

Kwantlen University College
Department of Chemistry
Chemistry 1154 Final Examination
Thursday, December 22, 2005

Name: _____

Student number: _____

Instructions:

1. You are to work independently. Sharing of any information of any kind in any way with anyone is strictly forbidden.
2. Ensure that this exam has 16 pages (including this cover page, a periodic table, and a formula sheet).
3. There are 25 questions; read the exam carefully and judge your time accordingly.
4. All calculations must be shown in order to receive *any* credit for a question requiring them.
5. If you need extra space, use the back of a preceding page and clearly indicate the question number there.

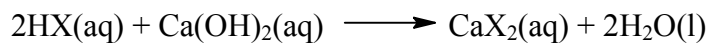
Page	Mark	Maximum
2		5
3		3
4		4
5		3
6		3.5
7		6
8		8
9		8
10		7
11		12
12		8
13		9
14		10
Total		86.5

1) **[5 marks total]** “Compound X” is known to contain carbon, hydrogen, and oxygen. When a fresh sample of “Compound X” was burned, it was found that the pressure of the H₂O gas created was twice the pressure of the CO₂ gas. It was further found that “Compound X” was 49.93 percent oxygen by mass.

a) **[3 marks]** What is the empirical formula of “Compound X”?

b) **[2 marks]** “Compound X”, when vaporized, effuses at a rate that is 3.987 times slower than H₂ gas. What is the molecular formula of “Compound X”?

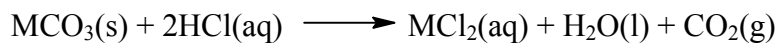
- 2) **[3 marks total]** A 10.00-mL aliquot of a solution of the acid “HX” required 21.62 mL of 0.004855 M Ca(OH)₂ for titration:



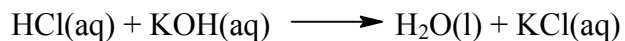
- a) **[1 mark]** What is the concentration of the acid, HX?

- b) **[2 marks]** The 10.00 mL aliquot of the HX solution was found to have a density of 1.007 g/mL, and to be 0.2666 percent HX by mass. What is the element, X?

- 3) **[4 marks]** A 2.0048-gram sample of MCO_3 was placed in a 100.0-mL volumetric flask and 15.00 mL of 2.000 M HCl added:

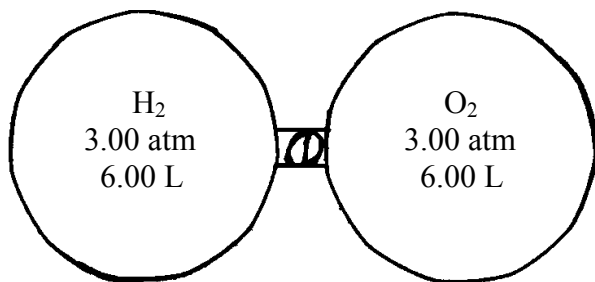


The resulting solution was made up to the mark and a 15.00 mL aliquot taken for titration with 0.1102 M KOH:

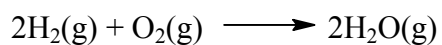


It took 13.18 mL of KOH to neutralize the remaining HCl. What is the metal, M?

4) [3 marks] The following apparatus was assembled:

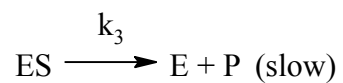
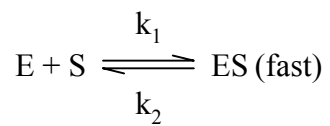


When the valve (of negligible volume) was opened, the following reaction occurred:



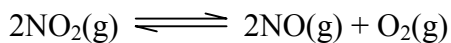
Assuming the temperature remained constant before, during, and after the reaction, what was the pressure of the excess reagent after the reaction occurred? Give your answer in atm.

- 5) **[3.5 marks total]** One possible mechanism for the conversion of a substrate (S) to a product (P) by an enzyme (E) is as follows:



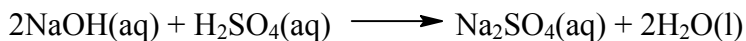
- a) **[0.5 marks]** What is the overall reaction?
- b) **[0.5 marks]** Is there a catalyst? If so, what is it?
- c) **[0.5 marks]** Is there a reactive intermediate? If so, what is it?
- d) **[2 marks]** What rate law is predicted by the mechanism above?

6) [2 marks] Consider the reaction:



If pure NO_2 is initially placed in a sealed container and allowed to reach equilibrium it is found that the partial pressure of $\text{NO}(\text{g})$ at equilibrium is 0.200 atm and the $P_{\text{total}} = 1.200$ atm. What is K_p for the reaction?

7) [3 marks] A 50.0 mL portion of 0.500 M H_2SO_4 ($S = 4.184 \text{ J/g}\cdot^\circ\text{C}$, $D = 1.00 \text{ g/mL}$) at 21.80°C was mixed with 100.0 mL of 0.500 M NaOH ($S = 4.184 \text{ J/g}\cdot^\circ\text{C}$, $D = 1.00 \text{ g/mL}$) at 21.80°C . The reaction



occurred, and the temperature of the mixture rose to 26.58°C . Calculate ΔH for the reaction above. Give your answer in kJ.

