

Chemical Principles 115
Department of Chemistry
Rutgers, The State University of New Jersey- Camden

EXAM 2 - B
November 4, 2015

Name: _____
 Last Key First Initial

RU Number: _____

Name: _____

SECTION I

MULTIPLE CHOICE: Choose the option that best completes the statement or answers the question. Each question is worth 2.0 points unless indicated otherwise.

- A solute is any substance that is dissolved in a solvent, and the solute can be a solid, liquid or gas.
 - True
 - False
- Which is a nonelectrolyte?
 - ammonium chloride, NH_4Cl
 - ethylene glycol, $\text{HOCH}_2\text{CH}_2\text{OH}$
 - nickel(II) sulfate, NiSO_4
 - sodium perchlorate, NaClO_4
 - zinc nitrate, $\text{Zn}(\text{NO}_3)_2$
- Which compound produces four ions per formula unit by dissociation when dissolved in water?
 - $\text{K}_2\text{C}_2\text{O}_4$ 3
 - $\text{Al}(\text{NO}_3)_3$
 - $\text{Hg}_2(\text{NO}_3)_2$ 3
 - NaBrO_3
 - $\text{Na}_2\text{S}_2\text{O}_3$
- Which substance does not produce ions when dissolved in water?
 - KClO
 - manganese(II) nitrate
 - CsCN
 - CH_2O
 - NaHS
- The equation for the reaction, $\text{BaCl}_2(\text{aq}) + \text{K}_2\text{CrO}_4(\text{aq}) \rightarrow \text{BaCrO}_4(\text{s}) + \text{KCl}(\text{aq})$, can be written as an ionic equation. In the ionic equation, the spectator ions are
 - Ba^{2+} and K^+
 - K^+ and CrO_4^{2-}
 - K^+ and Cl^-
 - Ba^{2+} and CrO_4^{2-}
 - Cl^- and CrO_4^{2-}

Handwritten ionic equation: $\text{Ba}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) + 2\text{K}^+(\text{aq}) + \text{CrO}_4^{2-}(\text{aq}) \rightarrow \text{BaCrO}_4(\text{s}) + 2\text{K}^+(\text{aq}) + 2\text{Cl}^-(\text{aq})$
- In the reaction between aqueous silver nitrate and aqueous potassium chromate, what is the identity of the ~~soluble substance~~ ^{precipitate} that is formed?
 - potassium nitrate
 - silver chromate
 - silver nitrate
 - potassium chromate
 - A soluble substance is not formed.

Handwritten reaction: $\text{AgNO}_3(\text{aq}) + \text{K}_2\text{CrO}_4 \rightarrow \text{KNO}_3(\text{aq}) + \text{Ag}_2\text{CrO}_4(\text{s})$

Name: _____

7. Which species is a molecular base?

- a. NaOH
 b. NH₃
 c. C₂H₅OH
 d. Li₂O
 e. NH₄⁺

8. When an strong base reacts with water, the products are:

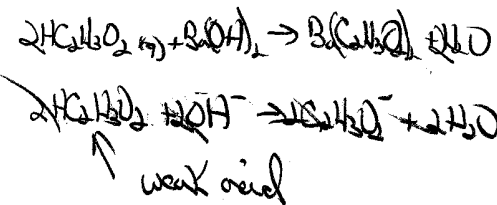
- a. hydroxide and cation
 b. hydroxide and water
 c. salt and hydroxide
 d. hydronium and cation
 e. hydronium and anion

9. Which is the net ionic equation for the reaction which takes place when HClO₃(aq) is added to KOH(aq)? (Neutralization)

- a. HClO₃(aq) + KOH(aq) → KClO₃(aq) + H₂O(l)
 b. H⁺(aq) + OH⁻(aq) → H₂O(l)
 c. HClO₃(aq) + OH⁻(aq) → ClO₃⁻(aq) + H₂O(l)
 d. H⁺(aq) + KOH(aq) → K⁺(aq) + H₂O(l)
 e. HClO₃(aq) + K⁺(aq) → KClO₃(aq) + H⁺(aq)

