

Chapter 1:
ENERGY AND CHEMICAL CHANGE
Section 1: Energy

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Section 1: Energy

Energy: Is the ability to do a work or produce heat.

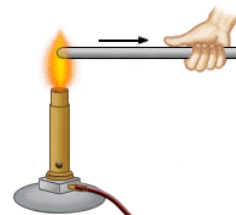
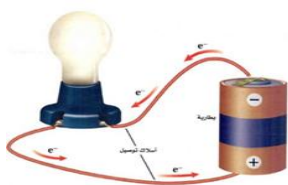
Energy exists in two basic forms

1) **Kinetic energy:** Energy of motion.

- Chemical systems contain both types of energy (kinetic and potential).
- **Kinetic energy** is always **related to** the random movement of the particles of a substance.
- **Kinetic energy** is directly proportional to the temperature, so the higher the temperature, the greater the movement of the particles.

Examples of kinetic energy :

- Electrical energy:
- Light energy:
- Thermal energy:



Q1- Which has greater kinetic energy, a solid with a temperature of 45°C and a liquid at the same temperature? With an explanation :

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Q2- Which has greater kinetic energy, a rod of iron at 45°C and a rod of iron at a temperature of 75°C ? With an explanation?

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2) **Potential energy:** Stored energy due to the position or composition of the object.

➤ **Types of potential energy :**

A- Gravitational potential energy: The energy possessed by an object as a result of its height from the surface of the earth.

- Gravitational potential energy depends on mass and height.

Q3- In what situation the potential energy is the greatest? With an explanation:



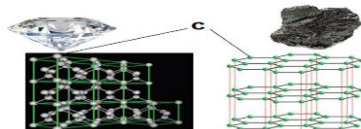
B- Chemical potential energy: It is the energy stored in the object as a result of the composition of the substance.

➤ Meaning that it is stored inside the substance due to the chemical bonds between the atoms.

➤ The chemical potential energy depends on the composition of the substance in terms of:

- The type of atoms.
- How they are arranged.
- The number and type of bonds between them.

متوسط طاقة الرابطة KJ/mol	الرابطة	متوسط طاقة الرابطة KJ/mol	الرابطة
432	H—H	316	C—C
358	C—O	610	C=C
803	C=O	835	C≡C
467	O—H	413	C—H



- Example: The energy stored in propane, methane, and gasoline is chemical potential energy, so when burned, heat energy is released.

C- Elastic potential energy: stored in elastic objects such as rubber.



Q4- Compare between different types of energy.

	Potential energy	kinetic energy
Definition		
It depends on		
Examples		

1) Law of Conservation of Energy (first law of thermodynamics)

Energy is neither destroyed nor created through a chemical reaction or physical process, but energy is transformed from one form to another.

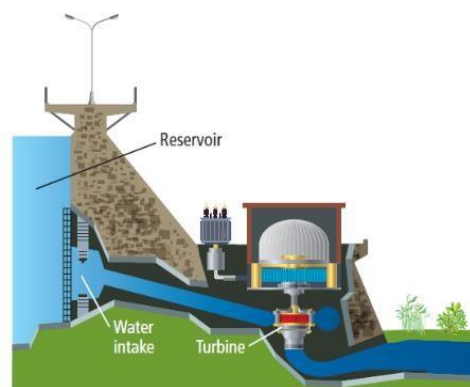
Example:

1- Hydroelectric energy:

-The gravitational potential energy stored in the water behind the dam is converted into kinetic energy and the generator converts it into electrical energy.

-While keeping the total amount of energy constant.

2- The combustion of fuels (propane, gasoline) turns chemical energy into thermal and light energy.



Heat: Here we must differentiate between three completely different concepts

Heat (q)	Temperature (T)	Thermal energy
It is the amount of heat energy that is transferred from a hot object to a cold one. It is measured indirectly with a calorimeter. Unit of measurement: joules (J) or calories (cal)	It is the average kinetic energy of particles in a substance. It is measured directly by a thermometer. Unit of measure: Kelvin (K) or Celsius (C).	The sum of the kinetic and potential energies of all the particles of matter.

- In an exothermic reaction, the chemical potential energy stored in the bonds is converted into thermal energy released from the system.
- In an endothermic reaction, thermal energy is absorbed and stored in the form of chemical potential energy in the bonds between atoms.

