

Recitation Worksheet (Optional Extra Practice)

Name:

UGA ID:

Textbook:

Chemistry & Chemical Reactivity

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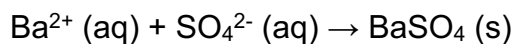
Instructions:

- This recitation worksheet is optional extra practice for Ch. 5.6-5.7.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. A student goes to lab and mixes two solutions together that are both originally at room temperature causing a reaction to occur. After mixing, the student notes that the temperature of the solution decreases. Which of the following statements are **true**? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

- A. The reaction is absorbing energy
- B. The reaction is releasing energy
- C. The reaction is exothermic
- D. The reaction is endothermic

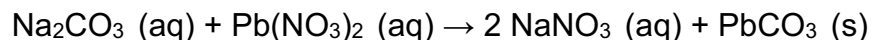
2. In a coffee-cup calorimeter, 51.0 mL of 0.100 M $\text{Ba}(\text{NO}_3)_2$ and excess H_2SO_4 are mixed to yield the following reaction:



The two solutions were initially at 23.00 °C, and the final temperature is 23.80 °C. Calculate the heat that accompanies this reaction in kJ/mol of BaSO_4 formed. Assume that the combined solution has a mass of 102.0 g and has a specific heat capacity of 4.18 J/g·°C.

- A. -67 kJ/mol
- B. -340 kJ/mol
- C. -5.1×10^{-3} kJ/mol
- D. -0.34 kJ/mol
- E. -6.7×10^4 kJ/mol
- F. 67 kJ/mol

3. A student wants to use calorimetry to study the precipitation reaction of sodium carbonate and lead(II) nitrate according to the balanced reaction below:



They add 100. mL aliquots each of the two salts to a calorimeter with 200. mL of water (for a total final volume of 400. mL) and observe an increase in temperature of 0.999 °C. If the density of the mixture is 1.03 g/mL and the specific heat of the calorimeter is 4.18 J/g·°C, what was the original molarity of the lead(II) nitrate if they know sodium carbonate was in excess? The heat of precipitation in kJ/mol of lead(II) carbonate is -25.2 kJ/mol. Report your answer in **standard notation**.

M

4. Under what condition(s) is/are bomb calorimetry performed?

- A. Constant temperature
- B. Constant volume
- C. Constant pressure
- D. Both constant volume and pressure
- E. None of the above

5. A 7.10 g sample of aniline ($\text{C}_6\text{H}_5\text{NH}_2$, molar mass 93.13 g/mol) was combusted in a bomb calorimeter with a heat capacity of 13.87 kJ/°C. If the initial temperature was 25.8°C, what is the final temperature of the calorimeter? The heat of combustion for aniline is -3.20×10^3 kJ/mol. Report your answer in **standard notation**.

°C

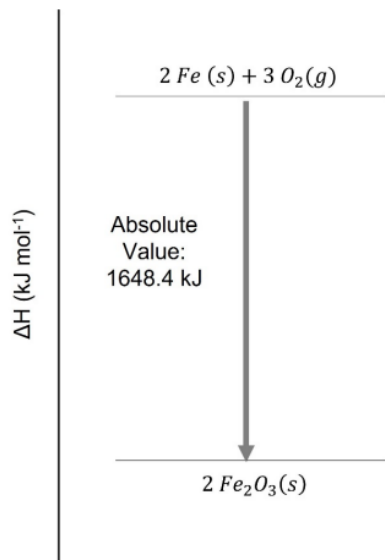
6. A new biofuel is being tested in a bomb calorimeter. The bomb calorimeter has a heat capacity of 11.2 kJ/K. If 0.9884 g of the biofuel is combusted, causing the temperature of the calorimeter to rise by 2.76 K, what is the heat of combustion of the biofuel in kJ per gram of the biofuel? Report your answer in **standard notation**.

kJ/g

7. A student goes to the lab to perform a bomb calorimetry experiment using 7.00 grams of an organic compound. Upon combustion, they note a temperature increase from 25.50 °C to 33.50 °C in their bomb calorimeter. Based on this information, what was the heat capacity of the calorimeter in kJ/°C? The molar mass of the compound is 342.34 g/mol and its heat of combustion is -1.917×10^3 kJ/mol. Report your answer in **standard notation**.