- 8) **[12 marks total]** The “generic” weak acid H_2A is a diprotic acid ($K_{a1} = 1 \times 10^{-3}$ and $K_{a2} = 2 \times 10^{-7}$). A 20.00 mL sample of 0.2000 M H_2A is titrated with 0.3252 M NaOH.
- a) **[1 mark]** Calculate the volumes of base added to reach each equivalence point.
- b) **[2 marks]** Calculate the pH at the start of the titration (before any base has been added) as well as the % ionization of H_2A at this point.
- c) **[1 mark]** Calculate the pH at the first equivalence point.
- d) **[2 marks]** Calculate the volume of NaOH added and the pH when $[\text{H}_2\text{A}] = [\text{HA}^{-1}]$.
- e) **[2 marks]** Calculate the volume of NaOH added and the pH when $[\text{A}^{-2}] = 4[\text{HA}^{-1}]$.

f) **[3 marks]** Calculate the pH at the second equivalence point.

g) **[1 mark]** Explain whether or not an indicator with a pK_a of 7.2 would be suitable for this titration.

9) **[4 marks]** Calculate $\varepsilon_{\text{cell}}$ for the following voltaic cell at 298 K:



The K_{sp} for NiCO_3 is 1.4×10^{-7} and the standard reduction potential for $\text{Ni}^{2+}/\text{Ni(s)}$ is 0.257 V.

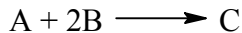
10) **[7 marks total]** For a certain electrolysis experiment, 1.44 g of silver (molar mass 107.9 g) was plated out in one electrolysis cell containing aqueous AgNO_3 solution, while 0.120 g of an unknown metal X was plated out in another electrolysis cell containing an aqueous XCl_3 solution. The two electrolysis cells were connected in series with a current of 1.50 amperes passing through them.

a) **[5 marks]** Calculate the atomic mass of metal X and the time taken for the plating.

b) **[2 marks]** At which electrode (cathode or anode) was metal X plated out, and to which terminal (positive or negative) of your DC source was the electrode connected?

*Note: Grading for part (b) will be **RIGHT** minus **WRONG**.*

11) [6 marks total] The rate law for the reaction



was determined to be $k[A][B]^2$.

a) [1 mark] The units for the rate constant are:

- i) M/s ii) 1/s iii) $M^{-1}s^{-1}$ iv) $M^{-2}s^{-1}$ v) $M^{-3}s^{-1}$

b) [1 mark] The overall order of the reaction is

- i) 0 ii) 1 iii) 2 iv) 3 v) 4

c) [2 marks] When $[A] = 0.10 \text{ M}$ and $[B] = 0.20 \text{ M}$, the rate of disappearance of B is 0.30 M/s . The numerical value of the rate constant for the reaction is:

- i) 7.5 ii) 15 iii) 37.5 iv) 75 v) 150

d) [2 marks] Which of the following statements is **TRUE**?

- i) The reaction mechanism occurs in a single step.
ii) There is a catalyst.
iii) The E_a for the forward step is the same as the E_a for the reverse step.
iv) The reaction mechanism contains a bimolecular step.
v) None of (i), (ii), (iii), or (iv) is true.

12) [4 marks] For a certain reaction, a plot of $\ln k$ vs. $1/T$ was made. The slope was found to be -17500 K and the y-intercept 21.599 .

a) The activation energy (in kJ/mol) for the reaction is:

- i) 1.77 ii) 145.5 iii) 179.5 iv) 810 v) 1436

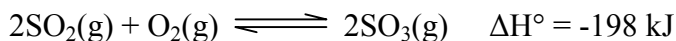
b) The pre-exponential factor (A) is:

- i) 3.07 ii) 9.77 iii) 180 iv) 17500 v) 2.4×10^{-9}

13) [2 marks] A certain reaction follows first-order kinetics. It takes 10.0 minutes for the concentration of the reactant to drop to 20.0 percent of its initial value. The half-life of the reaction, in minutes, is:

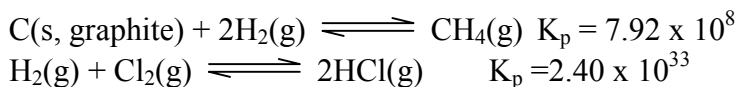
- a) 4.31 b) 6.25 c) 10.0 d) 25.0 e) 31.1

14) [2 marks] Choose the correct statement about a container in which the following equilibrium is established:

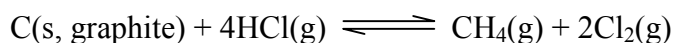


- a) A decrease in the amount of O_2 will decrease the amount of SO_2 present.
- b) An increase in the amount of O_2 will increase the amount of SO_2 present.
- c) A decrease in temperature will decrease the amount of SO_2 present.
- d) A decrease in the amount of SO_3 present will increase the amount of SO_2 present.
- e) A decrease in volume will increase the amount of SO_2 present.

