

3.E: Exercises

Q3.6

Calculate the work done by the reaction

[Math Processing Error]

when 1 mole of hydrogen gas is collected at 273 K and 1.0 atm. (Neglect volume changes other than the change in gas volume, and assume that the gas behaves ideally.)

Q3.11a

If the internal energy of 3 moles of Cl_2 is 3.96 KJ, what is the temperature of the system?

Q3.11b

The internal energy of 3 moles of neon gas (Ne) is 4.87 kJ. Assuming conditions are ideal, what is the temperature of the system?

S3.11b

Since we can assume that conditions are ideal, we know that the temperature is 25°C or 298 K. This assumption allows us to ignore the small change in volume of the gas.

Q3.12a

Some ice cubes are placed inside a sealed plastic bag on a hot day, what is the sign of *[Math Processing Error]*, *[Math Processing Error]*, *[Math Processing Error]*, *[Math Processing Error]*? What does this mean about the system?

Q3.12b

A sports bottle containing Gatorade is held in a man's hand while running on a treadmill. Suppose the Gatorade is the system in question. Answer the subsequent questions.

- Will the temperature rise due to the movement caused by the man's running?
- Was any heat actually added to the system? If so, what was the source?
- Was work done onto the system?
- In what ways has the internal energy of the system been affected, if affected at all?

S3.12b

- The man's running motion causes the Gatorade to be shaken. The shaking motion adds energy to the system and increases the random motion of the molecules. Since the motion of the molecules rises, so does the temperature of the system.
- Yes, heat exchange did occur between the system and its surroundings (the heat given off from the man's hand).
- Yes, work was done onto the system via the shaking motion.
- The internal energy has been increased.

Q3.12c

Consider an ice cube melting.

- Is the change of enthalpy positive or negative for this process?
- Is the change of entropy positive or negative for this process?

S3.12c

- Enthalpy is positive because the ice must gain heat in order to melt.
- Entropy is also positive because the water molecules are gaining kinetic energy and moving to a more disordered state.

Q3.13

2.5 moles of CO_2 expands against an external pressure of 1.5 atm. It was initially at 9.0 atm and 30°C. The final volume is 35.0 L.

- What is the final temperature?
- Calculate q , w , and *[Math Processing Error]* for the process.

S3.13

a) *[Math Processing Error]*

b) *[Math Processing Error]*

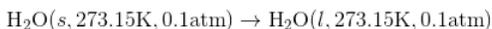
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[Math Processing Error]

- For calculating work, expression for Isothermal reversible process has been used instead of correct $-P_{ext}dV$ as it is a irreversible expansion against external pressure. -Wrong method for calculating q. Instead Internal energy would be calculated using nC_vdT .

Q3.17

Determine the $\Delta_{\text{vap}}\bar{H}^\circ$ at 343.15 K for H_2O . (Note: The heat of vaporization for water is known to be $40.79 \text{ kJ mol}^{-1}$ at 273.15 K, the \bar{C}_P of $\text{H}_2\text{O}(l)$ was determined to be $85.6 \text{ J K}^{-1} \text{ mol}^{-1}$ and the \bar{C}_P of $\text{H}_2\text{O}(s)$ was determined to be $54.35 \text{ J K}^{-1} \text{ mol}^{-1}$). Use the reaction below and give your final answer in kJ mol^{-1} .



S3.17

$$\Delta_{\text{vap}}\bar{H}_{343.15\text{K}} = \Delta\bar{H}_1 + \Delta\bar{H}_2 + \Delta\bar{H}_3$$

$$\Delta\bar{H}_1 = \bar{C}_P(l)\Delta T = 85.6 \times (273.15 - 343.15) = 3.852\text{kJmol}^{-1}$$

$$\Delta\bar{H}_2 = \Delta_{\text{vap}}\bar{H}_{273.15\text{K}}^\circ = +40.79\text{kJmol}^{-1}$$

$$\Delta\bar{H}_3 = \bar{C}_P(g)\Delta T = 54.35 \times (343.15 - 273.15) = -2.446\text{kJmol}^{-1}$$

$$\Delta H = 3.825 + 40.79 + (-2.446) = 42.17\text{kJmol}^{-1}$$

$$\Delta_V\bar{H}_{343.15\text{K}} - \Delta_V\bar{H}_{273.15\text{K}} = \Delta\bar{C}_P(T_{343.15} - T_{273.15})$$

$$\Delta_V\bar{H}_{343.15\text{K}} = \Delta_V\bar{H}_{273.15\text{K}} + \Delta\bar{C}_P(T_{343.15} - T_{273.15})$$

$$= 40.79 + (54.35 - 85.6) \times (343.15 - 273.15) = 40.79\text{kJmol}^{-1}$$

Q3.18

,Is *[Math Processing Error]* true for a cyclic process?

