Unit 3 Temperature

Text A

Listening in

Listen to the passage and fill in the blanks.

Can You Feel the Temperature?

The temperature of regular stuff is basically just a measurement of jiggliness of the ____1____ and molecules that make that stuff up. More jiggling, higher temperature. Less jiggling, lower temperature. Of course, when something's at a high temperature, it feels hot, and when something's at a low temperature, it feels cold. Right? Not exactly.

If you touch a piece of metal and a book that have been sitting in your fridge, the metal will feel much colder than the book. The metal and the book are ____2____ at the same temperature as measured by a thermometer, but the metal feels colder. This isn't just a trick of the mind, though — we experience the metal as "colder" than the book for a very ____3____ reason: metal is a ____4____, and paper is an insulator, so the energy, or jiggliness of the molecules in our hands, is absorbed more quickly by the metal than by the book. Even though the book and the metal are at the same temperature, the metal causes the temperature of our hands to go down faster, and thus, we experience the metal as being colder — because the temperature of our hands is what we really feel. It's like how, technically, a ____5____ thermometer really only measures its own temperature and you can only ____6____ measure temperatures of other things by putting them in ____7____ with it. Similarly, the thermoreceptive nerves in our skin can only directly measure the temperature of the skin itself and not of anything else. So when we touch something, we don't feel its temperature, but rather, we feel its effect on our skin: that is, how much and how

quickly it transfers thermal energy — that's the jiggling of molecules — to or from us. The ____8____ to transfer thermal energy is also why a blast of steam from your stovetop can feel so much hotter than a blast of hot dry air from your oven, even though the oven has a higher temperature: water vapor transfers more molecular jiggling to your skin than air by itself.

In fact, it's tempting to say that "hot" and "cold" are ____9____ different concepts from "high temperature" and "low temperature", even though we usually use the words ____10____. "Hot" really means "it gives off a lot of energy" while high temperature means "it has a lot of energy" and as anyone who's tried fundraising knows, just because somebody has a lot of something doesn't necessarily mean they give a lot of it away.

Word Notebook

jiggliness 震动　　molecule 分子
thermoreceptive nerve 温度感觉神经
a blast of 一阵　　stovetop 炉盘
vapor 蒸汽　　fundraising 筹款

Lead in questions

1. If you keep rubbing your hands, how will you feel on your hands? And why?
2. When you touch a piece of ice or a stove accidentally, how do you feel? And why?
3. We tend to achieve "a state of equilibrium" between individual and society, or between people. Would you like to explain it for us?

Temperature and Zeroth Law of Thermodynamics

All matter is made of particles — atoms or molecules — that are in constant motion. Because the particles are in motion, they have kinetic energy. The faster the particles are moving, the more kinetic energy they have. What does temperature have to do with kinetic energy? Well, as described in this figure, the more kinetic energy the particles of an object have, the higher is the temperature of the object.

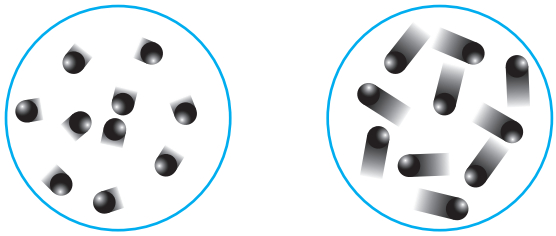


Figure 1 The gas particles on the right have more kinetic energy than those on the left. So the gas on the right is at a higher temperature.

Temperature is an average measure. Particles of matter are constantly moving, but they don't all move at the same speed and in the same direction all the time. As we can see in figure 1, the motion of the particles is random. The particles of matter in an object move in different directions, and some particles move faster than others. As a result, some particles have more kinetic energy than others. So what determines an object's temperature? An object's temperature is the best approximation of the kinetic energy of the particles. When we measure an object's temperature, we measure the average kinetic energy of the particles in the object.

The higher the temperature, the faster the molecules of the substance move, on the average. Dyes will spread more rapidly through hot water than cold water. This is because of the increased motion of the molecules. Temperature does not have to do with the number of molecules involved. Under given conditions, the temperatures of 10-ml and 100-ml samples of boiling water are equal. This means that the average kinetic energy of the molecules is the same for the two different quantities of water.

Temperature is different from heat, although the two concepts are linked. Temperature is a measure of the internal energy of a system, while heat is a measure of how energy is transferred from one system (or body) to another, or, how temperatures in one system are raised or lowered by interaction with another.

Temperature is a property that distinguishes thermodynamics from other sciences. This property can distinguish between hot and cold. When two or more bodies at different temperatures are brought into contact, then after some time, they attain a common temperature and they are said to exist in thermal equilibrium.

Thermal equilibrium refers to the situation where two objects that can transfer heat to each other stay at a constant temperature over time. Heat can be transferred several

ways, including if the objects are in contact with one another or if heat is radiated from a source like a lamp or a sun. Two objects are not in thermal equilibrium if the overall temperature changes with time, but they can approach thermal equilibrium as the hotter object transfers heat to the colder one.

Consider, for example, a colder object touching a hotter object — like ice that has been dropped in a hot cup of coffee. After some time, the ice (later water) and the coffee will reach a certain temperature that is in between that of the ice and the coffee. Though the two objects were not in thermal equilibrium at the beginning, they approach — and eventually reach — thermal equilibrium, the temperature in between the hot and cold temperatures.