15) [2 marks] Given the following equilibria and their respective constants, all determined at a temperature of 25°C :

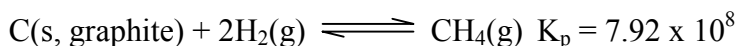


a) Determine the value of K_p at 25°C for the equilibrium:



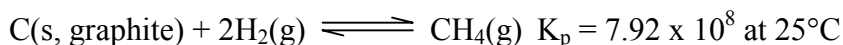
- i) 1.38×10^{-58} ii) 3.30×10^{-25} iii) -2.40×10^{33} iv) -1.90×10^{42} v) 1.90×10^{42}

16) [2 marks] Determine the value of K_c (at 25°C) for the equilibrium



- i) 3.19×10^5 ii) 3.42×10^7 iii) 1.94×10^{10} iv) 4.74×10^{11} v) 1.96×10^{12}

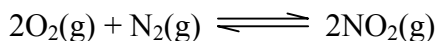
17) [2 marks] ΔH° for the equilibrium



Is -74.9 kJ . Determine K_p for this equilibrium at 125°C .

- i) 1.15×10^{-334} ii) 5.07×10^{-117} iii) 4.01×10^5 iv) 1.56×10^{12} v) none of these

18) [2 marks] At 25°C, $K_p = 9.32 \times 10^{-19}$ for the equilibrium



A flask was charged with 1.0 atm of N_2 and 2.00 atm of O_2 and equilibrium established. The pressure of $\text{NO}_2(\text{g})$, in atmospheres, when equilibrium had been attained, was:

- a) 9.32×10^{-19} b) 3.73×10^{-18} c) 9.65×10^{-10} d) 1.93×10^{-9} e) 2.0

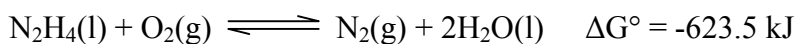
19) [2 marks] Phenol red indicator changes from yellow to red in the pH range from 6.6 to 8.0. State what colour the indicator will assume if 10.0 mL of 0.100 M NaOH are mixed with 6.00 mL of 0.150 M HCl.

- a) green
b) red
c) orange
d) yellow
e) There is not enough information to answer this question.

20) [2 marks] Choose the **FALSE** statement:

- a) ΔG is always zero at equilibrium.
b) Combustion of any hydrocarbon is always spontaneous.
c) Electrolysis is not a spontaneous process.
d) If ΔS_{system} is positive, the process will always be spontaneous.
e) The molar entropy of a substance in the liquid phase will always be less than in the gas phase.

21) [3 marks total] Use the following reaction to answer the following questions:



a) [1 mark] Given that there are four electrons transferred, what, in volts, is the standard potential (ϵ°) for the reaction?

- i) +3.24 ii) +1.62 iii) +0.81 iv) -0.81 v) -1.62

b) [2 marks] What is K_p for the above reaction?

- i) 6×10^{-108} ii) 1.3 iii) 1.2×10^{11} iv) 2×10^{109} v) 3×10^{251}

22) [2 marks] What is the $[\text{Ag}^+]$ in a saturated solution of Ag_3PO_4 ? The K_{sp} of Ag_3PO_4 is 1.3×10^{-20} .

- a) $4.7 \times 10^{-6} \text{ M}$
- b) $1.4 \times 10^{-5} \text{ M}$
- c) $2.4 \times 10^{-5} \text{ M}$
- d) $1.9 \times 10^{-5} \text{ M}$
- e) none of these

23) [4 marks] Match the following aqueous solutions with their freezing points (assume ideal solution behaviour and maximum “i” value).

- a) 0.010 m NaCl _____ $-x^\circ\text{C}$
- b) 0.010 m sucrose _____ $-2x^\circ\text{C}$
- c) 0.010 m CrCl_3 _____ $-3x^\circ\text{C}$
- d) 0.006 m $\text{Al}_2(\text{SO}_4)_3$ _____ $-4x^\circ\text{C}$

24) [2 marks] A metal crystallizes in a body-centered cubic structure (bcc) with the length of the unit cell = 286 pm. How many atoms are in the unit cell of this metal and what is the atomic radius of an atom in this metal?

- a) 2 atoms and atomic radius = 143 pm
- b) 2 atoms and atomic radius = 124 pm
- c) 2 atoms and atomic radius = 101 pm
- d) 4 atoms and atomic radius = 143 pm
- e) 4 atoms and atomic radius = 124 pm
- f) 4 atoms and atomic radius = 101 pm

25) The triple point of phosphorus is at 43 atm and 590°C . Some phosphorus at 500°C is heated to 590°C at a constant pressure of 40 atm. The change(s) of state(s) occurring in this process are:

- a) solid to gas
- b) solid to liquid to gas
- c) liquid to gas
- d) solid to liquid
- e) No change in state occurs at constant pressure.