

OXIDATION-REDUCTION REACTIONS

1. (8 points) Consider the reaction of aluminum with copper(II) ions in aqueous solution.



- (a) Which species has been reduced (Al or Cu^{2+})? _____ Which has been oxidized?

- (b) Has Al transferred electrons to Cu^{2+} or has Cu^{2+} transferred electrons to Al?

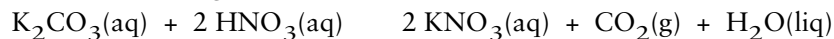
- (c) The oxidizing agent is _____
2. (6 points) Assign an oxidation number to each of the underlined atoms.
- (a) Al $_2\text{O}_3$ _____ (d) H $\text{P}\underline{\text{O}}_3^{2-}$ _____
- (b) Cl O_4^- _____ (e) C $_4\text{H}_{10}$ _____
- (c) S $_2\text{O}_3^{2-}$ _____ (f) HF _____

MAKING SOLUTIONS/CONCENTRATION UNITS

1. (3 points) What mass of sodium oxalate, $\text{Na}_2\text{C}_2\text{O}_4$ (molar mass = 111 g/mol) is required to prepare 500. mL of a 0.12 M solution of sodium oxalate?
- (a) 0.00054 g
(b) 6.66 g
(c) 26.6 g
(d) 462 g
(e) 6,660 g
(f) none of the above
2. (6 points) What is the concentration of each ion in a 0.15 M aqueous solution of CuBr_2 ?
- Cation = _____ Concentration = _____
- Anion = _____ Concentration = _____
3. (3 points) Suppose you add 4.0 mL of water to 6.0 mL of 0.16 M CuSO_4 . What is the concentration of copper(II) ion in the diluted solution?
- (a) 0.240 M
(b) 0.160 M
(c) 0.107 M
(d) 0.0960 M
(e) 0.0640 M

SOLUTION STOICHIOMETRY

1. (3 points) What mass of K_2CO_3 (molar mass = 138.2 g/mol) is required to react completely with 25.0 mL of 0.155 M HNO_3 ?



- (a) 0.134 g
(b) 0.268 g
(c) 0.536 g
(d) 2.67 g
(e) None of the above, I think?
2. (6 points) You have 42.5 mL of a 0.453 M solution of NaOH. What quantity of NaOH, in moles, is contained in this solution?
- (a) 0.0193 mol NaOH
(b) 10.7 mol NaOH
(c) 19.3 mol NaOH
(d) 93.8 mol NaOH
(e) None of the above, I think.

Now suppose you mix 25.0 mL of 0.234 M AlCl_3 solution with 42.5 mL of 0.453 M NaOH. What is the maximum mass of $\text{Al}(\text{OH})_3$ (molar mass = 78.0 g/mol) that can be obtained by the following reaction?



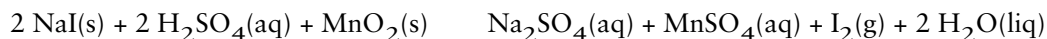
- (a) 0.456 g $\text{Al}(\text{OH})_3$
(b) 0.501 g $\text{Al}(\text{OH})_3$
(c) 0.780 g $\text{Al}(\text{OH})_3$
(d) 1.52 g $\text{Al}(\text{OH})_3$
(e) None of the above
3. (3 points) You have 0.893 g of an unknown acid, H_3A . You only know that it supplies three H^+ ions on reacting with a base such as NaOH.
- $$\text{H}_3\text{A}(\text{aq}) + 3 \text{NaOH}(\text{aq}) \rightarrow \text{Na}_3\text{A}(\text{aq}) + 3 \text{H}_2\text{O}(\text{liq})$$
- If 34.53 mL of 0.512 M NaOH are required to titrate the acid to the equivalence point, what is the molar mass of the acid?
- (a) 16.8 g/mol
(b) 38.0 g/mol
(c) 50.5 g/mol
(d) 76.0 g/mol
(e) 152 g/mol

4. (10 points) The powder from which a soft drink is prepared contains an unknown amount of citric acid, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$ (molar mass = 192.1 g/mol). If 17.523 g of the powdered soft drink requires 33.51 mL of 0.102 M NaOH to neutralize the citric acid completely, what is the weight percent of citric acid in the soft drink? The reaction of citric acid and NaOH is



Please show your work completely and clearly! You can only receive part credit if you show your work clearly.

5. (10 points) The following reaction can be used to prepare iodine in the laboratory. (See SQ 101 on page 234 of *Chemistry & Chemical Reactivity*.)



- (a) Give the following oxidation numbers

I in NaI = _____

Mn in MnO_2 = _____

Mn in MnSO_4 = _____

- (b) The oxidizing agent in the reaction is _____ and the reducing agent is _____

- (c) What is the maximum quantity of iodine, I_2 (molar mass = 253.8 g/mol), that can be prepared if 20.0 g of NaI (molar mass = 149.9 g/mol) is mixed with 10.0 g of MnO_2 (molar mass = 86.9 g/mol)?