kJ/°C

8. What is true of the reaction represented by the following diagram? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

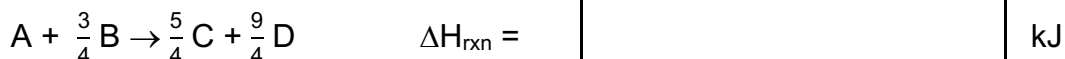
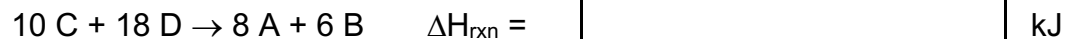


- A. It is endothermic
- B. It is exothermic
- C. 824.2 kJ of heat are released when 1 mole of Fe_2O_3 (s) is formed
- D. 1648.4 kJ of heat are absorbed when 2 mole of Fe (s) and 3 moles of O_2 (g) react
- E. 1648.2 kJ of heat are absorbed when 2 moles of Fe_2O_3 (s) is formed

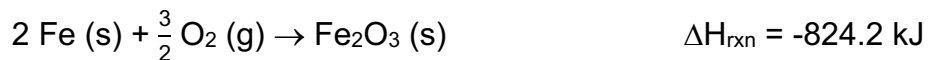
9. Consider a hypothetical reaction below...



...then determine ΔH_{rxn} of the hypothetical reactions below using this information. Report your answer in **standard notation** and **four significant figures**.



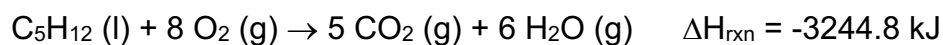
10. Determine ΔH_{rxn} for the reaction: $\text{Fe}_2\text{O}_3 (\text{s}) + 3 \text{CO} (\text{g}) \rightarrow 2 \text{Fe} (\text{s}) + 3 \text{CO}_2 (\text{g})$



Report your answer in **standard notation** and **three significant figures**.

$\Delta H_{\text{rxn}} =$ kJ

11. Determine ΔH_{rxn} for the reaction: $5 \text{C} (\text{s}) + 6 \text{H}_2 (\text{g}) \rightarrow \text{C}_5\text{H}_{12} (\text{l})$



Report your answer in **standard notation** and **four significant figures**.

$\Delta H_{\text{rxn}} =$ kJ

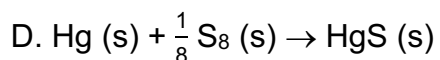
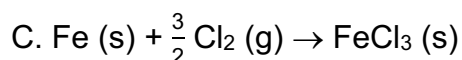
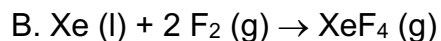
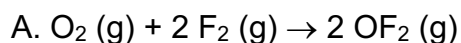
12. Which of the following statements regarding standard states and standard enthalpies of formation are **false**? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

- A. The standard state of a pure gas has a pressure equal to 1 torr
- B. The standard state of a solution has a concentration equal to 1 M
- C. The ΔH°_f of a pure compound is the change in enthalpy when 1 or more moles of a compound forms from its constituent elements regardless of their state (i.e. solid, liquid, etc.)
- D. A pure element in its standard state has a ΔH°_f equal to 0
- E. The ΔH°_f of solid fluorine, $F_2(s)$, is equal to that of gaseous fluorine, $F_2(g)$, because they have the same chemical composition

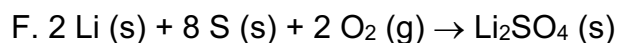
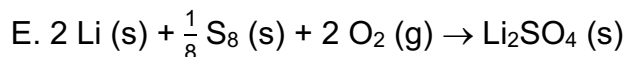
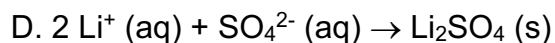
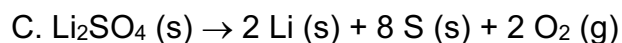
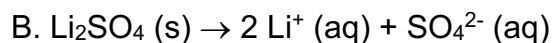
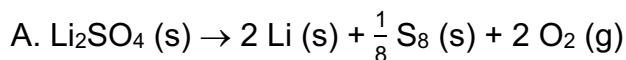
13. Which of the following elements below is **not** in its standard state? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