10. Which is the net ionic equation for the reaction which takes place when HC₂H₃O₂(aq) is added to Ba(OH)₂(aq)?

- a. HC₂H₃O₂(aq) + Ba(OH)₂(aq) → Ba(C₂H₃O₂)₂(aq) + H₂O(l)
 b. H⁺(aq) + OH⁻(aq) → H₂O(l)
 c. HC₂H₃O₂(aq) + OH⁻(aq) → C₂H₃O₂⁻(aq) + H₂O(l)
 d. H⁺(aq) + Ba(OH)₂(aq) → Ba²⁺(aq) + H₂O(l)
 e. HC₂H₃O₂(aq) + Ba²⁺(aq) → Ba(C₂H₃O₂)₂(aq) + H⁺(aq)

11. A solution is made by taking 54.62 grams of K₂CrO₄ in enough water to make 250.0 mL of solution. The molarity of the solution is therefore

- a. 1.125 M
 b. 0.0002813 M
 c. 0.001125 M
 d. 0.2813 M
 e. 1.409 M

K₂CrO₄ 194.19 g/mol

$$54.62 \text{ g K}_2\text{CrO}_4 \left(\frac{1 \text{ mol}}{194.19 \text{ g K}_2\text{CrO}_4} \right) \left(\frac{1}{0.250 \text{ L}} \right) = 1.125 \text{ M}$$

12. How many mL of 1.0 M HCl solution would need to be diluted to produce 0.250 L of 0.8 M HCl?

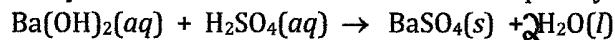
- a. 100 mL
 b. 200 mL
 c. 0.10 mL
 d. 160 mL
 e. 2.5 mL

$$M_1 V_1 = M_2 V_2$$

$$V_2 = \left(\frac{M_1}{M_2} \right) V_1 = \left(\frac{0.8}{1.0} \right) (250 \text{ mL}) = 200 \text{ mL}$$

Name: _____

13. A student wants to know how many mL of 0.300 M sulfuric acid is to be added to 50.0 mL of 0.250 M barium hydroxide solution to neutralize it completely. The reaction is:



- a. 20.8 mL
 b. 30.0 mL
 c. 41.7 mL
 d. 60.0 mL
 e. 110. mL

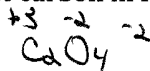
$$50.0 \text{ mL} \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{0.250 \text{ mol Ba(OH)}_2}{1 \text{ L}} \right) \left(\frac{1 \text{ mol H}_2\text{SO}_4}{1 \text{ mol Ba(OH)}_2} \right) \left(\frac{1 \text{ L}}{0.300 \text{ mol H}_2\text{SO}_4} \right) \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) = 41.7 \text{ mL}$$

14. Oxidation is defined as

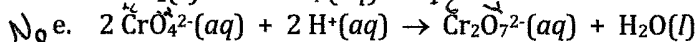
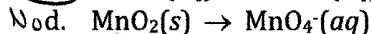
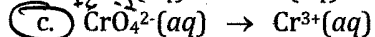
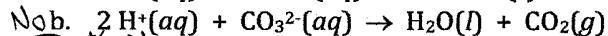
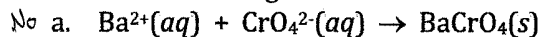
- a. gain of a proton.
 b. loss of a proton.
 c. gain of an electron.
 d. loss of an electron.
 e. capture of an electron by a neutron.

15. What is the oxidation number of carbon in $\text{K}_2\text{C}_2\text{O}_4$?

- a. 0
 b. -4
 c. +3
 d. +4
 e. +6



16. Which of the following involves reduction?

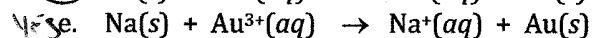
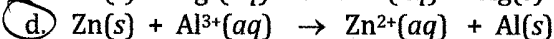
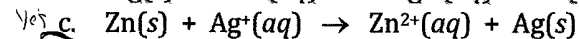
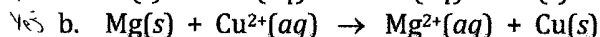
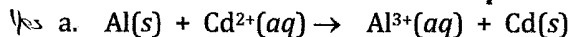