S3.18

Yes, *[Math Processing Error]* is a true statement. It is true because *[Math Processing Error]* for any cyclic process is equal to zero.

Q3.22

A 10.0 g sheet of gold with a temperature of 18.0°C is laid flat on a sheet of iron that weights 20.0 g and has a temperature of 55.6°C . Given that the specific heats of Au and Fe are $0.129 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ and $0.444 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$, respectively, what is the final temperature of the combined metals? (Hint: The heat gained by the gold must be equal to the heat lost by the iron.)

Q3.23

You are cooking 100 grams of chicken soup at 300K. You know that it will take 500 J to raise the temperature of your soup to the desired 350K. Assuming constant pressure, calculate the molar heat capacity of this chicken soup.

Q3.24

Why does the molar heat of vaporization for water decrease as temperature increases?

Q3.24

The value of ΔH for heating 1 mole of hexane is 28.9kJ/mole at 342 K and 25.6 kJ/mole at 298 K. Explain why those values are different.

Q3.25

What is ΔH if of 3.00 moles of $\text{O}_2(g)$ are cooled from 175°C to 35.0°C and *[Math Processing Error]*

S3.25

[Math Processing Error]

Q3.25

For a constant-pressure process, the heat capacity per mole is given by the expression:

$$C_p \text{ per mole} = (16.0 + 4.35 \times 10^{-3} T + 1.15 T^2) \text{ J K}^{-1} \text{ mol}^{-1}$$

Find the molar heat capacity of oxygen gas from 38°C to 115°C

S3.25

[Math Processing Error]

Q3.26

What is the heat capacity ratio ([Math Processing Error]) if of an ideal gas if its [Math Processing Error]?

S3.26

since [Math Processing Error]

[Math Processing Error]

Q3.29

Explain (in terms of thermo chemistry) why Emperor Penguins huddle together in the Antarctic.

Q3.30a

Through laboratory experiment, a group of students found out that molar mass of a solid element can be calculated in term of the specific heat capacity :

$$\text{Molar mass} \times \text{the specific heat of metals} = 25 \text{ (Eq.1)}$$

They were also obtaining the values of the three metals, Aluminum (0.900 J/g °C), Zinc (0.381 J/g °C), and Arsenic (0.329 J/g °C).

Determine which metal violate the above equation (Eq.1)

S3.30a

Aluminum (Al) can not be applied in this equation because the specific heat capacity of Al is approximately equal 1.0 J g⁻¹ (°C⁻¹)

Q3.30b

What is the molar heat capacity of lead given its specific heat is 0.128J/(g°C) at 25°C?

S3.30b

The first thing we do is find the molar mass of lead which is 207.2 g/mol.

We multiply our molar mass by the specific heat to get the molar heat capacity.

$$207.2 \frac{\text{g}}{\text{mol}} * 0.128 \frac{\text{J}}{\text{g}^\circ\text{C}} = 26.52 \frac{\text{J}}{\text{mol}^\circ\text{C}}$$

Q3.31

What is the total work done on 2.00 moles of an ideal monatomic gas at 3.00 atm and 4.00 L when it adiabatically expands to 7.00 L?

S3.31

The equation for work is

[Math Processing Error]

For a monatomic gas,

[Math Processing Error]

[Math Processing Error]

Solve for T_1 :

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Solve for T_2 :

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Solve for work:

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.31

You notice your system changes volume from 10 L to 30 L with a constant pressure at 770 torr. Then, there is a decrease in pressure to 740 torr with the volume staying constant at 30 L. Calculate the total amount of work done.

S3.31

We split up the solution into two parts.

Work done during the volume change and the work done during the pressure change.

