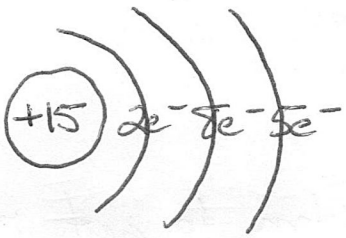
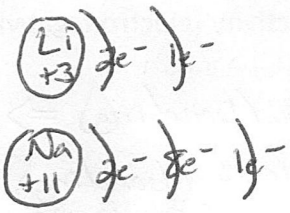
2nd Semester Chemistry Review Packet

1) Draw the Bohr model for Phosphorous. Identify the following values using your model:
   a. Number and location of valence electrons / valence shell
   b. Number of shielding electrons 10
   c. Nuclear charge +15
   d. Effective nuclear charge +5 (+15 − 10 = +5)
   e. Full electron configuration $1s^2 2s^2 2p^6 3s^2 3p^3$

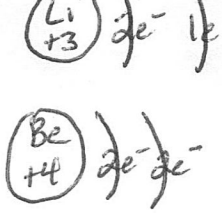


2) Explain why atomic radius:
   a. Increases down a group.
   b. Decreases across a period.

a) Add energy levels as you go down a group. Effective nuclear charge stays the same



b) Increase nuclear charge, pulling e⁻ in tighter (increased effective nuclear charge). Energy levels stay the same.



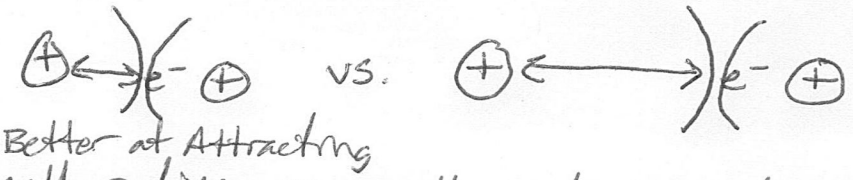
3) What are electronegativity and ionization energy measurements of?

Electronegativity - A measure of an atom's ability to attract the valence e⁻ of another atom.

Ionization Energy - the energy required to remove a valence electron from an atom.

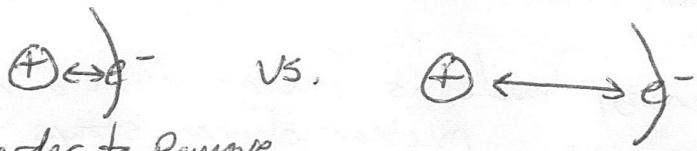
4) Why do atoms with smaller radii exhibit:
   a. Higher electronegativity.
   b. Higher ionization energy.

a) Small radius allows the atom to get its nucleus closer to the e⁻ it is trying to attract.



Better at Attracting

b) Small radius means the atom's valence e⁻ are closer to the nucleus, increasing attractive force



Harder to Remove

5) Choose and explain. Which is a better indicator of reactivity (electronegativity or ionization energy) for:
   a. Metals : give e⁻ during reactions (bonding) => ionization energy
   b. Non-Metals : take e⁻ during reactions (bonding) => electronegativity

6) Explain how electronegativity determines the type of bonds that form between atoms. Be sure to include a discussion on what happens to the electrons in each bond type and why.

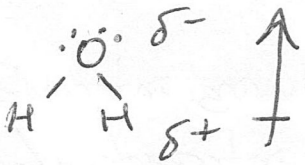
The difference in EN between two bonding atoms determines how the e^- behave in the bond & therefore the type of bond.

ΔEN		
≤ 0.35	= even share =	non-polar covalent
0.36 - 1.7	= uneven sharing =	polar covalent
>1.7	= e^- donation =	ionic

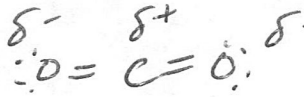
7) How do bonds result in polarity? Give an example of how a molecule made of polar-covalent bonds can still be non-polar over-all.

- Bonds that result in the formation of charges* can cause a molecule to be polar if the charges are unevenly distributed.

