

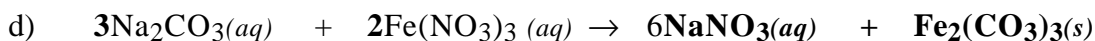
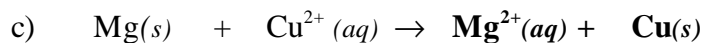
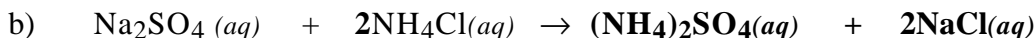
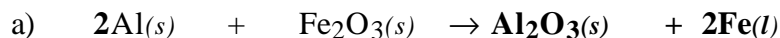
Name _____
TA's Name _____
Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 9 different pages. The last four pages include a periodic table, a solubility table, a table of enthalpy's 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 – 8.
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>(34)</u>	<u>(25)</u>	<u>(21)</u>	<u>(20)</u>	<u>(100)</u>

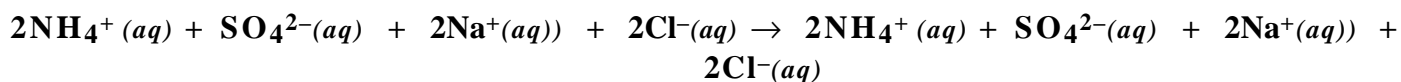
(12) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous. If no reaction occurs write NR.



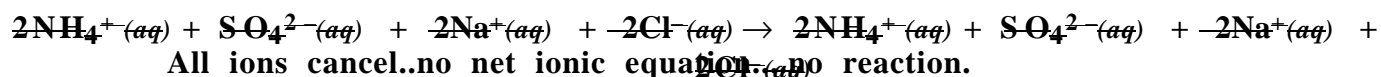
(12) 2. Write the ionic and net ionic chemical equations for 1b) and 1d).

1b)

Ionic equation:

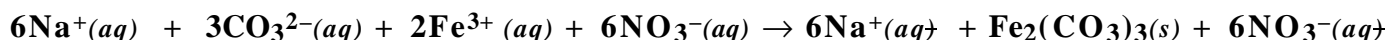


Net Ionic equation:

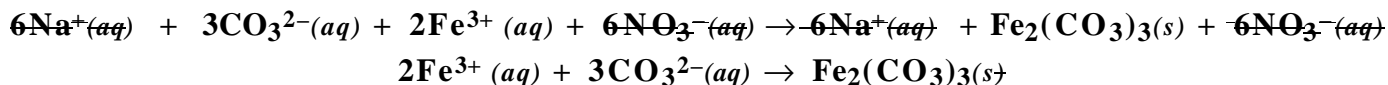


1d)

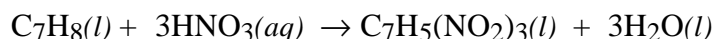
Ionic equation:



Net Ionic equation:



(10) 3. An explosive, trinitrotoluene, is prepared by reacting toluene with nitric acid according to the equation



What mass of toluene and nitric acid are required to produce 50.0 g of trinitrotoluene?

$$50.0 \text{ g TNT} \left(\frac{1 \text{ mol}}{227 \text{ g}} \right) = 0.220 \text{ Mol TNT}$$

$$0.220 \text{ Mol TNT} \left(\frac{1 \text{ mol C}_7\text{H}_8}{1 \text{ mol TNT}} \right) \left(\frac{92.0 \text{ g}}{1 \text{ mol C}_7\text{H}_8} \right) = 20.3 \text{ g C}_7\text{H}_8$$

$$0.220 \text{ Mol TNT} \left(\frac{3 \text{ mol HNO}_3}{1 \text{ mol TNT}} \right) \left(\frac{63.0 \text{ g}}{1 \text{ mol HNO}_3} \right) = 41.6 \text{ g HNO}_3$$

- (15) 4. Boric acid is formed in the reaction between boron trifluoride and water. The reaction is,



What is the maximum number of grams of boric acid which can be obtained when 150. g of boron trifluoride is reacted with 35.0 g of water?

