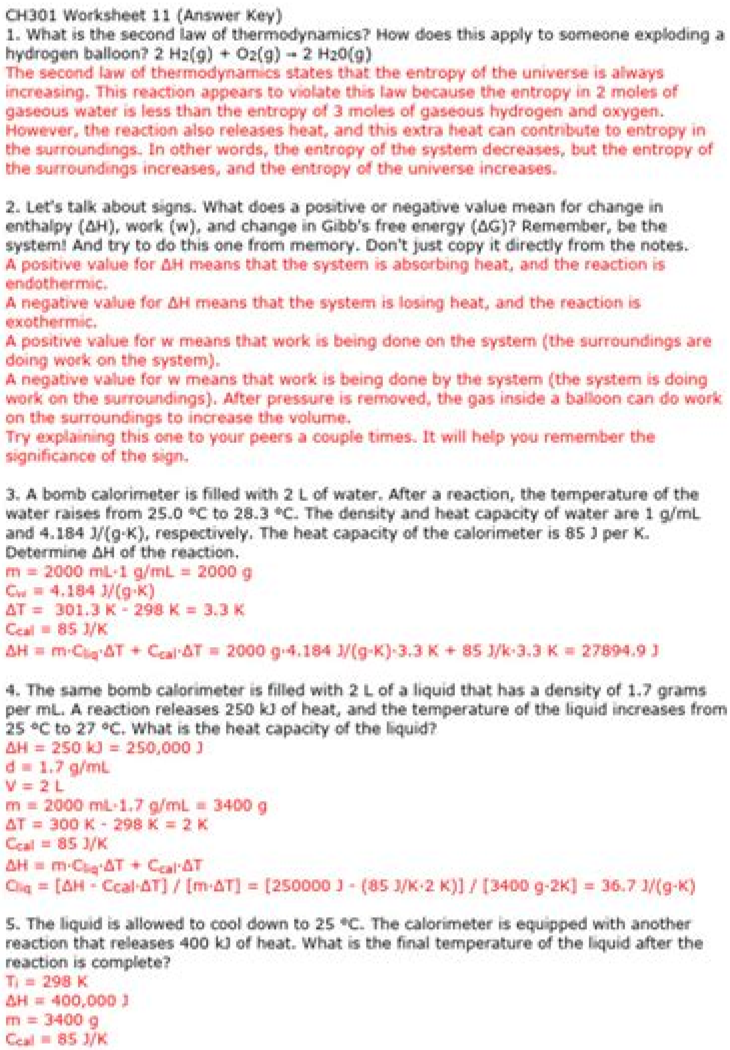
Electricity And Thermodynamics Answer Key



CH301 Worksheet 11 (Answer Key)

1. What is the second law of thermodynamics? How does this apply to someone exploding a hydrogen balloon? $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

The second law of thermodynamics states that the entropy of the universe is always increasing. This reaction appears to violate this law because the entropy in 2 moles of gaseous water is less than the entropy of 3 moles of gaseous hydrogen and oxygen. However, the reaction also releases heat, and this extra heat can contribute to entropy in the surroundings. In other words, the entropy of the system decreases, but the entropy of the surroundings increases, and the entropy of the universe increases.

2. Let's talk about signs. What does a positive or negative value mean for change in enthalpy (ΔH), work (w), and change in Gibb's free energy (ΔG)? Remember, be the system! And try to do this one from memory. Don't just copy it directly from the notes.

A positive value for ΔH means that the system is absorbing heat, and the reaction is endothermic.

A negative value for ΔH means that the system is losing heat, and the reaction is exothermic.

A positive value for w means that work is being done on the system (the surroundings are doing work on the system).

A negative value for w means that work is being done by the system (the system is doing work on the surroundings). After pressure is removed, the gas inside a balloon can do work on the surroundings to increase the volume.

Try explaining this one to your peers a couple times. It will help you remember the significance of the sign.

3. A bomb calorimeter is filled with 2 L of water. After a reaction, the temperature of the water raises from 25.0 °C to 28.3 °C. The density and heat capacity of water are 1 g/mL and 4.184 J/(g·K), respectively. The heat capacity of the calorimeter is 85 J per K. Determine ΔH of the reaction.

