Last Name: _____

First name: _____

Student Number: _____

CHM 1311 B
Final Exam
December 2013

Professor: Dr. Goto

There are 13 pages in this test. A periodic table, data tables, and a formula sheet are provided at the end. You may rip these pages off of the exam.

Please show all work to receive partial credit.

Marks may be deducted if an unreasonable number of sig figs are shown in your final answer.

You have 180 minutes to complete the exam.

Question	Points Possible	Points Earned
1	22	
2	10	
3	10	
4	10	
5	8	
6	10	
7	10	
8	10	
TOTAL	90	

Question 1. (22 marks)

a) How many protons and electrons are in an ion of zinc having a 2+ charge?

Protons: _____ Electrons: _____

b) Give the name for $K_2CO_3 \cdot 2H_2O$: _____

c) The molecular formula for ferrous oxide is: _____

d) Will the addition of a strong acid lead to some precipitation of silver sulphate from a pure saturated solution of Ag_2SO_4?

YES NO

e) What volume of 1.00 mol/L $KMnO_4$ is required prepare a 50 mL solution of 0.100 mol/L $KMnO_4$?

Volume = _____

f) Write the full ground-state *spdf* electron configuration of the monoatomic ion most likely to be formed by Br.

g) At the top of Mt. Everest atmospheric pressure is approximately 0.300 atm. The height of mercury in a barometer be at the top of this mountain is:

_____

h) Circle the term that is NOT a state function:

ENTHALPY TEMPERATURE INTERNAL ENERGY HEAT

i) The change in internal energy for an ideal gas that absorbs 560 J of heat and does 350 J of work is: _____

j) A frying pan is used to transfer energy from a stove-top heating element to food. Refer to the data sheet to identify the material that the pan should be constructed from to best perform this function. (Circle one.)

aluminum gold glass (SiO_2) graphite

k) Circle the quantum number designation that corresponds to an electron in a 3*d* orbital:

$n = 2, l = 2\ m_l = 1$ $n = 3, l = 2, m_l = 3$ $n = 3,\ l = 1, m_l = 0$ $n = 3, l = 2, m_l = -2$

l) When the volume of the reaction vessel is increased, the equilibrium reaction

$$CaC_2O_4\ (s) \rightleftharpoons CaCO_3\ (s) + CO\ (g)$$

shifts towards the:

PRODUCTS REACTANTS

m) When a strong acid such as HCl is added to a solution of NH_3, the strong ammonia smell is eliminated. Write the equation of the equilibrium constant for this reaction in the box provided:

n) Circle one of the following combinations that will NOT produce a buffer.

$NH_3 + HNO_3$ $NH_4^+ + NH_3$ $NH_4Cl + HCl$ $NH_4^+ + NaOH$

o) If a plot of $\frac{1}{[A]_t}$ versus time yields a straight line then the reaction is _____ order in A.

p) Circle the species in the chemical reaction below that is the strongest acid, given that the equilibrium constant K for this reaction is <1.

$$H_2PO_4^-\ (aq) + HNO_2\ (aq) \leftrightarrows H_3PO_4\ (aq) + NO_2^-\ (aq)$$

q) Increasing the temperature of an exothermic reaction will:

i) Increase the yield and rate ii) Decrease the yield and increase the rate

iii) Increase the yield and decrease the rate iv) Decrease the yield and rate

r) How many orbitals make up the 3d sublevel? _____

s) How many nodal planes are in the d orbital? _____

Question 2.

a) A buffer that contains 0.150 mol/L NaF and 0.210 mol/L HF has a pH of 3.33. What is the pKa of HF? (2 marks)

pKa = _____

b) If 35.00 mL of a 0.150 mol/L solution of HF is titrated with 0.1000 mol/L NaOH, what volume of this NaOH solution will be required to reach the equivalence point? (3 marks)

Answer: _____

c) What will be the pH of the solution at the equivalence point? (5 marks)

Answer: _____

Question 3.

