

## HW13 - 1st Law and Calorimetry

1 1 point

A 100 W electric heater ( $1 \text{ W} = 1 \text{ J/s}$ ) operates for 11 min to heat the gas in a cylinder. At the same time, the gas expands from 1 L to 6 L against a constant atmospheric pressure of 3.527 atm. What is the change in internal energy of the gas?

- 48.37 kJ  
 62.47 kJ  
 67.79 kJ  
 64.21 kJ

2 1 point

The definition of internal energy is

$$\Delta U = q + w$$

Which of these three values are state functions? Select all of the correct answers.

- q  
 w  
  $\Delta U$

3 1 point

When 2.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston with an external pressure of 2.00 atm, the nitrogen gas expands from 2.00 to 5.00 L. What is the change in internal energy of this system?

- 0.608 kJ  
 +2.61 kJ  
 -2.61 kJ  
 0  
 +1.39 kJ

4 1 point

A system had 150 kJ of work done on it and its internal energy increased by 60 kJ. How much energy did the system gain or lose as heat?

- The system lost 210 kJ of energy as heat.  
 The system gained 60 kJ of energy as heat.  
 The system gained 90 kJ of energy as heat.  
 The system lost 90 kJ of energy as heat.  
 The system gained 210 kJ of energy as heat.

5 1 point

If a process is carried out at constant pressure and the volume of the system decreases, then  $\Delta V$  is

and the work is .

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6 1 point

Which of the following will best help determine the direction of heat flow in a system?

- enthalpy  
 temperature  
 internal energy  
 pressure  
 work

7 1 point

Which of the following statements concerning the first law of thermodynamics is/are true? Select all of the correct answers.

- The internal energy of the universe is always increasing.  
 The universe is an isolated system.  
 Internal energy lost by a system is always gained by the surroundings.

8 1 point

What is the value of work when a piston of volume 0.2 L expands against an external pressure of 200 kPa to a volume of 3.4 L?

- 3.40 kJ  
 -3.40 kJ  
 -640 J  
 640 J

9 1 point

When 4.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston at an external pressure of 3.00 atm, the nitrogen gas expands from 1.00 L to 4.00 L against this constant pressure. What is  $\Delta U$  for the process? Note:  $1 \text{ L} \cdot \text{atm} = 0.1013 \text{ kJ}$ .

- 0.912 kJ  
 +3.09 kJ  
 -4.91 kJ  
 +4.91 kJ

10 1 point

A piece of metal with a mass of 22 g at  $92^\circ\text{C}$  is placed in a calorimeter containing 53.7 g of water at  $21^\circ\text{C}$ . The final temperature of the mixture is  $55.3^\circ\text{C}$ . What is the specific heat capacity of the metal? Assume that there is no energy lost to the surroundings.

- $9.5 \text{ J g}^{-1}\text{C}^{-1}$   
  $1.3 \times 10^4 \text{ J g}^{-1}\text{C}^{-1}$   
  $-1.3 \times 10^4 \text{ J g}^{-1}\text{C}^{-1}$   
  $-9.5 \text{ J g}^{-1}\text{C}^{-1}$

11 1 point

Consider the following specific heat capacities:

$$\text{H}_2\text{O (s)} = 2.09 \text{ J/g}\cdot^\circ\text{C}$$

$$\text{H}_2\text{O (l)} = 4.18 \text{ J/g}\cdot^\circ\text{C}$$

$$\text{H}_2\text{O (g)} = 2.03 \text{ J/g}\cdot^\circ\text{C}$$

The heat of fusion for water is 334 J/g and its heat of vaporization is 2260 J/g. Calculate the amount of heat required to convert 93 g of ice at  $-36^\circ\text{C}$  completely to liquid water at  $35^\circ\text{C}$ .

