

# MEMORIAL UNIVERSITY OF NEWFOUNDLAND

St. John's, Newfoundland and Labrador

**Chemistry 1010**

December 14, 2015

FINAL EXAMINATION

TIME: 2.5 hours

NAME: \_\_\_\_\_ STUDENT NUMBER: \_\_\_\_\_

Instructor/class: (circle) Poirier 8am Hattenhauer 10 am Reardon 2 pm

## READ THE FOLLOWING CAREFULLY.

1. This examination has 11 pages of three sections. SECTION A is "fill in the blank", SECTION B is short-answer and SECTION C is long-answer questions. Ensure that this examination paper is complete, i.e. that all pages are present.
2. Failure to submit this paper in its entirety at the end of the examination may result in disqualification.
3. A Periodic Table and physical constants are provided. These follow the last page of the examination and **may be detached** for use during the examination.
4. Answer each question in the space provided. Should you require more space, use the back of the previous page and **indicate clearly** where this has been done.
5. When answering questions in **all** SECTIONS, **show all relevant calculations and justify simplifying assumptions.**
6. Numerical answers should be reported to the **appropriate number of significant digits.**

**Do not write in the enclosed area below.**

Questions	Value	Mark
Section A	30	
B1, B2, B3	12	
B4, B5, B6	15	
B7, B8	9	
C1	7	
C2	8	
C3	6	
C4	7	
C5	6	
<b>Total</b>	<b>100</b>	

## Section A

### “Fill in Blank” Questions

You should allow ~ 40 min for this section. Each question is worth 2 marks.

A1. How many ns are in 16 ms?

Answer: \_\_\_\_\_

A2. If the number of moles of gas is doubled at constant temperature and volume, the pressure of the gas will

Answer: \_\_\_\_\_

A3. Determine whether each salt will form a solution that is **acidic**, **basic** or **neutral**.

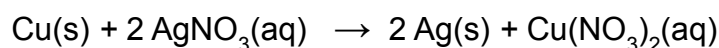
NaF            Answer: \_\_\_\_\_

NH<sub>4</sub>Br        Answer: \_\_\_\_\_

A4. What is the molecular formula of a compound with an empirical formula of HCO<sub>2</sub> and a molar mass of 90.0 g · mol<sup>-1</sup>?

Answer: \_\_\_\_\_

A5. Write the equation that represents the *reduction half reaction* for the following redox reaction:



Answer: \_\_\_\_\_

A6. Write the reaction that represents the enthalpy of formation for Ca(NO<sub>3</sub>)<sub>2</sub>(s)

Answer: \_\_\_\_\_

A7. A balloon contains 0.76 mol N<sub>2</sub>, 0.18 mol O<sub>2</sub>, 0.031 mol He and 0.026 mol H<sub>2</sub> at a total pressure of 744 mm Hg. What is the partial pressure of O<sub>2</sub>?

Answer: \_\_\_\_\_

A8. What is the name of the compound with the formula N<sub>2</sub>O<sub>4</sub>?

Answer: \_\_\_\_\_

A9. Calculate the [OH<sup>-</sup>] for a solution with a pH=11.23:

Answer: \_\_\_\_\_

A10. Round off 00907506 to four significant figures.

Answer: \_\_\_\_\_

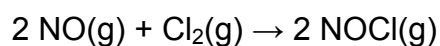
A11. Write the expression for the equilibrium ionization constant of a weak acid HA.

Answer:

A12. What is the concentration of formaldehyde ( $\text{CH}_2\text{O}$ ,  $\text{MM} = 30.0259 \text{ g mol}^{-1}$ ) in a solution containing 0.225 g of formaldehyde in 1.0 L?

Answer: \_\_\_\_\_

A13. Given the following balanced equation, if the rate of  $\text{Cl}_2$  loss is  $4.84 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$ , what is the rate of formation of  $\text{NOCl}$ ?