The zeroth law of thermodynamics is one of the four laws of thermodynamics, which states that if two systems are in thermal equilibrium with a third system, then they are in thermal equilibrium with one another. The credit for formulating the law goes to Ralph H. Fowler. Interestingly, the zeroth law of thermodynamics was actually developed much later than the original three laws. However, there was some confusion regarding the nomenclature, whether it should be named the fourth law or some other name. The complication arose because the new law gave a much clearer definition of the temperature and basically replaced what the other three laws had to state. Fowler finally came up with the name to end this conflict.

The zeroth law of thermodynamics is seen in many everyday situations. First, the thermometer may be the most well-known example of the zeroth law in action. For example, say the thermostat in your bedroom reads 67 degrees Fahrenheit. This means that the thermostat is in thermal equilibrium with your bedroom. However, because of the zeroth law of the thermodynamics, you can assume that both the room and other objects in the room (say, a clock hanging in the wall) are also at 67 degrees Fahrenheit. Several temperature scales exist. In the United States, the Fahrenheit temperature is most commonly used, though the International System of Units (SI unit) Centigrade (or Celsius) is used in most of the rest of the world. The Kelvin scale is used often in physics and is adjusted so that 0 degrees Kelvin is equal to absolute zero, which is, in theory, the coldest possible temperature and at which point all kinetic motion ceases. Second, if you take a glass of ice water and a glass of hot water and place them on the kitchen countertop for a few hours, they will eventually reach thermal equilibrium with the room, with all 3

reaching the same temperature. Third, if you place a package of meat in your freezer and leave it overnight, you assume that the meat has reached the same temperature as the freezer and the other items in the freezer.

The zeroth law is incredibly important as it allows us to define the concept of a temperature scale and enables us to use thermometers to compare the temperatures of any objects we like.

Words

particle /ˈpɑːtɪkəl/	*n.*	one of the very small pieces of matter that an atom consists of 粒子；微粒
atom /ˈætəm/	*n.*	the smallest part of an element that can exist alone or can combine with other substances to form a molecule 原子
molecule /ˈmɒlɪkjuːl/	*n.*	the smallest unit into which any substance can be divided without losing its own chemical nature, usually consisting of two or more atoms 分子
constant /ˈkɒnstənt/	*adj.*	happening regularly or all the time 不断的
kinetic //kɪˈnetɪk/	*adj.*	relating to movement 运动的
random /ˈrændəm/	*adj.*	happening or chosen without any definite plan, aim, or pattern 随机的
approximation /əˌprɒksəˈmeɪʃən/	*n.*	something that is similar to another thing, but not exactly the same 接近；类似
average /ˈævərɪdʒ/	*adj.*	the average amount is the amount you get when you add together several quantities and divide this by the total number of quantities 平均（数）的；中等的；普通的
dye /daɪ/	*n.*	a substance you use to change the color of your clothes, hair, etc. 染料，染液

(Continued)

property /ˈprɒpəti/	*n.*	a quality or characteristics that something has 特性，属性
thermodynamics /ˌθɜːməʊdaɪˈnæmɪks/	*n.*	the science that deals with the relationship between heat and other forms of energy 热力学
attain /əˈtein/	*v.*	to reach a particular level, age, size, etc. 达到
thermal /θɜːməl/	*adj.*	relating to or caused by heat 热的；热量的
equilibrium /ˌiːkwəˈlɪbriəm/	*n.*	(formal) a balance between different people, groups, or forces that compete with each other, so that none is stronger than the others and a situation is not likely to change suddenly 平衡；均衡
radiate /ˈreɪdieɪt/	*v.*	if something radiates light or heat, or if light or heat radiates from something, the light or heat is sent out in all directions 辐射
approach /əˈprəʊtʃ/	*v.*	to come near to somebody/something in distance or time 接近
eventually /ɪˈventʃuəli/	*adv.*	after a long time, or after a lot of things have happened 最终，结果
zeroth /ˈziərəuð/	*adj.*	being numbered zero in a series 第零的
credit /ˈkredɪt/	*n.*	approval or praise that you give to someone for something they have done 荣誉；信用
formulate /ˈfɔːmjəleɪt/	*v.*	to develop something such as a plan or a set of rules, and decide all the details of how it will be done 制订；构想出
confusion /kənˈfjuːʒən/	*n.*	when you do not understand what is happening or what something means because it is not clear 困惑；混淆