$$150. \text{ g BF}_3 \left(\frac{1 \text{ mol BF}_3}{67.8 \text{ g}} \right) = 2.21 \text{ mol B} \qquad 35.0 \text{ g H}_2\text{O} \left(\frac{1 \text{ mol H}_2\text{O}}{18.0 \text{ g}} \right) = 1.94 \text{ mol H}_2\text{O}$$

$$2.21 \text{ mol BF}_3 \left(\frac{3 \text{ mol H}_2\text{O}}{4 \text{ mol BF}_3} \right) = 1.66 \text{ mol H}_2\text{O required}$$

1.66 mol H₂O required and 1.94 mol H₂O are available. So the water is in excess and BF₃ is limiting.

$$2.21 \text{ mol BF}_3 \left(\frac{1 \text{ mol H}_3\text{BO}_3}{4 \text{ mol BF}_3} \right) \left(\frac{61.8 \text{ g}}{1 \text{ mol H}_3\text{BO}_3} \right) = 34.1 \text{ g H}_3\text{BO}_3$$

Calculate the final mass of both reactants after the reaction has gone to completion.

0 g of BF₃ left

$$1.66 \text{ mol H}_2\text{O} \left(\frac{18.0 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \right) = 29.9 \text{ g H}_2\text{O reacted}$$

35.0 g – 29.9 g = 5.1 g H₂O remain unreacted.

- (10) 5. Calculate the mass of oxalic acid that reacts with 0.680 mLs of 2.44×10^{-3} M KMnO₄ in excess sulfuric acid. The equation which describes the reaction between oxalic acid, potassium permanganate and sulfuric acid is,

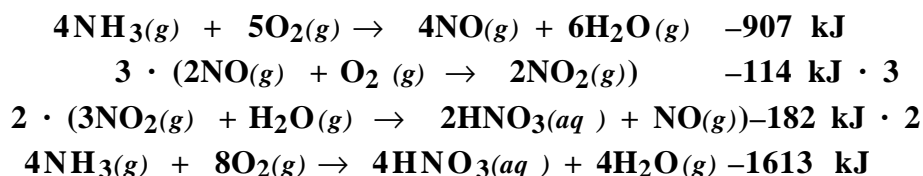


$$0.680 \text{ mLs} \left(\frac{1 \text{ L}}{1000 \text{ mLs}} \right) \left(\frac{2.44 \times 10^{-3} \text{ mol KMnO}_4}{1 \text{ L}} \right) \left(\frac{5 \text{ mol H}_2\text{C}_2\text{O}_4}{2 \text{ mol KMnO}_4} \right) \left(\frac{90.0 \text{ g}}{1 \text{ mol H}_2\text{C}_2\text{O}_4} \right) = 0.373 \text{ g of H}_2\text{C}_2\text{O}_4$$

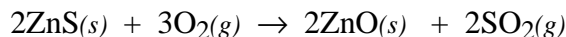
- (9) 6. The industrial preparation of nitric acid, the Ostwald Process, converts ammonia to nitric acid. Using the following standard enthalpy of reaction data and Hess' Law determine the enthalpy for production of nitric acid from ammonia. (Note: While ammonia and nitric acid are the only two substances mentioned it should be realized other substances may be needed to obtain a balanced chemical equation which describes the conversion of ammonia to nitric acid.)

Reaction	ΔH°
$4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g)$	-907 kJ
$2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)$	-114 kJ
$3\text{NO}_2(g) + \text{H}_2\text{O}(g) \rightarrow 2\text{HNO}_3(aq) + \text{NO}(g)$	-182 kJ

Clearly demonstrate how the given equations are to be manipulated to obtain the final equation.



