Chapter 6 practice test

1. $3\ C_2H_2(\mathbf{g}) \rightarrow C_6H_6(\mathbf{g})$

What is the standard enthalpy change $\Delta\mathbf{H}^\circ$, for the reaction represented above?
($\Delta\mathbf{H}^\circ_f$ of $C_2H_2(\mathbf{g})$ is 230 kJ mol^{-1};
($\Delta\mathbf{H}^\circ_f$ of $C_6H_6(\mathbf{g})$ is 83 kJ mol^{-1};)

(A) -607 kJ ✓

(B) -147 kJ

(C) -19 kJ

(D) +19 kJ

(E) +773 kJ

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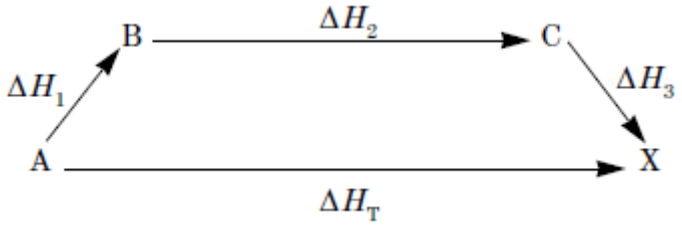
2. $A \rightarrow X$

The enthalpy change for the reaction represented above is $\Delta\mathbf{H}_T$. This reaction can be broken down into a series of steps as shown in the diagram:



A relationship that must exist among the various enthalpy changes is

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(A) $\Delta H_T - \Delta H_1 - \Delta H_2 - \Delta H_3 = 0$ ✓

(B) $\Delta H_T + \Delta H_1 + \Delta H_2 + \Delta H_3 = 0$

(C) $\Delta H_3 - (\Delta H_1 + \Delta H_2) = \Delta H_T$

(D) $\Delta H_2 - (\Delta H_3 + \Delta H_1) = \Delta H_T$

(E) $\Delta H_T + \Delta H_2 = \Delta H_1 + \Delta H_3$

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3. A 100g sample of a metal was heated to 100°C and then quickly transferred to an insulated container holding 100g of water at 22°C. The temperature of the water rose to reach a final temperature of 35°C. Which of the following can be concluded?

(A) The metal temperature changed more than the water temperature did; therefore the metal lost more thermal energy than the water gained.

(B) The metal temperature changed more than the water temperature did, but the metal lost the same amount of thermal energy as the water gained. ✓

(C) The metal temperature changed more than the water temperature did; therefore the heat capacity of the metal must be greater than the heat capacity of the water.

(D) The final temperature is less than the average starting temperature of the metal and the water; therefore the total energy of the metal and water decreased.

$K(\mathbf{s}) + \frac{1}{2} Cl_2(\mathbf{g}) \rightarrow KCl(\mathbf{s})$ $\Delta H° = -437 kJ/mol_{rxn}$

The elements K and Cl react directly to form the compound KCl according to the equation above. Refer to the information above and the table below to answer the questions that follow.

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Process	ΔH° (kJ/mol_{rxn})
$K(s) \rightarrow K^+(g)$	v
$K(g) \rightarrow K^+(g) + e^-$	w
$Cl_2(g) \rightarrow 2\ Cl(g)$	x
$Cl(g) + e^- \rightarrow Cl^-(g)$	y
$K^+(g) + Cl^-(g) \rightarrow KCl(s)$	z

4. $Cl_2(\mathbf{g}) + 2e^- \rightarrow 2Cl^-(\mathbf{g})$

Which of the following expressions is equivalent to $\Delta\mathbf{H}^\circ$ for the reaction represented above?

(A) **x + y**

(B) **x - y**

(C) **x + 2y** ✔

(D) $\frac{x}{2} - y$

5. How much heat is released or absorbed when 0.050 mol of $Cl_2(\mathbf{g})$ is formed from KCl(**s**)?

(A) 87.4 kJ is released

(B) 43.7 kJ is released

(C) 43.7 kJ is absorbed ✔

(D) 87.4 kJ is absorbed

6. Which of the values of $\Delta\mathbf{H}^\circ$ for a process in the table is (are) less than zero (i.e., indicate(s) an exothermic process)?

