Recitation Worksheet Thirteen

Name: Key UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: mine is jmj81738). Do *not* enter your 81x number.
- Download this worksheet and print it if you have a printer. Write the answers in the answer boxes and show your work when appropriate. Using the instructions in the Welcome module on eLC, convert your worksheet to a PDF and then upload it to Gradescope. If you have an iPhone or Android device, you can scan and upload directly through the Gradescope app. The pages must be in the correct order or Gradescope will not be able to read it.
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- Answers must be written in the corresponding answer box or no credit will be awarded.
- This worksheet is due no later than **11:59 PM on the Friday of the recitation week.**
- The instructions for uploading worksheets to Gradescope can be found in the Content area of eLC in the Welcome Module.
- **You must show your work to receive credit.**

1. Of the following, which is a state function? Select all that apply.

A D

A. Enthalpy
B. Heat
C. Work
D. Internal Energy
E. None of the above

2. Which of the following statements about energy is/are true? Select all that apply.

BC

A. The energy stored in bonds is a type of kinetic energy
B. Thermal energy is a type of kinetic energy
C. A reaction that releases heat is considered exothermic
D. None of the above are true

3. The combustion of liquid hydrogen and liquid oxygen produces water vapor to propel a rocket into space. Which of the following would a chemist most likely define as part of the system? Select all that apply.

ABC

A. $H_2(l)$
B. $O_2(l)$
C. $H_2O(g)$
D. The fuel tank
E. The rocket
F. The atmosphere around the rocket
G. The Earth

→ positive

4. A hot air balloon is filled with gas. Upon absorbing 934 J of heat, the gas expands, performing 478 J of work. What is the change in internal energy in Joules?

→ negative

C

$\Delta E = q + w$

$= 934\ J + (-478\ J)$

A. 1412 J
B. -456 J
C. 456 J
D. -1412 J

5. Which of the following reactions would **not** result in pressure-volume work by either the system or the surroundings? Select all that apply.

C D

A. $C_3H_4\ (g) + 2\ H_2\ (g) \rightarrow C_3H_8\ (g)$ 3 mol (g) → 1 mol (g)

B. $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$ 3 mol (g) → 0 mol (g)

C. $2\ C_3H_4\ (g) + 8\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 4\ H_2O\ (g)$ 10 mol (g) → 10 mol (g)

D. $Fe_2O_3\ (s) + 3\ CO\ (g) \rightarrow 2\ Fe\ (s) + 3\ CO_2\ (g)$ 3 mol (g) → 3 mol (g)

E. $2\ NH_3\ (g) \rightarrow N_2\ (g) + 3\ H_2\ (g)$ 2 mol (g) → 4 mol (g)

F. All of the reactions listed would result in pressure-volume work

6. Consider a system whose volume changes from 19.50 L to 16.50 L at 1.50 atm pressure. If the system is giving off 25.0 kJ of heat, what is the change in internal energy (in kJ)?

→ negative

$w = -P\Delta V$

$= -1.50\ atm\ (16.50\ L - 19.50\ L)$

$= -1.50\ atm\ (-3.00\ L)$

$= 4.50\ L \cdot atm \left(\frac{101.325\ J}{1\ L \cdot atm}\right)$

$= 455.962\ J$

$= 0.455962\ kJ$

don't forget this step!

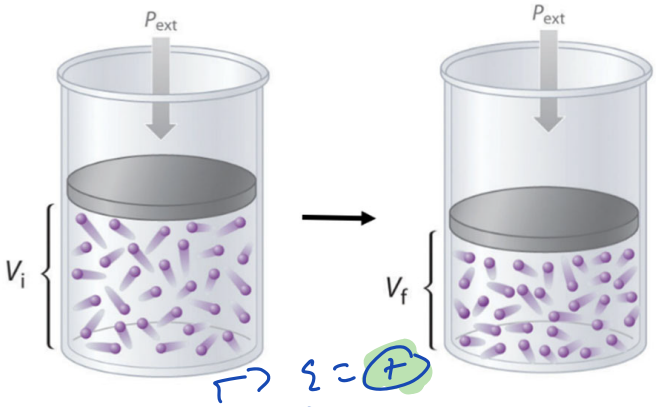
−24.5 kJ

$\Delta E = q + w$

$= -25.0\ kJ + 0.455962\ kJ$

$= -24.5\ kJ$

Answer questions 7-8 using the illustration of the cylinders below.



7. If V_f is less than V_i and heat is absorbed, which of the following options are true for the system?

D

$w = -P\Delta V$

$= -P(V_f - V_i)$

$= (+)$

$\Delta E = q + w$

A. The sign for work is negative; the total internal energy change is negative
B. The sign for work is negative; the total internal energy change is positive
C. The sign for work is positive; the total internal energy change is negative
D. The sign for work is positive; the total internal energy change is positive
E. There is not enough information to answer without knowing the exact decrease in volume and the exact amount of heat that is absorbed

8. If V_i is 15.00 L and V_f is 5.00 L for the same cylinders, what is the change in work for the system if the external pressure is 1.13 atm?

