

This examination is the culmination of the first semester's work in *General Chemistry*. To cap off this experience, the exam will focus on the chemistry of sulfur.

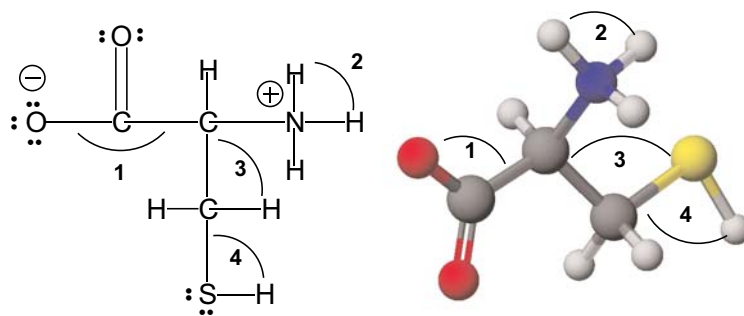
1. (7 points) *Names of Sulfur-Containing Compounds*

Formula of Cation	Formula of Anion	Formula of Compound	Name of Compound
$\text{Al}^{3+}$	$\text{SO}_4^{2-}$		
$\text{Na}^+$		$\text{Na}_2\text{SO}_3$	
			cobalt(III) sulfide

2. (18 points) *Properties of the element*

- (a) Sulfur is in Group \_\_\_\_\_ and in the \_\_\_\_\_ period of the periodic table.
- (b) Sulfur has an atomic number of \_\_\_\_\_ and an atomic weight of \_\_\_\_\_.
- (c) The element has four isotopes but only two of any abundance,  $^{32}\text{S}$  and  $^{34}\text{S}$ . Which of these is more abundant? \_\_\_\_\_
- (d) In the  $^{34}\text{S}$  isotope, there are \_\_\_\_\_ protons and \_\_\_\_\_ neutrons.
- (e) Write the electron configuration of the sulfur atom using the *orbital box notation*.
- (e) Write the electron configuration of the sulfide ion using the *spdf notation* (e.g.,  $1s^2$ ).
- (f) Oxygen and sulfur are in the same group in the periodic table. One of these elements has an ionization energy (IE) of 1314 kJ/mol and the other has an IE of 1000 kJ/mol. Which element has an IE of 1314 kJ/mol, O or S? \_\_\_\_\_
- (g) Solid sulfur has a density of  $2.07 \text{ g/cm}^3$ . If you have a 150 mL beaker full of sulfur, the mass of the sulfur is
- i) 72.5 g                      iii) 150 g
- ii) 138 g                      iv) 310 g
- (h) If you have 15.6 g of sulfur, the amount of sulfur is \_\_\_\_\_ mol and the number of sulfur atoms is \_\_\_\_\_

3. (14 points) One of the essential amino acids, cysteine, contains sulfur.



(a) The formula of cysteine is: C \_\_\_ H \_\_\_ N \_\_\_ O \_\_\_ S \_\_\_

(b) The molar mass of cysteine is \_\_\_\_\_ g/mol

(c) Calculate the weight % of C in cysteine. **Show your work here!**

(d) What amount (moles) of cysteine is found in 12.5 g of the amino acid? **Show your work here!**

(e) *Bond angles in cysteine*

Angle 1 = \_\_\_\_\_

Angle 3 = \_\_\_\_\_

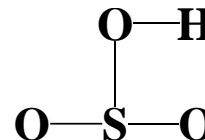
Angle 2 = \_\_\_\_\_

Angle 4 = \_\_\_\_\_

4. (20 points) Sodium bisulfite (sodium hydrogen sulfite),  $\text{NaHSO}_3$ , is a preservative used in dried fruit, fresh shrimp, and in wine.

**Part 1:** To draw the electron dot structure of the hydrogen sulfite ion,  $\text{HSO}_3^-$ , first give the number of valence electrons. \_\_\_\_\_

The structure is illustrated here. *Add lone pairs as required* to complete the bonding picture in the ion.

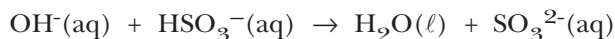


The *electron pair geometry* around the S atom is \_\_\_\_\_ and the O—S—O bond angle is \_\_\_\_\_

**Part 2:** You want to prepare 250 mL of a 0.15 M solution of  $\text{NaHSO}_3$  (molar mass = 104 g/mol). What mass of  $\text{NaHSO}_3$  is required?