17. Consider the redox equation, $2\text{VO}_4^{3-}(\text{aq}) + \text{SO}_2(\text{g}) + 8\text{H}^+(\text{aq}) \rightarrow 2\text{VO}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$

The oxidizing agent is

- a. $\text{VO}_4^{3-}(\text{aq})$
 b. $\text{VO}^{2+}(\text{aq})$
 c. $\text{H}^+(\text{aq})$
 d. $\text{SO}_2(\text{g})$
 e. $\text{SO}_4^{2-}(\text{aq})$

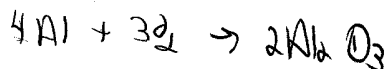
18. Which reaction below *does not occur spontaneously* upon mixing the reagents shown?



Name: _____

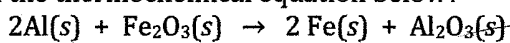
19. The oxidation of aluminum occurs slowly due to the formation of which substance on the surface of the metal?

- a. $\text{Al}_2\text{O}_3(\text{s})$
 b. $\text{AlCl}_3(\text{s})$
 c. $\text{Al}_2(\text{SO}_4)_3(\text{s})$
 d. $\text{Al}(\text{NO}_3)_3(\text{s})$
 e. $\text{Al}(\text{OH})_3(\text{s})$



20. When aluminum metal reacts with iron(III) oxide to form aluminum oxide and iron metal, 429.6 kJ of heat are given off for each mole of aluminum metal consumed, under constant pressure and standard conditions. What is the correct value for the standard enthalpy of reaction in the thermochemical equation below?

- a. +429.6 kJ
 b. -429.6 kJ
 c. +859.2 kJ
 d. -859.2 kJ
 e. -1289 kJ



$$(-429.6 \text{ kJ}) \times 2 = (-859.2 \text{ kJ})$$

21. For the reaction below:



How many grams of CaO must be reacted by this reaction to release 1050 kJ of heat?

- a. 16.2 g
 b. 909 g
 c. 1817 g
 d. 454 g
 e. 56.1 g

$$\text{CaO} \Rightarrow 56.08 \text{ g/mol}$$

$$-1050 \text{ kJ} \left(\frac{1 \text{ mol CaO}}{-64.8 \text{ kJ}} \right) \left(\frac{56.08 \text{ g CaO}}{1 \text{ mol}} \right) = 908.7 \text{ g}$$

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SECTION II

Complete each of the following.

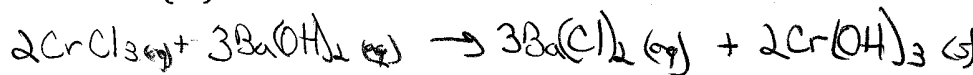
Show all work. No Credit will be given for answer only.

1. (10 Points) Match the name with the correct formula.

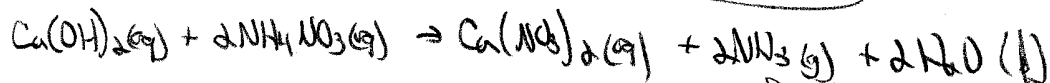
Name	Chemical Formula Name	Potential Chemical Name
3 sulfurous acid	H ₂ SO ₃	1. Nitric Acid
1 nitric acid	HNO ₃	2. Nitrous Acid
4 chloric acid	HClO ₃	3. Sulfurous Acid
2 nitrous acid	HNO ₂	4. Chloric Acid
6 hydrocyanic acid	HCN	5. Carbonic Acid
		6. Hydrocyanic acid
		7. Chlorous Acid

2. (15 Points) Complete and balance the overall chemical reactions and select the type of equation: Precipitation, Neutralization, Gas Forming and Single Displacement.