(Continued)

nomenclature /nəʊˈmeŋklətʃə/	*n.*	a system of naming things, especially in science 术语，命名法
complication /ˌkɒmplɪˈkeɪʃən /	*n.*	a problem or situation that makes something more difficult to understand or deal with 复杂；复杂化的事物
thermometer /θəˈmɒmitə/	*n.*	a piece of equipment that measures the temperature of the air, of your body, etc. 温度计，体温计
thermostat /ˈθɜːməstæt/	*n.*	an instrument used for keeping a room or a machine at a particular temperature 温度调节器，恒温器
Fahrenheit /ˈfærənhaɪt/	*n.*	a scale of temperature in which water freezes at 32° and boils at 212° 华氏温度
scale /skeil/	*n.*	a system of numbers that is used for measuring the amount, speed, quality, etc. of something 尺度，刻度
centigrade /ˈsentəgreɪd/	*n.*	a scale for measuring temperature in which water freezes at 0° and boils at 100° 摄氏温度
Kelvin /ˈkelvɪn/	*n.*	a scale of temperature in which water freezes at 273.15 K and boils at 373.15 K 绝对温标
cease /siːs/	*v.*	to stop doing something or stop happening 终止，结束
countertop /ˈkaʊntətɒp/	*n.*	the flat working surface on top of waist-level kitchen cabinet 厨柜台面
package /ˈpækɪdʒ/	*n.*	something wrapped in paper, packed in a box, and then sent by mail or delivered 包裹；包
freezer /ˈfriːzə/	*n.*	a large piece of electrical kitchen equipment in which food can be stored at very low temperatures for a long time 冰箱；（冰箱）冷冻室
incredibly /ɪnˈkredəbli/	*adv.*	(informal) extremely 极端地，非常

Expressions

have to do with 与……有关	on (the) average 一般来说，平均
over time 随着时间过去	in contact with 接触；与……有联系
come up with 想出；提出	the zeroth law of thermodynamics 热力学第零定律
in thermal equilibrium with 与……达到热平衡状态	thermal equilibrium 热平衡
equal to 等同于	

Note

kinetic energy: 动能

Kinetic energy is the energy that is produced when something moves. For example, the kinetic energy of an asteroid falling towards the Earth is very large.

Background Reading

Ralph Howard Fowler

Fowler was a British physicist and astronomer. In 1935, Fowler was reading the texts of two physicists Meghnad Saha and B. N. Srivastava and he came up on the text that "Every physical quantity must be measurable in numeric terms. " They wrote in their text "Any of the physical properties of A which change with the application of heat may be observed and utilized for the measurement of temperature." In this postulate, they didn't use the term "zeroth law of thermodynamics." There were many similar postulates mentioned in the previous physics texts published by authors before 1935, but they didn't use the term "zeroth law" in their texts.

Then in 1935, Ralph Fowler framed the term "zeroth law of thermodynamics" and along with his co-author he gave the postulate: "If two assemblies are each in thermal equilibrium with a third assembly, they are in thermal equilibrium with each other." They concluded that if two or more assemblies are in thermal equilibrium with each other, then there must be some physical quantity which will be common in those assemblies. This physical quantity is termed as "temperature." Thus they proved the existence of physical property named "temperature" through this zeroth law of thermodynamics.

Integrated Exercises

Exercise 1

Read Text A carefully and make a decision on the best choice for each of the following questions.

1. Which of the following statements is NOT true about the concept of temperature?

A. Kinetic energy is in direct proportion to temperature.
B. Temperature has something to do with the size of the object.
C. The temperature of an object depends on the kinetic energy of the particles.
D. Under given conditions, the temperatures of the boiling water in different quantities remain the same.

2. Which of the following statements about temperature and heat is true?

A. Heat and temperature are synonymous to scientists.
B. Temperature measures the kinetic energy.
C. Temperature measures the heat.
D. Heat is a measure of the internal energy of a system.

3. Zeroth law of thermodynamics states that _____.

A. If two systems are in thermal equilibrium, then the third system will also be in thermal equilibrium
B. Two thermodynamic systems are always in thermal equilibrium with each other
C. When two systems are in thermal equilibrium with a third system, then the two systems are in thermal equilibrium with each other
D. Two systems that are not in thermal equilibrium with a third system are also not in thermal equilibrium with each other

4. Which of the following situations CANNOT be explained by the zeroth law of thermodynamics?

A. Imagine a glass of ice water and a glass of hot water are put on the table in a room for a few hours. They will eventually reach the same temperature with the room.

B. If a package of meat in the freezer is left overnight, it will reach the same temperature as the freezer and the other items in the freezer.

C. The Thermometer reads 25℃ in your room.

D. Hot coffee cools down automatically.

5. Zeroth law of thermodynamics _____.

A. is only valid for three objects

B. is in any way trivial

C. is named because it is more fundamental than the other three laws of thermodynamics

D. matters how many objects are present

Exercise 2

Choose a suitable word in the box to complete each sentence. Change the form where necessary.

cease	equilibrium	approximation	formulate	approach
property	assume	random	atom	credit

1. The human body seeks _____ or its own balance.
2. No one could deny the remarkable achievements made in the cooperation, not with their _____ or imagination.
3. The temperature measuring robot can _____ people and take their body temperatures. When it detects an abnormal body temperature, the robot will tell the person about this status and then report the situation to epidemic prevention and control staff members.

4. Farmers without any _____ record could not get loans to buy seeds and fertilizers（化肥）.
5. This material exhibited unusual physical _____ that had never been observed in nature.
6. Electrons and protons are _____ particles.
7. He visited some local bookshops at _____, and came across many books related to his academic study and personal interests.
8. We will actually identify changes, adeptly（熟练地）respond to them, and work to steer them in a favorable direction. We will never become rigid and never _____ making progress.
9. We will _____ an action plan to reach the peak of carbon dioxide emissions by 2030.
10. We can use known quantities, such as the height of a person, to determine an _____ measurement of unknown quantities, such as the height of a high-rise building.