First part:

$$w = P_{\text{ex}}\Delta V$$

$$770\text{torr} \cdot \frac{1\text{atm}}{760\text{torr}} = 1.01\text{atm}$$

$$w = (-1.01\text{atm})(20\text{L})\left(101.3 \frac{\text{J}}{1\text{L} \cdot \text{atm}}\right) = -2046.3\text{J}$$

Second part:

Convert pressure to atm:

$$740\text{torr} \cdot \frac{1\text{atm}}{760\text{torr}} = 0.974\text{atm}$$

$$w = -P_2V_2 \ln \frac{P_1}{P_2}$$

$$w = -(0.974\text{atm})(30\text{L}) \ln \frac{0.974}{1.0} \cdot \frac{101.3\text{J}}{1\text{L} \cdot \text{atm}}$$

$$= 107.4\text{J}$$

Then add up the two works

$$w_{\text{tot}} = -2046.3 + 107.4 = -1938.9 \text{ J}$$

Q3.33

Calculate the values of q , w , ΔU , and ΔH for the reversible adiabatic expansion of 1 mole of a diatomic ideal gas from 10.00 m^3 to 35.0 m^3 with an initial temperature of 298 K.

Q3.33

Calculate the values of q , w , ΔU , and ΔH for the reversible adiabatic expansion of 1 mole of a diatomic ideal gas from 10.00 m^3 to 40.0 m^3 with an initial temperature of 298K.

Q3.34

A quantity of 0.27 mole of argon is confined in a container at 3.0 atm and 298 K and then allowed to expand adiabatically under two different conditions: (a) reversibly to 0.80 atm and (b) against a constant pressure of 0.80 atm. Calculate the final temperature in each case.

Q3.34

In an adiabatic process 0.5 moles of He_2 in a container are allowed to expand against a constant pressure of 1.00 atm and 298 K. The final temperature after the gas has expanded is 205 K. Calculate the initial pressure inside the container.

S3.34

In an adiabatic process

[Math Processing Error]

we get

[Math Processing Error]

we rearrange and get

[Math Processing Error]

we solve for

[Math Processing Error] and get *[Math Processing Error]*

[Math Processing Error]

[Math Processing Error]

Q3.34

A quantity of 0.27 mole of argon is confined in a container at 3.0 atm and 298 K and then allowed to expand adiabatically under two different conditions:

1. reversibly to 0.80 atm and
2. against a constant pressure of 0.80 atm.

Calculate the final temperature in each case.

Q3.35a

Two moles of ideal diatomic gas *[Math Processing Error]* expand from 2.00 atm to 1.30 atm while being cooled from 550 K to 250 K. Compute the Change of Enthalpy (ΔH) and Change of Internal Energy (ΔU) for 2 different processes: a. reversible and b. irreversible. Explain and calculate the difference a and b?

Q3.35b

0.5 mole of Helium at 298 K are allowed to expand reversibly from 5 atm to 1 atm. Find q , w and ΔU if

- a. the process is adiabatic and
- b. if the process is isothermal.

Q3.36a

808 kJ/mol of heat is released by burning x (gram) amount of Iron in a constant volume bomb calorimeter. The calorimeter containing 100 g water inside has a heat capacity of $2100 \text{ J}\cdot\text{C}^{-1}$. Evaluate the amount of Iron needed to increase the water by 5.20C ?

Q3.36b

In your constant-volume bomb calorimeter you have a 0.3677 g sample of Potassium. The water surrounding the sample increase from $18.08 \text{ }^\circ\text{C}$ to $20.667 \text{ }^\circ\text{C}$. The calorimeter has a heat capacity of $1515 \text{ J}/(\text{g}^\circ\text{C})$. What is the change in internal energy?

S3.36b

Since the bomb calorimeter has a constant volume *[Math Processing Error]*, there is no (PV) work so the first law of thermodynamics

[Math Processing Error]

can be simplified to

[Math Processing Error]

Then the relationship between heat and temperature change

[Math Processing Error]

can be changed

[Math Processing Error]

which for this case is

[Math Processing Error]

[Math Processing Error]

Q3.37

The enthalpy of combustion for benzoic acid (*[Math Processing Error]*) is commonly used as the standard *[Math Processing Error]*, for calibrating bomb calorimeters at a constant-volume process.