- A. Na (s)
- B. Cl_2 (s)
- C. Ne (l)
- D. Hg (g)
- E. S_8 (s)
- F. Ti (s)

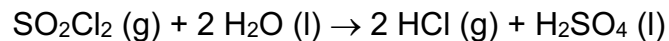
14. Which of the following is a standard formation reaction? You may assume the states of matter of the *products* are written in their standard state. Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).



15. Which of the following correctly illustrates the ΔH°_f of lithium sulfate?



16. Determine $\Delta H^\circ_{\text{rxn}}$ for the reaction below using the given ΔH°_f values in the table.

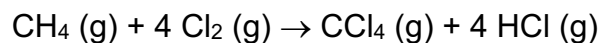


Substance	ΔH°_f (kJ/mol)
$\text{SO}_2\text{Cl}_2 (\text{g})$	-364
$\text{H}_2\text{O} (\text{l})$	-286
$\text{HCl} (\text{g})$	-92
$\text{H}_2\text{SO}_4 (\text{l})$	-814

Report your answer in **standard notation** and **two significant figures**.

kJ

17. Determine $\Delta H^\circ_{\text{rxn}}$ for the reaction below using the given ΔH°_f values in the table.

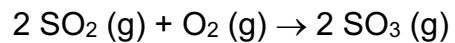


Substance	ΔH°_f (kJ/mol)
$\text{CH}_4 (\text{g})$	-75
$\text{Cl}_2 (\text{aq})$	-23
$\text{Cl}_2 (\text{g})$	0
$\text{CCl}_4 (\text{g})$	-96
$\text{HCl} (\text{g})$	-92

Report your answer in **standard notation** and **three significant figures**.

kJ

18. What is ΔH°_f for SO_3 (g) if the $\Delta H^\circ_{\text{rxn}}$ for the reaction below is -198 kJ?



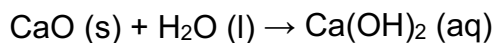
Substance	ΔH°_f (kJ/mol)
SO_2 (g)	-297

Report your answer in **standard notation** and **three significant figures**.

kJ

Additional Practice Questions:

1. A 5.45 g sample of calcium oxide is dissolved in a 101.50 g of water in a coffee cup calorimeter. Afterward, the temperature of the solution is observed to increase from 23.4 °C to 41.2 °C. If the specific heat of the solution is 4.18 J/g·°C, what is the enthalpy change for the reaction of CaO with water (shown below) in kJ/mol? Report your answer in **standard notation**.



Hint: the mass of the solution is the sum of both calcium oxide and water.

kJ/mol

2. The heat capacity of a bomb calorimeter can be determined by burning 7.59 g of methane, which has an energy of combustion of -802 kJ/mol CH_4 . The temperature of the calorimeter was initially measured at 23.2°C and rose to 31.2°C . What is the heat capacity ($\text{kJ}/^\circ\text{C}$) of the bomb calorimeter? Report your answer in **standard notation**.

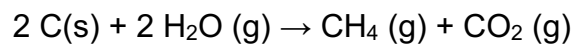
$\text{kJ}/^\circ\text{C}$

3. When 3.12 g of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, is burned in a bomb calorimeter, the temperature of the calorimeter increases from 23.8°C to 35.6°C . The student running the experiment forgot to calibrate the calorimeter, but they know the calorimeter contains 775 g of water and the bomb instrument itself has a heat capacity of $893 \text{ J}/^\circ\text{C}$. Estimate the heat of combustion (kJ/mol) of the glucose sample. Report your answer in **standard notation**.