Exercise 3

Choose a suitable phrase in the box to complete each sentence. Change the form where necessary.

on average	in contact with	over time
come up with	equal to	have to do with
in thermal equilibrium with	credit for	

1. One should be _____ the world as much as possible to enrich one's personal experience and broaden one's horizon.
2. Force is _____ mass times acceleration（加速度）.
3. China deserves _____ going beyond scrutinizing the dynamic nature of civilization by making innovations to society to be shared by all, on the basis that humans share the same planet, breathe the same air and share a common heritage

and destiny.

4. _____, a time zone spans 15° of longitude（经度）.
5. We need to _____ new ideas to add impetus（动力）and inspiration to the development of our civilization.
6. These three basic vehicles were upgraded significantly _____.
7. If we consider an ideal gas in which the individual particles do not interact with each other, but where we allow the particles to interact with the container walls, then we can consider each particle as a system which is _____ the walls.
8. Our research _____ electrons moving and accelerating.

Translation

Conversion

Conversion is the way to change the parts of speech of some words during translation. There are some differences in the structure of Chinese and English language, such as the number and form of predicate in a sentence, the sentence length, the use of passive voice, etc.. Without consciousness of it, you are more likely to translate based on the way of thinking in your first language. The lack of transpositional consideration in the course of translation fails to convey the meaning of the original text. In order to present a natural, faithful and smooth translation, it is quite indispensable to change the part of speech of some words, which is to apply the conversion technique. Conversion often occurs between two word classes, such as noun to verb, preposition to verb, adjective to noun, verb to noun, verb to adjective, verb to preposition, and so on.

1. Conversion: English→Chinese

A. noun→verb

A noun deriving from a verb can be converted into a verb in Chinese.

e.g. *An object's temperature is the best **approximation** of the kinetic energy of the particles.*

物体的温度极大地**反映**了粒子动能的大小。

B. preposition → verb

The use of prepositions in English occurs in higher frequency than it does in Chinese. The prepositions with the obvious sense of action, such as *across*, *against*, *past*, *toward*, *through*, etc., can be converted into verbs properly in Chinese to achieve a natural way of expression.

e.g. *Dyes **spread** faster in hot water than in cold water.*

染料在热水中比在冷水中**扩散**得更快。

C. adjective → noun

The structure of "the + adjective" is often applied to express the meaning of a certain class of people. The adjective in this structure is often converted into noun in Chinese, and "the sick — 病人," "the rich — 富人" are among the numerous examples. There are still some other occasions you can cope with in a free way to translate the adjectives into nouns.

e.g. *The book is **typical** of its kind.*

这本书是同类书中的**典型**。

2. Conversion: Chinese→English

The multi-use of verbs in Chinese is one of the typical and major differences in the two highly-developed language systems. The sentence-making function of verbs in Chinese is much stronger than it is in English. For example, in the sentence "我们通常使用温度计测量温度," there are two verbs（使用、测量）in Chinese. However, there is only one predicate verb in the corresponding sentence in English: "We usually **use** thermometers to measure temperature." In addition to the structural consideration, conversion is an alternative in translation, which means the verbal meaning in Chinese can be conveyed through various classes of words other than one predicate verb in English. Here are some examples.

A. verb → noun

With Chinese verbs converted into English nouns or noun phrases, the number of verbs is effectively reduced in English. Meanwhile, sentence variety and conciseness can be achieved. This is often employed in the translation of political and technical essays.

e.g. 滥用枪支是构成社会安全隐患的重要问题之一。

*The **misuse** of guns has become one of the most serious problems threatening social security.*

B. verb → adjective

The verbs showing one's psychological state can be converted into English adjectives, taking the form of "be + adjective."

e.g. 不要**满足**于现有成就。

*Don't **be content with** the present achievement.*

C. verb → preposition

Prepositions in English not only convey functional and static meaning, but also attract people with their dynamic meaning. The appropriate use of prepositions helps to avoid Chinglish expression.

e.g. 我们全部**赞成**他的提议。

*We were all **in favor of** his proposal(s).*

Exercise 4

Translate the following sentences into Chinese / English.

1. Conversely, when systems having the same temperature were put together, they would surely be **in** thermal equilibrium.
2. Too much **exposure** to cell phones will do great harm to the eyesight of children.
3. Water is in continuous **expansion** below 4℃.
4. 他**希望**大学毕业后取得一份理想的工作。
5. 探测器的**任务**是研究火星的稀薄大气。

Reading Skills

Identifying Topic and Details

There are usually 2 basic elements in a paragraph: (1) topic, and (2) supporting details. The topic tells the main idea of a paragraph. The sentences that explain the main idea are called supporting details. These details can be the information, such as data, examples, reasons, personal experiences or facts, supporting the topic sentence. These two paragraph elements can help the reader get an easy understanding and remember what they read. The particular reading skill introduced in this unit is to help

identify topic and recognize details as you read.

How to identify topic and details:

▶ To find the similarities and differences among the details

▶ To classify and categorize the details. The details usually perform such functions as explanation, exemplification, reasoning, listing, and so on, which serve the topic better.

▶ To find general information which includes all the other details. The general information can serve as a label for these details.

Take paragraph 9 in text A as an example. The function and classification of each sentence in this paragraph are shown in the following table.

e.g.