B

$w = -P\Delta V$

$= -1.13\ atm\ (5.00\ L - 15.00\ L)$

$= -1.13\ atm\ (-10.00\ L)$

$= 11.3\ L \cdot atm$

$11.3\ L \cdot atm \left(\frac{101.325\ J}{1\ L \cdot atm}\right) = 1140\ J$

↳ don't forget this step!

A. -1140 J
B. 1140 J
C. -11.3 J
D. 11.3 J
E. -0.112 J
F. 0.112 J

9. What is **true** about enthalpy?

B

A. It is path-dependent
B. It is equal to the heat exchanged at a constant pressure
C. It is equal to the heat exchanged at a constant volume
D. It is always a positive value

10. Which statement is true if ΔH = - 85 J?

C

A. The system is gaining 85 J; the surroundings are losing 85 J. The process is exothermic.
B. The system is gaining 85 J; the surroundings are losing 85 J. The process is endothermic.
C. The system is losing 85 J; the surroundings are gaining 85 J. The process is exothermic.
D. The system is losing 85 J; the surroundings are gaining 85 J. The process is endothermic.
E. Both the system and surroundings are losing 85 J. The process is exothermic.

11. If 100. g of each of the following metals is heated to 100°C and placed in a coffee-cup calorimeter, which metal would cause the **lowest** rise in temperature?

C

A. Sn: 0.218 J/g·°C

B. Ag: 0.239 J/g·°C

C. Au: 0.126 J/g·°C

smallest heat capacity

D. Al: 0.921 J/g·°C

12. What is **false** about a coffee-cup calorimeter?

C

A. It is a form of constant-pressure calorimetry
B. Any heat change by the system is equal but opposite to the heat change of the calorimeter
C. The heat exchanged measured must have correction made for PV work before the enthalpy can be calculated
D. The heat exchanged is equal to the enthalpy change
E. More than one of the above is false

13. A piece of copper metal with a mass of 150. g is placed into a refrigerator. If the initial temperature of the metal was 23.0°C, and it is cooled to 5.0°C, how much heat (kJ) did the refrigerator absorb? The specific heat of copper is 0.380 J/g·K.

°C = K

C

$q = mc\Delta T$

$= (150.\ g)(0.380\ J/g.K)(5.0°C - 23.0°C)$

$= -1.026 \times 10^3\ J$

$= -1.026\ kJ$ → copper lost this

refrigerator gained this

A. 7.11 kJ
B. -1.03 kJ
C. 1.03 kJ
D. 790. kJ
E. -790. kJ

14. A technician goes to the lab and finds a 1252 g block of metal that has been heated to 157.2 °C. Over the duration of some time, the block loses 1.53 kJ of energy. What is the new temperature after this change in energy has occurred? The specific heat of the metal is 0.279 J/g·°C.

$q = mc\Delta T$

B

$-1.53\ kJ \left(\frac{1000\ J}{1\ kJ}\right) = 1252\ g\ (0.279\ J/g°C)(T_F - 157.2°C)$

$T_F = 152.8\ °C$

A. 161.6 °C
B. 152.8 °C
C. 143.3 °C
D. 135.6 °C
E. 157.2 °C (negligible change)

15. A 20.0 g block of aluminum is heated to 75.0°C and is then placed on a 10.0 g sheet of copper at room temperature (22.0°C). The specific heat capacity for aluminum is 0.900 J/g·°C and the specific heat capacity for copper is 0.385 J/g·°C. What is the final temperature of the aluminum assuming that no heat is lost to the surroundings?

65.7 °C

$q_{Al} = -q_{Cu}$

$mC\Delta T = -mC\Delta T$

$(20.0\ g)(0.900\ J/g°C)(T_F - 75.0°C) =$

$-(10.0\ g)(0.385\ J/g°C)(T_F - 22.0°C)$

$(18.0\ J/°C)(T_F) - 1350\ J = (-3.85\ J/°C)(T_F) + 84.7\ J$

$(21.85\ J/°C)(T_F) = 1434.7\ J$

$T_F = 65.7\ °C$

16. An undergraduate student goes to chemistry lab to perform the bomb calorimetry experiment using benzoic acid (q_{comb} = -3225 kJ/mol; molar mass = 122.12 g/mol). They see a temperature change of approximately 4.10 ºC. If the heat capacity of the calorimeter is 12.1 kJ/ºC, what was the starting mass of benzoic acid used?

1.88 g

$q_{cal} = C_{cal}\Delta T$

$= (12.1\ kJ/°C)(4.10°C)$

$= 49.61\ kJ$

$q_{cal} = -q_{comb}$

$49.61\ kJ \left(\frac{mol}{3225\ kJ}\right)\left(\frac{122.12\ g}{mol}\right) = 1.88\ g$

17. A 6.16 g sample of benzene (C_6H_6), an organic compound with a q_{comb} = -41.74 kJ per gram of benzene, is combusted in a bomb calorimeter. What will the change in temperature of the bomb calorimeter be if the heat capacity of the calorimeter is 50.4 kJ/K?

