, HW: 37, 38, 39, 45

9) If I place 3 moles of N_2 and 4 moles of O_2 in a 35 L container at a temperature of 25^0 C, what will the pressure of the resulting mixture of gases be? (hint: use the ideal gas equation)

4.88 atm or 494.5 kPa (hint: Boyle & Dalton)

n = 3 + 4 mol
V = 35 L
T = 298 K
P = ?

$P_{total} = \frac{nRT}{V} = \frac{(7\ mol)(8.31\ \frac{kPa \cdot L}{mol \cdot K})(298\ K)}{35\ L}$

= 495 kPa = 500 kPa (1 sig fig)

10) What's the partial pressure of carbon dioxide in a container that holds 5 moles of carbon dioxide, 3 moles of nitrogen, and 1 mole of hydrogen and has a total pressure of 1.05 atm?
0.583 atm

$P_{total} = 1.05$ atm

Of the 9 moles present: 5 mols CO_2, 3 mol N_2, 1 mol H_2

$P_{CO_2} = P_{total}\left(\frac{5\ mol}{9\ mol}\right) = 1.05\left(\frac{5}{9}\right) = 0.58$ atm

$P_{N_2} = P_{total}\left(\frac{3\ mol\ N_2}{9\ mol\ total}\right) = 1.05(3/9) = 0.35$ atm

$P_{H_2} = P_{total}\left(\frac{1\ mol\ H_2}{9\ mol\ total}\right) = 1.05(1/9) = 0.12$ atm

∴ 9 parts can be divided among the 3 gases

11) ~~Oxygen and chlorine~~ gas are mixed in a container with partial pressures of 351 mm Hg and 0.783 atm, respectively. What is the total pressure inside the container in kPa (ans. 126 kPa,)

$P_{O_2} = \frac{351\ mmHg \times 101.3\ kPa}{760\ mmHg} = 46.8$ kPa

$P_{Cl_2} = \frac{0.783\ atm \times 101.3\ kPa}{1\ atm} = 79.3$ kPa

$P_{total} = 46.8\ kPa + 79.3\ kPa = 126.1\ kPa$

12) What is the ratio of the speed of carbon dioxide gas molecules to that of oxygen gas when both gases are at the same temperature? (ans. 1.2)

$\frac{rate_{light}}{rate_{heavy}} = \sqrt{\frac{MM_{heavy}}{MM_{light}}}$ ∴ $\frac{rate_{O_2}}{rate_{CO_2}} = \sqrt{\frac{44\ g/mol\ CO_2}{32\ g/mol\ O_2}} = \sqrt{\frac{11}{8}} = 1.17$

∴ O_2 travels 1.17x faster than CO_2

13) What is the ratio of the speed of Helium gas and ammonia gas in a sealed container at standard temperature and pressure?

$\frac{rate_{He}}{rate_{NH_3}} = \sqrt{\frac{MM_{NH_3}}{MM_{He}}} = \sqrt{\frac{17\ g/mol\ NH_3}{4\ g/mol\ He}} = 2.06$

∴ At the same temp, He ~~gas~~ gaseous atoms will travel 2.06x faster through the air than gaseous NH_3 molecules