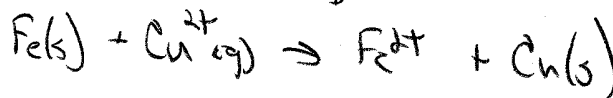
a. Chromium (III) chloride + barium hydroxide



Precipitation

b. $\text{Ca}(\text{OH})_2(\text{aq}) + 2\text{NH}_4\text{NO}_3(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + 2\text{NH}_4\text{OH}(\text{aq})$ c. $2\text{Na}_3\text{PO}_4(\text{aq}) + 3\text{SrCl}_2(\text{aq}) \rightarrow 6\text{NaCl}(\text{aq}) + \text{Sr}_3(\text{PO}_4)_2(\text{s})$ gas forming
Precipitationd. $\text{Fe}(\text{s}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{FeSO}_4(\text{aq}) + \text{Cu}(\text{s})$

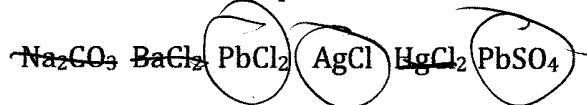
single displacement

e. $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{KI}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) + 2\text{KNO}_3(\text{aq})$

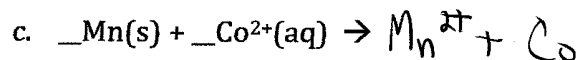
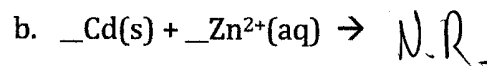
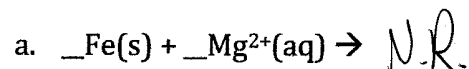
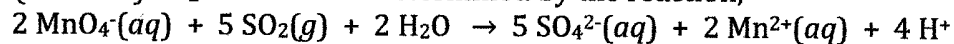
precipitation

Name: _____

3. (6 Points) Circle which of the compounds are insoluble in water?



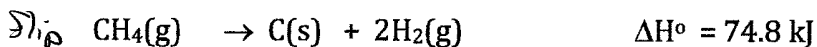
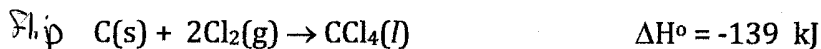
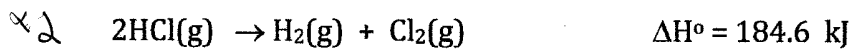
4. (6 Points) Use the activity table to predict the outcome of the following reactions. If no reaction occurs, write N.R.. If a reaction occurs, write a balance chemical equation for it.

5. (7 Points) SO_2 in air can be determined by the reaction,It required 185 mL of 0.0200 M $\text{MnO}_4^- (\text{aq})$ solution to completely react with all the SO_2 in a sample of air. How many grams of SO_2 were in the sample?

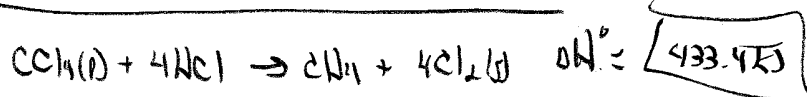
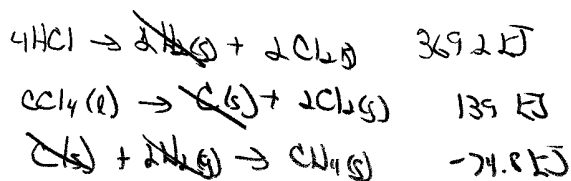
$$185 \text{ mL} \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right) \left(\frac{0.0200 \text{ mol MnO}_4^-}{1 \text{ L}} \right) \left(\frac{5 \text{ mol SO}_2}{2 \text{ mol MnO}_4^-} \right) \left(\frac{64.06 \text{ g SO}_2}{1 \text{ mol SO}_2} \right) = 0.5925 \text{ g}$$

Name: _____

6. (7 Points) Determine the standard enthalpy change, ΔH° , for the reaction, $\text{CCl}_4(l) + 4\text{HCl}(g) \rightarrow \text{CH}_4(g) + 4\text{Cl}_2(g)$, given the following thermochemical equations:



Does the reaction is endothermic or exothermic?