- When 1.567 g of benzoic acid burned in a calorimeter the temperature increased by *[Math Processing Error]*. Calculate the heat capacity of the calorimeter.
- For a different experiment 0.6792g of ethanol was burned in the calorimeter which rose from $16.42\text{ }^\circ\text{C}$ to $26.58\text{ }^\circ\text{C}$. Calculate the enthalpy of combustion for ethanol, the value of *[Math Processing Error]* for the combustion, and the molar enthalpy of formation.

S3.37

(a)

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

(b) (Hint: Calorimeter absorbs heat transferred from the combustion of maltose)

[Math Processing Error]

Step 1: Calculate *[Math Processing Error]*

[Math Processing Error]

[Math Processing Error]

Step 2: Calculation of enthalpy of combustion

[Math Processing Error]

[Math Processing Error]

Therefore,

[Math Processing Error]

Step 3: Calculate the molar enthalpy of formation.

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.38a

A quantity of 2.50×10^2 mL of 0.468 M HBr is mixed with 2.50×10^2 mL of 0.425 M KOH in a constant-pressure calorimeter that has a heat capacity of $437 \text{ J } ^\circ\text{C}^{-1}$. The initial temperature of the HBr and KOH solutions is the same at 21.35°C . For the process

[Math Processing Error]

the heat of neutralization is $-56.2 \text{ kJ mol}^{-1}$. What is the final temperature of the mixed solution?

Q3.38b

In a constant-pressure calorimeter with a heat capacity of 395 [Math Processing Error], you mix [Math Processing Error] of HBr at 0.788M and [Math Processing Error] [Math Processing Error] at $.394\text{M}$. For this process to occur the heat of neutralization is [Math Processing Error]. The initial temperature of both solutions is [Math Processing Error].

[Math Processing Error]

Find the final temperature of the mixed solution.

S3.38b

Step 1: (Hint: Determine the number of moles of the reactants)

[Math Processing Error]

[Math Processing Error]

Step 2: (Hint: Calculate the thermal energy released by the reaction)

[Math Processing Error]

Step 3: (Hint: Assume the density of the solutions are the same as water and specific heat is same as water too.)

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Step 4:

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Step 5:

[Math Processing Error]

[Math Processing Error]

Q3.38

A quantity of [Math Processing Error] of [Math Processing Error] is mixed with [Math Processing Error] of [Math Processing Error] in a constant-pressure calorimeter that has a heat capacity of $437 \text{ J } ^\circ\text{C}^{-1}$. The initial temperatures of the [Math Processing Error]

Error and *[Math Processing Error]* solutions are the same at 21.35 °C. The heat of neutralization for the below reaction is \ (-56.2; kJ/mol¹)

[Math Processing Error]

What is the final temperature of the mixed solution?

Q3.39

1.52 g of toluene *[Math Processing Error]* is combusted in a constant volume bomb calorimeter at 25°C. Calculate the *[Math Processing Error]* and *[Math Processing Error]* for this reaction given that 39.183 kJ of heat was released.

S3.39

First we need to construct the balanced reaction that occurs

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.39

The ΔU of the combustion of naphthalene (C₁₀H₈) are -480 kJ mol⁻¹. The heat evolved from the combustion in a constant-volume calorimeter is 7.5 KJ. Calculate the mass of naphthalene in grams in the calorimeter.

Q3.40

For the reaction

[Math Processing Error]

- Balance the reaction
- Calculate the *[Math Processing Error]* of reaction using the *[Math Processing Error]* data

Q3.40B

Consider the following reaction:

[Math Processing Error]

What is the value of *[Math Processing Error]* if

- the equation is multiplied throughout by 4;
- the direction of the reaction is reversed;
- [Math Processing Error]* was a liquid instead of gas?

S3.40B

- [Math Processing Error]*;
- [Math Processing Error]*;
- Ethane exist as a liquid at temperatures of below 184.6 K. If we used ethane liquid instead of ethane gas, then according to *[Math Processing Error]* the number of moles would change and the temperature of the reaction would also change.

Q3.41a

On what basis is the 0 value for standard enthalpy of formation assigned to a substance at a specific temperature? Base on that, identify which substances have $\Delta_f H^\circ = 0$ and which do not at 1 atm and 25°C (give explanation for those that do not).

H₂(g), O₃(g), Al(s), Br₂(g), NaCl(s), Cl₂(g)

Hint: Look at [standard enthalpy of formation](#)

S3.41a

0 value for standard enthalpy of formation is assigned to elemental substances that are in their natural/standard physical state at that specific condition of temperature and pressure.