(i) 58.4 g I_2

(ii) 33.9 g I_2

(iii) 29.2 g I_2

(iv) 16.9 g I_2

(v) 14.6 g I_2

(vi) 8.50 g I_2

THERMOCHEMISTRY

1. (3 points) Which requires more heat energy to warm from 22 °C to 37 °C, 25.0 g of water or 100. g of aluminum?
- (a) 25.0 g of water
- (b) 100 g of aluminum
2. (3 points) You transfer 6000 J of heat energy to 25.0 g of ice. What is the final temperature of the system?
- (a) 0.0 °C
- (b) 2.5 °C
- (c) 5.0 °C
- (d) 6.9 °C
- (e) None of the above

3. (3 points) An “ice calorimeter” can be used to determine the specific heat capacity of an object. A piece of metal, of known mass, is heated to 100 °C in boiling water and then dropped onto ice. The quantity of heat transferred from the hot metal is determined from the quantity of ice melted. In a typical experiment a piece of metal (9.85 g) is heated to 100.0 °C and dropped onto 11.59 g of ice. When the temperature of the metal has dropped to 0.0 °C, it is found that 9.92 g of ice remains; the rest of the ice melted to water at 0.0 °C. What is the specific heat capacity of the metal?
- (a) 0.283 J/g•K
(b) 0.446 J/g•K
(c) 0.565 J/g•K
(d) 1.45 J/g•K
(e) None of the above?
4. (7 points) Ethanol, CH₃CH₂OH, is a possible automobile fuel. The alcohol burns in air according to the equation
- $$\text{CH}_3\text{CH}_2\text{OH}(\text{liq}) + 7/2 \text{O}_2(\text{g}) \rightarrow 2 \text{CO}_2(\text{g}) + 3 \text{H}_2\text{O}(\text{liq})$$
- What quantity of heat energy does ethanol produce when 1.00 mol burns in air?
- (a) -1922.1 kJ
(b) -1644.4 kJ
(c) -1366.7 kJ
(d) -401.6 kJ
(e) -277.7 kJ
(f) None of the above

The reaction of ethanol with air is (exothermic)(endothermic) _____. The reducing agent is _____ and the substance reduced is _____.

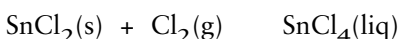
5. (3 points) Isooctane (2,2,4-trimethylpentane), a component of gasoline (molar mass = 114 g/mol) burns in air
- $$2 \text{C}_8\text{H}_{18}(\text{liq}) + 25 \text{O}_2(\text{g}) \rightarrow 16 \text{CO}_2(\text{g}) + 18 \text{H}_2\text{O}(\text{liq}) \quad \Delta H_{\text{rxn}}^\circ = -10,922 \text{ kJ}$$
- If you burn exactly 500 mL of the hydrocarbon (density = 0.6878 g/mL), what quantity of heat is evolved or absorbed?

- (a) $1.81 \times 10^3 \text{ kJ}$
 (b) $5.46 \times 10^3 \text{ kJ}$
 (c) $1.65 \times 10^4 \text{ kJ}$
 (d) $3.30 \times 10^4 \text{ kJ}$
 (e) None of the above

6. (4 points) Which of the following enthalpy changes can be designated as a standard molar enthalpy of formation? (*There may be more than one answer.*)

- (a) $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g}) \quad \Delta H^\circ = -296.8 \text{ kJ}$
 (b) $\text{PCl}_3(\text{liq}) \rightarrow \frac{1}{4} \text{P}_4(\text{s}) + \frac{3}{2} \text{Cl}_2(\text{g}) \quad \Delta H^\circ = +319.7 \text{ kJ}$
 (c) $\text{Ca}(\text{s}) + \text{C}(\text{s}) + \frac{3}{2} \text{O}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s}) \quad \Delta H^\circ = -1206.9 \text{ kJ}$
 (d) $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g}) \quad \Delta H^\circ = -802.3 \text{ kJ}$

7. (6 points) What is the enthalpy change under standard conditions for the following reaction?



- (a) +186.2 kJ
 (b) -186.2 kJ
 (c) -325.1 kJ
 (d) -511.3 kJ
 (e) -836.4 kJ

The reaction is (exothermic)(endothermic) _____. In the reaction, _____ is reduced and _____ is the oxidizing agent.

8. (3 points) One of the most important reactions in our economy is the reduction of iron oxide (iron ore) with carbon monoxide to give metallic iron.



What is the enthalpy change for this reaction?

- (a) +541.2 kJ
 (b) -24.8 kJ
 (c) -153.7 kJ
 (d) -687.8 kJ
 (e) -1673.2 kJ
 (f) -2336.3 kJ

9. (3 points) Using information in Table 6.2 or Appendix K, and the following experimentally determined enthalpy changes,
- $$\text{BaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ba(OH)}_2\text{(s)} \quad \Delta H^\circ = -105.4 \text{ kJ}$$
- $$\text{Ba(s)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{BaO(s)} \quad \Delta H^\circ = -553.5 \text{ kJ}$$
- calculate the standard molar enthalpy of formation of $\text{Ba(OH)}_2\text{(s)}$.
- (a) -373.1 kJ/mol
(b) -162.3 kJ/mol
(c) -733.9 kJ/mol
(d) -944.7 kJ/mol
(e) +944.7 kJ/mol
10. (4 points) An exothermic reaction is carried out in a test tube. Circle each of the true statements about this process.
- (a) Heat is absorbed by the system.
(b) The test tube feels warmer after the reaction is complete.
(c) The enthalpy of the products is higher than the enthalpy of the reactants.
(d) $q_{\text{reaction}} > 0$
(e) $q_{\text{reaction}} + q_{\text{surroundings}} = 0$
11. (3 points) Three ice cubes, each with a mass of 45 g, are dropped into 500. mL of tea initially at 20.0 °C. How much ice melts when the temperature of the iced tea becomes 0 °C? (Assume the tea is weak enough so that the specific heat capacity of the tea is the same as that of pure water. Also assume the density of the tea is 1.00 g/mL.) (See Study Question 89, page 288.)
- (a) 6.3 g
(b) 18.9 g
(c) 45 g
(d) 90 g
(d) 126 g
(e) None of the above?