endothermic

7. (7 Points) Given the equation for the reaction, $4\text{NH}_3(g) + 7\text{O}_2(g) \rightarrow 4\text{NO}_2(g) + 6\text{H}_2\text{O}(g)$, and the following standard enthalpies of formation, ΔH_f° :

$$\text{NH}_3(g): -80.3 \text{ kJ mol}^{-1}$$

$$\text{NO}_2(g): +33.2 \text{ kJ mol}^{-1}$$

$$\text{H}_2\text{O}(g): -241.8 \text{ kJ mol}^{-1}$$

$$\text{H}_2\text{O}(l): -285.8 \text{ kJ mol}^{-1}$$

What is the standard enthalpy of reaction, in kJ for the reaction shown?

$$\Delta H_{\text{rxn}}^\circ = (4 \times 33.2 \text{ kJ} + 6 \times -241.8 \text{ kJ}) - (4 \times -80.3 \text{ kJ})$$

$$\boxed{-990.8 \text{ kJ}}$$

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SECTION III: BONUS POINTS

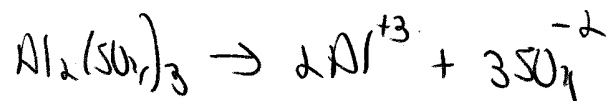
Complete each of the following showing mathematical procedures if necessary.

Show all work. No Credit will be given for answer only.

1. (2 Points) What is the oxidation number of oxygen in $\overset{+1}{\text{H}}_2\overset{-1}{\text{O}}_2$?

$$0 = (-1)$$

2. (2 Points) Write the dissociation reaction for $\text{Al}_2(\text{SO}_4)_3$



3. (2 Points) What happens to the temperature when you mix NaCl and water?

the reaction is endothermic thus
the temperature slightly is reduced

4. (2 Points) Define endothermic and exothermic reactions.

endothermic requires energy
exothermic releases energy

reactant + heat \rightarrow product
reactant \rightarrow product + heat

Name: _____

Periodic Table of the Elements

1A 1 H 1.008	2A 4 Be 9.012											3A 5 B 10.81	4A 6 C 12.01	5A 7 N 14.01	6A 8 O 16.00	7A 9 F 18.99	8A 2 He 4.003																																																		
3 Li 6.939												13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95																																																		
11 Na 22.99	12 Mg 24.31	3B 21 Sc 44.96	4B 22 Ti 47.90	5B 23 V 50.94	6B 24 Cr 52.00	7B 25 Mn 54.94	8B 26 Fe 55.85		27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80																																																	
19 K 39.10	20 Ca 40.08	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [99]	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.	53 I 126.9	54 Xe 131.3																																																		
37 Rb 85.47	38 Sr 87.62	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	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 (210)	85 At [210]	86 Rn [222]																																																		
55 Cs 132.9	56 Ba 137.3	Lanthanum series 58 Ce 140.1										61 Pm (145)	62 Sm 150.4										63 Eu 152.0	64 Gd 157.3										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
87 Fr [223]	88 Ra [226]	Actinium series 89 Ac (227)										90 Th 231	91 Pa 231	92 U 238.0	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)																																										

Name: _____

	$C_2H_3O_2^-$	AsO_4^{3-}	Br^-	CO_3^{2-}	Cl^-	CrO_4^{2-}	OH^-	I^-	NO_3^-	$C_2O_4^{2-}$	O^{2-}	PO_4^{3-}	SO_4^{2-}	S^{2-}	SO_3^{2-}
Al^{3+}	S	I	S	-	S	-	I	S	S	-	I	I	S	d	-
NH_4^+	S	S	S	S	S	S	S	S	S	S	-	S	S	S	S
Ba^{2+}	S	I	S	I	S	I	s	S	S	I	s	I	I	d	I
Bi^{3+}	-	s	d	I	d	-	I	I	d	I	I	s	d	I	-
Ca^{2+}	S	I	S	I	S	S	I	S	S	I	I	I	I	d	I
Co^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I
Cu^{2+}	S	I	S	I	S	I	I	-	S	I	I	I	S	I	-
Fe^{2+}	S	I	S	s	S	-	I	S	S	I	I	I	S	I	s
Fe^{3+}	I	I	S	I	S	-	I	-	S	S	I	I	S	I	-
Pb^{2+}	S	I	I	I	I	I	I	I	S	I	I	I	I	I	I
Mg^{2+}	S	d	S	I	S	S	I	S	S	I	I	I	S	d	s
Hg^{2+}	S	I	I	I	S	s	I	I	S	I	I	I	d	I	-
K^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ag^+	s	I	I	I	I	I	-	I	S	I	I	I	I	I	I
Na^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Zn^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I