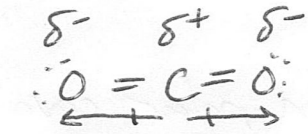
* Ionic (+/-) or Polar Covalent (δ^-/δ^+)



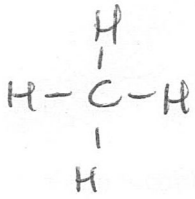
- If the charges are symetrical, the molecule will still be non-polar



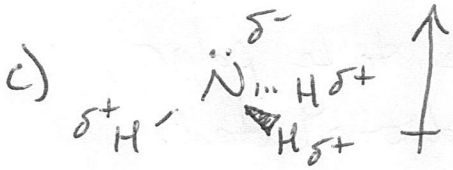
8) Draw a Lewis Dot model for each of the following molecules. Identify whether it is polar or non-polar and give it's geometric shape (linear, bent, trigonal planar, trigonal pyramidal, or tetrahedral)
   a. Carbon Dioxide
   b. Methane (CH_4)
   c. Ammonia (NH_3)
   d. HNO
   e. Boron Trichloride

a) 

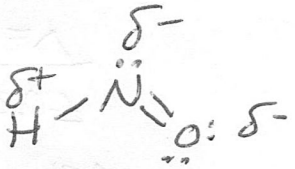
non-polar, linear

b) 

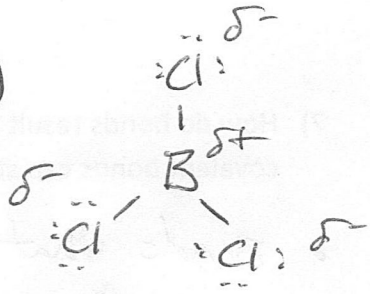
non-polar, tetrahedral

c) 

polar, trigonal pyramidal

d) 

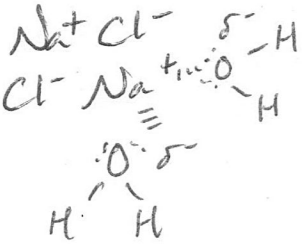
polar, bent

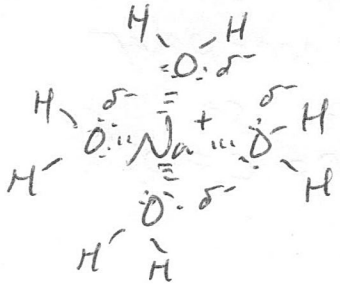
e) 

non-polar, trigonal planar

9) Explain what happens at the molecular level when a solute dissolves in a solvent. Use a diagram to support your answer.

The solute goes from having intermolecular attraction with itself to having intermolecular attraction with the solvent. Ionic salts' individual ions are dissolved, covalent molecules' atoms are not pulled apart, the entire molecule is surrounded by solvent.





10) Explain why polar/polar substances and non-polar/non-polar substances dissolve each other.

Polar/Polar: Dissolves due to opposite charge attraction

Non/Non: Dissolves b/c there is nothing to prevent their mixing

Non/Polar: Do not dissolve b/c they won't mix. All polar molecules will clump together, forcing non-polar into a separate layer.

11) Why do polar and non-polar substances not mix/dissolve? (Because they have different polarities is not good enough)

12) You know that permanent marker doesn't wash off with water. Explain why and hypothesize what type of solvent permanent marker ink is dissolved in.

Water is polar, the permanent marker must be non-polar since they don't mix/dissolve. The water stays clumped/attracted to itself instead of mixing with the marker.

13) What is molarity a measurement of? Write the molarity equation and provide the units for molarity.

Molarity/Concentration = moles of solute per liter of solution

$M = \frac{mol}{L}$

14) Provide a detailed procedure for properly making 500mL of a 0.25M solution of calcium hydroxide.

$0.500\ L\ Ca(OH)_2 \left(\frac{0.25\ mol}{1\ L}\right)\left(\frac{74.10\ g}{1\ mol}\right) = 9.3\ g\ Ca(OH)_2$

1) Weigh & Quantitatively transfer 9.3 g of $Ca(OH)_2$ to a 500 mL volumetric flask.
2) Fill half-way with dH_2O, swirl to dissolve the solute.
3) Fill to the graduated mark with dH_2O
4) Cap, invert to mix

15) How much 1.2M solution could be prepared from 4.52g of lithium bromide?

$4.52\ g\ LiBr \left(\frac{1\ mol}{86.84\ g}\right) = 0.052\ mol\ LiBr \left(\frac{1\ L}{1.2\ mol\ LiBr}\right) = \boxed{0.043\ L}$

16) Provide a detailed procedure for diluting the calcium hydroxide solution in question ~~18~~ 14 to a volume of 50mL and a molarity of 0.01M.

