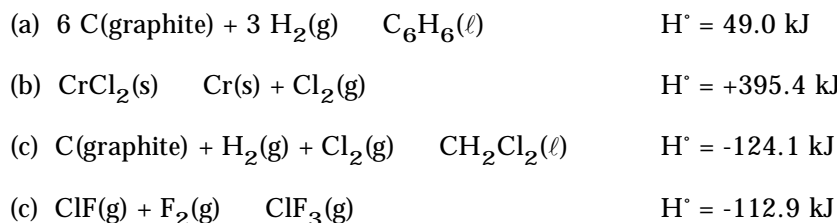
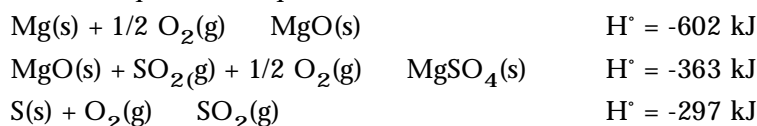


## THERMOCHEMISTRY

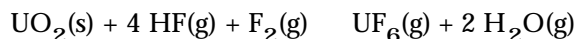
1. (4 points) Which of the following enthalpy changes can be designated as a standard molar enthalpy of formation of a compound? (*There may be more than one answer.*)



1. (3 points) Using the enthalpy data below, and Hess's Law, calculate the standard molar enthalpy of formation [  $H^\circ_f$  ] of  $\text{MgSO}_4(\text{s})$ .



- (a)  $H^\circ_f = +668 \text{ kJ/mol}$
- (b)  $H^\circ_f = -668 \text{ kJ/mol}$
- (c)  $H^\circ_f = +1262 \text{ kJ/mol}$
- (d)  $H^\circ_f = -1262 \text{ kJ/mol}$
- (e)  $H^\circ_f = -536 \text{ kJ/mol}$
- (f) None of the above
3. (4 points) An important method purifying uranium for nuclear power plants is the following reaction:



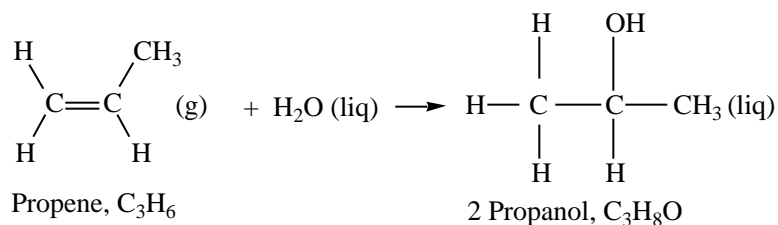
Using the data below, and any other data you may need from Appendix L or Table 6.2, calculate the enthalpy change for the reaction of  $\text{UO}_2$  with HF and  $\text{F}_2$ . (*Answers are rounded to the nearest whole number.*) (Study Question 6-71.)

Compound	$\Delta H_f^\circ$ (kJ/mol)
$\text{UO}_2(\text{s})$	-1085
$\text{UF}_4(\text{s})$	-1914
$\text{UF}_6(\text{g})$	-2147

- (a)  $H^\circ_{\text{rxn}} = -461 \text{ kJ}$
- (b)  $H^\circ_{\text{rxn}} = +461 \text{ kJ}$
- (c)  $H^\circ_{\text{rxn}} = -800 \text{ kJ}$
- (d)  $H^\circ_{\text{rxn}} = +800 \text{ kJ}$
- (e) None of the above

Is the reaction of  $\text{UO}_2$ , HF, and  $\text{F}_2$  an exo- or endothermic reaction? \_\_\_\_\_

4. (3 points) In organic chemistry it is well known that alcohols can be prepared by the addition of water to alkenes. An example, is the preparation of propanol from propene.

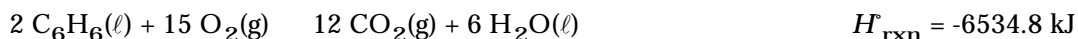


The enthalpy change for this reaction is -52.3 kJ. If the standard molar enthalpy of formation of 2-propanol is -318.1 kJ/mol, what is the standard enthalpy of formation of propene, C<sub>3</sub>H<sub>6</sub>?

- (a)  $H_f^\circ[\text{C}_3\text{H}_6] = -551.6 \text{ kJ}$
- (b)  $H_f^\circ[\text{C}_3\text{H}_6] = +551.6 \text{ kJ}$
- (c)  $H_f^\circ[\text{C}_3\text{H}_6] = -20.0 \text{ kJ}$
- (d)  $H_f^\circ[\text{C}_3\text{H}_6] = +20.0 \text{ kJ}$
- (e)  $H_f^\circ[\text{C}_3\text{H}_6] = +84.6 \text{ kJ}$
- (e) None of the above
5. (5 points) Isooctane burns in air. The enthalpy change for the reaction is
- $$2 \text{C}_8\text{H}_{18}(\ell) + 25 \text{O}_2(\text{g}) \longrightarrow 16 \text{CO}_2(\text{g}) + 18 \text{H}_2\text{O}(\ell) \quad H_{\text{rxn}}^\circ = -10,922 \text{ kJ}$$
- What quantity of heat is evolved if 1.50 g of isooctane (molar mass = 114.2 g/mol) burns?

