Ryerson University
Department of Chemistry and Biology

CHY 102, General Chemistry
Midterm #2, November 2012

Version A

Instructors: A McWilliams
D. Heyd
D. Foucher

Instructions:

1. The complete examination consists of 24 multiple choice questions worth one mark each.
2. All questions are to be answered. Only ONE answer is correct for each question.
3. Answer each question by filling in the corresponding bubble on the TRS form **using pencil only**.
4. There are 4 different versions of this test. **Fill in the corresponding version in question # 100 on the TRS form.** The TRS form will not be marked unless the test version is identified in question # 100.
5. Fill in your answers on your TRS form (which appropriately indicates your name, student number and course section) as you do the test. **You will not be given additional time to fill in answers.**
6. At the conclusion of the test hand in the TRS form. Failure to submit the TRS form will result in a grade of zero (0) for the test.
7. Answers recorded on the TRS form are considered final.
8. A periodic table and data is supplied on the back page of the exam.

Enter All Answers in the Scantron Sheets

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) In which of the following reactions will $K_c = K_p$?

A) $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$

B) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

C) $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$

D) $CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g)$

E) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g)$

2) Consider the following reaction and its equilibrium constant:

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g) \qquad K_c = 0.33$$

A reaction mixture contains 0.39 M SO_2, 0.14 M NO_2, 0.11 M SO_3 and 0.14 M NO. Which of the following statements is TRUE concerning this system?

A) The reaction will shift in the direction of products.

B) The equilibrium constant will decrease.

C) The reaction quotient will decrease.

D) The reaction will shift in the direction of reactants.

E) The system is at equilibrium.

$Q = 0.282$

$Q < K_c$

3) Determine the pH of a 0.116 M $Ba(OH)_2$ solution at 25°C.

A) 12.56

B) 0.63

C) 13.06

D) 8.62

? E) 13.37

$pOH = -\log(0.116)$

4) Which of the following statements is TRUE?

A) Energy is given off when the attraction between two molecules is broken.

B) Intermolecular forces are generally stronger than bonding forces.

C) The potential energy of molecules always decreases as they get closer together.

D) Increasing the pressure on a solid usually causes it to become a liquid.

E) None of the above are true.

Enter All Answers in the Scantron Sheets

$P = 3.75 \times 10^{-3}$ atm
$V = 0.100$ L
$T = 298$ K

5) An aqueous solution is prepared by dissolving 1.05 grams of hemoglobin in 100.0 ml of solution. The solution has an osmotic pressure of 2.85 mmHg at 25°C. What is the molar mass of hemoglobin?

A) 68,400 g/mol
B) 622 g/mol
C) 5740 g/mol
D) 90.0 g/mol
E) 68.4 g/mol

$n = \frac{PV}{RT} = 1.53275 \times 10^{-5}$ mol

$M = \frac{m}{n} = 68,504.24$ g/mol

6) Determine the normal boiling point of a substance whose vapor pressure is 55.1 mm Hg at 35°C and has a ΔH_{vap} of 32 .1 kJ/mol.

A) 466 K
B) 390. K
C) 368 K
D) 412 K
E) 255 K

$\ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$P_1 = 389.5$ K

7) Consider the following reaction:

$$NO(g) + SO_3(g) \rightleftharpoons NO_2(g) + SO_2(g)$$
0.86 0.86 0 0

A reaction mixture initially contains 0.86 atm NO and 0.86 atm SO_3. Determine the equilibrium pressure of NO_2 if K_p for the reaction at this temperature is 0.0118.

A) 0.78 atm
B) 0.084 atm
C) 0.012 atm
D) 0.048 atm
E) 0.85 atm

$-x$ $-x$ $+x$ $+x$
$(0.86-x)$ $(0.86-x)$ x x

$K_p = \frac{x^2}{(0.86-x)^2}$

$0.0118 = \frac{x^2}{(0.86-x)^2}$

$\sqrt{0.0118} = \frac{x}{0.86-x}$

$0.0934 - x\sqrt{0.0118} = x$

$0.0934 = 1.1086x$

$x = 0.084266$ atm

8) What is the pH of pure water at 40.0°C if the K_w at this temperature is 2.92×10^{-14}?

A) 7.000
B) 8.446
C) 0.465
D) 6.767
E) 7.233

$2.92 \times 10^{-14} = x^2$

$pH = -\log(x)$

$= 6.767308$

Enter All Answers in the Scantron Sheets

9) Which of the following will cause the volume of an ideal gas to triple in value?

A) Lowering the pressure by a factor of 3 while the temperature stays constant.

B) Raising the temperature from 25°C to 75°C at constant pressure.