Stock	Dilute
? mL	50 mL
0.25 M	0.01 M

$M_1V_1 = M_2V_2$

$(0.25\ M)V_1 = (0.01\ M)(50\ mL)$

$V_1 = 2.0\ mL$

1) Use a 2.0 mL volumetric pipette to deliver 2 mL of stock solution to a 50 mL volumetric flask.
2-4) Same as #14

17) What would be the final concentration of a 100mL solution prepared using 40mL of a 3.0M sulfuric acid solution? $M_1V_1 = M_2V_2$

$M_1 = 3.0\ M$

$V_1 = 40\ mL$

$M_2 = ?$

$V_2 = 100\ mL$

$(3.0\ M)(40\ mL) = M_2(100\ mL)$

$M_2 = \boxed{1.2\ M}$

18) How much (grams) copper (II) chloride would be needed to produce 15.60g of copper (II) hydroxide if you react copper (II) chloride with excess silver hydroxide? Identify the type of reaction also.

$$CuCl_2\,(aq) + 2AgOH\,(aq) \longrightarrow Cu(OH)_2\,(s) + 2AgCl\,(s)$$

$$15.60\ g\ Cu(OH)_2 \left(\frac{1\ mol\ Cu(OH)_2}{97.57\ g}\right)\left(\frac{1\ mol\ CuCl_2}{1\ mol\ Cu(OH)_2}\right)\left(\frac{134.45\ g}{1\ mol\ CuCl_2}\right) = \boxed{21.50\ g\ CuCl_2}$$

Double Displacement

19) How much (grams) aluminum sulfate would be needed to completely react 8.4g of lithium? Identify the type of reaction also.

$$6Li\,(s) + Al_2(SO_4)_3\,(aq) \longrightarrow 2Al\,(s) + 3Li_2SO_4\,(aq)$$

$$8.4\ g\ Li \left(\frac{1\ mol\ Li}{6.94\ g\ Li}\right)\left(\frac{1\ mol\ Al_2(SO_4)_3}{6\ mol\ Li}\right)\left(\frac{342.14\ g}{1\ mol\ Al_2(SO_4)_3}\right) = \boxed{69\ g\ Al_2(SO_4)_3}$$

Single Displacement

20) What is the limiting reagent during the reaction of 110.0g of oxygen and 35.1g of hexane (C_6H_{14})? Identify the type of reaction also.

$$2C_6H_{14}(l) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(g)$$

$110.0\text{ g } O_2 \left(\frac{1\text{ mol } O_2}{32.0\text{ g}}\right) = \boxed{3.44\text{ mol } O_2 \text{ (Limiting)}}$

$3.44\text{ mol } O_2 \left(\frac{2\text{ mol } C_6H_{14}}{19\text{ mol } O_2}\right) = 0.36\text{ mol } C_6H_{14}$ Need

$35.1\text{ g } C_6H_{14} \left(\frac{1\text{ mol } C_6H_{14}}{86.17\text{ g}}\right) = 0.407\text{ mol } C_6H_{14}$ (Excess)

21) How much (grams) water could you produce from the reaction in question 24?

$$3.44\text{ mol } O_2 \left(\frac{14\text{ mol } H_2O}{19\text{ mol } O_2}\right)\left(\frac{18.02\text{ g}}{1\text{ mol } H_2O}\right) = \boxed{45.7\text{ g } H_2O}$$

22) If 42.9g of water was actually produced by the reaction during your experiment, what is the percent yield and percent error of the experiment?

$$\frac{42.9\text{ g}}{45.7\text{ g}}(100) = 93.9\%\text{ Yield}$$

$$\left|\frac{42.9 - 45.7}{45.7}\right|(100) = 6.1\%\text{ Error}$$

23) What would be the concentration of a 15mL solution of sulfuric acid that was titrated with 40.0mL of 0.24M sodium hydroxide to neutralization? Identify the type of reaction also.

$$0.040\ L_{NaOH}\left(\frac{0.24\ mol\ NaOH}{1\ L}\right)\left(\frac{1\ mol\ OH^-}{1\ mol\ NaOH}\right) = 0.0096\ mol\ OH^-$$

@ neutral $OH^- = H^+$

$$0.0096\ mol\ H^+\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ H^+}\right) = 0.0048\ mol\ H_2SO_4$$

$$[H_2SO_4] = \frac{mol}{L} = \frac{0.0048\ mol}{0.015\ L} = \boxed{0.032\ M\ H_2SO_4}$$

24) What is pH a measurement of and why is a pH of 7 considered neutral?

pH is a measurement of the amount of H^+ in solution. A pH of 7 = neutral, >7 = basic, <7 = acidic.

25) Explain the difference between a strong and a weak acid.