5.10 K

$6.16\ g \left(-41.74\ kJ/g\right) = -257.1184\ kJ$

$q_{cal} = -q_{comb}$

$= +257.1184\ kJ$

$q_{cal} = C_{cal} \Delta T$

$+257.1184\ kJ = (50.4\ kJ/K)(\Delta T)$

$\Delta T = 5.10\ K$

Extra Practice Questions: these questions will not be graded.

1. Which of the following are forms of *kinetic* energy? Select all that apply.

AD

A. The energy associated with random molecular motion
B. The energy stored in chemical bonds
C. The energy of a stretched spring
D. The energy of a ball rolling down a hill
E. The energy resulting from position, composition, or condition

2. What is *true* when heat goes from the surroundings to the system? Select all that apply.

CE

A. The sign of the heat change in the surroundings is positive
B. Work is done on the system
C. The internal energy of the system increases
D. The potential energy of the surroundings increases
E. The sign of the heat change in the system is positive

3. What is *true* about heat but *false* about work?

D

A. The SI unit is the joule
B. It is a force acting over a distance
C. It is one of the ways internal energy can be exchanged
D. It is the transfer of thermal energy due to a temperature difference
E. More than one of the above is true about heat but false about work

4. A student is making popcorn on the stove but wants to practice their thermochemistry definitions. The popcorn container starts to expand as the stovetop heats it (like in the picture below). The student says that, for the system, q = +52 J and w = -18 J. What have they likely defined as the system?

A

A. The popcorn container
B. The stove top
C. The kitchen
D. The house

5. Another student is making the same type of popcorn from the previous question (Jiffy Pop). The popcorn container (mass of 127 g, c = 1.050 J/g·°C) is initially at room temperature (23.7°C) and reaches a temperature of 30.6°C before being removed from the stove. While heating, the container expands by 0.69 L against an atmospheric pressure of 1.01 atm. What is the change in internal energy (J) for the popcorn?

850 J

① $q = mc\Delta T$

$= 127\,g\,(1.050\ J/g{\cdot}°C)(30.6-23.7)\,°C$

$= 127\,g\,(1.050\ J/g{\cdot}°C)(6.9\,°C)$

$= 920.115\ J$

② $w = -P\Delta V = -(1.01\ atm)(0.69\ L)$

$= -0.6969\ L{\cdot}atm$

$-0.6969\ L{\cdot}atm\left(\frac{101.325\ J}{1\ L{\cdot}atm}\right) = -70.6134\ J$

③ $\Delta E = q + w$

$= 920.115\ J + (-70.6134\ J)$

$= 850\ J$

6. In which of the following reactions would PV work be performed? Select all that apply.

BC

A. $2\ NaCl\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow 2\ NaNO_3\ (aq) + PbCl_2\ (s)$

B. $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$ 25 mol (g) → 34 mol (g)

C. $I_2\ (s) \rightarrow I_2\ (g)$ 0 mol (g) → 1 mol (g)

D. $CH_4\ (g) + F_2\ (g) \rightarrow CH_2F_2\ (g) + H_2\ (g)$

E. $C_2H_5OH\ (s) \rightarrow C_2H_5OH\ (l)$

7. A student goes to the lab and performs a synthesis reaction in a large round bottom flask. The last step of the synthesis involves heating the reaction to a high temperature, and then allowing it to cool down to room temperature. To expedite the process, they decide to submerge the flask in a liquid solvent to facilitate heat transfer from the flask to the solvent.

Given the information below, which of the following would be most efficient at cooling the flask?

Solvent	Molar mass (g/mol)	Specific heat (kJ/kg·K)
Propylene glycol	76.09	2.50
Methanol	32.04	2.51
Ethanol	46.07	2.85

C

A. Propylene glycol because it has the lowest specific heat
B. Propylene glycol because it has the highest molar mass
C. Either propylene glycol or methanol because they both have similar specific heats that are both the lowest in the table
D. Methanol because it has a very low specific heat and the lowest molar mass
E. Ethanol because it has the highest specific heat

8. A solution of 50.0 mL of sodium hydroxide (d = 1.10 g/mL) absorbs 1712 J of heat. If sodium hydroxide has a specific heat of 4.10 J/g·°C, how many degrees will the temperature of the solution go up?

7.59 °C

$q = mc\Delta T$

$1712\ J = (50.0\ mL)(1.10\ g/mL)(4.10\ J/g^{\circ}C)(\Delta T)$

$\Delta T = 7.59^{\circ}C$

9. 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?

needs to be negative!

−31.3	kJ/g

$q_{cal} = C_{cal} \Delta T$

$= (11.2 \text{ kJ/K})(2.76 \text{ K})$

$= 30.912 \text{ kJ}$

$q_{cal} = -q_{comb}$

$q_{comb} = -30.912 \text{ kJ}$

$q_{comb}\,(\text{kJ/g}) = \dfrac{-30.912 \text{ kJ}}{0.9884 \text{ g}} = -31.3 \text{ kJ/g}$