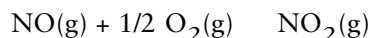


OXIDATION-REDUCTION

1. (6 points) One of the reactions that occurs in polluted air is



_____ is the oxidizing agent and _____ is the reducing agent. The oxidation number of N in NO is _____.

2. (8 points) A reaction demonstrated in class has the net ionic equation



Which of the reactants, Al or Cu^{2+} , has been oxidized? _____

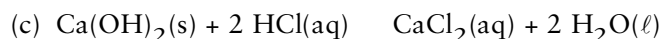
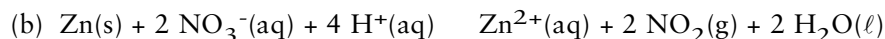
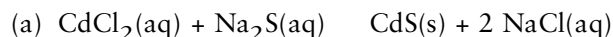
Which of the reactants, Al or Cu^{2+} , is the reducing agent? _____

Has Al transferred electrons to Cu^{2+} or has Cu^{2+} transferred electrons to Al? That is, what is the direction of electron transfer?

As the reaction proceeds, the solution becomes quite warm. The reaction is

- (a) exothermic (b) endothermic

3. (2 points) Which of the following is an oxidation-reduction reaction?



4. (3 points) Assign an oxidation number to each underlined atom.

**MAKING SOLUTIONS/CONCENTRATION**

1. (3 points) What mass, in grams, of Na_3PO_4 ($M = 167 \text{ g/mol}$) is required to prepare exactly 125 mL of a 0.0102 M solution of Na_3PO_4 ?

(a) 0.213 g

(b) 1.28 g

(c) 13.6 g

(d) 213 g

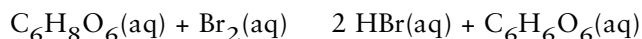
(e) None of the above

2. (4 points) In the laboratory you worked with a solution of the ionic compound sodium oxalate, $\text{Na}_2\text{C}_2\text{O}_4$. If the solution has a concentration of $[\text{Na}_2\text{C}_2\text{O}_4] = 0.12 \text{ M}$, the concentration of the sodium ion $[\text{Na}^+]$ is _____ and the concentration of the oxalate ion $[\text{C}_2\text{O}_4^{2-}]$ is _____
3. (3 points) If you add exactly 6.0 mL of water to 14 mL of 0.16 M CuSO_4 , the concentration of CuSO_4 in the dilute solution is
- (a) $[\text{CuSO}_4] = 0.080 \text{ mol/L}$
 - (b) $[\text{CuSO}_4] = 0.112 \text{ mol/L}$
 - (c) $[\text{CuSO}_4] = 0.160 \text{ mol/L}$
 - (d) $[\text{CuSO}_4] = 0.320 \text{ mol/L}$
4. (3 points) One-half liter (500. mL) of 2.50 M HCl is mixed with 250. mL of 3.75 M HCl. Assuming the total solution volume after mixing is 750. mL, what is the concentration of hydrochloric acid in the resulting solution?
- (a) $[\text{HCl}] = 0.938 \text{ mol/L}$
 - (b) $[\text{HCl}] = 1.25 \text{ mol/L}$
 - (c) $[\text{HCl}] = 2.19 \text{ mol/L}$
 - (d) $[\text{HCl}] = 2.92 \text{ mol/L}$

SOLUTION STOICHIOMETRY

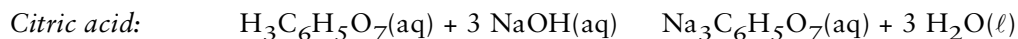
1. (3 points) The mineral dolomite contains magnesium carbonate. How many milliliters of 0.155 M HCl are required to react with 0.268 g of MgCO_3 ($M = 84.3 \text{ g/mol}$)
- $$\text{MgCO}_3(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell)$$
- (a) 20.5 mL
 - (b) 31.8 mL
 - (c) 41.0 mL
 - (d) 63.6 mL

2. (3 points) Vitamin C is the simple compound $C_6H_8O_6$. Besides being an acid, it is also a reducing agent. One method for determining the amount of vitamin C in a sample is therefore to titrate it with a solution of bromine, Br_2 , an oxidizing agent.

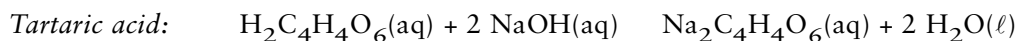


Suppose a 1.00-g “chewable” vitamin C tablet requires 27.85 mL of 0.102 M Br_2 for titration to the equivalence point. How many grams of vitamin C ($M = 176.12$ g/mol) are in the tablet?

- (a) 0.176 g
(b) 0.284 g
(c) 0.500 g
(d) 1.00 g
(e) none of the above
3. (10 points) You find that a 0.956-g sample of an unknown acid requires 29.1 mL of 0.513 M NaOH for titration to the equivalence point. What is the unknown acid?



Molar mass of citric acid = 192.12 g/mol



Molar mass of tartaric acid = 150.09 g/mol

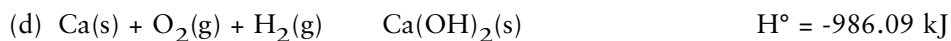
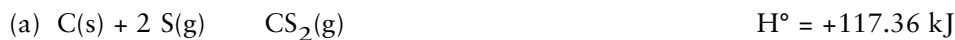
Show your work!

