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Name Key
(Please Print)

Student Number _____

Chem 115 - Section 1
Hour Examination II
November 8, 2006

This test consists of six (6) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

Show all numeric answers to the proper number of significant digits.

A separate copy of the periodic table will be distributed with this test packet. Feel free to use it in conjunction with any test question. In addition you may need some of the following relationships and constants:

1 Å = 1 x 10^{-10} m = 0.1 nm (exact relationships) Planck's constant = 6.626 x 10^{-34} J·s

speed of light *in vacuuo* = 2.998 x 10^{8} m·s^{-1}

DO NOT WRITE BELOW THIS LINE

1.

2.

3.

4.

5.

6.

TOTAL

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1. (10 points; 2 points each) Who did what? Match the person with the concept or discovery.

People

Arrhenius	Balmer	Bohr	Brackett
Einstein	Hess	Lenard	Lymann
Pfund	Planck	Rutherford	Thomson

Concepts and Discoveries

a. Bohr Predicted lowest energy electron in hydrogen has $r = 0.529$ Å

b. Planck Used the idea of quantized energy to explain black-body radiation

c. Einstein Explained photoelectric effect in terms of wave-particle duality

d. Arrhenius Described acids and bases in terms of electrolyte theory

e. Hess Enthalpy does not depend upon path

2. (12 points; 6 points each) Write the *net ionic equations* for the reactions that occur when the following are mixed together. Indicate all states (e.g., *s*, *l*, *g*, *aq*).

a. $Pb(NO_3)_2(aq) + KI(aq)$

$Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \rightarrow PbI_2(s) + 2NO_3^-(aq) + 2K^+(aq)$

$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

b. $HClO_4(aq) + NaC_2H_3O_2(aq)$

$H^+(aq) + ClO_4^-(aq) + Na^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_2(aq) + ClO_4^-(aq) + Na^+(aq)$

$H^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_2(aq)$

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3. (32 points; 4 points each) Circle the correct answer to each of the following.

a. Which one of the following is *soluble* in water (i.e., all others are insoluble or only sparingly soluble)?

$Mg(OH)_2$ NiS Hg_2Cl_2 Ag_2CO_3 $Ba(OH)_2$

b. Which one of the following is a weak electrolyte in water?

$HClO_4$ $Ca(OH)_2$ H_2SO_3 C_2H_5OH HBr

c. If the following solutions were each treated with excess HCl(*aq*), which one would produce a gas?

$NH_4Cl(aq)$ $CH_3OH(aq)$ $Na_2CO_3(aq)$ $KClO_4(aq)$ $CaBr_2(aq)$

d. Which one of the following has the highest concentration of *catons* in solution?

0.10 M NaCl 0.050 M $Al_2(SO_4)_3$ 0.10 M K_2SO_4 0.050 M $CaCl_2$ 0.10 M $HC_2H_3O_2$

e. In which one of the following reactions is iodine undergoing *reduction*?

$2\ KI(aq) + Cl_2(aq) \rightarrow I_2(s) + 2\ KCl(aq)$

$2\ KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(aq) + 2\ KNO_3(aq)$

$KIO_3(aq) + 6\ Hg(l) + 6\ HCl(aq) \rightarrow KI(aq) + 3\ Hg_2Cl_2(s) + 3\ H_2O(l)$

f. Each of the following denotes an electronic transition from an initial to a final state in the hydrogen atom, $n_{initial} \rightarrow n_{final}$. Which transition results in the emission of visible radiation?

$1 \rightarrow \infty$ $2 \rightarrow 5$ $5 \rightarrow 4$ $3 \rightarrow 2$ $2 \rightarrow 1$

g. Which of the following has the highest energy?

x-rays ultraviolet infrared red light radio waves

h. What is the energy in joules (J) of a photon whose wavelength is 623 nm?

