CHM 1311 **Supplemental Exam** **Feb 18- 2009**

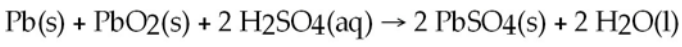
(Prof. Sandro Gambarotta)

Your Name: _____ Student #: _____

time: 3hours

1. You **MUST DELIVER** the entire booklet (you can take home the scratch paper). The solution key will be posted today on the web.
2. You must respond to all the exercises.
3. Blank pages are at the end.
4. You can keep **ONLY** your textbook but no notes of any kind.
5. No computers are allowed.
6. In order to get partial marks for wrong answers we will need to see your calculations. Summarize them BRIEFLY in the space below the text of the exercise

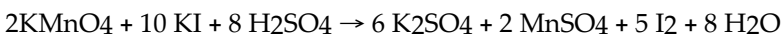
1) The chemical reaction occurring during the discharge of a lead storage battery can be represented by the equation:



$$Pb(s) + PbO_2(s) + 2\ H_2SO_4(aq) \rightarrow 2\ PbSO_4(s) + 2\ H_2O(l)$$

What mass of lead sulfate would result from the complete reaction of 41.4 g of lead?

2) Given the reaction:



$$2KMnO_4 + 10\ KI + 8\ H_2SO_4 \rightarrow 6\ K_2SO_4 + 2\ MnSO_4 + 5\ I_2 + 8\ H_2O$$

How many moles of H_2SO_4 are required to produce 2.0 moles of I_2, given the other reactants are in excess?

3) To measure the volume of an irregularly shaped container filled with water, 1.00 mL of 2.00 M potassium chloride solution is added. After stirring, a 5.00 mL sample was found to contain 2.54×10^{-2} mg of potassium ion. What is the volume of the container?

4) 42.6 g Cu are combined with 84.0 g of HNO_3 according to the reaction:

$$3\ Cu + 8\ HNO_3 \rightarrow 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O.$$

Which reagent is limiting and how many grams of $Cu(NO_3)_2$ are produced?

5) Balance the following equation in basic solution and give the sum of the coefficients:

$$Br_2 + Mn^{2+} \rightarrow MnO_2 + Br^-$$

6) What volume of 0.110 M H_2SO_4 is required to exactly neutralize 10.0 mL of 0.085 M NaOH?

7) A 0.411 g sample of powdered copper mixed with an inert, soluble additive was fully consumed by 23.4 mL of 0.602 M nitric acid, producing copper(II) nitrate, water and nitric oxide (NO) gas. What was the percent copper (by mass) in the sample?

$$3\ Cu + 8\ HNO_3 \rightarrow 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$$

8) A 5.00 L container of unknown gas at 25.0 °C has a pressure of 2.45 atm. The mass of the gas is 32.1 g. What gas is in the container?

SO_2 NO_2 SO_3 F_2 Cl_2

9) A 1.37 L vessel contains He at a temperature of 24.5 °C and a pressure of 205 mmHg. A 721 mL vessel contains Ne at a temperature of 36.2 °C and a pressure of 0.185 atm. Both of these gases are placed in a 2.00 L vessel at 302 K. What is the final pressure (in atm) in the 2.00 L vessel?

10) How much work, in joules, is done when the pressure is suddenly released from 4.56 atm to 1.25 atm on 45.4 g of O_2 at 45 °C?

11) Using the heat of combustion of methanol as –726.6 kJ and the following data:

$C(graph) + 1/2O_2 \rightarrow CO(g)$ $\Delta H° = -110.5$ kJ

$C(graph) + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -393.5$ kJ

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -285.8$ kJ

Determine $\Delta H°$ for the following reaction:

$CO(g) + 2\ H_2(g) \rightarrow CH_3OH(l)$

12) Calculate $\triangle H^{o}f$ of octane, $C_8H_{18}(l)$, given the enthalpy of combustion of octane to $CO_2(g)$ and $H_2O(l)$, −5471 kJ/mol, and the standard enthalpies of formation of $CO_2(g)$ and $H_2O(l)$, −393.5 kJ/mol and −285.8 kJ/mol, respectively.

13) What is the wavelength of a bullet that is 0.450 g traveling at 2000. m/s?

14) What is the orbital designation for the quantum numbers $n = 2$, $l = 1$?

15) Which one of the following set of quantum numbers would not be allowed?

A) $n = 3$, $\ell = 2$, $m\ell = -1$

B) $n = 3$, $\ell = 2$, $m\ell = 1$

C) $n = 3$, $\ell = 1$, $m\ell = -1$

D) $n = 3$, $\ell = 0$, $m\ell = 0$

E) $n = 3$, $\ell = 3$, $m\ell = 1$

16) Choose the groups of molecules below in which all the molecules have a net dipole moment.