- 7 kJ  
 52 kJ  
 38 kJ  
 21 kJ

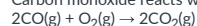
12 1 point

The specific heat for liquid argon and gaseous argon is  $25.0 \text{ J/mol}^\circ\text{C}$  and  $20.8 \text{ J/mol}^\circ\text{C}$ , respectively. The enthalpy of vaporization of argon is  $6506 \text{ J/mol}$ . How much energy is required to convert 1 mole of liquid Ar from  $5^\circ\text{C}$  below its boiling point to 1 mole of gaseous Ar at  $5^\circ\text{C}$  above its boiling point?

- 125 J  
 229 J  
 6610 J  
 6735 J  
 6631 J

13 1 point

Carbon monoxide reacts with oxygen to form carbon dioxide by the following reaction:



$\Delta H$  for this reaction is  $-135.28 \text{ kcal}$ . How much heat would be released if 12.0 moles of carbon monoxide reacted with sufficient oxygen to produce carbon dioxide? Use only the information provided in this question.

- 135 kcal  
 812 kcal  
 1620 kcal  
 412 kcal

14 1 point

What mass of liquid ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) must be burned to supply 500 kJ of heat? The standard enthalpy of combustion of ethanol at 298 K is  $-1368 \text{ kJ/mol}$ .

- 10.9 g  
 126 g  
 16.8 g  
 29.7 g

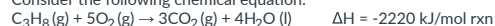
15 1 point

Burning 1 mol of methane in oxygen to form  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{g})$  produces 803 kJ of energy. How much energy is produced when 3 mol of methane is burned?

- 803 kJ  
 268 kJ  
 1606 kJ  
 2409 kJ

16 1 point

Consider the following chemical equation:



How much thermal energy is given off when 11.0 g of propane gas ( $\text{C}_3\text{H}_8$ ) is burned at constant pressure?

- 26.0 kJ  
 2220 kJ  
 555 kJ  
 1670 kJ

17 1 point

For a certain reaction at constant pressure, the change in internal energy is  $-52 \text{ kJ}$ . In addition, the system does  $46 \text{ kJ}$  of expansion work. What is  $\Delta H$  for this process?

- 98 kJ  
  $-98 \text{ kJ}$   
  $-6 \text{ kJ}$   
 6 kJ

18 1 point

If the products of a reaction have higher energy than the reactants, then the reaction...

- is endothermic.  
 is not spontaneous.  
 is exothermic.  
 must be spontaneous.

19 1 point

The specific heats and densities of several materials are given below:

Material	Specific Heat (cal/g $^\circ\text{C}$ )	Density (g/cm $^3$ )
Brick	0.220	2.0
Concrete	0.270	2.7
Steel	0.118	7
Water	1.00	1.00

Calculate the change in temperature produced by the addition of 1 kcal of heat to 100 g of steel.

- $1.43^\circ\text{C}$   
  $37.0^\circ\text{C}$   
  $84.7^\circ\text{C}$   
  $1.18^\circ\text{C}$

20 1 point

A 1.00 g sample of *n*-hexane ( $\text{C}_6\text{H}_{14}$ ) undergoes complete combustion with excess  $\text{O}_2$  in a bomb calorimeter. The temperature of the 1502 g of water surrounding the bomb rises from  $22.64^\circ\text{C}$  to  $29.30^\circ\text{C}$ . The heat capacity of the hardware component of the calorimeter (everything that is not water) is  $4042 \text{ J/}^\circ\text{C}$ . What is  $\Delta U$  for the combustion of *n*- $\text{C}_6\text{H}_{14}$ ? One mole of *n*- $\text{C}_6\text{H}_{14}$  is 86.1 g. The specific heat of water is  $4.184 \text{ J/g}^\circ\text{C}$ .

- $-9.96 \times 10^3 \text{ kJ/mol}$   
  $-5.92 \times 10^3 \text{ kJ/mol}$   
  $-4.52 \times 10^3 \text{ kJ/mol}$   
  $-1.15 \times 10^4 \text{ kJ/mol}$

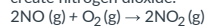
21 1 point

When 0.485 g of compound X is burned completely in a bomb calorimeter containing 3000 g of water, a temperature rise of  $0.285^\circ\text{C}$  is observed. What is  $\Delta U$  of the reaction for the combustion of compound X? The hardware component of the calorimeter has a heat capacity of  $3.81 \text{ kJ/}^\circ\text{C}$ . The specific heat of water is  $4.184 \text{ J/g}^\circ\text{C}$ , and the MW of X is  $56.0 \text{ g/mol}$ .

