Name: ______________________ **Section (please circle): A(Rice) — B(McKinney)**

<u>Part I. Short Answer</u>: 4 points each (answer ALL 8 questions).

1. Which of the following compounds is *insoluble*?
   a) $Ba(C_2H_3O_2)_2$
   b) $MgBr_2$
   c) $(NH_4)_3PO_4$
   d) PbI_2
   e) $CoNO_3$

2. Which of the following is *not* a strong acid?
   a) H_3PO_4
   b) H_2SO_4
   c) HNO_3
   d) $HClO_3$
   e) HI

3. The following oxidation-reduction reaction occurs in acid solution:

   $$5\,U^{4+}(aq) + MnO_4^-(aq) + 6\,H_2O \rightarrow 5\,UO_2^+(aq) + Mn^{2+}(aq) + 12H^+(aq)$$

   4+

   The oxidation number of U in UO_2^+ is __+5__, and the reducing agent in the reaction is __U^{4+}__.

4. Write a *total ionic equation* for the neutralization of hydrofluoric acid with magnesium hydroxide.

   $$2HF(aq) + Mg(OH)_2(aq) \longrightarrow 2H_2O_{(l)} + 2F^-_{(aq)} + Mg^{2+}_{(aq)}$$

   HF is a weak acid and $Mg(OH)_2$ is relatively insoluble so the best representation of these is as compounds, not ions.

5. The internal energy of a system is always increased by ________.
   a) adding heat to the system
   b) having the system do work on the surroundings
   c) withdrawing heat from the system
   d) adding heat to the system and having the system do work on the surroundings
   e) increasing the system's volume

6. The volume of an ideal gas is zero at ________.
   a) 0 °C
   b) -45 °F
   c) -273 K
   d) -363 K
   e) -273 °C

7. The density of air at STP is 1.285 g/L. A balloon of which of the following gases at STP is least likely to float in air?

   a) CH_4
   b) NO
   c) Ne
   d) NH_3
   e) HF

8. The decomposition of copper (II) oxide into copper metal and oxygen gas is an endothermic process:

$$2\,CuO_{(s)} \rightarrow 2Cu_{(s)} + O_{2\,(g)} \quad \Delta H° = +312.2\text{ kJ}$$

What is the standard enthalpy of formation of copper (II) oxide? −156.1 kJ/mol

Part II. Short Problems: 10 points each (answer ALL 3 questions; you must show your work – partial credit is available).

9. The ΔH° for the reaction below is +570.37 kJ.

$$PCl_{3\,(g)} + 3\,HCl_{(g)} \rightarrow 3\,Cl_{2\,(g)} + PH_{3\,(g)}$$

Compound	$\Delta H°_f$ (kJ/mol)
PCl_3 (g)	-288.07
HCl (g)	-92.30

a) Using the data in the table, calculate $\Delta H_f°$ of $PH_{3\,(g)}$.

$$\Delta H°_{rxn} = 3\Delta H_f°(Cl_2) + \Delta H_f°(PH_3) - \Delta H_f°(PCl_3) - 3\Delta H_f°(HCl)$$

$$+570.37\text{ kJ} = 0 + \Delta H_f°(PH_3) - (-288.07\text{ kJ/mol})1\text{ mol} - 3\text{mol}(-92.30\text{ kJ/mol})$$

$$\Delta H_f°(PH_3) = \frac{(+570.37\text{ kJ} - 564.97\text{ kJ})}{\text{mol}} = +5.40\text{ kJ/mol}$$

b) Is the formation of $PH_{3\,(g)}$ endothermic or exothermic? endothermic

10. 79.3 mL of a 1.50 M sodium carbonate solution is reacted with excess hydrochloric acid to form sodium chloride, water, and carbon dioxide. If the reaction takes place in an evacuated 1.00 L container at 25.0 °C, what will be the final pressure in the container? You may neglect the volume occupied by the solution.

