Lakehead
UNIVERSITY

2 October, 2013

DEPARTMENT OF CHEMISTRY
Midterm Examination
Chemistry 1110 (Modern Chemistry I)

NOTE: THERE WERE 3 DIFFERENT TESTS SO YOUR ORDER OF QUESTIONS MAY VARY

Question 1 Multiple choice, **select 1 answer only**. Do *all 11* questions (2 points each, 22 total; there is no penalty for a wrong guess):

(i) Boyle's Law relates volume with pressure. Which of the following is true,

(b) $V \alpha {}^{1}/_{P}$

(c) is only true if all other conditions (n and T) are kept constant

(e) both (b) and (c)

(ii) Temperature is,

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

(iii) Absolute zero temperature is,

(b) 0 K

(iv) If 0.10 mol of N_2 effuses through a hole in a container in 34.8 s, how long will it take 0.10 mol of Ar to effuse through the same hole?

(c) 41.6 s

The rate for N_2 is 0.1/34.8 = 0.0029 mol/s; therefore the rate for Ar will be

$(0.0029)(28.02)^{1/2}/(39.95)^{1/2} = 0.0024$ mol/s

Time for 0.10 mol of Ar to diffuse = 0.10 mol/0.0024 mol/s = 41.6 s

(v) 100.0 g of hematite (Fe_2O_3) was converted to iron by the following reaction,

$$2\ Fe_2O_3\ (s)\ +\ 2\ C\ (s)\ \rightarrow\ 4\ Fe\ (s)\ +\ 3\ CO_2\ (g)$$

If 60.0 g of iron was isolated, what is the percent yield?

(b) 85.8 %

Theoretical yield is,

(100 g Fe_2O_3 / 159.70 g/mol) * (4 mol Fe / 2 mol Fe_2O_3) * (55.85 g/mol) = 69.9 g Fe

Therefore % yield is 60.0/69.9 = 85.8%

(vi) What type of reaction is the conversion of hematite to iron metal (as shown in (v))?

(c) this is a redox reaction

(vii) The vapour pressure of a solvent is the amount of gaseous molecules over an open vessel of the solvent. A 50/50 mixture of benzene and toluene has 46.7 Torr of benzene and 13.5 Torr of toluene at STP. What is the pressure of air over this mixture?

e) 699.8 Torr

The total pressure is 760 Torr, of which 46.7 is benzene and 13.5 is toluene. Therefore, all remaining pressure (760-46.7-13.5 = 699.8 Torr) must be air.

(viii) The van der Waals equation converts the Ideal Gas Law into an empirical law that takes into account non-ideal behaviour. What approximations of ideals gasses are corrected in this equation?

a) molecules are point masses (have themselves 0 volume)

c) molecules have no attractive (or repulsive forces)

d) (a) and (c)

(ix) What is its chemical formula of ammonium sulfate?

(e) $(NH_4)_2SO_4$

(x) What is the correct IUPAC name of La_2O_3?

(b) lanthanum(III) oxide

(xi) A weak electrolyte is,

(b) a material that partially forms ions in solution

2. Balance the following redox equation (3 points).

$$MnO_4^- (aq) + C_2O_4^{2-} (aq) \rightarrow MnO_2 (s) + CO_2 (g)$$

$$3\ e^- + 4\ H^+ + MnO_4^- \rightarrow MnO_2 + 2\ H_2O$$

$$C_2O_4^{2-} \rightarrow 2\ CO_2 + 2\ e^-$$

$$8\ H^+ + 2\ MnO_4^- + 3\ C_2O_4^{2-} \rightarrow 2\ MnO_2 + 4\ H_2O + 6\ CO_2$$

3. Answer **1 of the following 2**. (5 points)

(a) A chemist wants to test the concentration of a commercial peroxide (H_2O_2) solution. He takes a 10.00 mL portion and dilutes it to 500.00 mL. A 25.00 mL portion of the diluted solution has 1.15×10^{-4} mol of H_2O_2. What was the concentration of the original solution?

diluted $[H_2O_2] = 1.15 \times 10^{-4}$ mol / 0.02500 L = 0.00460 mol/L

the concentration in the 500.00 mL flask is the same. The total number of moles (which all came from the original 10.00 mL portion) in the 500.00 mL flask is
mol H_2O_2 = 0.00460 mol/L * 0.50000 L = 0.00230 mol

This is how many moles were in the original 10.00 mL aliquot, therefore the original concentration is:
original $[H_2O_2]$ = 0.00230 mol / 0.01000 L = 0.230 mol/L

(b) A chemist mixes 25.00 mL of an unknown HCl solution with 10.00 mL of NaOH solution. She determines that the resulting solution (after mixing) has a pH of 2.041. The NaOH solution is known to have a molarity of 0.01322 mol/L. What was the concentration of the original HCl solution?

The original amount of HCl will equal the amount left (found by solving from the pH) and the amount consumed by the base (equal to the amount of OH^- added).

consumed H^+ = amount of OH^- = 0.01322 mol/L * 0.01000 L = 1.322×10^{-4} mol

$[H^+]$ left = $10^{-pH} = 10^{-2.041} = 9.10 \times 10^{-3}$ mol/L (this is the correct s.f. for a log operation!)
moles of H^+ left = 9.10×10^{-3} mol/L * 0.03500 L = 3.18×10^{-4} mol

total original moles $H^+ = 1.322 \times 10^{-4}$ mol + 3.18×10^{-4} mol = 4.51×10^{-4} mol
therefore, original [H+] = 4.51×10^{-4} mol / 0.02500 L = 0.0180 mol/L