- A strong acid completely dissociates in solution
  - 100 out of 100 split into ions (donates all H^+ into solution)
- A weak acid does not completely dissociate
  - 1 out of 100 split into ions (donates less H^+ into solution)

26) Calculate the pH of a 100mL solution containing 3.02g of hydrobromic acid.

$$3.02\ g\ HBr\left(\frac{1\ mol\ HBr}{80.91\ g}\right)\left(\frac{1\ mol\ H^+}{1\ mol\ HBr}\right) = 0.0373\ mol\ H^+$$

$$[H^+] = \frac{mol}{L} = \frac{0.0373\ mol\ H^+}{0.100\ L} = 0.373\ M\ H^+$$

$$pH = -\log[H^+] = -\log(0.373) = \boxed{0.43}$$

27) Calculate the concentration of hydronium ions in a 1.3M solution of nitric acid.

$$1.3\ M\ HNO_3 = \frac{1.3\ mol\ HNO_3}{1\ L}\left(\frac{1\ mol\ H^+}{1\ mol\ HNO_3}\right) = \frac{1.3\ mol\ H^+}{1\ L}$$

$$= \boxed{1.3\ M\ H^+}$$

28) Would a mixture of 20mL of 1.2M sulfuric acid and 20mL of 1.0M barium hydroxide be neutral? Support with a calculation of the final pH of the mixture.

$$0.020\ L\ H_2SO_4\left(\frac{1.2\ mol\ H_2SO_4}{1\ L}\right)\left(\frac{2\ mol\ H^+}{1\ mol\ H_2SO_4}\right) = 0.048\ mol\ H^+$$

$$0.020\ L\ Ba(OH)_2\left(\frac{1.0\ mol\ Ba(OH)_2}{1\ L}\right)\left(\frac{2\ mol\ OH^-}{1\ mol\ Ba(OH)_2}\right) = 0.040\ mol\ OH^-$$

0.048 mol H^+ (have)
0.040 mol H^+ (used)
0.008 mol H^+ excess

$$[H^+] = \frac{mol}{L} = \frac{0.008\ mol}{0.040\ L} = 0.2\ M$$

$$pH = -\log[H^+] = -\log(0.2) = \boxed{0.70}$$

29) Identify the type of reaction and write out a complete equation for each reaction. If no reaction occurs, write No Rxn on the product side.

a. Calcium nitrate reacts with sodium hydroxide.

$$Ca(NO_3)_2\ (aq) + 2NaOH\ (aq) \longrightarrow 2NaNO_3\ (aq) + Ca(OH)_2\ (s)$$

Double Displacement

b. Magnesium sulfate reacts with copper.

$$MgSO_4\ (aq) + Cu\ (s) \longrightarrow \text{No Rxn}$$

single Displacement

c. Carbonic acid produces carbon dioxide and water.

$$H_2CO_3\ (aq) \longrightarrow CO_2\ (g) + H_2O\ (l)$$

Decomposition

d. Carbon dioxide and water produce glucose ($C_6H_{12}O_6$).

$$6CO_2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(s) + 6O_2(g)$$

Synthesis

e. Barium reacts with zinc phosphate.

$$3Ba(s) + Zn_3(PO_4)_2(aq) \longrightarrow Ba_3(PO_4)_2(s) + 3Zn(s)$$

single Displacement

f. Propane (C_3H_8) is burned.

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$

Combustion

g. Potassium nitrate reacts with magnesium acetate.

$$KNO_3(aq) + Mg(C_2H_3O_2)_2(aq) \longrightarrow \text{No Rxn}$$

(both products are aq)

30) Write the complete ionic equation to prove whether or not a reaction occurs during the combination of ammonium phosphate and zinc chloride.

$$2(NH_4)_3PO_4(aq) + 3ZnCl_2(aq) \longrightarrow 6NH_4Cl(aq) + Zn_3(PO_4)_2(s)$$

$$6NH_4^+(aq) + 2PO_4^{3-}(aq) + 3Zn^{2+}(aq) + 6Cl^-(aq) \longrightarrow 6NH_4^+(aq) + 6Cl^-(aq) + Zn_3(PO_4)_2(s)$$

$$3Zn^{2+}(aq) + 2PO_4^{3-}(aq) \longrightarrow Zn_3(PO_4)_2(s)$$

Yes, new solid is formed

31) What does it mean when all of the species (on the reactant and product side) in a total ionic equation are aqueous?

No reaction occured. All reactants were spectators, no new product (solid/liquid/gas) was created.

32) What is a spectator ion?

An ion that does not change from the reactant to product side and is therefore not part of the reaction.