1.06×10^{-27} J 1.06×10^{-36} J $4.81 \times 19^{+14}$ J 3.19×10^{-19} J 3.19×10^{-28} J

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4. (16 points; 8 points each part) Answer both parts. Show work in the spaces provided to justify your answers.

a. How many grams of NaCl(*s*) (f.w. = 58.44 u) are needed to prepare exactly 250 mL of a 0.1252 M NaCl(*aq*) solution?

$$\text{mol NaCl} = (0.2500\text{L})(0.1252\text{M}) = 0.03130\text{ mol}$$

$$\text{g NaCl} = (0.03130\text{ mol})\left(\frac{58.44\text{ g}}{\text{mol}}\right) = 1.829\text{ g}$$

b. How many milliliters (mL) of 0.1252 M NaCl(*aq*) solution are need to completely precipitate all the silver ion in 25.00 mL of 0.1200 M $AgNO_3$(*aq*) solution by the reaction

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

$$\text{mmol } AgNO_3 = (25.00\text{mL})(0.1200\text{M}) = 3.000\text{ mmol} = \text{mmol NaCl}$$

$$\text{mL NaCl soln} = \frac{3.000\text{ mmol}}{0.1252\text{ mmol/mL}} = 23.96\text{ mL}$$

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5. (16 points) Calculate the enthalpy of the following reaction

$$K_2O(s) + H_2O(l) \rightarrow 2\ KOH(s) \qquad \Delta H^\circ = ?$$

Given the following thermochemical equations:

a $2\ KOH(s) + CO_2(g) \rightarrow K_2CO_3(s) + H_2O(l)$ $\Delta H^\circ = +193.05$ kJ

b $4\ K(s) + O_2(g) + 2\ CO_2(g) \rightarrow 2\ K_2CO_3(s)$ $\Delta H^\circ = -2300.36$ kJ

c $4\ K(s) + O_2(g) \rightarrow 2\ K_2O(s)$ $\Delta H^\circ = -726.34$ kJ

$-a$ $K_2CO_3(s) + H_2O(l) \rightarrow 2KOH(s) + CO_2(g)$ $\Delta H^\circ = -193.05$ kJ

$\frac{1}{2}b$ $2K(s) + \frac{1}{2}O_2(g) + CO_2(g) \rightarrow K_2CO_3(s)$ $\Delta H^\circ = -1150.18$ kJ

$-\frac{1}{2}c$ $K_2O(s) \rightarrow 2K(s) + \frac{1}{2}O_2(g)$ $\Delta H^\circ = +363.17$ kJ

$K_2O(s) + H_2O(l) \rightarrow 2KOH(s)$ $\Delta H^\circ = -980.06$ kJ

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6. (14 points + 5 point bonus) The standard heat of combustion of diisopropyl ether, $(C_3H_7)_2O(l)$ (m.w. 102.17 u), is defined by the following thermochemical equation:

$$(C_3H_7)_2O(l) + 9\ O_2(g) \rightarrow 6\ CO_2(g) + 7\ H_2O(l) \qquad q_c = ?$$

a. (10 points) A student combusted a 1.950-g sample of diisopropyl ether in the bomb of a calorimeter having a heat capacity of 7.430 kJ/°C. The temperature of the water in the calorimeter rose from 21.15 °C to 31.45 °C. Based on this experiment, what is the value of the heat of the reaction *per gram* of diisopropyl ether?

$\Delta T = (31.45 - 21.15)°C = 10.30°C$

$q_{cal} = (7.430 kJ/°C)(10.30 °C) = 76.529 kJ$

$q_{rxn} = \dfrac{-76.529 kJ}{1.950 g} = -39.24_{56} kJ/g = -39.25\ kJ/g$

b. (4 points) What is the value of the heat of combustion *per mole* of diisopropyl ether?

$q_c = \left(\dfrac{-39.24_{56} kJ}{g}\right)\left(\dfrac{102.17 g}{mol}\right) = -4009.72\ kJ/mol$

$= -4010.\ kJ/mol$

c. (5 point bonus) Given the thermochemical equation for the combustion of diisopropyl ether and the following standard enthalpies of formation, calculate the standard enthalpy of formation, ΔH°_f, for $C_6H_{13}OH(l)$, assuming that your calculated value of q_c is essentially the standard enthalpy of combustion, ΔH°_c. (Your answer to part b must be essentially correct to receive bonus credit.)

$CO_2(g)$	$H_2O(l)$
–393.5 kJ/mol	–285.8 kJ/mol

$\Delta H^\circ_c = 6\Delta H^\circ_f(CO_2) + 7\Delta H^\circ_f(H_2O) - \Delta H^\circ_f((C_3H_7)_2O)$

$\Delta H^\circ_f((C_3H_7)_2O) = 6\Delta H^\circ_f(CO_2) + 7\Delta H^\circ_f(H_2O) - \Delta H^\circ_c$

$= (6)(-393.5 kJ) + (7)(-285.8 kJ) - (-4010 kJ)$

$= -2361.0 kJ - 2000.6 kJ + 4010 kJ$

$= -351.6 kJ = -352 kJ$