- $\text{H}_2(\text{g})$, $\text{Al}(\text{s})$, $\text{Cl}_2(\text{g})$ are substances with $\Delta_f H^\circ = 0$ kJ/mol
- $\text{O}_3(\text{g})$ is an elemental substance but does not occur naturally at 25°C , $\text{O}_2(\text{g})$ is.
- $\text{Br}_2(\text{g})$ is also not the standard state of bromine. At STP, the physical state of bromine is liquid
- NaCl does not have a 0 value because it is not an elemental substance

Q3.41b

Which of the following substances has a standard enthalpy of formation, at 298 K, of 0 K?

$\text{O}_2(\text{g})$, $\text{Br}_2(\text{g})$, $\text{Hg}(\text{s})$, $\text{CH}_4(\text{g})$

Q3.41c

Why is the standard enthalpy of formation of O_2 zero at a temperature of 298 K?

S3.41c

The standard enthalpy of formation of O_2 is zero at 298 K since O_2 is the most stable allotropic form of oxygen at that particular temperature.

Q3.42a

a) The ionization of a weak acetic acid is written as:

[Math Processing Error]

Suppose the change of reaction enthalpy for this reaction is $+1.0$ kJ/mol and the $\Delta_f H^\circ$ of CH_3COO^- is -486.01 kJ/mol. What would be the molar enthalpy of formation of aqueous acetic acid?

b) The acetic acid is reacted with a strong base NaOH . Calculate the enthalpy of neutralization for this reaction of weak acid strong base.

$\Delta_f H^\circ[\text{OH}^-(\text{aq})] = -229.6$ kJ/mol and $\Delta_f H^\circ[\text{H}_2\text{O}(\text{l})] = -285.8$ kJ/mol

Hint: Look at [enthalpy of neutralization](#)

S3.42a

a) *[Math Processing Error]*

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

b) Note that acetic acid is a weak acid, therefore only dissociates partially or does not dissociate at all. Therefore the complete ionic reaction of reaction is:

[Math Processing Error]

Since Na^+ cancels out, the net equation is

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.42b

Calculate the enthalpy of formation for Br^- ions in the following reactions:

a. *[Math Processing Error]*

b. *[Math Processing Error]*

S3.42b

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.42c

When determining standard enthalpies of formation of ions in aqueous solutions, set the value of [Math Processing Error] ion to 0 for [Math Processing Error]

- For the following reaction [Math Processing Error], [Math Processing Error]. Calculate the value of [Math Processing Error] for the Br ions.
- The standard enthalpy of neutralization between HBr and NaOH solutions is [Math Processing Error]. At [Math Processing Error], calculate the standard enthalpy of formation of the hydroxide ion.

S3.42c

(a)

$$\Delta_r H^\circ = -98.4 \text{ kJ mol}^{-1} = \Delta_f H^\circ[\text{H}^+(\text{aq})] + \Delta_f H^\circ[\text{Br}^-(\text{aq})] - \Delta_f H^\circ[\text{HBr}(\text{g})]$$

$$\Delta_f H^\circ[\text{Br}^-(\text{aq})] = -98.4 \text{ kJ mol}^{-1} - \Delta_f H^\circ[\text{H}^+(\text{aq})] + \Delta_f H^\circ[\text{HBr}(\text{g})]$$

$$= -98.4 \text{ kJ mol}^{-1} - 0 \text{ kJ mol}^{-1} + (-36.29 \text{ kJ mol}^{-1})$$

$$= -134.69 \text{ kJ mol}^{-1}$$

(b) The neutralization for 1 mole of [Math Processing Error] is [Math Processing Error]

$$\Delta_r H^\circ = \Delta_f H^\circ[\text{H}_2\text{O}(\text{l})] - \Delta_f H^\circ[\text{H}^+(\text{aq})] - \Delta_f H^\circ[\text{OH}^-(\text{aq})]$$

$$\Delta_f H^\circ[\text{OH}^-(\text{aq})] = \Delta_f H^\circ[\text{H}_2\text{O}(\text{l})] - \Delta_f H^\circ[\text{H}^+(\text{aq})] + 53.4 \text{ kJ mol}^{-1}$$

$$= (-285.8 \text{ kJ mol}^{-1}) - 0 \text{ kJ mol}^{-1} + 53.4 \text{ kJ mol}^{-1}$$

$$= -232.4 \text{ kJ mol}^{-1}$$

Q3.42d

For the following chemical reaction, calculate the $\Delta_r H^\circ$.