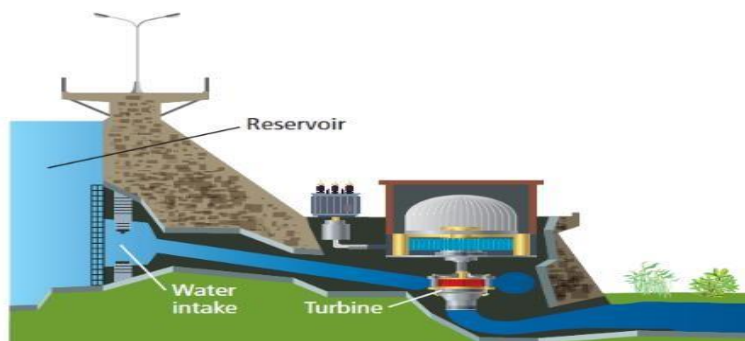
Choose the correct answer:

1- Which of the following is not kinetic energy?

- A- River.
- B- Avalanche.
- C- Separation of charges in a battery.
- D- Car race.

2- What are energy conversions in this figure?

- A- Gravitational potential energy → Kinetic energy → Electrical energy .
- B- Kinetic energy → Gravitational potential energy → Electrical energy.
- C- Electrical energy → Kinetic energy → Gravitational potential energy.
- D- Gravitational potential energy → Electrical energy → Kinetic energy.



3- In an exothermic reaction, the chemical potential energy stored in the bonds is

- A-Increased.
- B-Remained the same .
- C-Decreased.
- D-Non of the above .

4- In an endothermic reaction, the chemical potential energy stored in the bonds is

A-Increased.

B-Remained the same .

C-Decreased.

D-Non of the above .

Energy units:

1- **The joule (J):** It is the basic unit in the SI international system.

2- **The calorie (cal):** is the amount of energy required to raise the temperature of one gram of pure water by one degree Celsius (1°C).

3- **Nutritional Calorie (Cal):** It is used to measure the heat energy that results from the burning of sugars and fats in your body or in foodstuffs.

Important notes:

→ C is a capital letter in the Nutritional Calorie Cal.

→ c is a lowercase letter in cal.

→ The kilo(k)means 1000 units.

→ We use the start, down rule, (the given is at the bottom).

→ We use conversion coefficients to solve problems.

→ When converting from Cal to J we must first convert to cal .

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ J} = 0.2390 \text{ cal}$$

$$1 \text{ Cal} = 1000 \text{ cal}$$

$$1 \text{ Cal} = \text{kcal}$$

Solve the following problems:

1)- 230 Cal to J:

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2) You take a tablespoon of butter that contains about 30 Cal - how much heat would it release in Joule if burned completely?

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3) What units is thermal energy measured according to the international system (SI)?

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4) A meal contains 230 Cal. Express the amount of energy, it contains in joules.

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5) A piece of food contains 142 Cal that turn this energy into calories.

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6) An exothermic reaction releases 86.5 kJ of energy How much energy is produced in kcal units?

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7) How many joules are absorbed in a process that absorbs 0.5720 kcal?

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8) Ethanol is being used as an additive to gasoline. The combustion of 1 mol of ethanol releases 1367 kJ of energy. How many Calories are released?

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9) The combustion of one mole of ethanol releases 326.7Calories of energy. How many kilojoules are released?

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Specific Heat :

Is the amount of heat required to raise the temperature of one gram of this substance by one degree Celsius (1°C).

- The specific heat varies from one substance to another due to the different composition of the materials.
- Specific heat ($\text{J/g. }^{\circ}\text{C}$) measures the ability of materials to absorb heat energy.
- Since the specific heat of water is ($4.184 \text{ J/g. }^{\circ}\text{C}$), while the specific heat of concrete is ($0.84 \text{ J/g. }^{\circ}\text{C}$), the concrete temperature rises by five times the temperature of water when absorbing the same blocks for the same amount of energy.
- The reason for this is the high specific heat of water, where thermal energy is gained with difficulty and lost with difficulty, while concrete has low specific heat, so thermal energy is easily gained and lost easily.
- The element that has a high specific heat changes its temperature at a lower rate, while the element that has a low specific heat changes its temperature at a higher rate.
- There is an inverse relationship between specific heat and temperature change.

Equal masses of magnesium ,concrete, iron and barium were left under the sun at the same duration .What is the ascending order of those four substances according to the the increase in their temperature.

$C_{\text{Barium}} = 0.204 \text{ (J/g. } ^\circ\text{C)}$, $C_{\text{Magnesium}} = 1.023 \text{ (J/g. } ^\circ\text{C)}$, $C_{\text{Concrete}} = 0.84 \text{ (J/g. } ^\circ\text{C)}$, $C_{\text{Iron}} = 0.449 \text{ (J/g. } ^\circ\text{C)}$

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5- In an exothermic reaction, the chemical potential energy stored in the bonds is

- A-Increased.
- B- Remained the same .
- C-Decreased.
- D-Non of the above .