$m = 2000\ mL \cdot 1\ g/mL = 2000\ g$

$C_w = 4.184\ J/(g \cdot K)$

$\Delta T = 301.3\ K - 298\ K = 3.3\ K$

$C_{cal} = 85\ J/K$

$\Delta H = m \cdot C_{liq} \cdot \Delta T + C_{cal} \cdot \Delta T = 2000\ g \cdot 4.184\ J/(g \cdot K) \cdot 3.3\ K + 85\ J/k \cdot 3.3\ K = 27894.9\ J$

4. The same bomb calorimeter is filled with 2 L of a liquid that has a density of 1.7 grams per mL. A reaction releases 250 kJ of heat, and the temperature of the liquid increases from 25 °C to 27 °C. What is the heat capacity of the liquid?

$\Delta H = 250\ kJ = 250{,}000\ J$

$d = 1.7\ g/mL$

$V = 2\ L$

$m = 2000\ mL \cdot 1.7\ g/mL = 3400\ g$

$\Delta T = 300\ K - 298\ K = 2\ K$

$C_{cal} = 85\ J/K$

$\Delta H = m \cdot C_{liq} \cdot \Delta T + C_{cal} \cdot \Delta T$

$C_{liq} = [\Delta H - C_{cal} \cdot \Delta T] / [m \cdot \Delta T] = [250000\ J - (85\ J/K \cdot 2\ K)] / [3400\ g \cdot 2K] = 36.7\ J/(g \cdot K)$

5. The liquid is allowed to cool down to 25 °C. The calorimeter is equipped with another reaction that releases 400 kJ of heat. What is the final temperature of the liquid after the reaction is complete?

$T_i = 298\ K$

$\Delta H = 400{,}000\ J$

$m = 3400\ g$

$C_{cal} = 85\ J/K$

Electricity and thermodynamics answer key is a crucial resource for students and professionals alike, providing clarity on the intricate relationship between these two fundamental areas of physics. Understanding electricity and thermodynamics is essential for tackling complex problems in engineering, physics, and various applied sciences. This article explores the principles of electricity, the laws of thermodynamics, and their interconnections, providing a comprehensive overview that includes key concepts, equations, and applications.

Understanding Electricity

Electricity is the set of physical phenomena associated with the presence and flow of electric charge. It is a vital part of everyday life, powering everything from household appliances to large industrial machines. The study of electricity encompasses various concepts, including charge, current, voltage, resistance, and circuits.

Key Concepts of Electricity

1. Charge:
- Electric charge is a property of subatomic particles that causes them to experience a force when placed in an electromagnetic field. There are two types of charge: positive and negative.
- Units: The unit of electric charge is the coulomb (C).

2. Current:
- Electric current is the flow of electric charge, typically measured in amperes (A). It can be direct (DC) or alternating (AC).
- Formula: $I = \frac{Q}{t}$ where I is the current, Q is the charge, and t is the time.

3. Voltage:
- Voltage, or electric potential difference, measures the energy per unit charge available to move charges through a circuit.
- Units: The unit of voltage is the volt (V).

4. Resistance:
- Resistance is the opposition to the flow of current in a conductor, measured in ohms (Ω).
- Formula: $R = \frac{V}{I}$ where R is resistance, V is voltage, and I is current.

5. Ohm’s Law:
- Ohm's Law is a fundamental principle that relates voltage, current, and resistance in an electrical circuit.
- Formula: $V = I \times R$

Types of Electrical Circuits

1. Series Circuits:
- Components are connected end-to-end, so the same current flows through all components.
- Total Resistance: $R_{total} = R_1 + R_2 + R_3 + \ldots$

2. Parallel Circuits:
- Components are connected across the same voltage source, sharing voltage but allowing different currents.
- Total Resistance: $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

Basics of Thermodynamics

Thermodynamics is the branch of physics that deals with heat, work, temperature, and the statistical nature of energy transfer. It provides a framework for understanding how energy moves and transforms, and it plays a pivotal role in various scientific and engineering applications.

Key Concepts of Thermodynamics

1. System and Surroundings:
- A system is the part of the universe we are studying, while the surroundings are everything outside the system.
- Types of systems:
- Open System: Can exchange both energy and matter with surroundings.
- Closed System: Can exchange energy but not matter.
- Isolated System: Cannot exchange energy or matter.