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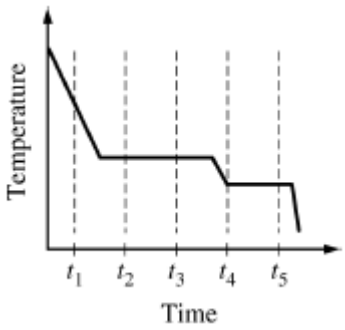
(A) **z** only

(B) **y** and **z** only ✓

(C) **x**, **y**, and **z** only

(D) **w**, **x**, **y**, and **z**

7.



The cooling curve above shows how the temperature of a sample varies with time as the sample goes through phase changes. The sample starts as a gas, and heat is removed at a constant rate. At which time does the sample contain the most liquid?

(A) t_1

(B) t_2

(C) t_3

(D) t_4 ✓

(E) t_5

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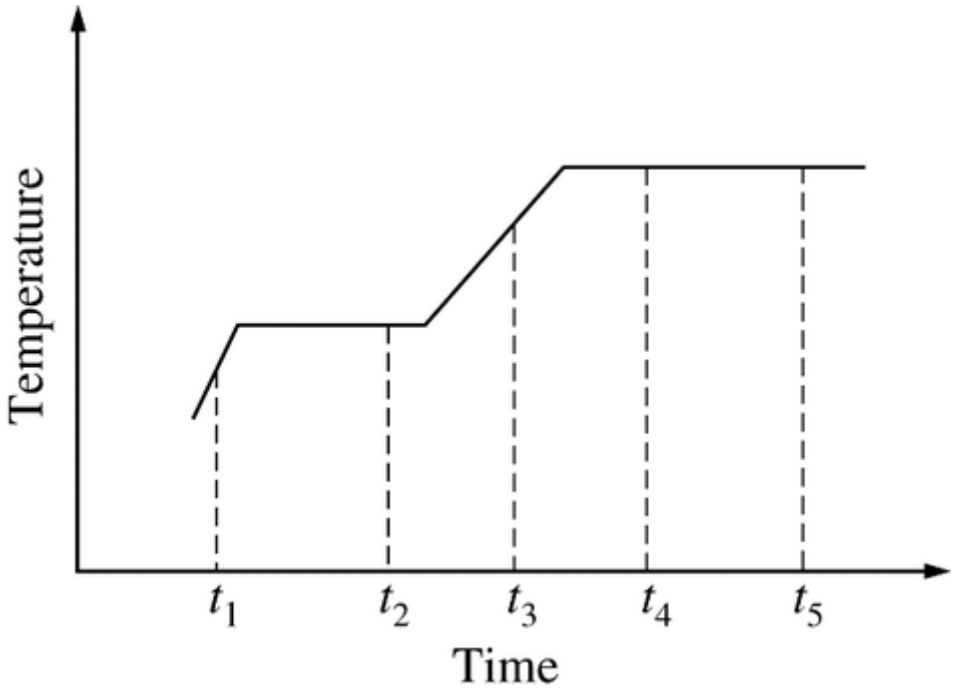
The following questions relate to the graph below. The graph shows the temperature of a pure substance as it is heated at a constant rate in an open vessel at 1.0 atm pressure. The substance changes from the solid to the liquid to the gas phase.



8. The substance is at its normal freezing point at time

(A) t_1

(B) t_2 ✓

(C) t_3

(D) t_4

(E) t_5

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9. Which of the following best describes what happens to the substance between $\mathbf{t}_4$ and $\mathbf{t}_5$?

(A) The molecules are leaving the liquid phase. ✔

(B) The solid and liquid phases coexist in equilibrium.

(C) The vapor pressure of the substance is decreasing.

(D) The average intermolecular distance is decreasing.

(E) The temperature of the substance is increasing.

