

Name _____

TA's Name _____

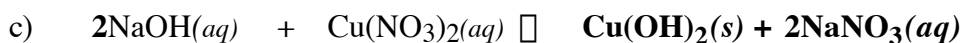
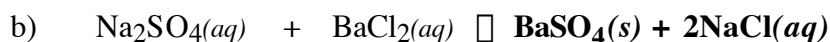
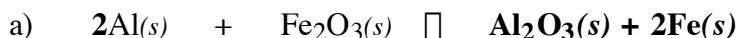
Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 8 different pages. The last three pages include a periodic table, a solubility table, a Table of Standard Heats of Formation, an Activity Series and some useful equations. All work should be done in this booklet.
2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.
3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice or short answer questions.
4. No credit will be awarded if your work is not shown in problems 3 – 6.
5. Point values are shown next to the problem number.
6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.
7. Look through the exam before beginning; plan your work; then begin.
8. **Relax** and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	<u> </u> (40)	<u> </u> (22)	<u> </u> (22)	<u> </u> (16)	<u> </u> (100)

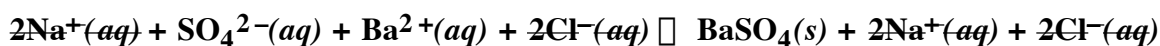
(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous.



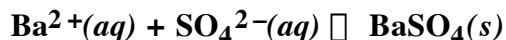
(8) 2. Write the ionic and net ionic chemical equations for 1b).

1b)

Ionic equation:



Net Ionic equation:



(20) 3. A sample of a pure gaseous hydrocarbon was analyzed by combustion analysis. Results revealed the sample contained 7.691 grams of carbon (C) and 1.709 grams of hydrogen (H).

a) What is the empirical formula of the compound?

$$7.691 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 0.6409 \text{ mol C}$$

$$1.709 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 1.695 \text{ mol H}$$

$$\frac{0.6409 \text{ mol C}}{0.6409} : \frac{1.695 \text{ mol H}}{0.6409}$$

$$1.00 \text{ mol C} : 2.645 \text{ mol H}$$

$$\text{multiply by 3 (1 C : 2.645 H) = 3 C : 8 H}$$



b) Another sample of this gaseous hydrocarbon with a mass of 4.16 grams contains 5.69×10^{22} molecules.

i) What is the molar mass of the hydrocarbon?

$$5.69 \times 10^{22} \text{ molecules C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{6.02 \times 10^{23} \text{ molecules C}_3\text{H}_8} = 0.0945 \text{ mol C}_3\text{H}_8$$

$$\frac{4.16 \text{ g C}_3\text{H}_8}{0.0945 \text{ mole C}_3\text{H}_8} = 44.0 \frac{\text{g}}{\text{mole}}$$

ii) Using the information from part a) what is the molecular formula of the hydrocarbon?

$$\text{EW} * n = \text{MM} \quad 44.0 * n = 44.0 \quad n = 1 \text{ molecular formula is C}_3\text{H}_8$$

- (22) 4a. In an experiment liquid hexane, $C_6H_{14}(l)$, is completely combusted to produce $CO_2(g)$ and $H_2O(l)$, according to the equation.



The ΔH° for this reaction is -8.39×10^3 kJ. Calculate ΔH_f° for $C_6H_{14}(l)$.

$$\Delta H_{rxn}^\circ = \sum \Delta H_f^\circ (\text{products}) - \sum \Delta H_f^\circ (\text{reactants})$$

$$\Delta H_{rxn}^\circ = 12\Delta H_f^\circ (CO_2) + 14\Delta H_f^\circ (H_2O(l)) - 2\Delta H_f^\circ (C_6H_{14})$$

$$2\Delta H_f^\circ (C_6H_{14}) = 12\Delta H_f^\circ (CO_2) + 14\Delta H_f^\circ (H_2O(l)) - \Delta H_{rxn}^\circ$$

$$2\Delta H_f^\circ (C_6H_{14}) = (12 \text{ mol} \left[\frac{393.5 \text{ kJ}}{\text{mol}} \right] + 14 \text{ mol} \left[\frac{285.85 \text{ kJ}}{\text{mol}} \right]) - (-8390 \left[\frac{\text{kJ}}{\text{mol}} \right])$$

$$\Delta H_f^\circ (C_6H_{14}) = \frac{-336 \left[\frac{\text{kJ}}{\text{mol}} \right]}{2} = -168 \text{ kJ}$$