- (a) 0.36 g
- (b) 3.9 g
- (c) 15 g
- (d) 62 g

**Part 3:** Your sample of solid  $\text{NaHSO}_3$  is impure. To analyze the sample, you titrate it with sodium hydroxide according to the balanced, net ionic equation



Suppose 25.34 mL of 0.0945 M NaOH is required to titrate the  $\text{HSO}_3^-$  ion in 0.978 g of impure  $\text{NaHSO}_3$ .

(a) What amount of NaOH (moles) is used in the titration? *Show your work here!*

(b) What amount of  $\text{HSO}_3^-$  (moles) was in the sample? *Show your work here!*

(c) What is the weight percent of  $\text{NaHSO}_3$  (104 g/mol) in the sample? *Show your work here!*

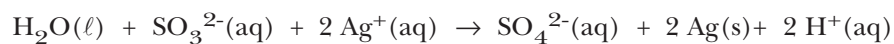
5. (3 points) Dimethylsulfoxide, DMSO, has been used as an anti-inflammatory. (However, health professionals caution against this use.) The compound has 30.75% C, 7.74% H, and 41.03% S. The remainder is O. What is the empirical formula of the compound?

- (a) CH<sub>3</sub>SO  
 (b) C<sub>2</sub>H<sub>6</sub>SO  
 (c) C<sub>2</sub>H<sub>6</sub>SO<sub>2</sub>  
 (d) C<sub>2</sub>H<sub>3</sub>S<sub>2</sub>O

6. (3 points) Sulfur can have one of many oxidation states in its compounds. For each compound below, decide on the oxidation number of S.

<i>Compound</i>	<i>S Oxidation Number</i>
SO <sub>2</sub>	_____
S <sub>2</sub> O <sub>4</sub> <sup>2-</sup>	_____
SO <sub>4</sub> <sup>2-</sup>	_____

7. (5 points) The SO<sub>3</sub><sup>2-</sup> ion can be involved in oxidation-reduction reactions. The net ionic equation for its reaction with silver(I) ion is



In this reaction, the oxidation number of Ag<sup>+</sup> is \_\_\_\_\_. The oxidizing agent is \_\_\_\_\_. The substance oxidized is \_\_\_\_\_.

8. (6 points) Consider the following reaction: BaCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> → BaSO<sub>4</sub> + 2 NaCl

What is the water-solubility of each compound in the reaction?

*Compound*    *Soluble in Water (Yes or No)*

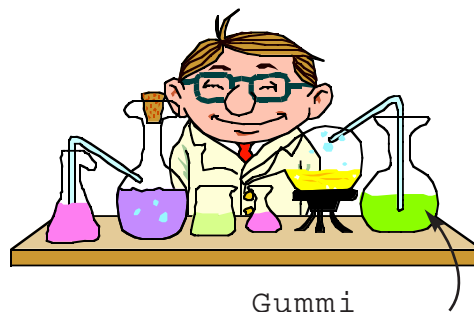
BaCl<sub>2</sub>    \_\_\_\_\_

Na<sub>2</sub>SO<sub>4</sub>    \_\_\_\_\_

BaSO<sub>4</sub>    \_\_\_\_\_

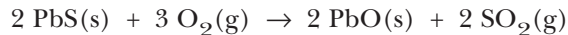
NaCl    \_\_\_\_\_

Write the net ionic equation for the reaction:



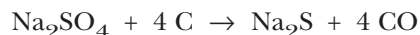
Gummi

9. (3 points) A major source of air pollution years ago was the metals industry. They “roasted” metal sulfides in the air:



If you heat 1.0 kg (1000 g) of PbS (239 g/mol) in the air, what mass of SO<sub>2</sub> (64.0 g/mol) is expected?

- (a) 0.0654 g SO<sub>2</sub>
- (b) 153 g SO<sub>2</sub>
- (c) 268 g SO<sub>2</sub>
- (d) 3730 g SO<sub>2</sub>
10. (5 points) Sodium sulfide, Na<sub>2</sub>S, is used in the leather industry to remove hair from hides. (This is the reason these kinds of plants stink!) The Na<sub>2</sub>S is made by the reaction



Suppose you mix 15 g of Na<sub>2</sub>SO<sub>4</sub> (molar mass = 142 g/mol) and 7.5 g of C. What is the limiting reactant? \_\_\_\_\_

Based on your limiting reactant, the yield of Na<sub>2</sub>S (molar mass = 62 g/mol) would be

- (a) 6.55 g
- (b) 9.69 g
- (c) 22.5 g
- (d) 38.8 g
11. (3 points) To standardize a sulfuric acid solution, you titrate it against sodium carbonate.