	Description	Function	Classification
Sentence 1	The zeroth law of thermodynamics in everyday situation	General idea	Topic
Sentence 2	Case 1: The thermometer	Example 1	Supporting details
Sentences 3—5	Specific description of thermometer used in life	Explanation	
Sentences 6—8	Temperature scales	Further explanation	
Sentence 9	Case 2: Ice water and hot water reaching the same temperature with the room	Example 2	
Sentence 10	Case 3: The temperature of the meat in the refrigerator remains the same with the other items there	Example 3	

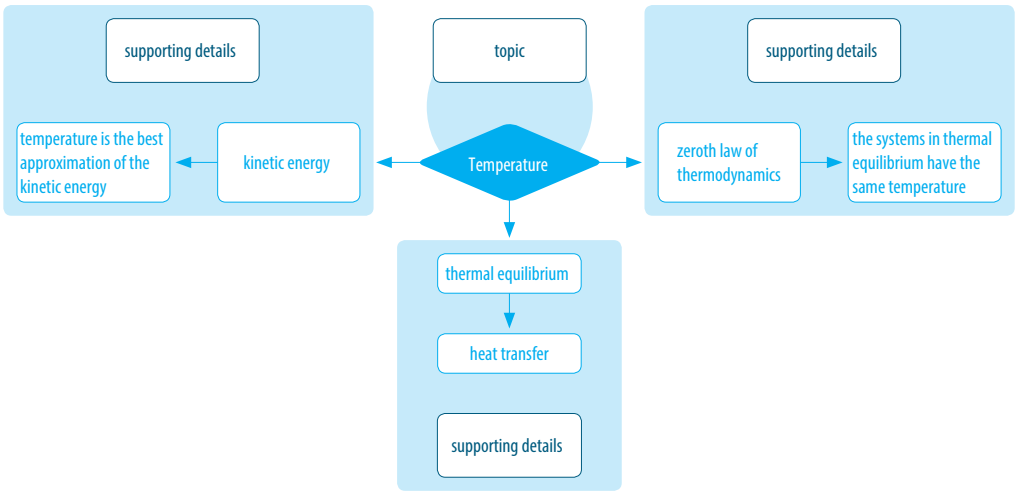
The topic "The zeroth law of thermodynamics in everyday situation" is made clear in the first sentence — also a topic sentence. It is expounded by all the other sentences. The other sentences, showing the information in the same category, explain three applications of zeroth law of thermodynamics in life: the thermometer, the thermal equilibrium arrived

at by 3 bodies (cold water, hot water and the room) and the freezer. All of these sentences help support the main idea: the zeroth law of thermodynamics can be everywhere in our life.

While reading, in order to identify the main idea and supporting details, you can construct a web to display:

- the topic in the center, and
- the supporting details branched off.

The web of text A can be drawn like this:

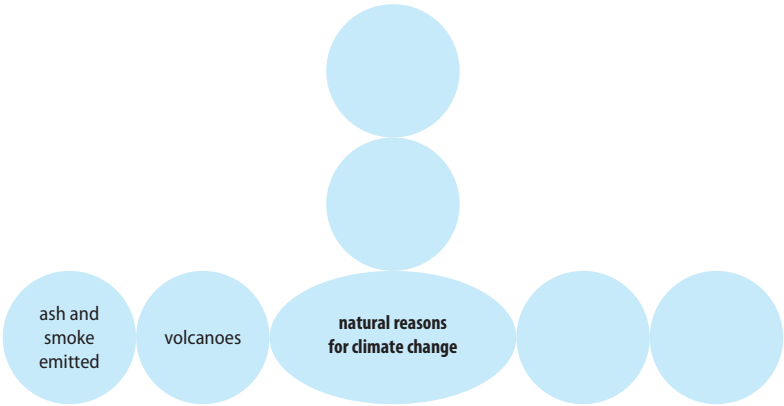


Exercise 5

Read the passage and answer the questions that follow.

There are some natural causes for climate change. Volcanoes are one of the largest natural contributors to global warming. The ash and smoke emitted during volcanic eruptions goes out into the atmosphere and affects the climate. Water vapor is a kind of greenhouse gas. Due to the increase in the earth's temperature more water gets evaporated from the water bodies and stays in the atmosphere adding to global warming. Permafrost is there where glaciers are present. It is a frozen soil that has environmental gases trapped in it for several years. As the permafrost melts, it releases the gases back into the atmosphere, increasing the earth's temperature.

1. Fill in the empty circles based on your reading.



2. Please tell the main idea of this passage and explain why you think it is the main idea. You can refer to the information in the web to help you complete the following sentences.

The main idea of this passage is

_____

_____

The main idea is supported by the details from the passage. The passage says volcanoes are the largest natural contributors because

_____

_____

Water vapor increases the earth's temperature because of

_____

_____

Melting permafrost adds to global warming because of

_____

_____

Text B

Listening in

Listen to the passage and fill in the blanks.

Fever Detection

Sticking a thermometer into an armpit, mouth, ear or other body cavity is the most ____1____ way to take someone's temperature. Understandably, though, this cannot be done at airports or checkpoints set up elsewhere to screen the masses for feverish victims when there is a pandemic. So, in a bid to detect the warmth produced by a fever without touching any bodies, officials have opted for ____2____.