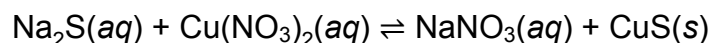
Answer: \_\_\_\_\_

A14. Without performing complex calculations, determine the order of a reaction that has the following initial rates for the specified starting concentration:

$[\text{A}] (\text{mol L}^{-1})$	Initial Rate ( $\text{mol L}^{-1} \text{ s}^{-1}$ )
0.10	0.020
0.20	0.080
0.30	0.180

Answer: \_\_\_\_\_

A15. Express the equilibrium constant (K) for the following reaction:



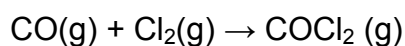
Answer:

SECTION B SHORT ANSWER QUESTIONS  
SHOW ALL CALCULATIONS

Allow ~ 70 min to complete

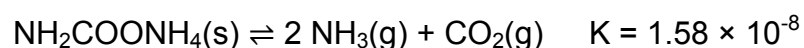
- [4] B1. A solution of sulfuric acid was made by diluting 20.00 mL of concentrated 12.0 mol L<sup>-1</sup> sulfuric acid with water to give a total volume of 0.250 L. Calculate the concentration of the diluted acid.

- [4] B2. The K for the reaction below is  $1.49 \times 10^8$  at 100.0 °C:



In an equilibrium mixture of the three gases,  $P_{\text{CO}} = P_{\text{Cl}_2} = 2.22 \times 10^{-4}$  bar. Find the partial pressure of the product, phosgene (COCl<sub>2</sub>).

- [4] B3. Consider the following reaction and equilibrium constant at a particular temperature. Determine the equilibrium concentration of CO<sub>2</sub>(g) if the equilibrium concentration of NH<sub>3</sub> =  $2.9 \times 10^{-3}$  mol L<sup>-1</sup>.



[6] B4. Consider the following two-step mechanism for a reaction:



a) What is the overall reaction?

[2]

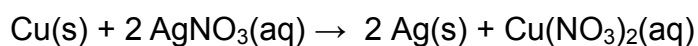
b) Identify the reactive intermediate(s) in the mechanism.

[2]

c) "What is the predicted rate law for the overall reaction?"

[2]

[6] B5. For the following oxidation-reduction reaction:



(a) Element oxidized \_\_\_\_\_

Change in oxidation # from \_\_\_\_ to \_\_\_\_

(b) Element reduced \_\_\_\_\_

Change in oxidation # from \_\_\_\_ to \_\_\_\_

(c) The reducing agent is \_\_\_\_\_

- [3] B6. The reaction of CO (g) and I<sub>2</sub>O<sub>5</sub> (g) is described by the equilibrium shown below.



Indicate whether the following changes **increase**, **decrease** or **not change** the yield of I<sub>2</sub> (g).

Change in Condition	Yield of I <sub>2</sub> (g)
(a) Increase the temperature	_____
(b) Decrease the volume	_____
(c) Adding a catalyst	_____

- [4] B7. A sample of a diatomic gas has a mass of 9.271 g. Its volume at STP is 5.54 L. Calculate its molar mass and determine the identity of the gas.

- [5] B8. Calculate the amount of heat (in kJ) necessary to raise the temperature of 47.8 g benzene by 57.0 K. The specific heat capacity of benzene is 1.05 J g<sup>-1</sup> °C<sup>-1</sup>.

## SECTION C

### LONG ANSWER QUESTIONS

**Note: Show all calculations**    **Allow a minimum 80 min to complete**

- [7] C1. Butyric acid contains carbon, hydrogen and oxygen. Combustion of a 4.30 g sample of this compound produced 8.59 g of CO<sub>2</sub> and 3.52 g H<sub>2</sub>O. Find the empirical formula for butyric acid.

Given:    Molar mass (H<sub>2</sub>O) = 18.0153 g mol<sup>-1</sup>  
            Molar mass (CO<sub>2</sub>) = 44.011 g mol<sup>-1</sup>

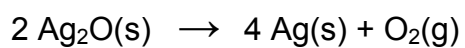
- [8] C2. Determine the pH of a  $0.188 \text{ mol L}^{-1}$   $\text{NH}_3$  solution at  $25 \text{ }^\circ\text{C}$ . The  $K$  of  $\text{NH}_3$  is  $1.76 \times 10^{-5}$ .



- [6] C3. The decomposition of certain metal oxides is a convenient way of producing small quantities of oxygen for chemical synthesis.

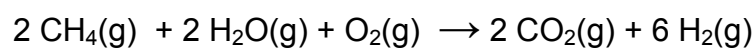
In the reaction given below, what mass of  $\text{Ag}_2\text{O}$  (in grams) is required to produce 388 mL of oxygen gas at a  $P = 978.7$  mbar and  $25.0$  °C?