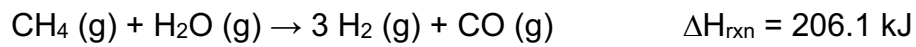
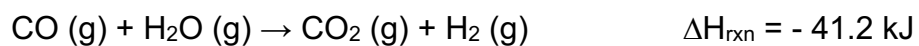
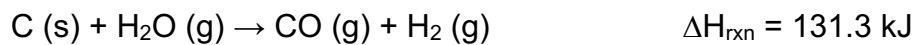
Hint: the heat produced by the reaction is absorbed by the water and the bomb.

kJ/mol

4. The combination of coke and steam produces a mixture called coal gas, which can be used as a fuel or as a starting material for other reactions. The equation for the production of coal gas is:

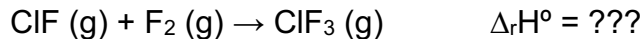


Determine the standard enthalpy change for this reaction based on the standard enthalpies of reaction below. Report your answer in **standard notation** and **three significant figures**.

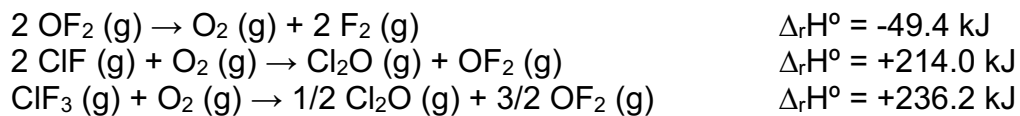


kJ

5. Chlorine monofluoride can react with fluorine to form chlorine trifluoride:

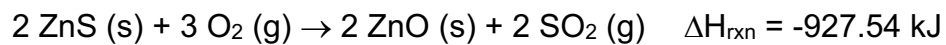


Use the reactions below to determine $\Delta_r H^\circ$ for the above reaction.



- A. -104.5 kJ
- B. +2.5 kJ
- C. -153.9 kJ
- D. +367.9 kJ

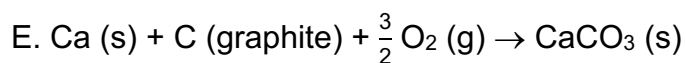
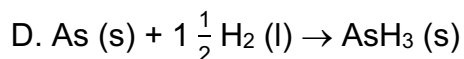
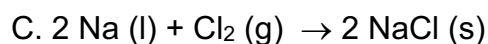
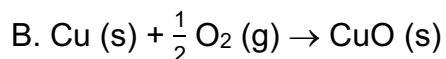
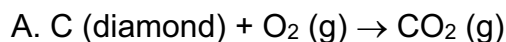
6. Determine ΔH_{rxn} for the reaction: $\text{Zn (s)} + \frac{1}{8} \text{S}_8 \text{ (s)} + 2 \text{O}_2 \text{ (g)} \rightarrow \text{ZnSO}_4 \text{ (s)}$



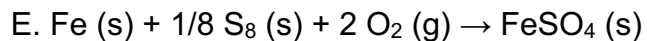
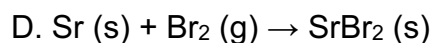
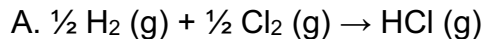
Report your answer in **standard notation** and **five significant figures**.

$\Delta H_{\text{rxn}} =$ kJ

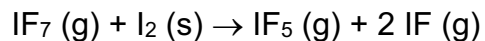
7. Which of the following is **not** a standard formation reaction at room temperature? You may assume the states of matter of the *products* are written in their standard state. Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).



8. Which of the following is a standard formation reaction at room temperature? You may assume the states of matter of the *products* are written in their standard state. Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).



9. What is ΔH°_f for IF (g) if the ΔH°_{rxn} for the reaction below is -89 kJ?



Substance	ΔH°_f (kJ/mol)
IF ₇ (g)	-941
IF ₅ (g)	-840

Report your answer in **standard notation** and **two significant figures**.

kJ/mol

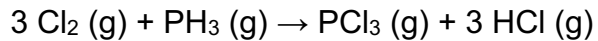
10. Ethanol (C₂H₅OH) has been proposed as an alternative fuel. Calculate the standard enthalpy of combustion (kJ/mol) for ethanol.

