Unit 6 Summative Assessment Practice

Show your work for each question in the space provided. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

$$KOH(s) \rightarrow K^+(aq) + OH^-(aq) \qquad \Delta H = -58 \text{ kJ/mol}$$

1. Solid potassium hydroxide, $KOH(s)$, undergoes dissociation into aqueous ions upon dissolution in water as shown above. The value of ΔH for this process is –58 kJ/mol.

   A student prepared a solution of $KOH(aq)$ by combining samples of $KOH(s)$ and water, each initially at room temperature, in a Styrofoam coffee cup. The mixture was stirred gently until all of the solid dissolved completely. The student observed that the temperature of the mixture changed during the dissolution of the solid.

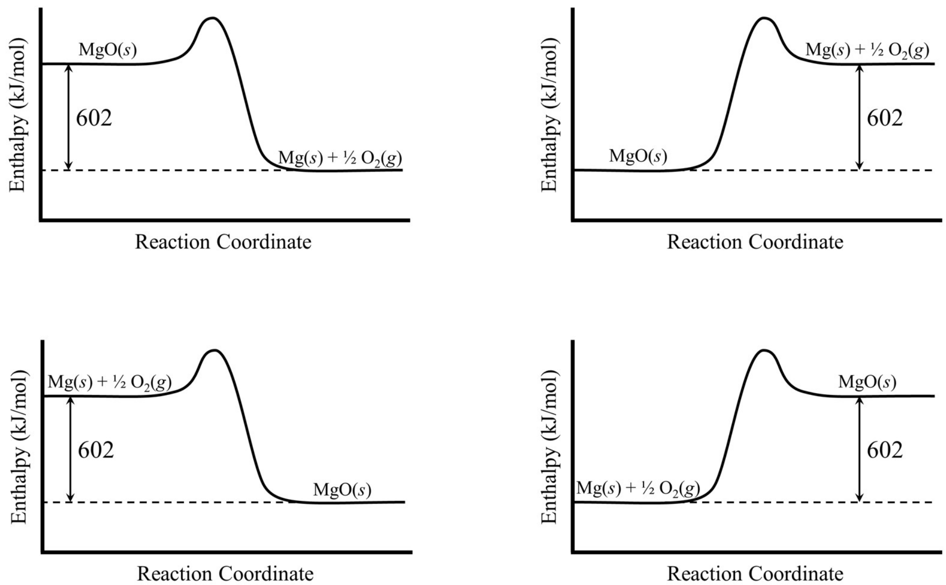
   (a) Do you predict that the temperature of the mixture decreased or increased? Justify your answer in terms of the information given above.

   (b) Does the sentence shown in the box below provide a valid explanation for the fact that the value of ΔH associated with the dissolution of $KOH(s)$ has a negative sign? Justify your answer in terms of changes in attractive forces between particles that occur during the dissolution of $KOH(s)$ in water.

Strong attractive forces exist between the K^+ ions and the OH^- ions in the crystal lattice of $KOH(s)$.

Substance	ΔH_f^o (kJ/mol)
$MgO(s)$	–602

2. Based on the information in the table above, select the energy diagram that best represents the enthalpy change associated with the formation of $MgO(s)$ from its constituent elements.



Information about the Metal	
Mass	95.0 g
Initial Temperature	100.0°C
Maximum Final Temperature	27.2°C

Information about the Water	
Mass	55.0 g
Initial Temperature	20.0°C
Maximum Final Temperature	27.2°C

3. A sample of metal is placed in a boiling water bath at 100.0°C for several minutes. Then the metal is quickly transferred to a sample of water in a calorimeter. Data from the experiment is shown above. Assume that no heat is lost to the container or the surroundings outside the container. Based on the information given above, fill in the missing information in the table below. Include the correct units with each answer.

Information about the Metal	
Change in Temperature (ΔT)	
Specific Heat Capacity	

Information about the Water	
Change in Temperature (ΔT)	
Specific Heat Capacity	4.18 J/(g·°C)

4. A student does a calorimetry experiment to determine the change in enthalpy associated with the dissolution of ammonium nitrate, NH_4NO_3, in water. Data from the experiment are shown in the table below. Assume that the specific heat capacity of the calorimeter is negligible.