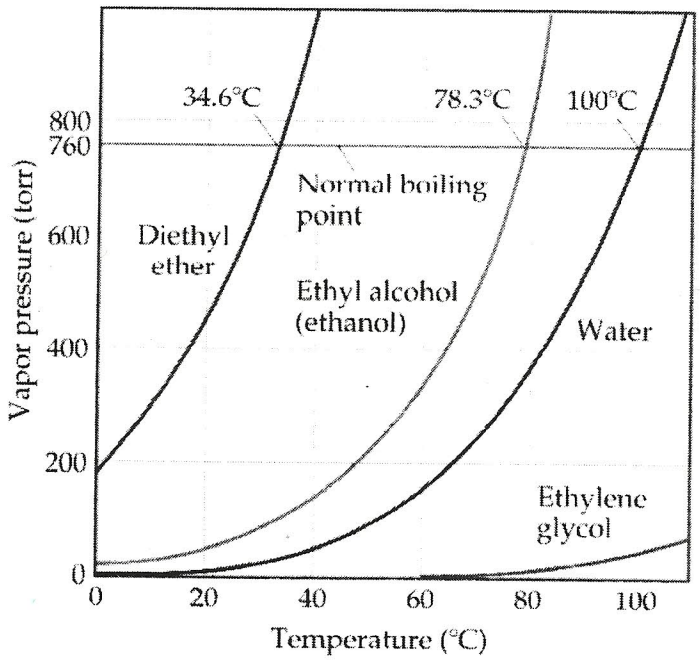
C) Lowering the absolute temperature by a factor of 3 at constant pressure.

D) Lowering the absolute temperature by a factor of 3 while increasing the pressure by a factor of 3.

E) Raising the absolute temperature by a factor of 3 while increasing the pressure by a factor of 3.

$P \propto \frac{1}{V}$

$V \propto T$



10) Based on the figure above, the boiling point of diethyl ether under an external pressure of 1.32 atm is _____ °C.

A) 34.6

B) 30

C) 40

D) 10

E) 20

11) Which of the following is NOT a conjugate acid-base pair?

A) NH_4^+/NH_3

B) H_2SO_3/HSO_3^-

C) H_3O^+/OH^-

D) $C_2H_3O_2^-/HC_2H_3O_2$

E) All of the above are conjugate acid-base pairs.

Enter All Answers in the Scantron Sheets

$M_S = 32.06$ g/mol

12) Determine the volume of H_2S (at 375 K and 1.20 atm) needed to produce 55.0 g of S. Assume that there is excess SO_2 present.

$$2\,H_2S(g) + SO_2(g) \rightarrow 3\,S(s) + 2\,H_2O(g)$$

A) 22.7 L
B) 29.3 L
C) 44.0 L
D) 66.0 L
E) 34.1 L

$PV = nRT$

$V = \frac{nRT}{P}$

$= \frac{\frac{55.0}{32.06} \times \frac{2}{3} \times 0.08206 \times 375}{1.20}$

$= 29.3\,L$

13) Consider the following reaction:

$$CH_4(g) + 2\,H_2S(g) \rightleftharpoons CS_2(g) + 4\,H_2(g)$$

0.50 0.75 0 0

A reaction mixture initially contains 0.50 M CH_4 and 0.75 M H_2S. If the equilibrium concentration of H_2 is 0.44 M, find the equilibrium constant (K_c) for the reaction.

A) 2.9
B) 0.23
C) 10.
D) 0.34
E) 0.038

$-x \quad -2x \quad +x \quad +4x$

0.39 0.53 0.11 0.44

$4x = 0.44$

$x = 0.11$

$K_c = \frac{(0.11)(0.44)^4}{(0.39)(0.53)^2}$

$= 0.0376$

14) What volume will a balloon occupy at 1.0 atm, if the balloon has a volume of 7.6 L at 3.8 atm?

A) 29 L
B) 5.0 L
C) 35 L
D) 17 L
E) 2.0 L

$PV = nRT$

$T = \frac{P_1V_1}{nR}$

$\frac{P_1V_1}{nR} = \frac{P_2V_2}{nR}$

$V_1 = 28.88\,L$

15) Determine the solubility of N_2 in water exposed to air at 25°C if the atmospheric pressure is 1.2 atm. Assume that the mole fraction of nitrogen is 0.78 in air and the Henry's law constant for nitrogen in water at this temperature is 6.1×10^{-4} M/atm.

A) 5.7×10^{-4} M
B) 6.5×10^{-4} M
C) 1.8×10^{-4} M
D) 1.5×10^{-4} M
E) 3.6×10^{-4} M

$C = k_H P$

$= (6.1 \times 10^{-4}\ \frac{M}{atm})(0.78 \times 1.2\ atm)$

$= 5.7 \times 10^{-4}\ M$

Enter All Answers in the Scantron Sheets

16) Determine the vapor pressure of a solution at 25°C that contains 76.6 g of glucose ($C_6H_{12}O_6$) in 250.0 g of water. The vapor pressure of pure water at 25°C is 23.8 torr.