The ____3____ "thermometer guns" now ubiquitous in China, among other places, are one option. These instruments, known technically as spot pyrometers, use a device called a bolometer to ____4____ an object's temperature. A bolometer's electrical ____5____ depends on how hot it is. That, in turn, depends on the amount of infrared radiation falling on it from whatever it is pointing at. Spot pyrometers are used widely in industry to check equipment for signs of overheating, but the infrared signals they rely on can be muddled by dust, moisture, smoke, a change in ambient temperature, a smudge on the device's ____6____ or even by radio signals. Beyond all this, a person checking a stream of foreheads may, for reasons of personal safety, be reluctant to hold the gun close enough to obtain an accurate reading.

An alternative technology, the thermal camera, is costlier. But it can operate from farther away. Instead of a single bolometer, it has an array of them. These form the pixels which ____7____ the camera's image, thus building up a heat map of whatever that camera is looking at. One type of thermal camera, can detect ____8____ in radiation which correspond to temperature differences within an image of just 0.02°C. But this merely shows whether one part of the object being examined is warmer or cooler than another. When measuring the object's actual temperature, this type of thermal camera is accurate only to about 2°C. For a single reading, this is enough to mistake normal body temperature for a raging fever. In practice, however, the camera's software looks for ____9____ from the average temperature of passers-by. Those

noticeably hotter than their fellows can then be selected for closer ____10____.

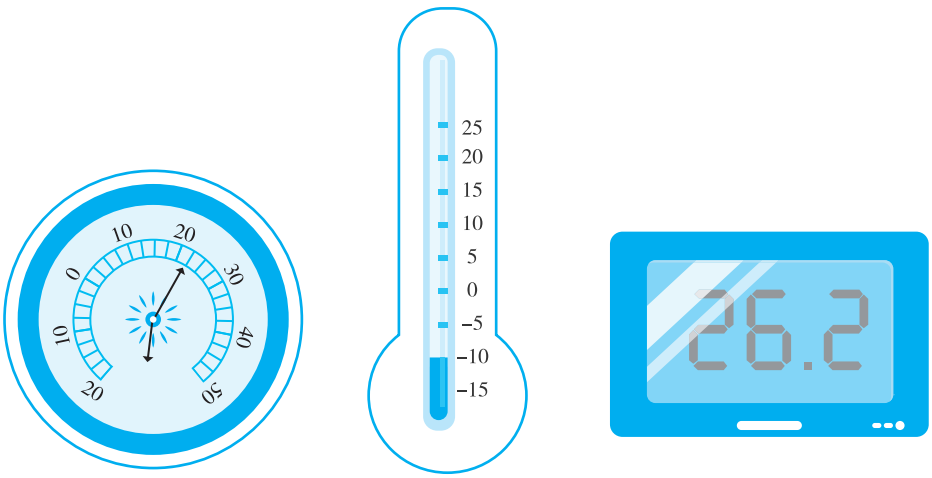
Word Notebook

armpit 腋窝
opt 选择
bolometer 辐射热测定器
smudge 污点
pixel 像素
cavity 腔
ubiquitous 无处不在的
muddle 弄乱
reluctant 不情愿的
raging 强烈的
in a bid to 为了
pyrometers 高温计
ambient 周围的
an array of 一批

Lead in questions

1. List some applications of thermometers in life.
2. How do the ancient Chinese tell the temperature?

How Does a Thermometer Measure Air Temperature?



How warm is it outside? How cold will it be tonight? A thermometer — an instrument used to measure air temperature — easily tells us this. But how it tells us is

another question entirely.

To understand how a thermometer works, we need to keep one thing in mind from physics: that a liquid expands in volume (the amount of space it takes up) when its temperature warms and decreases in volume when its temperature cools.

When a thermometer is exposed to the atmosphere, the surrounding air's temperature will permeate it, eventually balancing the thermometer's temperature with its own — a process whose fancy scientific name is "thermodynamic equilibrium." If the thermometer and it's inside liquid must warm to reach this equilibrium, the liquid (which will take up more space when warmed) will rise because it is trapped inside of a narrow tube and has nowhere to go but up. Likewise, if the thermometer's liquid must cool to reach the air's temperature, the liquid will shrink in volume and lower down the tube. Once the thermometer's temperature balances that of the surrounding air, its liquid will stop moving.

The physical rise and fall of the liquid inside of a thermometer is only part of what makes it work. Yes, this action tells you that a temperature change is occurring, but without a numerical scale to quantify it, you'd be unable to measure just what the temperature change is. In this way, the temperatures attached to a thermometer's glass play a key (albeit passive) role.

Who invented it: Fahrenheit or Galileo?

When it comes to the question of who invented the thermometer, the list of names is endless. That's because the thermometer developed from a compilation of ideas through the 16th to 18th centuries, starting in the late 1500s when Galileo Galilei developed a device using a water-filled glass tube with weighted glass buoys that would float high in the tube or sink depending on the hotness or coldness of air outside of it (sort of like a lava lamp). His invention was the world's first "thermoscope."