- (12) 7a. When a sulfide is combusted sulfur dioxide is a product. Calculate $\Delta H_{\text{rxn}}^\circ$ for the combustion of zinc sulfide.



$$\begin{aligned}
 \Delta H_{\text{rxn}}^\circ &= \Sigma \Delta H_f^\circ (\text{products}) - \Sigma \Delta H_f^\circ (\text{reactants}) \\
 \Delta H_{\text{rxn}}^\circ &= \left(2 \text{ mol} \left(-348 \frac{\text{kJ}}{\text{mol}} \right) + 2 \text{ mol} \left(-297 \frac{\text{kJ}}{\text{mol}} \right) \right) \\
 &- \left(2 \text{ mol} \left(-206 \frac{\text{kJ}}{\text{mol}} \right) + 3 \text{ mol} \left(0 \frac{\text{kJ}}{\text{mol}} \right) \right) = -878 \text{ kJ} \cdot (2 \text{ mol ZnS})^{-1}
 \end{aligned}$$

- (20)8a. 45.0 g of water at 33.0 °C are added to 24.0 g of water, in a calorimeter, at 21.0 °C. The final temperature of the mixture is 27.8 °C. Calculate the heat capacity of the calorimeter.

$$q_{\text{hot}} = -(q_{\text{cold}} + q_{\text{calorimeter}})$$

$$4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \cdot 45.0 \text{ g} \cdot (27.8 ^\circ\text{C} - 33.0 ^\circ\text{C}) = -(4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \cdot 24.0 \text{ g} \cdot (27.8 ^\circ\text{C} - 21.0 ^\circ\text{C}) + \text{HC}_{\text{calorimeter}} \cdot (27.8 ^\circ\text{C} - 21.0 ^\circ\text{C}))$$

$$-979 \text{ J} = - (682 \text{ J} + \text{HC}_{\text{calorimeter}} \cdot 6.8 ^\circ\text{C})$$

$$\text{HC}_{\text{calorimeter}} = \frac{297 \text{ J}}{6.8 ^\circ\text{C}} = 43.7 \frac{\text{J}}{^\circ\text{C}}$$

- b. 1.980 g of KOH are added to the same calorimeter used in the experiment in part a) above which now holds 50.0 mLs of water. The initial temperature of the water in the calorimeter 22.6 °C. If the final temperature of the solution in the calorimeter after adding the KOH is 31.2 °C, calculate the molar heat of solution for KOH. (Assume the specific heat of the solution is equal to the specific heat of pure water.)

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

$$q_{\text{reaction}} = -(4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \cdot 51.98 \text{ g} \cdot (31.2 ^\circ\text{C} - 22.6 ^\circ\text{C}) + 43.7 \frac{\text{J}}{^\circ\text{C}} \cdot (31.2 ^\circ\text{C} - 22.6 ^\circ\text{C}))$$

$$= \frac{-2246 \text{ J}}{1.98 \text{ g KOH}} \left(\frac{56.0 \text{ g}}{1 \text{ mol KOH}} \right) = -63.5 \text{ kJ} \cdot \text{mol}^{-1}$$

Periodic Table of the Elements

	IA																VIIIA					
1	1 H 1.008																2 He 4.00					
2	3 Li 6.94	IIA	4 Be 9.01									III A	5 B 10.81	IVA	6 C 12.01	VA	7 N 14.01	VIA	8 O 16.00	VIIA	9 F 19.00	10 Ne 20.18
3	11 Na 22.99		12 Mg 24.30	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95			
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80				
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3				
6	55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)				
7	87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)													

Lanthanides	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
Actinides	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)

Useful Information

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

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

$$\text{Specific heat of H}_2\text{O}(g) = 1.84 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}$$

$$\text{Heat of fusion of H}_2\text{O}(s) = 6.01 \frac{\text{kJ}}{\text{mol}}$$

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

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

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

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

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

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

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

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

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
TiO ₂ (s)	-945	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
		SiF ₄ (g)	-1614.9
H ₂ (g)	0		
H(g)	217	TiO ₂ (s)	-944.7
H ⁺ (aq)	0	TiCl ₄ (g)	-763
OH ⁻ (aq)	-230		
H ₂ O(l)	-286	ZnO(s)	-348
H ₂ O(g)	-242	ZnS(s)	-206

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

