Lakehead UNIVERSITY

DEPARTMENT OF CHEMISTRY
Midterm Solutions
Chemistry 1110 (Modern Chemistry I)
3 October, 2012

This is the solution key for the white test. The yellow test answers are indicated when different.

Question 1 Multiple choice, **select 1 answer only**. Do *all 10* questions (2 points each, 20 total; there is no penalty for a wrong guess):

(i) Pressure is,

(a) created by the effect of gas particles colliding with the walls of the container

(c on the yellow test)

(ii) Temperature is,

(d) the average kinetic energy of the molecules in a system

(iii) At the temperature of absolute zero (0K),

(c) an ideal gas has 0 volume

(b on the yellow test)

(iv) If 0.10 mol of H_2 effuses through a hole in a container in 4.6 s, how long will it take 0.10 mol of N_2 to effuse through the same hole?

(c) 17.2

(b on the yellow test)

(v) Gold is isolated from its ore by reaction with cyanide ion,

$$Au\ (s)\ +\ 2\ CN^-\ (aq)\ \rightarrow\ Au(CN)_2^-\ (aq)$$

What amount of ammonium cyanide is required to react with 0.947 g of gold?

(d) 0.424 g

(c on the yellow test)

(vi) What type of reaction is the solublization of gold shown in 1. (v)?

(c) this is a redox reaction

(e on the yellow test)

(vii) A weak electrolyte is,

(b) a material that partially forms ions in solution

(a on the yellow test)

(viii) Gasses are transported in cylinders at high pressure (non-ideal conditions). If the 40.0 L nitrogen tank in my research lab contains 12.0 kg of gas at 20.°C, what is the pressure in the tank? For N_2, the van der Waals constants are a = 1.39 atm L^2 mol^{-2} and b = 0.0391 L mol^{-1}.

c) 283 atm

(d on the yellow test)

(ix) What is its chemical formula of calcium phosphate?

(a) $Ca_3(PO_4)_2$

(d on the yellow test)

(x) What is the correct IUPAC name of $TiCl_3$?

(b) titanium(III) chloride

(a on the yellow test)

2. Answer **1 of the following 2**. If you need more room, use the back of this page. (4 points)

(a) Explain Boyle's Law ($V \propto {}^{1}/_{P}$) using kinetic molecular theory.

Pressure is the effect of particles (molecules or atoms) hitting the walls. If the volume is decreased, the space in which the particles move is smaller, therefore they will hit the walls more often, giving an increase in pressure

(a) Yellow test: Explain Charles's Law.

If temperature is the average kinetic energy (and therefore speed for a given molecule), as temperature goes up the speed goes up. If the particles were confined to a given volume, as the temperature increased the pressure would have to increase (more collisions with the walls of the container). Therefore, to maintain constant pressure, the volume must get larger so the faster molecules take the same amount of time to reach and hit the walls).

(b) In question 1. (viii) above, it was stated that compressed high pressure cylinders contain gasses at non-ideal conditions. Explain why increasing pressure leads to non-ideality.

As the volume decreases, there are more molecules in a given volume. Because one of the postulates of ideality is that molecules have zero volume, the more densely packed the molecules, the greater the amount of percent space is taken up by the actual volume of the molecule. The second effect is that, the closer the molecules are to each other, the greater their chance of interacting and therefore intermolecule forces (assumed to be 0 in ideal conditions) have a greater effect. In both cases, a posulate of ideality is broken.

3. Answer **1 of the following 2**. If you need more room, use the back of this page. (6 points)

(a) The insecticide DDT ($C_{14}H_9Cl_5$) is made by the following reaction:

$$2\ C_6H_5Cl + HOC_2Cl_3 \rightarrow C_{14}H_9Cl_5 + H_2O$$

700. g of C_6H_5Cl is reacted with 420. g of HOC_2Cl_3 to give 942 g of DDT. What is the percent yield of this reaction?

This is a limiting reagent question and a percent yield question.
molar masses are: C_6H_5Cl = 112.56 g/mol; HOC_2Cl_3 = 147.39g/mol; DDT = 354.48 g/mol
possible amount of DDT if C_6H_5Cl is limiting: (700.g/112.56)*(1/2)*(354.48) = 1102 g
possible amount of DDT if HOC_2Cl_3 is limiting: (700.g/147.39)*(1/1)*(354.48) = 1010 g
Therefore, HOC_2Cl_3 is limiting.
% yield = 942 / 1010 = 93.3%

Yellow test:
possible amount of DDT if C_6H_5Cl is limiting: (400.g/112.56)*(1/2)*(354.48) = 629.9 g
possible amount of DDT if HOC_2Cl_3 is limiting: (700.g/147.39)*(1/1)*(354.48) = 769.6 g
Therefore, C_6H_5Cl is limiting.
% yield = 509 / 629.9 = 80.8%

(b) 2.750 g of sodium hydroxide (NaOH (*s*)) was added to 100.00 mL of aqueous phosphoric acid (H_3PO_4 (*aq*), concentration 0.200 *M*). Assuming the addition of NaOH does not change the volume of the solution, calculate the concentration of excess acid or base left in the solution after the reaction takes place.

Also a limiting reagent question. The molar mass of NaOH is 40.00 g/mol.
mol of base = 2.750/40.00 = 0.06875 mol OH^-
mol of acid = 0.200*0.100*3 = 0.0600 mol H^+ (each H_3PO_4 has three H^+)
therefore, the base is in excess, and there will be 0.06875 - 0.0600 = 0.00875 mol OH^- left
concentration of excess base after reaction = 0.00875/0.100 = 0.0875 mol/L

Yellow test had 1.680 g of NaOH
mol of base = 1.680/40.00 = 0.042 mol OH^-
mol of acid = 0.200*0.100*3 = 0.0600 mol H^+ (each H_3PO_4 has three H^+)
therefore, the acid is in excess, and there will be 0.0600 - 0.042 = 0.018 mol H^+ left
for the triprotic acid, 0.0018 mol H^+ is 0.006 mol of H_3PO_4
concentration of excess acid (H_3PO_4) after reaction = 0.006/0.100 = 0.060 mol/L