[Math Processing Error]

S3.42d

Use the following equation:

[Math Processing Error]

Solve

[Math Processing Error]

Click [here](#) for more information about standard enthalpies of reaction.

Q3.42e

The reaction for the dissociation of hydrobromic acid in water is as follows:

[Math Processing Error]

[Math Processing Error]

- Given the enthalpy of formation for HBr, what is the enthalpy of formation for the Bromine ion? Assume that the enthalpy of formation for the Hydrogen ion is 0.

b.) What is the enthalpy of reaction for the neutralization of HBr with KOH? Assume that the potassium and bromine ions remain in solution following the [neutralization](#).

[Math Processing Error]

S3.42e

a.) For any reaction,

[Math Processing Error]

For this reaction,

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

b.) For any neutralization reaction in solution,

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.43a

How much heat is given off when one explodes 24.65 grams of nitroglycerin? The equation for the combustion of nitroglycerin is given below:

[Math Processing Error]

S3.43a

The molar mass of nitroglycerin is 227.0865 g/mol.

To solve this question simply multiple the enthalpy of reaction by the amount moles of nitroglycerin.

[Math Processing Error]

Q3.43b

What is the enthalpy change from the formation of 5 grams of H_2CO_3 via $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{CO}_3(\text{g})$ via $\text{H}_2\text{CO}_3(\text{g})$ via $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{CO}_3(\text{g})$? The change in enthalpy associated with this reaction is +360.19 kJ/mol.

S3.43b

The enthalpy change from this reaction is given by the molar enthalpy change times the number of moles of product formed. Thus:

$$m_{\text{CO}_2} = 44.01 \text{ g mol}^{-1};$$

$$n_{\text{CO}_2} = 5 \text{ g} / 44.01 \text{ g mol}^{-1} = 0.1136 \text{ mol}$$

$$\Delta H = 0.1136 \text{ mol} * 360.19 \text{ kJ/mol} = 40.9 \text{ kJ}$$

Q3.43c

The following reaction was carried out at standard temperature and pressure:

[Math Processing Error]

If -148.16 KJ of heat was released during this reaction, how many grams of Ethane were formed?

S3.43c

For any reaction:

[Math Processing Error]

This can be rearranged as

[Math Processing Error]

The molar mass of ethane is

[Math Processing Error]

The mass of ethane produced, then, is

[Math Processing Error]

Q3.44a

When 2.3 g of calcium carbonate is decomposed under constant pressure, 178.3 kJ of heat were released. What is the [Math Processing Error] for this reaction?

[Math Processing Error]

S3.44a

[Math Processing Error]

Q3.44b

In a high school chemistry experiment, 10 grams of methane were combusted in the presence of excess oxygen under standard conditions. A calorimeter measured that 554.9 kJ of heat were released by the reaction to the surroundings. Assuming the calorimeter's measurement accounts for all heat changes associated with the reaction, write the reaction for the combustion of methane and calculate the change in enthalpy associated with it.

Q3.46

The isomerization process from 1-butene to 2-butene has a reaction enthalpy of -7.1 kJ/mol.

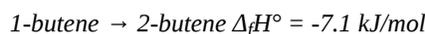


1-butene 2-butene

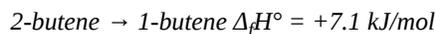
If the hydrogenation of 1 butene has a reaction enthalpy of -126.8 kJ/mol. How much energy would the hydrogenation of 2-butene takes? Keep in mind that both processes yield the same product.

Hint: Look at example problems of [change of standard reaction enthalpy](#)

S3.46



Reverse the 2nd reaction and combine the two reactions



$$\Delta_r H^\circ = -126.8 \text{ kJ/mol} + 7.1 \text{ kJ/mol}$$

$$\Delta_r H^\circ = -119.7 \text{ kJ/mol}$$

Q3.47a

From the reaction below, calculate the enthalpy of formation of methane gas.

[Math Processing Error]

S3.47a

Use the following equation:

[Math Processing Error]

Plug in appropriate values and solve. Change in enthalpy of oxygen is 0 because it is the reference form of a pure element.