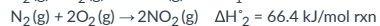
- $-4660 \text{ kJ/mol}$   
  $4660 \text{ kJ/mol}$   
  $538 \text{ kJ/mol}$   
  $-538 \text{ kJ/mol}$

22 1 point

Nitric acid can be manufactured in a multi-step process, during which nitric oxide is oxidized to create nitrogen dioxide.



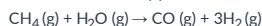
Calculate the standard reaction enthalpy for the above reaction using the following thermodynamic data.



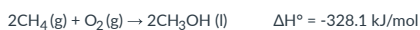
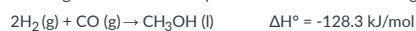
- 246.9 kJ/mol rxn  
 -252.4 kJ/mol rxn  
 -100.3 kJ/mol rxn  
 -114.1 kJ/mol rxn

23 1 point

Calculate the standard reaction enthalpy for the following chemical equation.



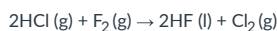
Use the following thermochemical equations to solve for the change in enthalpy.



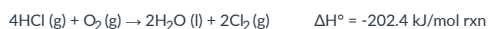
- +216 kJ/mol       +155.5 kJ/mol  
 +206.1 kJ/mol       +42.0 kJ/mol

24 1 point

Calculate the standard enthalpy change for the following chemical equation.



Use the following thermochemical equations to solve for the change in enthalpy.



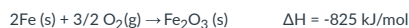
- +1088.2 kJ/mol rxn       +516.6 kJ/mol rxn  
 -1116.6 kJ/mol rxn       +1015.4 kJ/mol rxn  
 +1116.6 kJ/mol rxn       -516.6 kJ/mol rxn  
 -1587.2 kJ/mol rxn       -1015.4 kJ/mol rxn  
 -1088.2 kJ/mol rxn       +1587.2 kJ/mol rxn

25 1 point

Calculate the standard enthalpy change for the following chemical equation.



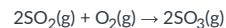
Use the following thermochemical equations to solve for the change in enthalpy.



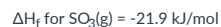
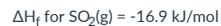
- 556 kJ/mol       -2726 kJ/mol  
 574 kJ/mol       -556 kJ/mol  
 -574 kJ/mol

26 1 point

Calculate the enthalpy change for the following chemical equation.



Use the following thermochemical data to solve for the change in enthalpy.



- 77.6 kJ/mol rxn       -5.0 kJ/mol rxn  
 -10.0 kJ/mol rxn       +5.0 kJ/mol rxn

27 1 point

Which of the following substances have  $\Delta H_f^\circ = 0$ ? Select all of the correct answers.

- $\text{F}_2(\text{g})$   
  $\text{C}(\text{s}, \text{graphite})$   
  $\text{HCl}(\text{g})$   
  $\text{Na}(\text{s})$   
  $\text{HCl}(\text{aq})$   
  $\text{C}(\text{s}, \text{diamond})$

28 1 point

Calculate the average S-F bond energy in  $\text{SF}_6$  using the following  $\Delta H_f^\circ$  values:



- 289 kJ/mol bonds       582 kJ/mol bonds  
 196 kJ/mol bonds       327 kJ/mol bonds  
 416 kJ/mol bonds

29 1 point

Using the bond energy data provided, calculate  $\Delta H$  for the following reaction:



**Bond Energies**



- 186 kJ/mol       -246 kJ/mol  
 246 kJ/mol       -186 kJ/mol

30 1 point

The standard molar enthalpy of formation of  $\text{NH}_3(\text{g})$  is  $-46.11 \text{ kJ/mol}$ . What is the standard molar internal energy of formation of  $\text{NH}_3(\text{g})$ ?

- 48.59 kJ/mol  
 2433 kJ/mol  
 -43.63 kJ/mol  
 -2525 kJ/mol