Suppose 0.594 g of Na<sub>2</sub>CO<sub>3</sub> (molar mass = 106 g/mol) requires 36.43 mL of H<sub>2</sub>SO<sub>4</sub> for titration to the equivalence point. What is the concentration of H<sub>2</sub>SO<sub>4</sub> in a solution?

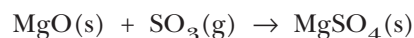
- (a) 0.650 M
- (c) 0.364 M
- (c) 0.154 M
- (d) 0.0056 M

## THERMOCHEMISTRY OF SULFUR AND ITS COMPOUNDS

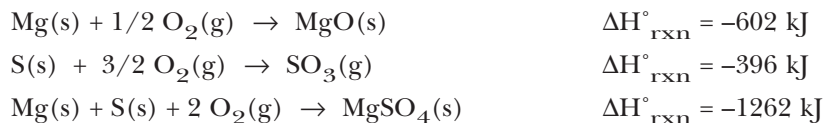
12. (3 points) Solid sulfur can be melted to an interesting form of sulfur called plastic sulfur. What quantity of heat is required to melt 25 g of sulfur if the heat of fusion of sulfur is 1.23 kJ/mol.

- (a) 0.635 kJ
- (b) 0.961 kJ
- (c) 1.04 kJ
- (d) 30.8 kJ

13. (5 points) We want to know the  $\Delta H^\circ_{\text{rxn}}$  for



The information we have is

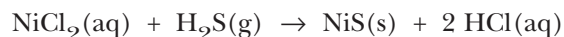


$\Delta H^\circ_{\text{rxn}}$  for the formation of  $\text{MgSO}_4$  from  $\text{MgO}$  and  $\text{SO}_3$  is

- (a) -264 kJ
- (b) -1056 kJ
- (c) -1468 kJ
- (d) -2260 kJ

My calculations show this reaction is (*exothermic*) (*endothermic*) \_\_\_\_\_

14. (5 points) What is the value of  $\Delta H^\circ_{\text{rxn}}$  for the reaction of nickel(II) chloride with hydrogen sulfide.



The required data are given in a table at the right.

- (a) +154 kJ
- (b) -13 kJ
- (c) -409 kJ
- (d) -422 kJ
- (e) -831 kJ

Compound	$\Delta H^\circ_f$ (kJ/mol)
$\text{NiCl}_2\text{(aq)}$	-388 kJ
$\text{H}_2\text{S(g)}$	-21 kJ
$\text{NiS(s)}$	-88
$\text{HCl(aq)}$	-167

This reaction is a (*acid-base*)(*precipitation*)(*gas-forming*) reaction. \_\_\_\_\_

**Structural Chemistry of Sulfur-Containing Compounds (29 points)**

Draw the electron dot structure for each compound below and answer the questions pertaining to that compound.

*Sulfur dioxide, SO<sub>2</sub>*                      Number of valence electrons = \_\_\_\_\_

Electron dot structure — *include all possible resonance structures.*

The formal charge on S is \_\_\_\_\_. The electron pair geometry is \_\_\_\_\_  
and the molecular geometry is \_\_\_\_\_. Is the SO<sub>2</sub> molecule polar (*yes or no*)? \_\_\_\_\_

*Thionyl difluoride, OSF<sub>2</sub>*                      Number of valence electrons = \_\_\_\_\_

Electron dot structure

Electron pair geometry = \_\_\_\_\_ and molecular geometry = \_\_\_\_\_

Is the S—F bond polar? \_\_\_\_\_ Is the molecule polar? \_\_\_\_\_

*Sulfate ion, SO<sub>4</sub><sup>2-</sup>*                      Number of valence electrons = \_\_\_\_\_

Electron dot structure —

The formal charge on S in the compound is \_\_\_\_\_. The electron pair geometry is \_\_\_\_\_  
and molecular geometry is \_\_\_\_\_



## PAGE 1

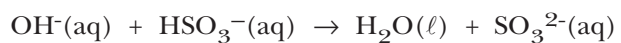
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## PAGE 3

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