6- In an endothermic reaction, the chemical potential energy stored in the bonds is

- A-Increased.
- B- Remained the same .
- C-Decreased.
- D-Non of the above .

7- It is the basic unit in the SI international system for energy.

- A- Calorie.
- B- Nutritional calorie .
- C- kilogram.
- D- Joule .

8- A meal contains 435 Cal. Express the amount of energy it contains in joules (J).

A- 1.82×10^3 J

B- 1.82×10^6 J

C- 1.0×10^3 J

D- 1.0×10^5 J

$$1\text{Cal} = 1000\text{cal}$$

$$1\text{cal} = 4.184 \text{ J}$$



9- A meal contains 1.04×10^5 joules (J). Express the amount of energy it contains in Cal.

A- 22 Cal

B- 52 Cal

C- 25 Cal

D- 35 Cal

$$1\text{Cal} = 1000\text{cal}$$

$$1\text{cal} = 4.184 \text{ J}$$



10- The amount of heat required to raise the temperature of one gram of this substance by one degree Celsius (1°C).

A- Specific heat.

B- Calorie

C- Joule

D- Heat

11- Equal masses of magnesium ,concrete, iron, and barium were left under the sun at the same duration .What is the ascending order of those four substances according to the the increase in their temperature.

A- concrete→barium→iron→magnesium

B- magnesium→ concrete→barium→iron

C- magnesium→ concrete→ iron→ barium

D- barium→ iron→concrete→ magnesium

$$C_{\text{Barium}} = 0.204 \text{ (J/g.}^\circ\text{C)}$$

$$C_{\text{Magnesium}} = 1.023 \text{ (J/g. }^\circ\text{C)}$$

$$C_{\text{Concrete}} = 0.84 \text{ (J/g. }^\circ\text{C)}$$

$$C_{\text{Iron}} = 0.449 \text{ (J/g. }^\circ\text{C)}$$

12- Which of the following statements is true regarding the figure below?

- A- Thermal energy is converted into potential energy stored in the bonds of propane particles.
- B- The total amount of energy does not remain constant during the energy conversion.
- C- The potential energy stored in the bonds of propane particles is converted into thermal energy.
- D- Energy cannot be converted from one form to another.



Calculation Of Heat:

- **Calculation of absorbed heat:** When a material gains thermal energy or increases its temperature, the value of (q) is positive.
- **Calculation of the released heat:** When a substance loses heat energy or its temperature decreases, The value of (q) is negative.

Equation for Calculating Heat:

$$q = c \times m \times \Delta T \quad / \quad \Delta T = (T_f - T_i) \quad / \quad C = \frac{q}{m \times \Delta T}$$

q=heat (J)

ΔT = temperature change (c)

m= mass (g)

C= (specific heat (J/g. °C)

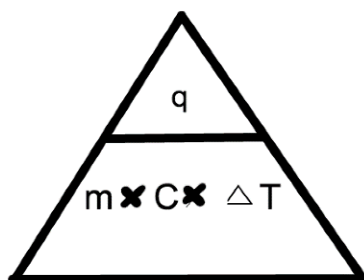


Table 15.2	Specific Heats at 298 K (25°C)
Substance	Specific heat J/(g·°C)
Water(l)	4.184
Ethanol(l)	2.44
Water(s)	2.03
Water(g)	2.01
Beryllium(s)	1.825
Magnesium(s)	1.023
Aluminum(s)	0.897
Concrete(s)	0.84
Granite(s)	0.803
Calcium(s)	0.647
Iron(s)	0.449
Strontium(s)	0.301
Silver(s)	0.235
Barium(s)	0.204
Lead(s)	0.129
Gold(s)	0.129

Problems Ideas:

- 1- Direct Compensation (C, q,m,)
- 2- Final temperature: a direct substitution to find ΔT and then add it to the initial temperature.
- 3- Sometimes the mass is unknown, calculate the volume from the equation ($v = lwh$) and calculate the mass from the equation ($m = D \times v$)
- 4- If the temperature in K is converted to C from the equation $C = K - 273$
- 5- If thermal energy is released, it is compensated with a negative value of (q)

1- A 90.0 g sample of an unknown metal absorbed 25.6 J of heat as its temperature increased by 1.18 °C what is the specific heat of the metal ?