- b) A 1.25 g sample of hexane is combusted in a bomb calorimeter according to the reaction in part a). The bomb calorimeter has a heat capacity of $1850 \frac{J}{^\circ C}$ and holds 4.00 kg of water. The initial temperature of the water in the bomb calorimeter is $23.82^\circ C$. Calculate the final temperature of the water and the calorimeter after the reaction is complete.

$$1.25 \text{ g } C_6H_{14} \left[\frac{1 \text{ mol } C_6H_{14}}{86.0 \text{ g}} \right] \left[\frac{-8.39 \times 10^3 \text{ kJ}}{2 \text{ mol } C_6H_{14}} \right] = -61.0 \text{ kJ}$$

$$q_{rxn} = -(q_{water} + q_{calorimeter})$$

$$-61,000 \text{ J} = -((4,000 \text{ g})(4.184 \frac{J}{g \cdot ^\circ C}) \Delta T + 1850 \frac{J}{^\circ C} \Delta T)$$

$$-61,000 \text{ J} = -(16740 \frac{J}{^\circ C}) \Delta T + 1850 \frac{J}{^\circ C} \Delta T)$$

$$-61,000 \text{ J} = -(18590 \frac{J}{^\circ C}) \Delta T)$$

$$\Delta T = 3.28^\circ C$$

$$T_f = 23.82^\circ C + 3.28^\circ C = 27.10^\circ C$$

- (22) 5. To remove ozone, O_3 , from air, an air sample is passed through an aqueous solution of sodium iodide. The reaction that occurs is described in the equation



2.35 grams of ozone are required to completely react with all of the NaI in a 400. mL of solution.

- a) how many grams of NaI are in the solution?

$$2.35 \text{ g } O_3 \times \frac{1 \text{ mol } O_3}{48.0 \text{ g } O_3} \times \frac{2 \text{ mol NaI}}{1 \text{ mole } O_3} \times \frac{150 \text{ g NaI}}{1 \text{ mole NaI}} = 14.7 \text{ g NaI}$$

- b) what was the concentration of the NaI solution before the reaction started?

$$\frac{0.0979 \text{ mol NaI}}{0.400 \text{ L}} = 0.245 \text{ M}$$

- c) How many grams of I_2 are formed in the reaction?

$$2.35 \text{ g } O_3 \times \frac{1 \text{ mol } O_3}{48.0 \text{ g } O_3} \times \frac{1 \text{ mol } I_2}{1 \text{ mole } O_3} \times \frac{254 \text{ g } I_2}{1 \text{ mole } I_2} = 12.4 \text{ g } I_2$$

(10) 6. Carbon monoxide can react with iron(III) oxide as described in the following equation



How many grams of Fe(s) are formed when 18.8 grams of Fe₂O₃(s) are combined with 11.1 grams of CO(g)?

$$18.8 \text{ g Fe}_2\text{O}_3 \times \frac{1 \text{ mol Fe}_2\text{O}_3}{160 \text{ g Fe}_2\text{O}_3} = 0.118 \text{ mol Fe}_2\text{O}_3$$

$$11.1 \text{ g CO} \times \frac{1 \text{ mol CO}}{28.0 \text{ g CO}} = 0.396 \text{ mol CO}$$

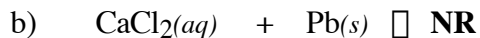
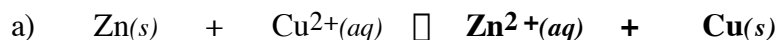
(moles Fe ₂ O ₃) _{initial}	(moles CO) _{required}	(moles CO) _{initial}	Conclusion
0.118	0.354	0.396 mol	

$$0.118 \text{ mol Fe}_2\text{O}_3 \times \frac{3 \text{ mol CO}}{1 \text{ mol Fe}_2\text{O}_3} = 0.354 \text{ mol CO}$$

0.354 mol CO required, and 0.396 mol of CO available initially. Therefore CO is in excess and Fe₂O₃ is the limiting reagent.

$$0.118 \text{ mol Fe}_2\text{O}_3 \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{55.8 \text{ g Fe}}{1 \text{ mol Fe}} = 13.2 \text{ g Fe}$$

(6) 7. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. If no reaction occurs write NR.