Key: S = Soluble in water

I = Insoluble in water (less than 1 g/100 g H₂O)

s = Slightly soluble in water

d = Decomposes in water

ing activity ↑

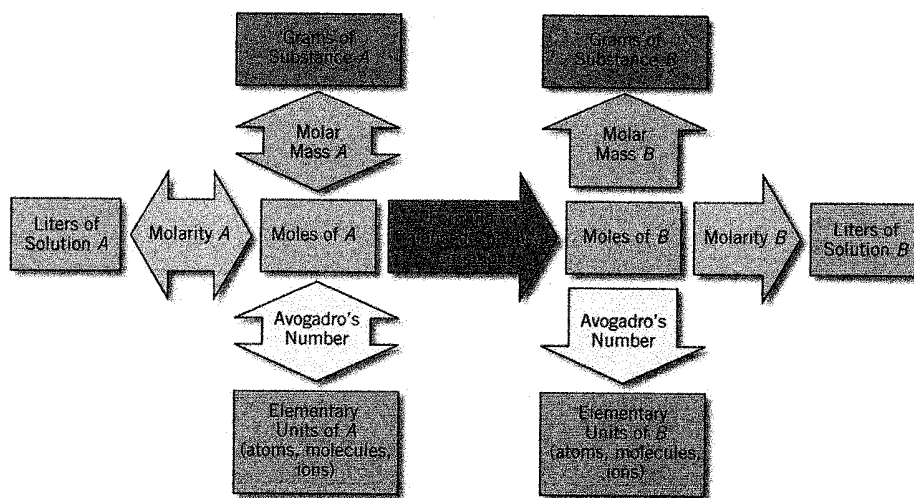
Name: _____

USEFUL INFORMATION

TABLE 5.3 Activity Series for Some Metals (and Hydrogen)

	Element	Ion
Least Active	Gold	Au ³⁺
	Mercury	Hg ²⁺
	Silver	Ag ⁺
	Copper	Cu ²⁺
	HYDROGEN	H ⁺
	Lead	Pb ²⁺
	Tin	Sn ²⁺
	Cobalt	Co ²⁺
	Cadmium	Cd ²⁺
	Iron	Fe ²⁺
	Chromium	Cr ³⁺
	Zinc	Zn ²⁺
	Manganese	Mn ²⁺
	Aluminum	Al ³⁺
	Magnesium	Mg ²⁺
	Sodium	Na ⁺
	Calcium	Ca ²⁺
	Strontium	Sr ²⁺
	Barium	Ba ²⁺
	Cesium	Cs ⁺
	Potassium	K ⁺
Most Active	Rubidium	Rb ⁺

Annotations:
 - Left side: "React with nonoxidizing acids to produce hydrogen" (points to elements above H⁺)
 - Right side: "React with water to form hydrogen" (points to elements below H⁺)
 - Middle: "Do not react with nonoxidizing acids" (points to elements above H⁺)
 - Far right: "Increasing ease of oxidation of the metal" (points down), "Increasing ease of reduction of the ion" (points up)



$$T_C = (T_F - 32^\circ F) \cdot \frac{5^\circ C}{9^\circ F}$$

$$N = \frac{\text{sample mass}}{\text{atom mass}} \quad N = nN_A \quad c = \frac{n}{V}$$

$$\% \text{Yield} = \frac{\text{actual}}{\text{theoretical}} \cdot 100$$

$$\text{Mass}\%_{\text{element}} = \frac{\text{mass}_{\text{element}}}{\text{mass}_{\text{total-sample}}} \cdot 100\%$$

$$M = m_{\text{atom}} N_A \quad m = nM$$

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

$$V_{\text{final}} \cdot C_{\text{final}} = V_{\text{initial}} \cdot C_{\text{initial}}$$

$$V_{\text{final}} \cdot C_{\text{final}} = V_{\text{initial}} \cdot C_{\text{initial}}$$