[Math Processing Error]

[Math Processing Error]

Click [here](#) for more information on standard enthalpies.

Q3.47b

For the following combustion reaction:

[Math Processing Error]

Calculate the enthalpy of formation for 2-propanol, given the following enthalpies of formation

[Math Processing Error]

S3.47b

In general:

[Math Processing Error]

In general,

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.48

Diatomic fluorine gas has a C_p of $31.3 \text{ J/K}\cdot\text{mol}$. What is its molar enthalpy of formation on the surface of the planet Venus (at standard pressure), where temperature is commonly 465 C ?

S3.48

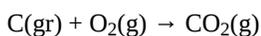
At constant pressure, the change in enthalpy with respect to temperature is given by C_p . By determining the change in temperature and multiplying it by C_p we can find the change in enthalpy.

$$\Delta T = 465 \text{ C} - 25 \text{ C} = 440\text{K}$$

$$\Delta H = 31.3 \text{ J/K}\cdot\text{mol} * 440\text{K} = 13.772 \text{ kJ/mol}$$

Q3.50

The combustion of graphite is



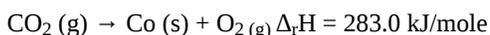
Calculate the change in the enthalpy of combustion from 298 K to 398 K . The molar C_p values are (in $\text{J K}^{-1} \text{ mol}^{-1}$): $\text{C}(\text{gr}):8.52$, $\text{O}_2(\text{g}):29.4$, and $\text{CO}_2(\text{g}):37.1$

Q3.53

What values are needed to calculate the change in standard enthalpy of a reaction?

Q3.54

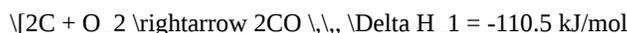
Consider the following reactions:



Find the enthalpy of formation of carbon dioxide (CO_2)

S3.54

The [Math Processing Error] of the reaction is the sum of [Math Processing Error] and [Math Processing Error]





thus the *[Math Processing Error]* of reaction is $(-110.5) + (-283.0) = -393.5 \text{ kJ/mol}$

Q3.55

What is $\Delta_r H^\circ$ of the following reaction? $\Delta_f H^\circ$ for O(g) is $249.4 \text{ kJ mol}^{-1}$ and $\Delta_f H^\circ$ for $\text{O}_3(\text{g})$ is $142.7 \text{ kJ mol}^{-1}$

[Math Processing Error]

S3.55

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[Math Processing Error]

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Q3.60

Methane combusts, what is the enthalpy of combustion for this reaction?

Substance	Standard Molar Enthalpies of Formation at 25°C
$\text{CH}_4(\text{g})$	-74.85 kJ/mol
$\text{CO}_2(\text{g})$	-393.5 kJ/mol
$\text{H}_2\text{O}(\text{g})$	-241.8 kJ/mol
$\text{H}_2\text{O}(\text{l})$	-285.8 kJ/mol

S3.60

Write the balanced formula for this reaction to identify the coefficients

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[Math Processing Error]

[Math Processing Error]

We do not include *[Math Processing Error]* because it is a standard state

[Math Processing Error]

[Math Processing Error]

Q3.62

Predict whether the values of q , w , ΔU , and ΔH are positive, zero, or negative for each of the following processes: (a) freezing of ice at 1 atm and 273 K, (b) melting of solid butanol at 1 atm and the normal melting point, (c) reversible isothermal compression of an ideal gas, and (d) reversible adiabatic compression of an ideal gas.

Q3.62

Predict whether the values of q , w , ΔU , and ΔH are positive, zero, or negative for each of the following processes: (a) freezing of ice at 1 atm and 273 K, (b) melting of solid butanol at 1 atm and the normal melting point, (c) reversible isothermal compression of an ideal gas, and (d) reversible adiabatic compression of an ideal gas.

Q3.63

The first law of thermodynamics states that energy is conserved. It cannot be destroyed nor created. Using Einstein's equation $E = mc^2$ explain how large amounts of energy are necessary to fuse atoms together. If energy is conserved where did all this energy go?

S3.63

When large amounts of energy are used to fuse atoms together (eg: fusion) we can observe that the mass of the atoms is very small compared to the amount of energy used. However, using Einstein's equation $E = mc^2$ we see that the mass is multiplied times the speed of light squared which will result in a very large number. The energy was not destroyed but rather stored in the chemical bonds of the atoms.