A) $SiHCl_3$, O_2, H_2O

B) HF, H_2O, N_2

C) CCl_4, HCl, NH_3

D) HF, $H_2C{=}CH_2$, H_2O

E) HF, CH_3Cl, H_2O

17) Draw the Lewis dot formulae for CO, NO and CH_2PH_3

18) According to principles of VSEPR theory specify the electron pair geometry and hybridization for the species $AsCl_5^{2-}$

19) For $BeCl_2$, the dipole moment of the molecule, hybridization on the central atom, and number of lone pairs on the central atom are:
   A) away from Be, sp^2, one
   B) toward Be, sp, one
   C) toward Be, sp^2, none
   D) none, sp^3, two
   E) none, sp, none

20) Choose the *INCORRECT* statement about NH_4^+.
   A) The hybridization of N is sp^3.
   B) There are two σ bonds.
   C) There is one lone pair of electrons on N.
   D) There are no π bonds.
   E) The molecule is tetrahedral.

21) According to the molecular orbital (M.O.) theory, when two oxygen atoms bond together, their 2*p* orbitals combine to form:
   A) two sigma M.O.'s and two pi M.O.'s
   B) four pi M.O.'s only
   C) one sigma and one pi M.O.
   D) two sigma M.O.'s and four pi M.O.'s
   E) none of these

22) The octahedral hybrid configuration is composed of which orbital combination?

A) sp^3d^2 B) spd^2 C) sp^2d^3 D) sp^3d E) sp^3

23) For the reaction: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ the rate law is:

$$\frac{\Delta[O_2]}{\Delta t} = k[N_2O_5]$$

At 300 K, the half–life is 2.50×10^4 seconds and the activation energy is 103.3 kJ/mol O_2. At the time when N_2O_5 is being consumed at a rate of 1.2×10^{-4} M/s, what is the rate at which NO_2 is being formed?

24) The reaction A + B → C + D is second order in A and zero order in B. The value of *k* is 0.012 M^{-1} min^{-1}. What is the rate of this reaction when [A] = 0.125 M and [B] = 0.435 M?

25) What is the rate law for the following mechanism?

$N_2O + NO \rightarrow N_2ONO^*$ (S)

$N_2ONO^* \rightarrow N_2 + NO_2$ (F)

A) Rate = $k[N_2O][NO]$
B) Rate = $k[N_2][NO_2]$
C) Rate = $k[N_2ONO]$
D) Rate = $k[NO]$
E) Rate = $k[N_2O]$

26) For the reaction: $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$ concentration – time data are:

t(s)	$[NO_2]$	$\log[NO_2]$	$\frac{1}{[NO_2]}$
0.00	2.000	.300	.500
0.40	1.467	.166	.682
0.80	1.076	.032	.929
1.20	.789	–.103	1.267
1.60	.579	–.237	1.727
2.00	.424	–.373	2.358

What is the order of the reaction with respect to $[NO_2]$?

A) zero
B) first
C) third
D) second
E) none of these

27) Consider the following equation:

$N_2O_4(g) \Leftrightarrow 2\ NO_2(g)$ $K_c = 5.8 \times 10^{-3}$

If the initial concentration of $N_2O_4(g)$ = 0.040 M and the initial concentration of $NO_2(g)$ is 0 M, what is the equilibrium concentration of $N_2O_4(g)$?

A) 1.9×10^{-2} M
B) 3.3×10^{-2} M
C) 2.6×10^{-2} M
D) 2.3×10^{-6} M
E) 1.7×10^{-2} M

28) 0.272 g of a monoprotic solid acid (mw = 189 g/mol) is dissolved in water to produce 25.0 mL of a solution with pH = 4.93. Determine the ionization constant of the acid.

A) 4.1×10^{-8}
B) 2.4×10^{-9}
C) 2.8×10^{-7}
D) 1.4×10^{-10}
E) 2.1×10^{-4}

29) What is the pH of a 0.253 M solution of ammonium chloride? $K_b = 1.2 \times 10^{-5}$

A) 2.7 B) 11.3 C) 9.1 D) 4.9 E) 9.9

30) In 0.100 M $HC_2H_3O_2(aq)$, $[H_3O^+(aq)] = [C_2H_3O_2^-(aq)] = 1.3 \times 10^{-3}$ M. If a few drops of concentrated HCl(aq) are added to this solution, the $C_2H_3O_2^-(aq)$ concentration is

A) $= 1.3 \times 10^{-3}$ M. B) $< 1.3 \times 10^{-3}$ M. C) 0.100 M. D) $> 1.3 \times 10^{-3}$ M.