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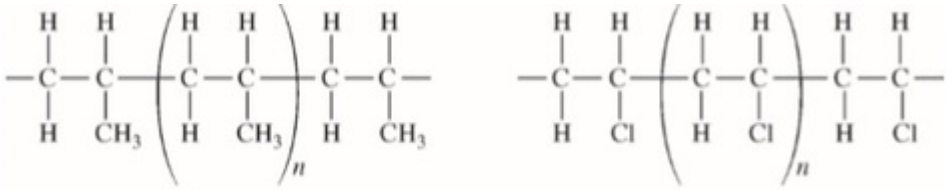
10. A student places a mixture of plastic beads consisting of polypropylene (PP) and polyvinyl chloride (PVC) in a 1.0 L beaker containing distilled water. After stirring the contents of the beaker vigorously, the student observes that the beads of one type of plastic sink to the bottom of the beaker and the beads of the other type of plastic float on the water. The chemical structures of PP and PVC are represented by the diagrams below, which show segments of each polymer.



PP PVC

a. Given that the spacing between polymer chains in PP and PVC is similar, the beads that sink are made of which polymer ? Explain.

PP is synthesized from propene, C_3H_6, and PVC is synthesized from vinyl chloride, C_2H_3Cl. The structures of the molecules are shown below.

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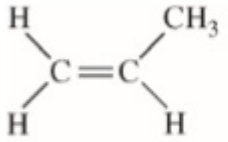
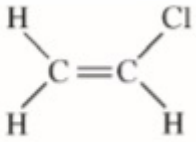


Propene



Vinyl Chloride (chloroethene)

b. The boiling point of liquid propene (226 K) is lower than the boiling point of liquid vinyl chloride (260 K). Account for this difference in terms of the types and strengths of intermolecular forces present in each liquid.

In a separate experiment, the student measures the enthalpies of combustion of propene and vinyl chloride. The student determines that the combustion of 2.00 mol of vinyl chloride releases 2300 kJ of energy, according to the equation below.

$2\ C_2H_3Cl(\mathbf{g}) + 5\ O_2(\mathbf{g}) \rightarrow 4\ CO_2(\mathbf{g}) + 2\ H_2O(\mathbf{g}) + 2\ HCl(\mathbf{g})\ \Delta\mathbf{H}° = -2300\ kJ/mol_{rxn}$

c. Using the table of standard enthalpies of formation below, determine whether the combustion of 2.00 mol of propene releases more, less, or the same amount of energy that 2.00 mol of vinyl chloride releases. Justify your answer with a calculation. The balanced equation for the combustion of 2.00 mol of propene is $2\ C_3H_6(\mathbf{g}) + 9\ O_2(\mathbf{g}) \rightarrow 6\ CO_2(\mathbf{g}) + 6\ H_2O(\mathbf{g})$.

Substance	$C_2H_3Cl(g)$	$C_3H_6(g)$	$CO_2(g)$	$H_2O(g)$	$HCl(g)$	$O_2(g)$
Standard Enthalpy of Formation (kJ/mol)	37	21	−394	−242	−92	0

Please respond on separate paper, following directions from your teacher.

Part A

1 point is earned for the correct polymer with a correct explanation.

The PVC beads sink. The spacing between chains is similar, but a Cl atom has a greater mass than CH_3.

0	1 ✓

The student response earns one of the following points:

1 point is earned for the correct polymer with a correct explanation.

The PVC beads sink. The spacing between chains is similar, but a Cl atom has a greater mass than CH_3.

Part B

1 point is earned for a discussion of intermolecular forces and for a comparison of their relative strengths.

Both substances have dipole-dipole interactions and London dispersion forces (or propene is essentially nonpolar with only LDFs while vinyl chloride has both LDFs and dipole-dipole forces). Propene contains a CH_3 group, but vinyl chloride contains a Cl atom. Vinyl chloride thus has a larger electron cloud, is more polarizable, and has a larger dipole moment. Thus intermolecular attractions are stronger in vinyl chloride, which results in it having a higher boiling point.

0	1 ✓

The student response earns one of the following points:

1 point is earned for a discussion of intermolecular forces and for a comparison of their relative strengths.