Ammonium carbamate (NH_2COONH_4) is a salt of carbamic acid that is found in the blood and urine of mammals. At 250°C $Kc = 1.58 \times 10^{-8}$ for the following equilibrium

$$NH_2COONH_4\,(s) \rightleftharpoons 2\,NH_3\,(g) + CO_2\,(g)$$

a) If 7.80 g of ammonium carbamate is put into a 0.500 L evacuated container, what is the total pressure at equilibrium? (6 marks)

Answer: _____

b) What is the percent yield for this reaction? (3 marks)

Answer: _____

c) If this reaction had been done under constant pressure conditions, would the work be positive, negative or zero? (1 mark)

Question 4.

a) An electron in the n=5 level of an H atom emits a photon wavelength 1281 nm. Calculate the energy level to which it moves. (5 marks)

Answer: _____

b) i) Draw a partial (valence–shell) orbital diagram for [Ar] $3d^8\ 4s^2$, and; ii) state the element that the neutral species corresponds to. (3 marks)

c) Draw Lewis structures for two resonance forms of NO_2^-. (2 marks)

Question 5.

The toxic gas phosgene is prepared by the reaction:

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

A kinetics study of this reaction gave the following data:

Experiment	Initial rate (mol/L•s)	Initial [CO] (mol/L)	Initial [Cl_2] (mol/L)
1	1.29×10^{-29}	1.00	0.100
2	1.33×10^{-30}	0.100	0.100
3	1.30×10^{-29}	0.100	1.00

a) Using the data provided, write the rate law for this reaction. (3 marks)

Answer: _____

b) What is the rate constant (including units) for this reaction? (2 marks)

Answer: _____

c) Adsorption of Cl_2 gas to a platinum surface can reduce the activation energy of this reaction by 16.5 kJ/mol at 50°C. How much faster will the reaction go in the presence of this catalyst? (3 marks)

Answer: _____

Question 6.

When 50.0 mL of 0.250 mol/L $Ba(OH)_2$ is mixed with 45 mL of 0.380 mol/L HCl in a coffee-cup calorimeter, the heat of the solution is 1.850 kJ.

a) Is this reaction exothermic or endothermic? (1 mark)

b) What is ΔT for the solution in reaction? (3 marks)

Answer: _____

c) What is the ΔH of the reaction in kJ/mol of H_2O formed? (6 marks)

Answer: _____

Question 7.

A steel tank at 21°C has a volume of 438 L and is filled with 1.257 kg of Ar. However, the valve was not completely closed, giving rise to a slow leak until it was discovered 6 hours later. According to the pressure gauge, the new pressure is 1.39 bar.

a) What mass of Ar was lost from the tank? (3 marks)

Answer: _____

b) How many atoms of argon were lost in a)? (1 mark)

c) Calculate the rate of effusion. (1 mark)

d) If the tank had contained N_2 in place of Ar, how many grams of N_2 would have been lost from the tank in this 6 hour period? (5 marks)

Answer: _____

Question 8.
The skeleton ionic equation for the reaction between $KMnO_4$ and K_2SO_3 is:

$$MnO_4^-\ (aq) + SO_3^{2-}\ (aq) \rightarrow MnO_2\ (s) + SO_4^{2-}\ (aq)$$

a) Which <u>compound</u> is the reducing agent in the reaction? (Do not just give the element.) (1 mark)

b) The solid product of this reaction is an oxide of manganese. What is the mass percent of manganese in this product? (1 mark)

c) Write the balanced molecular equation for this reaction in basic solution. (8 marks)

Final Balanced Equation:

Constants and Conversion Factors

1 mmHg = 1 torr 760 mmHg = 1 atm 1 atm = 101.325 kPa 1 atm = 1.013125 bar
1 cm^3 = 1 mL 1 dm^3 = 1 L = 1000 mL 1 m^3 = 1000 L
1 cal = 4.184 J