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2- the temperature of a sample of water increases from 20.0 °C to 46.6 °C as it absorbs 5650 J of heat. what is the mass of the sample ?

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3- how much heat is absorbed by a $2.00 \times 10^3 g$ granite boulder ($C_{\text{granite}} = 0.803 J/(g \cdot ^\circ C)$) as its temperature changes from 10.0 °C to 29.0 °C ?

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4- if the temperature of 34.4 g of ethanol increases from 25.0 °C to 78.8 °C how much heat has been absorbed by the ethanol ?

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5- a 155 g sample of an unknown substance was heated from $25.0\text{ }^{\circ}\text{C}$ to $40.0\text{ }^{\circ}\text{C}$ in the process , the substance absorbed 5696 J of energy , what is the specific heat of the substance ? identify the substance ?

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6- a 4.50 g nugget of pure gold absorbed 276 J of heat the initial temperature was $25.0\text{ }^{\circ}\text{C}$ what was the final temperature ?

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7- the temperature of a sample of iron with a mass of 10.0 g changed from $50.4\text{ }^{\circ}\text{C}$ to $25.0\text{ }^{\circ}\text{C}$ with the release of 114 J .what is the specific heat of iron ?

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8- if 335 g of water at $65.5\text{ }^{\circ}\text{C}$ loses 9750 J of heat , what is the final temperature ?

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9- calculate the amount of heat absorbed by 5.00×10^3 g block of concrete side walk if temperature increased by $6.0\text{ }^{\circ}\text{C}$ (C concrete = $0.84\text{ J}/(\text{g. }^{\circ}\text{C})$) and compare the absorbed heat by water if water has the same mass ?

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10- calculate the amount of heat absorbed when 5.5 g of aluminum is heated from 25.0 °C to 95 °C The specific heat of aluminum is 0.897 J/(g. °C)

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11- equal masses of Al , Au(gold) , iron (Fe) ,Ag(silver) were left to site in the sun at the same time and for the length of time , arrange the four metals according to the increase in their temperature. C Aluminum = 0.897 (J/g. °C) , C Gold = 0.129 (J/g. °C) , C Iron = 0.449 (J/g. °C) , C Silver = 0.235 (J/g. °C)

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➤ *Photovoltaic cells:*

✓ A device converts **solar radiation** directly to **electricity**

➤ **Why water is used to harness the energy from the sun?**

➤ Because the high specific heat of water

➤ *Advantages of photovoltaic cell:*

✓ These supply power for astronauts in space.

✓ Clean energy does n't pollute environment.

✓ Reduces uses of fossil fuel.

➤ *Disadvantages of photovoltaic cell*

✓ They are not used extensively for ordinary energy needs because the cost of supplying electricity by means of photovoltaic cells is high compared the cost of burning coal or oil.

✓ The solar energy does n't provides in all places.

Section review solution:

7- Explain how energy changes from one form to another in an exothermic and an endothermic reaction.

A 7: Chemical potential energy is transformed into heat in exothermic reactions, so heat is released, and heat is absorbed in endothermic reactions, and it is converted into chemical potential energy.

8- Distinguish between kinetic energy and potential energy in the following examples: two separate magnets; Avalanche, books on shelves, river, car race, Separation of charges in a battery.

A 8: The two separate magnets represent potential energy, and the potential energy in an avalanche is converted into kinetic energy. Books placed on a shelf represent potential energy. Potential energy in river water is converted into kinetic energy. In a racing car, chemical potential energy is converted into kinetic energy.

The separation of charges in a battery represents electrical potential energy.

9- Explain the relationship of light and heat in a burning candle to its chemical potential energy:

A 9: The chemical potential energy in the candle is converted into energy in the form of light and heat, and it is released when a chemical combustion reaction occurs.

10- Calculate the amount of heat absorbed when 50.0 g of aluminum is heated from a temperature of 25 °C to a temperature of 95.0 °C, given that the specific heat of aluminum is 0.897 J/g °C.

Answer: 3139.5 J

11- Interpretation of the data Equal masses of aluminum, gold, iron and silver were placed under the sun at the same time and for a specified period of time. Table 2-2 was used to arrange the four metals according to the increase in their temperatures from highest to lowest. C Aluminum = 0.897 (J/g.c) , C Gold = 0.129 (J/g.c) , C Iron = 0.449 (J/g.c) , C Silver = 0.235 (J/g.c)

A 11: The temperature change is inversely proportional to the specific heat; Gold, silver, iron, aluminum.

- Heat is continuously added to a sample of water to produce the curve In Figure explain what happens in sections A,B,C,D,E

Heating Curve for Water