31) Calculate the pH of a 1.00 L solution of 0.100 M $NH_3(aq)$ after the addition of 0.010 mol $NH_4Cl(s)$. For NH_3, $pK_b = 4.74$.

A) 9.26 B) 8.26 C) 10.26 D) 11.56

32) A solution has $[HC_7H_5O_2] = 0.100$ M and $[Ca(C_7H_5O_2)_2] = 0.200$ M. $K_a = 6.3 \times 10^{-5}$ for $HC_7H_5O_2$. The solution volume is 5.00 L. What is the pH of the solution after 10.00 ml of 5.00 M NaOH is added?

Solution keys

1. (gr Pb/ Mw Pb) x 2 x Mw($PbSO_4$) = 121 g

2. moles of I_2 = 2 x 8/5 = 3.2

3. The molarity of the solution in the container after the addition of the solution of KCl is

   5mL x M / 1000 = Moles KCl = 2.54exp(-5)/39
   M = 1.30exp(-4)

   Total amount of K present in the container is :

   1mL x 2M / 1000 = 1.30exp(-4) x V / 1000

   V = 15.4 L

4. moles of Cu available = 42.6/63.5 = 0.67
   Moles of HNO_3 available 84/63 = 1.333
   Stoichiometry ratio must be 3/8 HNO_3 is the limiting reagent

   gr $Cu(NO_3)_2$ = 187.5 x moles moles = moles HNO_3 /8 x 3 = 1.333/8 x 3

   gr = 93.8

5. $4OH^-$ + Br_2 + Mn^{2+} -----→ MnO_2 + $2Br^-$ + $2H_2O$ total coeff = 11

6. moles H_2SO_4 = moles NaOH / 2

   2 V x 0.110 = 10 x 0.085 V = 3.9 mL

7. moles HNO_3 = 23.4 x 0.601 / 1000 = 0.0140

   Moles Cu = moles HNO_3 x 3/8 = 0.00527

gr Cu = 0.00527 x 63.5 = 0.334 81.4%

8. moles gas = PV / RT = 0.5 Mw = gr /moles = 64.2

SO_2 is the only possibility

9. Mole He = 1.37 x 2.05/760 / 0.082 / 297.5 = = 0.0151

Moles Ne = 721/1000 x 0.185 / 0.082 / 309.2 = 0.00526

Total mole = moleHe + mole Ne = PV/RT from which P = 0.253 atm

10. Using PV = nRT calculate the V at the initial conditions = 8.11 L
Work = V ΔP x 101.3 (conversion factor for joules) = -2.73 10^3

11.

$CO_2 + 2H_2O \rightarrow CH_3OH + 3/2\ O_2$ $\Delta H° = +726.6$

$2H_2 + O_2 \rightarrow 2H_2O$ $\Delta H° = -571$

$CO \rightarrow C + ½\ O2$ $\Delta H° = +110.5$

$C + O_2 \rightarrow CO_2$ $\Delta H° = -393.5$

$2H_2 + CO \rightarrow CH_3OH$ $\Delta H° = -128$

12. $C_8H_{18} + 25/2\ O_2 \rightarrow 8CO_2 + 9\ H_2O$

$\Delta H_{rxn} = -5471 = 8\ (\Delta H°CO2 + 9\ (\Delta H°H_2O) - \Delta H°_{octane}$

$\Delta H°_{octane} = -249.2$ kJ/mol

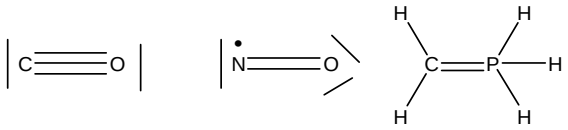
13. $\lambda = h/mv = 6.62\ 10^{-34} / 2\ 10^3\ 0.45010^{-3} = 7.36\ 10^{-34}$

14. 2p

15. E

16. E

17.



18. octahedral, d^2sp^3

19. E

20. C

21. D

22. A

23. rate of formation of NO_2 is twice as the rate of disappearance of N_2O_5 $= 2.4\ 10^{-4}$

24. rate = $k[A]^2[B]^0 = 0.012[0.125]^2 = 1.9\ 10^{-4}$

25. A

26. A (the ratio $\Delta A/\Delta t$ = constant for any given value)

27. B

28 B

29 D

30. B

31 C

32 We add 10 x 5 /1000 of NaOH to 5 L which is 0.01 mole per liter. Therefore [HA} will change from 0.1 to 0.09. The concentration of [A] will change from 0.4 to 0.41

pH = pKa + log[A]/[HA] = 4.86