In the early 1600s, Venetian scientist and friend to Galileo, Santorio, added a scale to Galileo's thermoscope so that the value of temperature change could be interpreted. In doing so, he invented the world's first primitive thermometer. The thermometer didn't take on the shape we use today until Ferdinando I de' Medici redesigned it as a sealed tube having a bulb and stem (and filled with alcohol) in the mid-1600s. Finally, in the 1720s, Fahrenheit took this design and "bettered it" when he began using mercury

(instead of alcohol or water) and fastened his own temperature scale to it. By using mercury (which has a lower freezing point, and whose expansion and contraction is more visible than water's or alcohol's), Fahrenheit's thermometer allowed temperatures below freezing to be observed and more precise measurements to be observed. And so, Fahrenheit's model was accepted as the best.

What kind of weather thermometer do you use?

Including Fahrenheit's glass thermometer, there are 4 main types of thermometers used to take air temperatures:

Liquid-in-glass. Also called bulb thermometers, these basic thermometers are still used in Stevenson Screen weather stations nationwide by National Weather Service Cooperative Weather Observers when taking the daily maximum and minimum temperature observations. They're made of a glass tube (the "stem") with a round chamber (the "bulb") at one end that houses the liquid used to measure the temperature. As the temperature changes, the volume of liquid either expands, causing it to climb up into the stem; or contracts, forcing it to shrink back down out of the stem toward the bulb.

Hate how fragile these old-fashioned thermometers are? Their glass is actually made very thin on purpose. The thinner the glass, the less material there is for the heat or cold to pass through, and the quicker the liquid responds to that heat or cold — that is, there's less lag.

Bimetallic. The dial thermometer mounted on your house, barn, or in your backyard is a type of bi-metal thermometer. (Your oven and refrigerator thermometers and furnace thermostat are other examples, too.) It uses a strip of two different metals (usually steel and copper) which expand at different rates to sense temperatures. The metals' two different expansion rates force the strip to bend one way if heated above its initial temperature, and in the opposite direction if cooled below it. The temperature can be determined by how much the strip/coil has bent.

Thermoelectric. Thermoelectric thermometers are digital devices that use an electronic sensor (called a "thermistor") to generate an electric voltage. As the electric current travels along a wire, its electrical resistance will change as temperature changes. By measuring this change in resistance the temperature can be calculated.

Unlike their glass and bimetallic cousins, thermoelectric thermometers are rugged, respond fast, and don't need to be read by human eyes, which makes them perfect for automated use. That's why they're the thermometer of choice for automated airport weather stations. (The National Weather Service uses data from these AWOS and ASOS stations to bring you your current local temperatures.) Wireless personal weather stations also use the thermoelectric technique.

Infrared. Infrared thermometers are able to measure the temperature at a distance by detecting how much heat energy (in the invisible infrared wavelength of the light spectrum) an object gives off and calculating a temperature from it. Infrared (IR) satellite imagery — which shows the highest and coldest clouds as a bright white, and low, warm clouds as gray — can be thought of as a kind of cloud thermometer.

Now that you know how a thermometer works, watch it closely each day to see what your highest and lowest air temperatures will be.

Words

volume /ˈvɒljuːm/	*n.*	the total amount of something, especially when it is large or increasing 体积；总量
permeate /ˈpɜːmieɪt/	*v.*	if liquid, gas, etc. permeates something, it enters it and spreads through every part of it 充满；渗透
fancy /ˈfænsi/	*adj.*	with a lot of decorations or bright colors 精致的；绚丽的
shrink /ʃrɪŋk/	*v.*	to become smaller, or to make something smaller, through the effects of heat or water 收缩；减少
numerical /njuːˈmerɪkəl/	*adj.*	expressed or considered in numbers 数字的
compilation /ˌkɒmpəˈleɪʃən/	*n.*	a book, list, record, etc. which consists of different pieces of information, songs, etc. 汇编物；辑；集子
weighted /ˈweɪtɪd/	*adj.*	having a particular weight 加重的

(Continued)

buoy /bɒɪ/	*n.*	an object that floats on the sea, a lake, etc. to mark a safe or dangerous area 浮标；航标
lava /ˈlɑːvə/	*n.*	hot liquid rock that flows from a volcano, or this rock when it has become solid （火山喷出的）熔岩，岩浆
float /fləʊt/	*v.*	if something floats, it moves slowly through the air or stays up in the air 漂浮，飘浮
thermoscope /ˈθɜːməskəʊp/	*n.*	a device that indicates a change in temperature, esp. one that does not measure the actual temperature 测温器，验温器
Venetian /vəˈniːʃən/	*adj.*	of or relating to Venice or its people 威尼斯的
primitive /ˈprɪmətɪv/	*adj.*	something that is primitive is very simple and does not have the extra modern parts that would make it faster, better, more comfortable, etc. 原始的；原生的
sealed /siːld/	*adj.*	shut or protected with something that prevents air, water, etc. from getting in or out 密封的
bulb /bʌlb/	*n.*	a root shaped like a ball that grows into a flower or plant 球茎（状物） the glass part of an electric light, that the light shines from 电灯泡
stem /stem/	*n.*	the long thin part of a wine glass, vase, etc., between the base and the wide top （酒杯、花瓶等的）颈
mercury /ˈmɜːkjəri /	*n.*	a heavy silver-white poisonous metal that is liquid at ordinary temperatures, and is used in thermometers. It is a chemical element: symbol Hg 水银