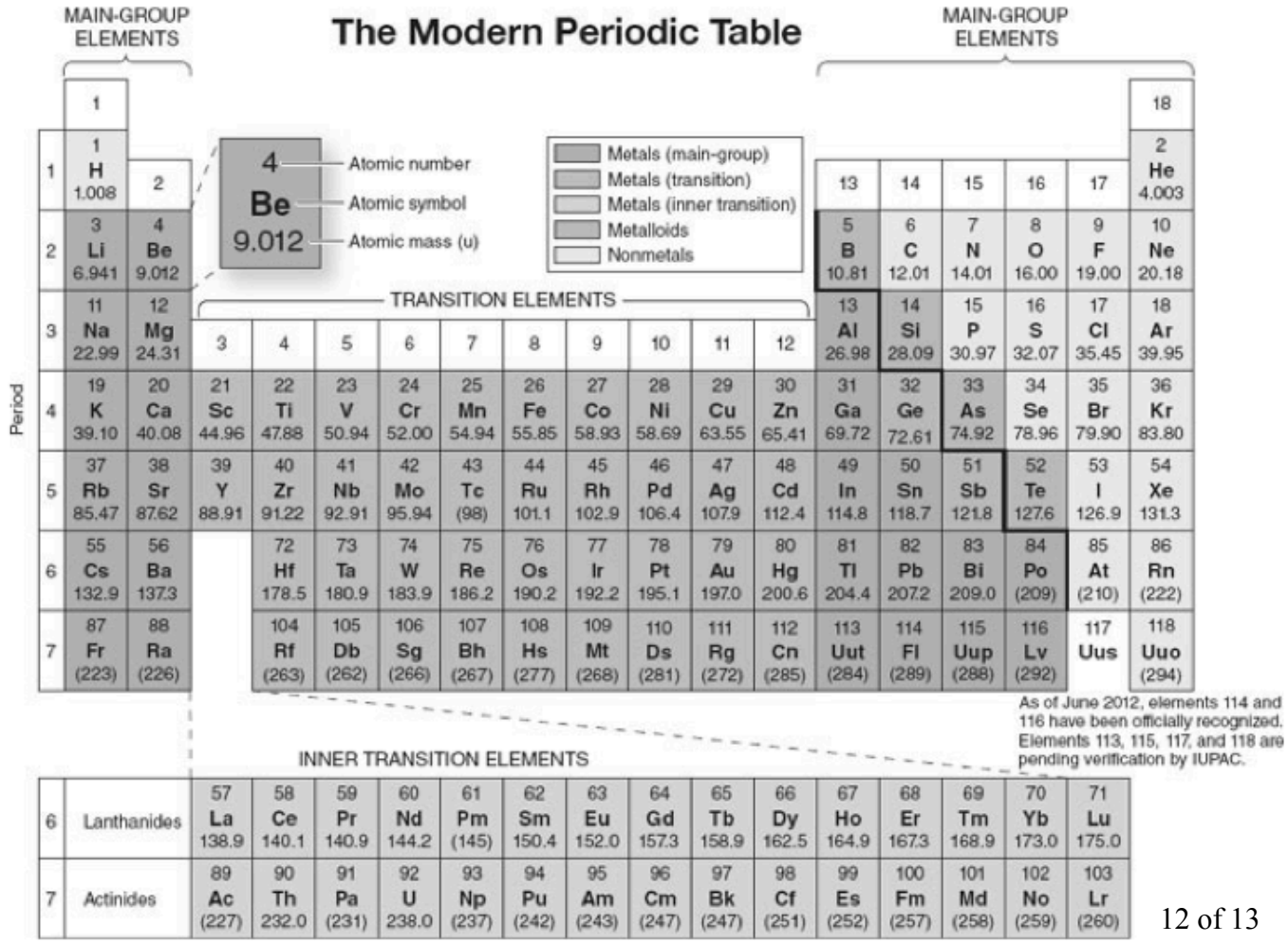
Avogadro's Number	N	6.022×10^{23} mol^{-1}
Atomic mass unit	u	1.66054×10^{-27} kg
Gas constant	R	8.31451 $J \cdot K^{-1} \cdot mol^{-1}$
	R	0.08206 $atm \cdot L \cdot K^{-1} \cdot mol^{-1}$
	R	8.31451 m^3 $Pa \cdot K^{-1} \cdot mol^{-1}$
	R	0.0831451 bar $L \cdot K^{-1} \cdot mol^{-1}$
Planck's constant	h	6.62608×10^{-34} J·s
Speed of Light	c	2.99792458×10^{8} $m \cdot s^{-1}$
Rydberg constant	R_H	2.18×10^{-18} J