Molar Mass ( $\text{Ag}_2\text{O}$ ) =  $231.735$  g mol<sup>-1</sup>



- [7] C4. When 0.514 g of biphenyl ( $C_{12}H_{10}$ ,  $MM=154.2074 \text{ g mol}^{-1}$ ) undergoes combustion in a bomb calorimeter, the temperature rises from  $25.8 \text{ }^\circ\text{C}$  to  $29.4 \text{ }^\circ\text{C}$ . Find  $\Delta_r U$  for the combustion of biphenyl in  $\text{kJ mol}^{-1}$ . The heat capacity of the bomb calorimeter, determined in a separate experiment is  $5.86 \text{ kJ }^\circ\text{C}^{-1}$ .

- [6] C5. Hydrogen gas used in fuel cell technology can be prepared industrially from a reaction of methane with water vapour and oxygen:



Using the standard enthalpies of formation below, calculate  $\Delta_r H^\circ$  for the reaction as written.

<u>Substance</u>	<u><math>\Delta_f H^\circ</math> (<math>\text{kJ mol}^{-1}</math>)</u>
$\text{CH}_4(\text{g})$	- 74.6
$\text{H}_2\text{O}(\text{g})$	- 241.83
$\text{CO}_2(\text{g})$	- 393.5

## PERIODIC TABLE OF THE ELEMENTS

	6	atomic number
atomic mass	<b>C</b>	12.0107
	<b>KEY</b>	

1 <b>H</b> 1.0079																	18 <b>He</b> 4.0026
3 <b>Li</b> 6.941	4 <b>Be</b> 9.0122											5 <b>B</b> 10.811	6 <b>C</b> 12.0107	7 <b>N</b> 14.0067	8 <b>O</b> 15.9994	9 <b>F</b> 18.9984	10 <b>Ne</b> 20.1797
11 <b>Na</b> 22.9898	12 <b>Mg</b> 24.3050											13 <b>Al</b> 26.9815	14 <b>Si</b> 28.0855	15 <b>P</b> 30.9738	16 <b>S</b> 32.065	17 <b>Cl</b> 35.453	18 <b>Ar</b> 39.948
19 <b>K</b> 39.0983	20 <b>Ca</b> 40.078	21 <b>Sc</b> 44.9559	22 <b>Ti</b> 47.867	23 <b>V</b> 50.9415	24 <b>Cr</b> 51.9961	25 <b>Mn</b> 54.9380	26 <b>Fe</b> 55.8475	27 <b>Co</b> 58.9332	28 <b>Ni</b> 58.6934	29 <b>Cu</b> 63.546	30 <b>Zn</b> 65.409	31 <b>Ga</b> 69.723	32 <b>Ge</b> 72.61	33 <b>As</b> 74.9216	34 <b>Se</b> 78.96	35 <b>Br</b> 79.904	36 <b>Kr</b> 83.798
37 <b>Rb</b> 85.4678	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.9059	40 <b>Zr</b> 91.224	41 <b>Nb</b> 92.9064	42 <b>Mo</b> 95.94	43 <b>Tc</b> (99)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.9055	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.8682	48 <b>Cd</b> 112.411	49 <b>In</b> 114.818	50 <b>Sn</b> 118.710	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.9045	54 <b>Xe</b> 131.29
55 <b>Cs</b> 132.9054	56 <b>Ba</b> 137.327	57 <b>La</b> 138.9055	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.9479	74 <b>W</b> 183.84	75 <b>Re</b> 186.207	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.217	78 <b>Pt</b> 195.078	79 <b>Au</b> 196.9665	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.3833	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.9804	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 <b>Ac</b> (227)	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (266)	107 <b>Bh</b> (264)	108 <b>Hs</b> (269)	109 <b>Mt</b> (268)									

Lanthanides

58 <b>Ce</b> 140.116	59 <b>Pr</b> 140.9077	60 <b>Nd</b> 144.24	61 <b>Pm</b> (147)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.964	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.925	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.9303	68 <b>Er</b> 167.259	69 <b>Tm</b> 168.9342	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.967
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Actinides

90 <b>Th</b> 232.0381	91 <b>Pa</b> 231.0359	92 <b>U</b> 238.0289	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)
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Parenthesis Indicates the most stable isotope