- (a) 71.7 kJ
- (b) 143.5 kJ
- (c) 7281 kJ
- (d) 10922 kJ

Benzene (C<sub>6</sub>H<sub>6</sub>) can also be burned in the same calorimeter.



If 1.50 g of isooctane and 1.50 g of benzene (molar mass = 78.0 g/mol) is burned in the same calorimeter, in which calorimeter would the temperature rise be greater?

- (a) Isooctane, C<sub>8</sub>H<sub>18</sub>
- (b) Benzene, C<sub>6</sub>H<sub>6</sub>

## ATOMIC PHYSICS

1. (11 points) A powerful laser emits a pulse of 532 nm photons.

Part I: In what region of the electromagnetic spectrum is the light found? \_\_\_\_\_

Part II: What is the frequency of light with a wavelength of 532 nm?

- (a)  $1.60 \times 10^9 \text{ s}^{-1}$
- (b)  $2.05 \times 10^{14} \text{ s}^{-1}$
- (c)  $5.32 \times 10^{14} \text{ s}^{-1}$
- (d)  $5.64 \times 10^{14} \text{ s}^{-1}$

Part III: What is the energy of each 532 nm photon emitted? (If you are not sure of your answer in Part II, choose one and work this part accordingly. What answer from II did you choose? \_\_\_\_\_)

- (a)  $3.74 \times 10^{-19} \text{ J}$
- (b)  $3.53 \times 10^{-19} \text{ J}$
- (c)  $1.36 \times 10^{-19} \text{ J}$
- (d)  $1.06 \times 10^{-24} \text{ J}$

Part IV: The total energy in a pulse of 532-nm radiation is 120 mJ ( $= 1.20 \times 10^{-1} \text{ J}$ ). How many photons are emitted in one pulse? **Show your work!** (If you are not sure of your answer in Part III, choose one and work this part accordingly. What answer from III did you choose? \_\_\_\_\_)

2. (4 points) The line emission spectra of several elements are shown in Figure 7.9 on page 305 of *Chemistry & Chemical Reactivity*. The most prominent line in the spectrum of **chromium** (which is *not* shown in this figure) is found at 425.4 nm. Other lines in the chromium spectrum are found at 357.9 nm, 359.3 nm, 360.5 nm, 427.5 nm, 429.0 nm, and 520.8 nm.

- (a) Which of these lines represents the **most** energetic light? \_\_\_\_\_
- (b) What color is light of 425.4 nm, the most prominent line in the spectrum? \_\_\_\_\_

## ATOMIC STRUCTURE

1. (8 points) Using the *spectroscopic notation* [e.g.,  $1s^22s^2$ ], write electron configurations for the following atoms or ions:

(a) Cl (*please do not use the noble gas notation for this element*)

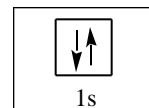
(b) Co

(c) Pt (platinum)

(d)  $Ni^{2+}$

2. (9 points) Using the *orbital box notation*, write electron configurations for the following atoms or ions. *Please use the noble gas notation for all the answers!*

(a) Si



(b)  $Cu^{2+}$

Is the copper(II) ion diamagnetic or paramagnetic? \_\_\_\_\_

(c) Am (americium, atomic number 95)

(d)  $S^{2-}$  (sulfide ion)

3. (5 points) Compare the ground state electron configurations of the following ions:  $K^+$ ,  $Cl^-$ ,  $S^{2-}$ , and  $Ca^{2+}$ . Are the configurations the same or different? If different, how do they differ? If the same, how are they the same?

Arrange the ions above in order of increasing size (ionic radius).

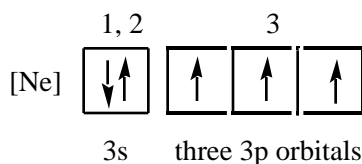
\_\_\_\_\_

**smallest ion**

\_\_\_\_\_

**largest ion**

4. (5 points) The configuration of an element is given below.



- (a) What is the identity of this element? \_\_\_\_\_
- (b) Write a complete set of quantum numbers for each of the electrons numbered in the configuration above.

