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	
Total	**100**	

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_4Br Answer: _____

A4. What is the molecular formula of a compound with an empirical formula of HCO_2 and a molar mass of 90.0 $g \cdot mol^{-1}$?

Answer: _____

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

$$Cu(s) + 2\ AgNO_3(aq) \rightarrow 2\ Ag(s) + Cu(NO_3)_2(aq)$$

Answer: _____

A6. Write the reaction that represents the enthalpy of formation for $Ca(NO_3)_2(s)$

Answer: _____

A7. A balloon contains 0.76 mol N_2, 0.18 mol O_2, 0.031 mol He and 0.026 mol H_2 at a total pressure of 744 mm Hg. What is the partial pressure of O_2?

Answer: _____

A8. What is the name of the compound with the formula N_2O_4?

Answer: _____

A9. Calculate the $[OH^-]$ 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 (CH_2O, MM= 30.0259 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 Cl_2 loss is 4.84×10^{-2} mol L^{-1} s^{-1}, what is the rate of formation of NOCl?

$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$

Answer: _____

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

[A] (mol L^{-1})	Initial Rate (mol L^{-1} 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:

$$Na_2S(aq) + Cu(NO_3)_2(aq) \rightleftharpoons NaNO_3(aq) + CuS(s)$$

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^{-1} 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 1.49×10^{8} at 100.0 °C:

$CO(g) + Cl_2(g) \rightarrow COCl_2\ (g)$

In an equilibrium mixture of the three gases, $P_{CO} = P_{Cl2} = 2.22 \times 10^{-4}$ bar. Find the partial pressure of the product, phosgene ($COCl_2$).

[4] B3. Consider the following reaction and equilibrium constant at a particular temperature. Determine the equilibrium concentration of $CO_2(g)$ if the equilibrium concentration of $NH_3 = 2.9 \times 10^{-3}$ mol L^{-1}.

$NH_2COONH_4(s) \rightleftharpoons 2\ NH_3(g) + CO_2(g)$ $K = 1.58 \times 10^{-8}$

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

Step 1: NO_2 (g) + F_2 (g) → FNO_2 (g) + F (g) Slow

Step 2: NO_2 (g) + F(g) → FNO_2 (g) Fast

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:

$Cu(s) + 2\ AgNO_3(aq) \rightarrow 2\ Ag(s) + Cu(NO_3)_2(aq)$

(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_2O_5 (g) is described by the equilibrium shown below.

$5CO\ (g) + I_2O_5\ (g) \rightleftharpoons I_2\ (g) + 5CO_2\ (g)$ $\Delta_r H° = -20\ kJ\ mol^{-1}$

Indicate whether the following changes **increase**, **decrease** or **not change** the yield of I_2 (g).

Change in Condition	Yield of I_2 (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^{-1} $°C^{-1}$.

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_2 and 3.52 g H_2O. Find the empirical formula for butyric acid.

Given: Molar mass (H_2O) = 18.0153 g mol^{-1}
Molar mass (CO_2) = 44.011 g mol^{-1}

[8] C2. Determine the pH of a 0.188 mol L^{-1} NH_3 solution at 25 °C. The K of NH_3 is 1.76×10^{-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 Ag_2O (in grams) is required to produce 388 mL of oxygen gas at a P= 978.7 mbar and 25.0 ^{o}C?

Molar Mass (Ag_2O) = 231.735 g mol^{-1}

$$2\ Ag_2O(s) \longrightarrow 4\ Ag(s) + O_2(g)$$

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

$$2\ CH_4(g)\ +\ 2\ H_2O(g) + O_2(g)\ \longrightarrow\ 2\ CO_2(g) + 6\ H_2(g)$$

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

Substance	$\Delta_f H°$ (kJ mol^{-1})
$CH_4(g)$	− 74.6
$H_2O(g)$	− 241.83
$CO_2(g)$	− 393.5

PERIODIC TABLE OF THE ELEMENTS

atomic mass — 6 C 12.0107 — atomic number

KEY

1												13	14	15	16	17	18
1 H 1.0079	2																2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.0107	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9380	26 Fe 55.8475	27 Co 58.9332	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.29
55 Cs 132.9054	56 Ba 137.327	57 La 139.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.9665	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.9804	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)									

Lanthanides	58 Ce 140.116	59 Pr 140.9077	60 Nd 144.24	61 Pm (147)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.9303	68 Er 167.259	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967
Actinides	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Parenthesis Indicates the most stable isotope

SOME USEFUL CONSTANTS

Quantity and Symbol	Value
Avogadro Constant, N	6.022×10^{23} particles·mol^{-1}
Density of $H_2O(\ell)$ at 4°C	1.00 g mL^{-1}
Standard Temperature and Pressure (STP)	273.15 K = 0.00°C and 1.000 bar
Molar Volume of an Ideal Gas at STP	22.71 L mol^{-1}
Ideal Gas Constant, R	0.08314 L bar mol^{-1} K^{-1} = 8.314 L kPa mol^{-1} K^{-1} = 8.314 J mol^{-1} K^{-1} = 8.206×10^{-2} L atm mol^{-1} K^{-1}
Specific Heat Capacity of $H_2O(\ell)$	4.184 J g^{-1} K^{-1}
ΔH_{fusion}, $H_2O(s)$ at 273 K	6.02 kJ mol^{-1}
$\Delta H_{vaporization}$, $H_2O(\ell)$ at 373 K	41.1 kJ mol^{-1}
Planck Constant, h	6.626×10^{-34} J s
Velocity of Light in a vacuum, c	2.998×10^{8} m s^{-1}
Ionization Constant of Water, K_w, at 25°C	1.008×10^{-14}
Faraday Constant, F	9.6485×10^{4} C mol^{-1}
	C = 1 Ampere (a) x seconds(s)
Rydberg constant, R_H	1.0973×10^{7} m^{-1}

CONVERSION FACTORS

1 bar = 100 kPa(exactly) = 750.1 torr (mmHg) = 0.9869 atm

1 atomic mass unit, u = 1.660×10^{-27} kg

1 cal = 4.184 J

1 mL = 1 cm^3

1 bar L = 100 J

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

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.