33) Discuss the 3 aspects of the Kinetic Molecular Theory.

1) All molecules/particles are in constant motion

2) Gas particles feel no attraction to each other

3) The particles are constantly colliding with each other & the container, but occupy insignificant volume.

34) Explain why the following gas relationships occur:

a. When temperature decreases inside a flexible container, volume decreases

↓T = weaker/fewer collisions & gas does not expand the walls of the container as much = ↓V

b. When temperature increases inside a rigid container, pressure increases

↑T = stronger/frequent collisions with container wall = ↑P

c. When moles of gas are removed from inside a rigid container, pressure decreases

↓n = fewer collisions with container walls = ↓P

d. When the volume inside a flexible container is decreased, pressure increases

↓V = more frequent collisions with container walls = ↑P

35) How many moles of gas would be found inside a 0.555L container that is experiencing 3.22 atm of pressure at 305K?

$$PV = nRT$$

$$(3.22\ atm)(0.555\ L) = n\left(0.0821\ \frac{atm \cdot L}{mol \cdot K}\right)(305\ K)$$

$$n = \boxed{0.0714\ mol}$$

36) A sample of nitrogen and oxygen gas inside a scuba tank exerts 8.00 atm of pressure on the tank walls at 298K. What pressure does the tank feel under water, where the tank is cooled to 283K?

$$\frac{P_1 \cancel{V_1}}{\cancel{n_1} T_1} = \frac{P_2 \cancel{V_2}}{\cancel{n_2} T_2}$$

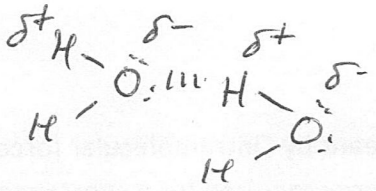
• Volume & moles are held constant

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \frac{8.00\ atm}{298\ K} = \frac{P_2}{283\ K} \qquad P_2 = \boxed{7.60\ atm}$$

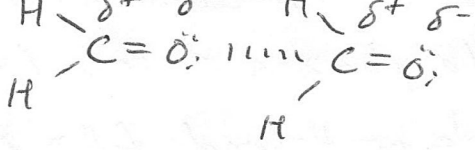
37) List the 4 types of intermolecular forces in order of decreasing strength and provide an example of the attraction in action between two molecules.

Ionic (strongest) $Na^+ \cdots Cl^-$

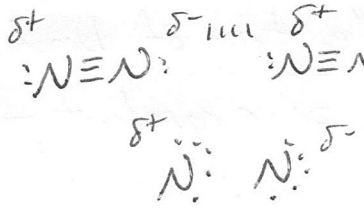
Hydrogen Bonding



Dipole/Dipole



London Dispersion (Weakest)

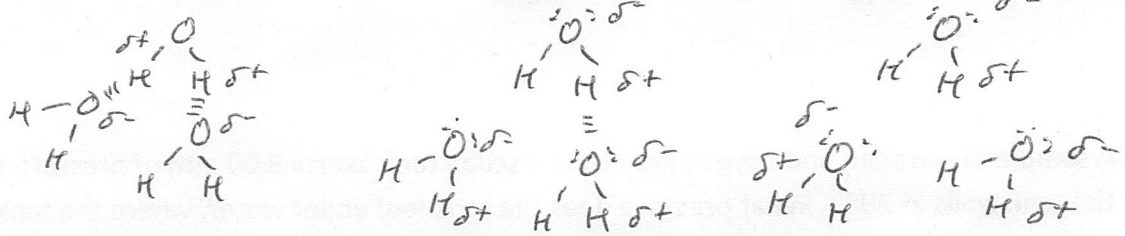


38) In order for a substance to go through a phase change:

a. What forces must be overcome? Draw a molecular diagram of boiling water to support your answer.

Intermolecular Forces

Solid | Liquid (Fewer IMF) | Gas (No IMF left intact)



b. How do you know the heat energy being applied to the substance isn't speeding the molecules up during a phase change?

Temp = KE = energy of motion

- so ↑T = ↑ particle motion

- During a phase change, Temp does <u>not</u> change, so the energy is not going towards changing particle speed

- It is used to break IMF's (see part a)

39) Discuss what is meant by "intramolecular forces determine intermolecular forces, which determine the energy required for a substance to experience a phase change".

The type of Intermolecular force a molecule has depends of the charges it has (no charges = london dispersion, partial = dipole or H-bond, full = ionic) & the charges come from the type of bond holding the atoms together (ionic → full, polar covalent → partial, non-polar covalent → no charges)