## SOME USEFUL CONSTANTS

## Quantity and Symbol Value

Avogadro Constant,  $N$   $6.022 \times 10^{23} \text{ particles} \cdot \text{mol}^{-1}$ Density of  $\text{H}_2\text{O}(\ell)$  at  $4^\circ\text{C}$   $1.00 \text{ g mL}^{-1}$ Standard Temperature and Pressure (STP)  $273.15 \text{ K} = 0.00^\circ\text{C}$  and  $1.000 \text{ bar}$ Molar Volume of an Ideal Gas at STP  $22.71 \text{ L mol}^{-1}$ Ideal Gas Constant,  $R$   $0.08314 \text{ L bar mol}^{-1} \text{ K}^{-1} = 8.314 \text{ L kPa mol}^{-1} \text{ K}^{-1} =$  $8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 8.206 \times 10^{-2} \text{ L atm mol}^{-1} \text{ K}^{-1}$ Specific Heat Capacity of  $\text{H}_2\text{O}(\ell)$   $4.184 \text{ J g}^{-1} \text{ K}^{-1}$  $\Delta H_{\text{fusion, H}_2\text{O}(\text{s})}$  at  $273 \text{ K}$   $6.02 \text{ kJ mol}^{-1}$  $\Delta H_{\text{vaporization, H}_2\text{O}(\ell)}$  at  $373 \text{ K}$   $41.1 \text{ kJ mol}^{-1}$ Planck Constant,  $h$   $6.626 \times 10^{-34} \text{ J s}$ Velocity of Light in a vacuum,  $c$   $2.998 \times 10^8 \text{ m s}^{-1}$ Ionization Constant of Water,  $K_w$ , at  $25^\circ\text{C}$   $1.008 \times 10^{-14}$ Faraday Constant,  $F$   $9.6485 \times 10^4 \text{ C mol}^{-1}$  $C = 1 \text{ Ampere (a) x seconds(s)}$ Rydberg constant,  $R_H$   $1.0973 \times 10^7 \text{ m}^{-1}$ 

## CONVERSION FACTORS

 $1 \text{ bar} = 100 \text{ kPa(exactly)} = 750.1 \text{ torr (mmHg)} = 0.9869 \text{ atm}$  $1 \text{ atomic mass unit, } u = 1.660 \times 10^{-27} \text{ kg}$  $1 \text{ cal} = 4.184 \text{ J}$  $1 \text{ mL} = 1 \text{ cm}^3$  $1 \text{ bar L} = 100 \text{ J}$ 

You may detach this page if you wish. It must be handed in with the examination paper!

Edited September 2014

**Do not turn the paper over until you are told that you may do so.**

**You may not leave the examination room during the first half hour or during the last half hour of the examination.**

**At the end of the examination:  
When you are told to stop writing you must do so.**

### **ACADEMIC OFFENCES**

Academic offences shall be deemed to include, but shall not be limited to, the following:

1. **Cheating on examinations, theses, assignments, work term reports, projects, internship reports, or any other tests.**  
Cheating includes copying from another student's work or allowing another student to copy from one's own work, consulting with any unauthorized person during an examination or test, or using unauthorized aids; or knowingly recording or reporting false empirical or statistical data. The work referred to includes examinations, theses, assignments, work term reports, projects, internship reports, or any other tests which are to be used in judging the student's performance in a course or programme of study, or on any special tests which the University may offer.
2. **Impersonating another student or allowing oneself to be impersonated.**  
By impersonation is meant the imitation of a student or entrance into an arrangement with another person to be impersonated for purposes of taking examinations or tests or carrying out laboratory or other assignments.
3. **Plagiarism.**  
Plagiarism is the act of presenting the ideas or works of another as one's own. This applies to all material such as essays, laboratory reports, work term reports, design projects, seminar presentations, statistical data, computer programmes and research results. The properly acknowledged use of sources is an accepted and important part of scholarship. Use of such material without acknowledgement, however, is contrary to accepted norms of academic behaviour.
4. **Theft of examination papers or other material.**  
By theft is meant obtaining by any improper means examination papers, tests, or any other such material.
5. **Use and/or distribution of stolen material.**  
The use of material which the student knows to have been improperly obtained and/or the distribution of such material is considered to be an academic offence.
6. **Submitting false information.**  
This offence includes falsifying academic forms or records, submitting false credentials, medical or other certificates, or making a false, misleading or incomplete declaration to the University.
7. **Submitting work for one course which has been or is being submitted for another course without express permission to do so.**  
This includes the presentation of an essay, report or assignment to satisfy some or all of the requirements of a course when that essay, report, or assignment has been previously submitted or is concurrently being submitted for another course without the express permission of the professor(s) involved.

**NOTE:** Procedures to be followed and penalties to be assessed in cases of academic dishonesty are outlined in the University Calendar.