2. Laws of Thermodynamics:
- Zeroth Law: If two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.
- First Law (Law of Energy Conservation): Energy cannot be created or destroyed, only transformed.
- Formula: $\Delta U = Q - W$ where ΔU is the change in internal energy, Q is heat added, and W is work done by the system.
- Second Law: The total entropy of an isolated system can never decrease over time. Heat cannot spontaneously flow from a colder to a hotter body.
- Third Law: As temperature approaches absolute zero, the entropy of a perfect crystal approaches zero.

Thermodynamic Processes

1. Isothermal Process:
- Temperature remains constant.
- Formula: $Q = W$

2. Adiabatic Process:
- No heat transfer occurs.
- Formula: $\Delta U = -W$

3. Isobaric Process:
- Pressure remains constant.
- Formula: $Q = \Delta U + P \Delta V$

4. Isochoric Process:
- Volume remains constant.
- Formula: $Q = \Delta U$

Interconnections Between Electricity and Thermodynamics

The relationship between electricity and thermodynamics is evident in various phenomena, particularly in the conversion of electrical energy into thermal energy and vice versa.

Joule's Law

Joule's Law describes the relationship between electric current and heat generation in a conductor. The heat produced (Q) is proportional to the square of the current (I) multiplied by the resistance (R) and the time (t) the current flows.

- Formula: $Q = I^2Rt$

Thermoelectric Effects

1. Seebeck Effect:
- A temperature difference between two different conductors produces an electromotive force (EMF).
- This principle is used in thermocouples to measure temperature.

2. Peltier Effect:
- An electric current passing through a junction of two different conductors can create a temperature difference.
- This effect is utilized in thermoelectric coolers.

3. Thomson Effect:
- A current passing through a conductor with a temperature gradient will absorb or release heat depending on the direction of the current.

Applications of Electricity and Thermodynamics

The interplay between electricity and thermodynamics is foundational to various technologies:

1. Heat Engines: Convert thermal energy into mechanical work using the principles of thermodynamics.
2. Refrigerators: Use the principles of thermodynamics and electricity to transfer heat from a cooler to a warmer environment.
3. Power Generation: Electricity is often generated from thermal energy sources, such as steam turbines in power plants.

Conclusion

The electricity and thermodynamics answer key serves as a vital tool for understanding the fundamental principles that govern energy transfer and transformation. By grasping these concepts, students and professionals can tackle real-world problems in physics and engineering. From the basics of electric charge and circuits to the intricate laws of thermodynamics, the interconnectedness of these fields underscores the importance of mastering both areas for future innovations and applications. Understanding how to apply these principles effectively can lead to advancements in technology, energy efficiency, and sustainable practices in various industries.

Frequently Asked Questions

What is the first law of thermodynamics and how does it relate to electricity?

The first law of thermodynamics states that energy cannot be created or destroyed, only transformed from one form to another. In electrical systems, this means that the electrical energy supplied to a circuit can be converted into other forms of energy, such as thermal energy in resistors.

How do resistors affect the flow of electricity in a circuit?

Resistors impede the flow of electric current, converting electrical energy into heat through the process of Joule heating. This is a practical application of thermodynamics, as it illustrates the conversion of electrical energy into thermal energy.

What is the relationship between voltage, current, and resistance in electrical circuits?

Ohm's Law defines the relationship: $V = I R$, where V is voltage, I is current, and R is resistance. This relationship is essential in understanding how energy is conserved and transformed in electrical systems, aligning with thermodynamic principles.

Can thermodynamic principles be applied in designing more efficient electrical circuits?

Yes, thermodynamic principles are crucial in designing efficient electrical circuits. Understanding heat generation and energy losses allows engineers to optimize components, reducing waste and improving overall energy efficiency in electrical systems.

What role does entropy play in the context of electricity and thermodynamics?

Entropy measures the disorder or randomness in a system and is a key concept in thermodynamics. In electrical systems, increasing entropy often relates to energy losses due to heat dissipation, which is an important consideration in maximizing efficiency.

[Electricity And Thermodynamics Answer Key]()

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