4. (3 points) Two students, Sam and Michelle, titrate different samples of the same solution of HCl using 0.100 M NaOH solution and phenolphthalein indicator. Sam pipets 20.0 mL of the HCl solution into a flask, adds 20 mL of distilled water and a few drops of phenolphthalein solution, and titrates until a lasting pink color appears. Michelle pipets 20.0 mL of the HCl solution into a flask, adds 60 mL of distilled water, and a few drops of phenolphthalein solution, and titrates to the first lasting pink color. Each student correctly calculates the molarity of the titrated HCl solution. Michelle's result will be:
- (a) Four times less than Sam's
 - (b) Four times more than Sam's
 - (c) Two times less than Sam's
 - (d) Two times more than Sam's
 - (e) The same as Sam's

THERMOCHEMISTRY

1. (2 points) If you add 200 J of heat energy to 100 g of water and to 100 g of iron, both initially at 20 °C, which will end up at the higher temperature? _____
2. (3 points) 74.8 J of heat is required to raise the temperature of 18.69 g of silver from 10.0 °C to 27.0 °C. What is the specific heat capacity of silver?
- (a) 0.235 g
 - (b) 0.409 g
 - (c) 4.25 g
 - (d) 68.0 g
3. (3 points) How much heat energy (in kilojoules) is required to heat all the aluminum in a roll of aluminum foil (500. g) from room temperature (25 °C) to the temperature of a hot oven (255 °C)?
- (a) $q = 41$ kJ
 - (b) $q = 104$ kJ
 - (c) $q = 115$ kJ
 - (d) $q = 481$ kJ
4. (6 points) Methane, CH₄, and ethane, C₂H₆, are used as fuels.
- | | | |
|--|---|-----------------|
| CH ₄ (g) + 2 O ₂ (g) | CO ₂ (g) + 2 H ₂ O(ℓ) | H° = -890.3 kJ |
| C ₂ H ₆ (g) + 7/2 O ₂ (g) | 2 CO ₂ (g) + 3 H ₂ O(ℓ) | H° = -1559.8 kJ |
- a) Which fuel provides more heat energy *per mole*? _____
 - b) Which fuel provides more heat energy *per gram*? _____

5. (4 points) Which of the following enthalpy changes can be designated as a standard enthalpy of formation?



6. (3 points) Chloromethane, CH_3Cl ($M = 50.5 \text{ g/mol}$), is used as a topical anesthetic. The temperature at which CH_3Cl liquid turns into a vapor (the boiling point) is -24.09°C . What quantity of heat must be absorbed by the liquid to convert 150. g of liquid to a vapor at -24.09°C ? The heat of vaporization of CH_3Cl is 21.40 kJ/mol .

(a) 7.20 kJ

(b) 63.6 kJ

(c) 354 kJ

(d) 3210 kJ

7. (8 points) A 237-g piece of molybdenum, initially at 100.0°C , is dropped into 244 g of water at 10.0°C . When the system comes to thermal equilibrium, the temperature is 15.3°C . What quantity of heat energy was transferred into the water?

(a) $q = +1020 \text{ J}$

(b) $q = +5411 \text{ J}$

(c) $q = +10210 \text{ J}$

(d) $q = +15600 \text{ J}$

What quantity of heat energy was transferred out of the molybdenum? $q =$ _____ J

What is the specific heat of the metal?

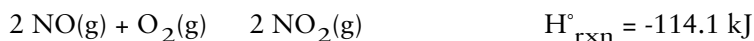
(a) $0.051 \text{ J/g}\cdot\text{K}$

(b) $0.27 \text{ J/g}\cdot\text{K}$

(c) $0.51 \text{ J/g}\cdot\text{K}$

(d) $0.78 \text{ J/g}\cdot\text{K}$

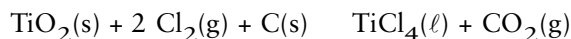
8. (5 points) Nitrogen monoxide has recently been found to be involved in a wide range of biological processes. The gas reacts with oxygen to give brown NO_2 gas.



Is the reaction endothermic or exothermic? _____

If 1.25 g of NO ($M = 30.0 \text{ g/mol}$) is converted completely to NO_2 , what quantity of heat is absorbed or evolved?

- (a) 2.38 kJ
(b) 4.75 kJ
(c) 7.30 kJ
(d) 17.1 kJ
9. (9 points) Titanium tetrachloride, TiCl_4 , is an important intermediate in making paint pigments. It is prepared by treating titanium dioxide with chlorine in the presence of graphite.



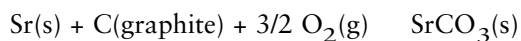
Calculate the standard enthalpy change, H°_{rxn} , for this reaction.

- (a) -258 kJ
(b) -1350 kJ
(c) +529 kJ
(d) +1350 kJ

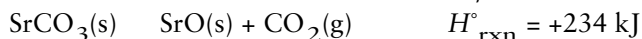
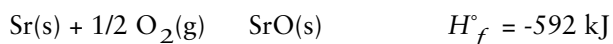
Is the reaction endothermic or exothermic? _____

The oxidizing agent in the reaction is _____, and the substance oxidized is _____

10. (3 points) Calculate the enthalpy change, H° , for the formation of 1 mol of strontium carbonate (the material that gives the red color in fireworks) from its elements.



The experimental information available is:



- (a) -36 kJ
(b) -752 kJ
(c) +1220 kJ
(d) -1220 kJ

Name _____

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11. (3 points) Suppose you are attending summer school and are living in a very old dormitory. The day is oppressively hot. There is no air conditioner, and you can't open the windows of your room because they are stuck shut from layers of paint. There is a refrigerator in the room, however. In a stroke of genius you open the door of the refrigerator, and cool air cascades out. The relief does not last long, though. Soon the refrigerator motor and condenser begin to run, and not long thereafter the room is hotter than it was before. Why did the room warm up?