	Trial 1	Trial 2
Mass of $H_2O(l)$	75.00 g	75.00 g
Mass of $NH_4NO_3(s)$	10.00 g	20.00 g
Initial Temperature of $H_2O(l)$ and $NH_4NO_3(s)$	22.0°C	22.0°C
Lowest Temperature Reached by the Solution	13.1°C	
Specific Heat Capacity of Solution	4.2 J/(g·°C)	4.2 J/(g·°C)

(a) Write a balanced equation that represents what happens to the particles of the solute when NH_4NO_3 dissolves in water. Include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

(b) Is the dissolution of NH_4NO_3 classified as an endothermic process or an exothermic process? Justify your answer in terms of the experimental data.

(c) Calculate the magnitude of heat (q) that was transferred in Trial 1 of this experiment. Include units in your answer.

(d) Calculate the number of moles of $NH_4NO_3(s)$ used in Trial 1 of this experiment.

4. (continued)

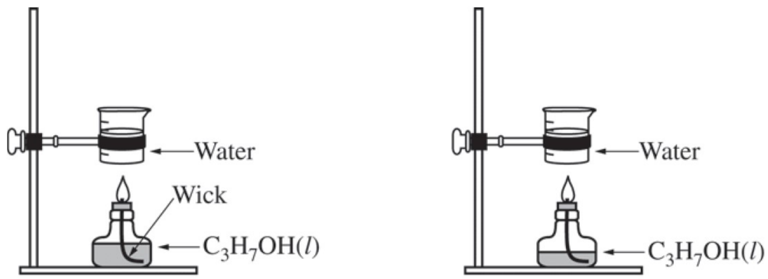
(e) Based on your answers to parts (b), (c), and (d), determine the experimental value of the change in enthalpy, ΔH, associated with the dissolution of NH_4NO_3 in water. Express your answer in units of kJ/mol, and include the appropriate algebraic sign of ΔH with your answer.

(f) In Trial 2 of this experiment, 20.00 g of NH_4NO_3 is dissolved completely into 75.00 g of water. Do you predict that the magnitude of heat (q) transferred in Trial 2 will be less than, equal to, or greater than the value of q that was determined in part (c)? Justify your answer.

(g) Do you predict that the magnitude of the calculated value of ΔH (in kJ/mol) for the dissolution of NH_4NO_3 in Trial 2 will be less than, equal to, or greater than the value of ΔH that was calculated in part (e)? Justify your answer.

$$2\ C_3H_7OH(l) \ + \ 9\ O_2(g) \ \rightarrow \ 6\ CO_2(g) \ + \ 8\ H_2O(g)$$

5. A student performs an experiment to determine the enthalpy of combustion of 2-propanol, $C_3H_7OH(l)$, which combusts in oxygen according to the equation above. The student heats a sample of water by burning some of the $C_3H_7OH(l)$ that is in an alcohol burner, as represented below. The alcohol burner uses a wick to draw liquid up into the flame. The mass of $C_3H_7OH(l)$ consumed in the reaction is determined by weighing the alcohol burner before and after the combustion.



Initial Final

Data from the experiment are given in the table below.

Mass of water heated in the beaker	125.00 g
Initial Temperature of Water	22.0°C
Final Temperature of Water	81.8°C
Specific Heat Capacity of Water	4.18 J/(g·°C)
Mass of $C_3H_7OH(l)$ Burner Before the Experiment	187.24 g
Mass of $C_3H_7OH(l)$ Burner After the Experiment	186.19 g

(a) Calculate the magnitude of heat that was transferred to the water in this experiment. Assume that the energy released from the combustion of $C_3H_7OH(l)$ in the burner is completely transferred to the water. Include units in your answer.

(b) Calculate the number of moles of $C_3H_7OH(l)$ consumed in the combustion experiment.

(c) Use your answers to parts (a) and (b) to determine the value of ΔH_{rxn} for the equation shown below. Include the appropriate algebraic sign of ΔH_{rxn} with your answer.