Periodic Table of the Elements

IA 1 H 1.008	IIA 3 Li 6.94												IIIA 5 B 10.81	IVA 6 C 12.01	VA 7 N 14.01	VIA 8 O 16.00	VIIA 9 F 19.00	VIII 2 He 4.00 10 Ne 20.18 18 Ar 39.95
	3 Na 22.99	4 Mg 24.30	IIIB 21	IVB 22	VB 23	VIB 24	VIIB 25	VIII 26-28	IB 29	IIB 30	IIIA 31 Ga 69.72	IVA 32 Ge 72.59	VA 33 As 74.92	VIA 34 Se 78.96	VIIA 35 Br 79.90	VIII 36 Kr 83.80		
4 K 39.10	Ca 40.08	Sc 44.96	Ti 47.88	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.38	Ga 69.72	Ge 72.59	As 74.92	Se 78.96	Br 79.90	Kr 83.80	
5 Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc (98)	Ru 101.1	Rh 102.9	Pd 106.4	Ag 107.9	Cd 112.4	In 114.8	Sn 118.7	Sb 121.8	Te 127.6	I 126.9	Xe 131.3	
6 Cs 132.9	Ba 137.3	La 138.9	Hf 178.5	Ta 180.9	W 183.8	Re 186.2	Os 190.2	Ir 192.2	Pt 195.1	Au 197.0	Hg 200.6	Tl 204.4	Pb 207.2	Bi 209.0	Po (209)	At (210)	Rn (222)	
7 Fr (223)	Ra 226.0	Ac 227.0	Rf (261)	Db (262)	Sg (266)	Bh (264)	Hs (269)	Mt (268)	(271)	(272)	(277)	(285)	(289)					

	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Lanthanides														
	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	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 (260)
Actinides														

Useful Information

$$\text{Specific heat of H}_2\text{O}(s) = 2.09 \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}} \quad \text{Specific heat of H}_2\text{O}(l) = 4.184 \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}}$$

$$\text{Specific heat of H}_2\text{O}(g) = 1.84 \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}} \quad \text{Heat of fusion of H}_2\text{O}(s) = 6.01 \frac{\text{kJ}}{\text{mol}}$$

$$\text{Heat of vaporization of H}_2\text{O}(l) = 40.67 \frac{\text{kJ}}{\text{mol}}$$

$$R = 0.08203 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \quad \text{or} \quad R = 8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}}$$

$$\Delta H = \Delta E + \Delta nRT$$

$$q(\text{heat flow}) = \text{mass} \cdot \text{specific heat} \cdot \Delta T$$

$$q_{\text{reaction}} = -(q_{\text{calorimeter}} + q_{\text{solution}})$$

$$q_{\text{reaction}} = -(q_{\text{calorimeter}} + q_{\text{water}})$$

$$\Delta H_{\text{rxn}}^{\circ} = \sum n\Delta H_{\text{f}}^{\circ}(\text{products}) - \sum m\Delta H_{\text{f}}^{\circ}(\text{reactants})$$

Table of Standard Heats of Formation

Substance and State	ΔH_f° (kJ/mol)	Substance and State	ΔH_f° (kJ/mol)
C(s) (graphite)	0	HCl(g)	-92.3
C(s) (diamond)	2	HBr(g)	-36.4
CO(g)	-110.5	HI(g)	26.5
CO ₂ (g)	-393.5	I ₂ (g)	62.25
CH ₄ (g)	-75	O ₂ (g)	0
CH ₃ OH(g)	-201	O(g)	249
CH ₃ OH(l)	-239	O ₃ (g)	143
H ₂ CO(g)	-116		
CCl ₄ (l)	-135.4	N ₂ (g)	0
HCOOH(g)	-363	NH ₃ (g)	-46
HCN(g)	135.1	NH ₃ (aq)	-80
CS ₂ (g)	117.4	NH ₄ ⁺ (aq)	-132
CS ₂ (l)	89.7	N ₂ H ₃ CH ₃ (l)	54
C ₂ H ₂ (g)	227	N ₂ H ₄ (l)	50.6
C ₂ H ₄ (g)	52	NO(g)	90.25
CH ₃ CHO(g)	-166	NO ₂ (g)	33.18
C ₂ H ₅ OH(l)	-278	N ₂ O(g)	82.0
C ₂ H ₅ O ₂ N(g)	-533	N ₂ O ₄ (g)	9.16
C ₂ H ₆ (g)	-84.7	N ₂ O ₄ (l)	20
C ₃ H ₆ (g)	20.9	HNO ₃ (aq)	-207.36
C ₃ H ₈ (g)	-104	HNO ₃ (l)	-174.10
C ₄ H ₁₀ (g)	-126	NH ₄ ClO ₄ (s)	-295
CH ₂ = CHCN(l)	152		
CH ₃ COOH(l)	-484	S ₂ Cl ₂ (g)	-18
C ₆ H ₁₂ O ₆ (s)	-1275	SO ₂ (g)	-296.83
		H ₂ S(g)	-20.6
Cl ₂ (g)	0	SOCl ₂ (g)	-213
Cl ₂ (aq)	-23		
Cl ⁻ (aq)	-167	SiCl ₄ (g)	-657
		SiO ₂ (s)	-910.94
H ₂ (g)	0	SiF ₄ (g)	-1614.9
H(g)	217		
H ⁺ (aq)	0	TiO ₂ (s)	-944.7
OH ⁻ (aq)	-230	TiCl ₄ (g)	-763
H ₂ O(l)	-286		
H ₂ O(g)	-242	ZnO(s)	-348
		ZnS(s)	-206