Q3.64

For the nuclear process we cannot apply the assumption that *[Math Processing Error]* for most stable elements because there are different components in the reactant and product sides. Explain this difference?

Q3.66

You eat 2 pounds of fries for lunch and the fuel value is approximately *[Math Processing Error]*. If you don't store any of the energy, calculate the amount of water (evaporated perspiration) needed to keep your body temperature constant.

S3.66

Step1: (Hint: Calculate the fuel value for 2 pound of fries)

[Math Processing Error]

Step 2: (Hint: Use *[Math Processing Error]* to calculate grams of *[Math Processing Error]*)

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.68

What is the final temperature of the following reaction:

[Math Processing Error]

Hint: first find *[Math Processing Error]*, then look up the standard molar heat capacities of the products.

S3.68

[Math Processing Error]

[Math Processing Error]

[Math Processing Error]

Q3.70

The reaction below is a oxidation of 2-propanol to make acetone



- Calculate the change of enthalpy of reaction by using bond enthalpies
- Compare the result with the reaction of the combustion 2-propanol that has an enthalpy of -1825.5 kJ/mol. What does this say about the two reactions. (Hint: Look at [bond enthalpies](#)).

S3.70

a)

Types of bonds formed	#of bonds formed	Bond Enthalpy (kJ/mol)	Enthalpy change (kJ/mol)
C-H	6	414	2484
C-C	2	347	694
C=O	1	724	724
O-H	1	460	460

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b) According to the enthalpy values, the enthalpy of the oxidation of 2-propanol into ketone is positive while its combustion is largely negative. This tells that although oxygen is involved, the two reactions are different. The combustion releases heat where as the other process needs an absorption of energy in order for the reaction to take place. In this case is usually the help of another catalyst.

Q3.71a

The molar enthalpy of sublimation for an unknown organic substance is found to be 58.05 KJ/mol, and the molar enthalpy of vaporization is 37.12 KJ/mol. Using these values, provide an estimate for the molar enthalpy of fusion for this substance.

Hint: Sublimation is the transition from solid to gas phase. Fusion and Vaporization, respectively, are the the transition from solid to liquid, then liquid to gas.

S3.71a

In general,

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[Math Processing Error]

Q3.71b

Calculate the standard enthalpy of sublimation of ethanol. $\Delta_{\text{fus}}H^\circ$ (ethanol) = 4.9 kJ mol⁻¹ and $\Delta_{\text{vap}}H^\circ$ (ethanol) = 38.56 kJ mol⁻¹.

S3.71b

You can estimate the standard enthalpy of sublimation by adding up the standard enthalpies of fusion and vaporization since sublimation consists of two simultaneous phase changes. See [here](#) for more information on it.

$$\Delta_{\text{sub}}H^\circ(\text{ethanol}) = 4.9 + 38.56 = \underline{43.46 \text{ kJ mol}^{-1}}$$

Q3.72

Nitric acid is neutralized by hydroxide via the reaction $\text{HNO}_3(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{NO}_3^-(\text{aq})$. The dissociation of water has an enthalpy change of 55.8 kJ/mol. What is the enthalpy change for the dissociation of nitric acid?

Chemical	HNO ₃	OH ⁻	H ₂ O	NO ₃ ⁻
$\Delta_f H$ (kJ/mol)	-207.6	-229.6	-285.8	-206.6

S3.72

The dissociation of water is $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}^+(\text{aq}) + \text{OH}^-(\text{aq})$, which when added to the neutralization reaction above, gives the overall reaction

[Math Processing Error]

which is the dissociation reaction for nitric acid. The enthalpy change of the first reaction is given by the difference in the total enthalpies of formation of the products and reactants, i.e.

$$\Delta_r H = (-206.6 \text{ kJ/mol} - 285.8 \text{ kJ/mol}) - (-229.6 \text{ kJ/mol} - 207.6 \text{ kJ/mol}) = -55.2 \text{ kJ/mol.}$$

When added to the enthalpy change for the dissociation of water to obtain the enthalpy change for the dissociation of nitric acid, we have:

$$\Delta_{\text{net}} H = -55.2 \text{ kJ/mol} + 55.8 \text{ kJ/mol} = 0.6 \text{ kJ/mol}$$

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