Both substances have dipole-dipole interactions and London dispersion forces (or propene is essentially nonpolar with only LDFs while vinyl chloride has both LDFs and dipole-dipole forces). Propene contains a CH_3 group, but vinyl chloride contains a Cl atom. Vinyl chloride thus has a larger electron cloud, is more polarizable, and has a larger dipole moment. Thus intermolecular attractions are stronger in vinyl chloride, which results in it having a higher boiling point.

Part C

1 point is earned for the calculation of the enthalpy of combustion of propene.

$\Delta \mathbf{H}^\circ = 6(-394) + 6(-242) - 2(21) = -3858 \text{ kJ/mol}_{\text{rxn}}$

1 point is earned for the comparison of propene to vinyl chloride that is consistent with the calculated value.

The combustion of 2.00 mol of propene releases more energy.

0	1	2 ✔

The student response earns two of the following points:

1 point is earned for the calculation of the enthalpy of combustion of propene.

$\Delta \mathbf{H}^\circ = 6(-394) + 6(-242) - 2(21) = -3858 \text{ kJ/mol}_{\text{rxn}}$

1 point is earned for the comparison of propene to vinyl chloride that is consistent with the calculated value.

The combustion of 2.00 mol of propene releases more energy.

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11. Aluminum metal can be recycled from scrap metal by melting the metal to evaporate

impurities.

a. Calculate the amount of heat needed to purify 1.00 mole of Al originally at 298 K by melting it. The melting point of Al is 933 K. The molar heat capacity of Al is 24 J/(mol·K), and the heat of fusion of Al is 10.7 kJ/mol.

b. The equation for the overall process of extracting Al from Al_2O_3 is shown below. Which requires less energy, recycling existing Al or extracting Al from Al_2O_3? Justify your answer with a calculation.

$Al_2O_3(\mathbf{s}) \rightarrow 2\ Al(\mathbf{s}) + \frac{3}{2}\ O_2(\mathbf{g})$ $\Delta \mathbf{H}^\circ = 1675\ kJ/mol_{rxn}$

Please respond on separate paper, following directions from your teacher.

Part A

1 point is earned for calculating the amount of heat needed to raise the temperature to 933 K.

To raise the temperature from 298 K to 933 K:

$$q = \frac{24\ \text{J}}{\text{mol K}} \times 1.00\ \text{mol} \times 635\ \text{K} = 15{,}000\ \text{J} = 15\ \text{kJ}$$

1 point is earned for adding the heat of fusion to the previous result to get a final answer.

It takes 10.7 kJ to melt the Al at 933 K.

15 kJ + 10.7 kJ = 26 kJ

0	1	2 ✓

The student response earns two of the following points:

1 point is earned for calculating the amount of heat needed to raise the temperature to 933 K.

To raise the temperature from 298 K to 933 K:

$$q = \frac{24\ \text{J}}{\text{mol K}} \times 1.00\ \text{mol} \times 635\ \text{K} = 15{,}000\ \text{J} = 15\ \text{kJ}$$

1 point is earned for adding the heat of fusion to the previous result to get a final answer.

It takes 10.7 kJ to melt the Al at 933 K.

15 kJ + 10.7 kJ = 26 kJ

Part B

1 point is earned for a calculation to get equal numbers of moles for comparison.

For extracting Al from ore:

$$1675\ \text{kJ/mol}_{rxn} \times \frac{1\ \text{mol of reaction}}{2\ \text{mol Al}} = 837.5\ \text{kJ per mol of Al}$$

Producing 1.00 mol of Al from Al_2O_3 requires 837.5 kJ.

1 point is earned for a correct comparison.

Because 26 kJ < 837.5 kJ, recycling requires less energy.

0	1	2 ✔

The student response earns two of the following points:

1 point is earned for a calculation to get equal numbers of moles for comparison.

For extracting Al from ore:

$$1675\ \text{kJ/mol}_{rxn} \times \frac{1\ \text{mol of reaction}}{2\ \text{mol Al}} = 837.5\ \text{kJ per mol of Al}$$

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Producing 1.00 mol of Al from Al_2O_3 requires 837.5 kJ.

1 point is earned for a correct comparison.

Because 26 kJ < 837.5 kJ, recycling requires less energy.