Activity Series

Metal	Half-Reaction Reaction
Gold	$\text{Au}^{3+} + 3\text{e}^{-} \rightarrow \text{Au}$
Platinum	$\text{Pt}^{2+} + 2\text{e}^{-} \rightarrow \text{Pt}$
Mercury	$\text{Hg}^{2+} + 2\text{e}^{-} \rightarrow \text{Hg}$
Silver	$\text{Ag}^{+} + \text{e}^{-} \rightarrow \text{Ag}$
Copper	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$
Hydrogen	$2\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{H}_2$
Lead	$\text{Pb}^{2+} + 2\text{e}^{-} \rightarrow \text{Pb}$
Tin	$\text{Sn}^{2+} + 2\text{e}^{-} \rightarrow \text{Sn}$
Nickel	$\text{Ni}^{2+} + 2\text{e}^{-} \rightarrow \text{Ni}$
Cobalt	$\text{Co}^{2+} + 2\text{e}^{-} \rightarrow \text{Co}$
Iron	$\text{Fe}^{2+} + 2\text{e}^{-} \rightarrow \text{Fe}$
Chromium	$\text{Cr}^{3+} + 3\text{e}^{-} \rightarrow \text{Cr}$
Zinc	$\text{Zn}^{2+} + 2\text{e}^{-} \rightarrow \text{Zn}$
Manganese	$\text{Mn}^{2+} + 2\text{e}^{-} \rightarrow \text{Mn}$
Aluminum	$\text{Al}^{3+} + 3\text{e}^{-} \rightarrow \text{Al}$
Magnesium	$\text{Mg}^{2+} + 2\text{e}^{-} \rightarrow \text{Mg}$
Sodium	$\text{Na}^{+} + \text{e}^{-} \rightarrow \text{Na}$
Calcium	$\text{Ca}^{2+} + 2\text{e}^{-} \rightarrow \text{Ca}$
Barium	$\text{Ba}^{2+} + 2\text{e}^{-} \rightarrow \text{Ba}$
Potassium	$\text{K}^{+} + \text{e}^{-} \rightarrow \text{K}$
Lithium	$\text{Li}^{+} + \text{e}^{-} \rightarrow \text{Li}$

Solubility Table

<u>Ion</u>	<u>Solubility</u>	<u>Exceptions</u>
NO_3^{-}	soluble	none
ClO_4^{-}	soluble	none
Cl^{-}	soluble	except Ag^{+} , Hg_2^{2+} , Pb^{2+}
I^{-}	soluble	except Ag^{+} , Hg_2^{2+} , Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+} , Ba^{2+} , Sr^{2+} , Hg^{2+} , Pb^{2+} , Ag^{+}
CO_3^{2-}	insoluble	except Group IA and NH_4^{+}
PO_4^{3-}	insoluble	except Group IA and NH_4^{+}
-OH	insoluble	except Group IA, Ca^{2+} , Ba^{2+} , Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^{+}
Na^{+}	soluble	none
NH_4^{+}	soluble	none
K^{+}	soluble	none

*slightly soluble