Electron	$n$	$l$	$m_l$	$m_s$
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____

## 5. (20 points) Atomic structure

- (a) The *shape* of an orbital is given by the quantum number \_\_\_\_\_
- (b) A photon of green light has (*more*) (*less*) \_\_\_\_\_ energy than a photon of red light.
- (c) For a  $6d$  orbital (as in the element Sg), the value of  $n$  is \_\_\_\_\_, the value of  $\ell$  is \_\_\_\_\_, and a possible value of  $m_\ell$  is \_\_\_\_\_.
- (d) The maximum number of orbitals that can be associated with a set of quantum numbers having  $n = 5$  and  $\ell = 2$  is \_\_\_\_\_
- (e) How many *electrons* can be associated with the following sets of quantum numbers?

**Number of Electrons**

$n = 4$ , and  $\ell = 2$  \_\_\_\_\_

$n = 3$ ,  $\ell = 0$ , and  $m_\ell = +1$  \_\_\_\_\_

$n = 5$ ,  $\ell = 2$ , and  $m_\ell = +1$  \_\_\_\_\_

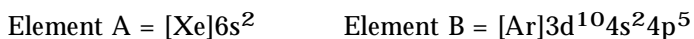
$n = 3$ ,  $\ell = 2$ ,  $m_\ell = -1$ , and  $m_s = +1/2$  \_\_\_\_\_

- (e) What element has the electron configuration  $[\text{Kr}]4d^7 5s^2$ ? \_\_\_\_\_
- (f) What element has a  $3+$  ion with the configuration  $[\text{Ar}]3d^3$ ? \_\_\_\_\_
- (g) What cation has the configuration  $[\text{Kr}]5s^2 4d^{10}$ ? \_\_\_\_\_
- (h) What element has a  $2-$  ion with the same configuration as Kr? \_\_\_\_\_
- (i) What anion has the electron configuration of a xenon atom,  $\text{S}^{2-}$ ,  $\text{Sb}^{3-}$ , or  $\text{Br}^-$ ? \_\_\_\_\_
- (j) Which ion (or ions) is (are) NOT likely to be found in a chemical compound?  $\text{Ca}^{2+}$ ,  $\text{Br}^{3-}$ ,  $\text{V}^{6+}$ , and  $\text{S}^{2-}$ ? \_\_\_\_\_
- (k) Which ion or ions is/are paramagnetic:  $\text{Mn}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{Al}^{3+}$ ,  $\text{Co}^{2+}$ , or  $\text{Ag}^+$ ? \_\_\_\_\_
- (l) Give the symbol or name of a cation that is isoelectronic with the bromide ion,  $\text{Br}^-$ . \_\_\_\_\_

6. (3 points) When you dissolve cobalt in aqueous HCl, you obtain  $\text{CoCl}_2$ . In contrast, when you dissolve the metal in aqueous  $\text{HNO}_3$ , you obtain  $\text{Co}(\text{NO}_3)_3$ . Briefly describe how you know that one of these contains the  $\text{Co}^{2+}$  ion and the other the  $\text{Co}^{3+}$  ion.

## PERIODIC TRENDS

1. (6 points) Answer the questions below about the elements A and B, which have the electron configurations shown.



- (a) Is element B a metal, nonmetal, or metalloid? \_\_\_\_\_
- (b) Which element would have the *smaller* ionization energy? \_\_\_\_\_
- (c) Which element should have the *smaller* affinity for an electron? \_\_\_\_\_
- (d) Which element has *smaller* atoms? \_\_\_\_\_
- (e) Which is more likely to form a cation? \_\_\_\_\_
- (f) If A and B were to combine to form a compound, what is the likely formula of that compound?  
\_\_\_\_\_

2. (10 points) Indicate the answer using the appropriate symbol or name.

- (a) Of the elements O, S, and F, which has the largest ionization energy? \_\_\_\_\_
- (b) Which is smaller, a Ca atom or a  $\text{Ca}^{2+}$  cation? \_\_\_\_\_
- (c) What element in the 3rd period has the largest ionization energy? \_\_\_\_\_
- (d) Place the following elements in order of increasing ionization energy: N, P, and Al.

\_\_\_\_\_

*smallest IE*

\_\_\_\_\_

*largest IE*

- (g) Which of the following groups of elements is arranged correctly in order of *decreasing* atomic radius?
- (i)  $\text{Mg} > \text{S} > \text{Al} > \text{Cl}$                       (iii)  $\text{Al} > \text{Mg} > \text{S} > \text{Cl}$
- (ii)  $\text{Mg} > \text{Al} > \text{S} > \text{Cl}$                       (iv)  $\text{Cl} > \text{S} > \text{Mg} > \text{Al}$
- (h) Which should have the largest difference between the first and second ionization energy: Si, Na, P, or Mg? \_\_\_\_\_
- (i) What element in Group 7A has the most positive electron affinity? \_\_\_\_\_
- (j) What element in the 4th period has the most positive electron affinity? \_\_\_\_\_
- (k) What element in the 6th period has the largest radius? \_\_\_\_\_