$2\ C_3H_7OH(l) \ + \ 9\ O_2(g) \ \rightarrow \ 6\ CO_2(g) \ + \ 8\ H_2O(g) \quad \Delta H_{rxn} =$ ________________ kJ/mol_{rxn}

Properties of $C_3H_6O(l)$	
Molar Heat Capacity	125 J/(mol·K)
Boiling Point	329 K
Enthalpy of Vaporization	31.3 kJ/mol

6. Properties of $C_3H_6O(l)$ are listed in the table above. Calculate the quantity of heat required to increase the temperature of a pure sample of 200.0 g of $C_3H_6O(l)$ from 298 K to the boiling point of 329 K and evaporate the liquid completely. Include units in your answer.

$$2\ C_2H_6(g) \quad + \quad 7\ O_2(g) \quad \rightarrow \quad 4\ CO_2(g) \quad + \quad 6\ H_2O(g) \qquad \Delta H = -2855\ \text{kJ/mol}_{rxn}$$

7. In a certain experiment, 125 g $C_2H_6(g)$ and 375 g $O_2(g)$ were added to a previously evacuated reaction vessel. The reaction mixture was sparked and the reaction represented by the equation shown above occurred until one of the reactants was completely consumed.

   (a) Convert each quantity of reactant into mol_{rxn}.

   (b) Which reactant, $C_2H_6(g)$ or $O_2(g)$, represents the limiting reactant in this experiment? Justify your answer in terms of your answer to part (a).

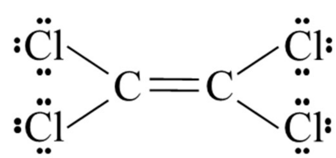
   (c) Calculate the amount of thermal energy, in kJ, that should be produced in this experiment.

8. Tetrachloroethylene, C_2Cl_4, reacts with oxygen gas according to the equation shown below.

$$C_2Cl_4(g) \ + \ 2\ O_2(g) \ \rightarrow \ 2\ CO_2(g) \ + \ 2\ Cl_2(g) \qquad \Delta H° = -774.6 \text{ kJ/mol}_{rxn}$$

(a) Use the information given in the chemical equation above and the information listed in the table below to calculate the standard enthalpy of formation, ΔH_f^o, for $C_2Cl_4(g)$. Include the appropriate algebraic sign of ΔH_f^o and the correct units with your answer.

	$C_2Cl_4(g)$	$CO_2(g)$
Standard Enthalpy of Formation (kJ/mol)	?	–393.5



(b) The Lewis electron-dot diagram of tetrachloroethylene is shown above. Use the information given in the chemical equation above, your knowledge of the correct Lewis electron-dot diagrams for O_2, CO_2, and Cl_2, and the information listed in the table below to calculate the bond enthalpy for the C–Cl bond. Include the correct units with your answer.

	C–Cl	C–C	C=C	O–O	O=O	C–O	C=O	Cl–Cl
Bond Enthalpy (kJ/mol)	?	348	614	146	498	358	799	243

Equation #1: $N_2(g) + O_2(g) \rightarrow 2\ NO(g)$ $\Delta H_{rxn} = +180.6$ kJ/mol$_{rxn}$

Equation #2: $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$ $\Delta H_{rxn} = -92.2$ kJ/mol$_{rxn}$

Equation #3: $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$ $\Delta H_{rxn} = -483.6$ kJ/mol$_{rxn}$

9. Equations #1, #2, and #3 shown above can be modified in a certain way so that, when the modified versions of each equation are added together, the following equation will be formed as a result.

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g) \quad \Delta H_{rxn} = ?$$

(a) How should equation #1 be modified? ____________________

(b) How should equation #2 be modified? ____________________

(c) How should equation #3 be modified? ____________________

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g) \quad \Delta H_{rxn} = ?$$

(d) Based on your answers to parts (a), (b), and (c), write the modified versions of Equations #1 – #3 in the space below. Show the modified values of ΔH_{rxn} next to each equation, and show how the equations can be added together to produce the equation shown above.

(e) Based on your answer to part (d), determine the value of ΔH_{rxn} for the overall reaction.