Data For Water

Density = 1.00 g/mL (at 25°C) $K_W = 1.0 \times 10^{-14}$
c = 4.184 J g^{-1} K^{-1} (liquid) $\Delta H°_{fus}$ = 6.02 kJ mol^{-1} $\Delta H°_{vap}$ = 40.7 kJ mol^{-1}

Heat Capacity Data

graphite: 8.52 J/mol/K SiO_2: 44.4 J/mol/K gold: 25.4 J/mol/K aluminum: 24.4 J/mol/K



Post-Midterm 2 Equations

$$\mathrm{pH} = \mathrm{p}K_a + \log\frac{\left[\mathrm{A\text{-}}\right]}{\left[\mathrm{HA}\right]} \qquad c = \lambda \times v \qquad \Delta E = nhv \qquad \lambda = \frac{h}{mv} \qquad E_n = -\frac{R_H}{n^2}$$

Midterm 2 Equations

$$\Delta_r H^o = \sum m\Delta_f H^o\left(\text{products}\right) - \sum n\Delta_f H^o\left(\text{reactants}\right) \qquad \Delta_r H^o = \sum m\text{BE}\left(\text{reactants}\right) - \sum n\text{BE}\left(\text{products}\right)$$

$$q = c \times m \times \Delta T \qquad \text{Rate} = \frac{1}{v_{\mathrm{X}}}\frac{\Delta\left[\mathrm{X}\right]}{\Delta t} \qquad \text{Rate} = k\left[\mathrm{A}\right]^m\left[\mathrm{B}\right]^n \ldots$$

$$k = Ae^{-\frac{E_a}{RT}} \qquad \left[\mathrm{A}\right]_t - \left[\mathrm{A}\right]_o = -kt \qquad \ln\frac{\left[\mathrm{A}\right]_o}{\left[\mathrm{A}\right]_t} = kt$$

$$\frac{1}{\left[\mathrm{A}\right]_t} - \frac{1}{\left[\mathrm{A}\right]_o} = kt \qquad \ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad K = K_c\left(RT\right)^{\Delta n(\text{gas})}$$

$$\ln\left(\frac{K_2}{K_1}\right) = -\frac{\Delta_r H^o}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad ax^2 + bx + c = 0 \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\mathrm{pH} = -\log\left[\mathrm{H_3O^+}\right] \qquad \mathrm{pOH} = -\log\left[\mathrm{OH^-}\right] \qquad \mathrm{pH} + \mathrm{pOH} = 14$$

$$K_a \times K_b = K_w \qquad pK_a = -\log K_a \qquad pK_b = -\log K_b$$

Midterm 1 Equations

$$T\left(\text{in K}\right) = T\left(\text{in }^{\circ}\text{C}\right) + 273.15\text{ K} \qquad n = \frac{m}{M} \qquad \%\text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}}$$

$$c\left(\text{mol / L}\right) = \frac{n}{V} \qquad m\left(\text{mol / }kg\right) = \frac{n_{solute}}{m_{solvent}} \qquad c_1V_1 = c_2V_2 = n$$

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2} \qquad pV = nRT \qquad p_T = p_1 + p_2 + p_3 + \ldots$$

$$p_A = X_A \times p_T \qquad X_A = \frac{n_A}{n_T} \qquad d = \frac{m}{V} = \frac{p \cdot MM}{RT}$$

$$E_K = \frac{1}{2}m\mathrm{v}^2 \qquad u_{rms} = \sqrt{\frac{3RT}{M}} \qquad \frac{Rate\ A}{Rate\ B} = \sqrt{\frac{M_B}{M_A}}$$

$$\left(p + \frac{n^2a}{V^2}\right)\left(V - nb\right) = nRT \qquad w = -p\Delta V \qquad \Delta U = U_{final} - U_{initial} = q + w$$

$$\Delta H = \Delta U + p\Delta V$$