A) 72.9 torr
B) 22.9 torr
C) 23.1 torr
D) 70.8 torr
E) 7.29 torr

$n_{C_6H_{12}O_6} = \frac{76.6\ g}{180.01\ g/mol} = 0.43\ mol$

$n_{H_2O} = \frac{250.0\ g}{18.02\ g/mol} = 13.88\ mol$

$X = \frac{0.43}{13.88} = 0.03098$

Vapor pressure = $0.03098 \times 23.8\ torr = 0.7375\ torr$

$\Rightarrow 23.8\ torr - 0.7375\ torr = 23.06\ torr = 23.1\ torr.$

17) The following reaction is used to generate hydrogen gas in the laboratory. If 243 mL of gas is collected at 25 °C and has a total pressure of 745 mm Hg, what mass of hydrogen is produced? A possibly useful table of water vapor pressures is provided below.

$M_{H_2} = (2 \times 1.008\ g/mol)$

$Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

T (°C)	P (mm Hg)
20	17.55
25	23.78
30	31.86

$n = \frac{m}{M}$

$\therefore m = 0.0190\ g$

A) 0.0449 g H_2
B) 0.0144 g H_2
C) 0.0717 g H_2
D) 0.0190 g H_2
E) 0.0196 g H_2

$P_T = P_{H_2} + P_{H_2O}$

$P_{H_2} = 721.22\ mm\ Hg = 0.94897\ atm$

$T = 298\ K$

$V = 0.243\ L$

$PV = nRT$

$n = \frac{PV}{RT} = 9.425 \times 10^{-3}\ mol$

18) Calculate the pH of a solution formed by mixing 250.0 mL of 0.15 M NH_4Cl with 100.0 mL of 0.20 M NH_3. The K_b for NH_3 is 1.8×10^{-5}.

A) 4.74
B) 9.53
C) 8.98
D) 9.25
E) 9.13

acid = 0.0375 mol base = 0.02 mol

$K_a = \frac{K_w}{K_b}$

$K_a = 5.5556 \times 10^{-10}$

$pH = pK_a + \log\left[\frac{base}{acid}\right]$

$= 8.98$

Enter All Answers in the Scantron Sheets

19) Place the following compounds in order of **decreasing** strength of intermolecular forces.

① HF ③ O_2 ② CO_2

A) $O_2 > CO_2 > HF$
B) $HF > CO_2 > O_2$
C) $CO_2 > HF > O_2$
D) $CO_2 > O_2 > HF$
E) $HF > O_2 > CO_2$

20) Find the percent ionization of a 0.337 M HF solution. The K_a for HF is 3.5×10^{-4}.

A) 4.7 %
B) 3.5×10^{-2} %
C) 1.1 %
D) 3.2 %
E) 1.2×10^{-2} %

$HF \rightleftharpoons H^+ + F^-$

0.337	0	0
$-x$	x	x

$K_a = \frac{[H^+][F^-]}{[HF]}$

$3.5 \times 10^{-4} = \frac{x^2}{(0.337 - x)}$

$\rightarrow x = 0.010886\,M$

$\therefore \% = \frac{x}{0.337\ M} \times 100$

$= 3.17\ \%$

21) A sample of gas initially has a volume of 859 mL at 565 K and 2.20 atm. What pressure will the sample have if the volume changes to 268 mL while the temperature is increased to 815 K?

A) 10.2 atm
B) 6.53 atm
C) 15.3 atm
D) 1.05 atm
E) 9.83 atm

$PV = nRT$

$n = \frac{PV}{RT}$

$\frac{P_1 V_1}{R T_1} = \frac{P_2 V_2}{R T_2}$

$P_2 = 10.17\ atm$

Enter All Answers in the Scantron Sheets

22) Express the equilibrium constant for the following reaction.

$$P(g) + 3/2\ Cl_2(g) \rightleftharpoons PCl_3(g)$$

A) $K = \dfrac{[P][Cl_2]^{3/2}}{[PCl_3]}$

B) $K = \dfrac{[PCl_3]^2}{[P]^2[Cl_2]^3}$

C) $K = \dfrac{[PCl_3]^{1/2}}{[P]^{1/2}[Cl_2]^{1/3}}$

(D) $K = \dfrac{[PCl_3]}{[P][Cl_2]^{3/2}}$

E) $K = \dfrac{[P]^2[Cl_2]^3}{[PCl_3]^2}$

23) Choose the solvent below that would show the greatest boiling point elevation when used to make a 0.10 *m* (m stands for molal) nonelectrolyte solution.

A) $CHCl_3$, $K_b = 4.70°C/m$

B) CH_3CH_2OH, $K_b = 1.99°C/m$

(C) CCl_4, $K_b = 29.9°C/m$

D) $CH_3CH_2OCH_2CH_3$, $K_b = 1.79°C/m$

E) C_6H_6, $K_b = 5.12°C/m$

24) A solution is prepared by dissolving 98.6 g of NaCl in enough water to form 875 mL of solution. Calculate the mass % of the solution if the density of the solution is 1.06 g/mL.

(A) 10.6%

B) 9.4%

C) 12.7%

D) 11.9%

E) 11.3%

$$d = \frac{m}{V}$$

$$1.06\ \frac{g}{mL} = \frac{m}{875\ mL}$$

$$m = 927.5\ g$$

$$\%\ mass = \frac{98.6\ g}{927.5\ g} \times 100\%$$

$$= 10.63\ \%$$