Substance	ΔH°_f (kJ/mol)
C ₂ H ₅ OH (g)	-278.0
CO ₂ (g)	-393.5
H ₂ O (l)	-286

Report your answer in **standard notation** and **four significant figures**.

kJ/mol

11. Determine $\Delta H^\circ_{\text{rxn}}$ for the reaction below using the given ΔH°_f values in the table.



Substance	ΔH°_f (kJ/mol)
$\text{PH}_3 (\text{g})$	5.40
$\text{HCl} (\text{g})$	-92.30
$\text{PCl}_3 (\text{g})$	-288.07

- A. -385.77 kJ
- B. 385.77 kJ
- C. -570.37 kJ
- D. 570.37 kJ
- E. More information is needed to determine ΔH°_f

1

1 H 1.01

3 Li 6.94	4 Be 9.01
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11 Na 22.99	12 Mg 24.31
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19 K 39.10	20 Ca 40.08	21 Sc 44.96
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37 Rb 85.47	38 Sr 87.62	39 Y 88.91
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37 Cs 132.91	56 Ba 137.33
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87 Fr [223]	88 Ra [226]
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18

2 He 4.00

5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
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13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
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31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
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49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
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81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
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113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]
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Periodic Table of the Elements

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

Formula Sheet

Length

1 kilometer = 0.62137 mile

1 inch = 2.54 centimeters (exactly)

1 Ångstrom = 1×10^{-10} meter

Energy

1 joule = $1 \text{ kg} \cdot \text{m}^2/\text{s}^2$

1 calorie = 4.184 joules

1 Calorie = 1 kilocalorie = 1000 calories

1 L·atm = 101.325 joules

Pressure

1 pascal = $1 \text{ N}/\text{m}^2 = 1 \text{ kg}/\text{m} \cdot \text{s}^2$

1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in²

1 bar = 1×10^5 Pa (exactly)

Temperature

0 K = -273.15°C

K = °C + 273.15

°C = (5/9)(°F - 32)

Mass

1 kg = 2.205 lbs

Volume

1 mL = 1 cm^3 = 1 cc

Constants

c = 2.998×10^8 m/sec

h = 6.626×10^{-34} J·sec

R = 0.08206 L·atm/mol·K = 8.314 J/mol·K

Specific heat of water = 4.184 J/g·K

Mass of an electron: 9.109×10^{-31} kg

Mass of a proton: 1.673×10^{-27} kg

RH = 2.18×10^{-18} J

Specific heat of water = 4.184 J/g·K

Avogadro's number: 6.022×10^{23}

F = 96485 J/(V·mol e⁻)

K_w = 1.0×10^{-14} at 25 °C

k_b = 1.381×10^{-23} J/K

Equations

$(P + a(n^2/V^2)) \cdot (V - nb) = nRT$

molar mass (M) = nRT/PV

density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\text{Rate of effusion A}}{\text{Rate of effusion B}} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

$$\ln \left(\frac{P_2}{P_1} \right) = \frac{\Delta H_{vap}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$C_g = kP_g$$

$$P_{\text{solution}} = P_{\text{solvent}} X_{\text{solvent}}$$

$$P_{\text{solution}} = \sum P_j = \sum P_j X_j$$

$$\pi = MRTi$$

Thermodynamic and Electrochemistry

$$S = k_b \times \ln(W)$$

$$\Delta S = q_{\text{rev}}/T$$

$$\Delta G = \Delta G^\circ + RT \cdot \ln Q$$

$$R = 8.314 \text{ J/mol.K}$$

$$\Delta G^\circ = -RT \cdot \ln K$$

$$\Delta G = -nFE_{\text{cell}}$$

$$E^\circ_{\text{cell}} = RT/nF \ln K$$

$$E^\circ_{\text{cell}} = (0.0257/n) \ln K = (0.0592/n) \log K$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (RT/nF) \ln Q$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - (0.0257/n) \ln Q$$

$$\text{Electrolysis: } Q (\text{total charge}) = I \times t = n \times F$$

Integrated Rate Laws & half-life

$$\ln \frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

Equilibrium and Acid / Base

$$K_p = K_c \times (RT)^{\Delta n}$$

$$\ln \frac{K_2}{K_1} = \frac{\Delta H_{rxn}^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$