$$0.0793\text{L} \times 1.50\text{M} = 0.119\text{ moles } Na_2CO_3 \times \frac{1\text{ mol } CO_2}{1\text{ mol } Na_2CO_3}$$

$$= 0.119\text{ moles } CO_2 \text{ produced}$$

$$P = \frac{nRT}{V} = \frac{(0.119\text{mol})(0.08206\ \frac{\text{L·atm}}{\text{mol·K}})(298\text{K})}{1.00\text{L}}$$

$$P = 2.91\text{ atm}$$

11. Balance the following redox reaction in acidic solution.

$$H_3AsO_{3\,(s)} + NO_3^-{}_{(aq)} \rightarrow H_3AsO_{4\,(aq)} + NO_{(g)}$$

$$3\left(H_3AsO_3(s) + H_2O \rightarrow H_3AsO_4(aq) + 2H^+ + 2e^-\right)$$

$$2\left(NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O\right)$$

$$3H_3AsO_3 + \cancel{3H_2O} + 2NO_3^- + \cancel{8}^{2}H^+ \rightarrow 3H_3AsO_4 + \cancel{6H^+} + 2NO + \cancel{4}^{1}H_2O$$

$$3H_3AsO_3 + 2NO_3^- + 2H^+ \rightarrow 3H_3AsO_4 + 2NO + H_2O$$

Part III. Problems (begins next page): Answer 2 of the following 3 questions. Clearly indicate which question you do NOT want counted for a grade, otherwise the first two answered questions will be graded. 14 points each (you must show your work – partial credit is available).

12. Various chemical reactions are used to make instant heating packs. One example is the formation reaction of iron (III) oxide, Fe_2O_3, for which ΔH_f° is -822.16 kJ/mol.

a) Write a balance equation for the formation of Fe_2O_3 from its reference form elements.

$$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

b) If you put this heat pack in your mitten while skiing and it produced 5.25 g of Fe_2O_3 (FW = 159.688 g/mol), what would be the change in temperature of your hand if 45.5% of the heat of the reaction were transferred directly to your hand? Assume that the average human hand weighs 0.500 kg and that its specific heat of your hand is equal to that of water (4.184 $J \cdot g^{-1} \cdot K^{-1}$).

$$5.25\,g\ Fe_2O_3 \times \frac{159.688\,g}{1\ mol} = 0.0329\ moles$$

$$0.0329\ moles\ Fe_2O_3 \times (-822.16\ kJ/mol) \times 0.455$$

$$= -12.3\ kJ = q_{sys}$$

$$q_{surr} = -q_{sys} = +12.3\ kJ = mC_s\Delta T$$

$$\Delta T = \frac{+12.3\,kJ\,(1000\,J/1\,kJ)}{(0.500\,kg)(1000\,g/kg)(4.184\,J\,g^{-1}K^{-1})}$$

$$\Delta T = 5.88\ ^\circ C$$

13. 0.109 mol of argon gas is injected into a 3.83 L container that already contains 1.00 atm of an unknown gas at 40.0 °C. The final volume and temperature remain unchanged.

a) What is the partial pressure of each gas in the final mixture?

$$P_{Ar} = \frac{n_{Ar}RT}{V} = \frac{(0.109\ \text{mol})(0.08206\ \text{L}\cdot\text{atm}/\text{mol K})(313.15\ \text{K})}{3.83\ \text{L}}$$

$$= 0.731\ \text{atm}$$

argon 0.731 atm unknown gas 1.00 atm

b) If the total mass of both gases in the container is 16.84 g, what is the identity of the second gas?

$$0.109\ \text{mol Ar} \times \frac{39.948\ \text{g}}{1\ \text{mol Ar}} = 4.35\ \text{g Ar}$$

$$16.84\ \text{g total} - 4.35\ \text{g Ar} = 12.49\ \text{g unk.}$$

$$n = \frac{PV}{RT} = \frac{(1.00\ \text{atm})(3.83\ \text{L})}{(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(313.15\ \text{K})} = 0.149\ \text{moles}$$

$$M_{unk} = 12.49\ \text{g}/0.149\ \text{moles} = 83.8\ \text{g/mol} \Rightarrow Kr$$

14. Acetylsalicylic acid ($HC_9H_7O_4$; FW = 180.157 g/mol) is a monoprotic acid commonly known as aspirin. Aspirin tablets typically contain only a small amount of the acid. To determine the quantity of aspirin in a 1.956 g tablet, the tablet is crushed, dissolved in water, and titrated with 0.150 M potassium hydroxide. If 12.25 mL of base is necessary to neutralize all of the acid, what percentage (by mass) of aspirin in an aspirin tablet?

$$0.01225\ \text{L} \times 0.150\ \text{mol/L} \times \frac{1\ \text{mol aspirin}}{1\ \text{mol KOH}} \times \frac{180.157\ \text{g}}{1\ \text{mol aspirin}}$$

$$= 0.339\ \text{g aspirin}$$

$$\frac{0.339}{1.956} \times 100 = 17.3\%\ \text{aspirin}$$