(Continued)

contraction /kənˈtrækʃən/	*n.*	the process of becoming smaller or narrower 收缩；缩小
chamber /ˈtʃeɪmbə/	*n.*	an enclosed space, especially in your body or inside a machine （人体、植物或机器内部的）腔;（作特殊用途的）房间
fragile /ˈfrædʒaɪl/	*adj.*	easily broken or damaged 易碎的；脆弱的
lag /læg/	*n.*	a delay or period of waiting between one event and a second event 间隔
bimetallic /ˌbaɪmɪˈtælɪk/	*adj.*	consisting of two metals （材料）双金属的
mount /maʊnt/	*v.*	to increase gradually in amount or degree 增加；上升
barn /bɑːn/	*n.*	a large farm building for storing crops, or for keeping animals in 谷仓；牲畜棚
furnace /ˈfɜːnɪs/	*n.*	a piece of equipment used to heat a building 火炉
strip /strɪp/	*n.*	a long narrow piece of paper, cloth, etc. 条；带
steel /stiːl/	*n.*	strong metal that can be shaped easily, consisting of iron and carbon 钢
copper /ˈkɒpə/	*n.*	a soft reddish-brown metal that allows electricity and heat to pass through it easily, and is used to make electrical wires, water pipes, etc. 铜
coil /kɔɪl/	*n.*	a continuous series of circular rings into which something such as wire or rope has been wound or twisted 卷，线圈
thermoelectric /ˈθɜːməʊɪˈlektrɪk/	*adj.*	producing electricity by a difference of temperatures 热电的
sensor /ˈsensə/	*n.*	a piece of equipment used for discovering the presence of light, heat, movement, etc. 传感器

(Continued)

thermistor /θɜːˈmɪstə/	*n.*	an electrical resistor making use of a semiconductor whose resistance varies sharply in a known manner with the temperature 电热调节器；热敏电阻
voltage /ˈvəʊltɪdʒ/	*n.*	electrical force measured in volts 电压
current /ˈkʌrənt/	*n.*	a flow of electricity through a wire 电流
resistance / rɪˈzɪstəns/	*n.*	the ability of a substance to stop the flow of an electric current through it 电阻；阻力
cousin /ˈkʌzən/	*n.*	something that has the same origins as something else 相似的人或物
rugged /ˈrʌgɪd/	*adj.*	a vehicle or piece of equipment that is rugged is strongly built and not likely to break easily 坚固的；结实的
automated /ˈɒːtəmeɪtɪd/	*adj.*	using computers or machines to do a job, rather than people 自动化的；机械化的
invisible /ɪnˈvɪzəbəl/	*adj.*	something that is invisible cannot be seen 看不见的；隐匿的
imagery /ˈɪmɪdʒəri/	*n.*	(formal) pictures, photographs, etc. 像；画像；照片

Expressions

keep...in mind 记住	take up 占据
attach ... to 把……附（在……上）	a compilation of 汇编
climb up 上升；增加	When it comes to… 谈论到，说到
dial thermometer 刻度盘温度计	give off 释放；散发

Proper Nouns

Galileo Galilei 伽利略·伽利雷	Santorio 桑塔里奥（人名）
Ferdinando I de' Medici 费迪南多一世·德·美第奇	

Notes

1. Stevenson Screen: (气象) 斯蒂文森百叶箱

A Stevenson screen (also known as an instrument shelter) is a meteorological screen to shield instruments against precipitation and direct heat radiation from outside sources, while still allowing air to circulate freely around them.

2. National Weather Service Cooperative Weather Observers: 国家气象服务合作气象观察员

The observers may act as severe storm spotters, phoning in reports of hazardous weather in the winter and summer.

3. AWOS: 即Automated Weather Observing System, 气象自动观测系统

Automated Weather Observing System is a fully configurable airport weather system that provides continuous, real-time information and reports on airport weather conditions.

4. ASOS: 即Automated Surface Observing Systems, 自动地面观测系统

Automated Surface Observing System is another type of an automated weather station, mainly used in the United States. Although similar to AWOS in nature, it is more sophisticated and is designed to provide the necessary information to generate weather forecasts. It serves as the primary climatology observing network in the United States.

Integrated Exercises

Exercise 6

Read Text B carefully and decide whether the following statements are True, False or Not Given.

( ) 1. It is Galileo Galilei who invented the thermometer.

( ) 2. Fahrenheit's model of thermometer was much popular and contributed a lot for precise measurements.

( ) 3. If the glass of a thermometer is thinner, the liquid inside will respond to the heat or cold within a shorter time.

( ) 4. The bi-metal thermometer is suited for use in the industrial and automatic environment because of its robustness and reliability.

( ) 5. Thermoelectric thermometers are a better choice for automated airport weather stations because they are designed to be used in difficult situations and respond fast.

Exercise 7

Choose a suitable word in the box to complete each sentence. Change the form where necessary.

permeate	shrink	primitive	mount	initial
resistance	precise	invisible	imagery	wavelength

1. Thicker conductors have less electrical _____ than thinner materials.
2. The language of the poem is quite simple, but it is full of rich _____ and emotion.
3. UV light gives off electromagnetic radiation with _____ shorter than visible light.
4. Throughout history, mankind has created and developed many colorful civilizations, from the earliest days of _____ hunting to the period of agriculture, and from booming industrial revolution to the information society.

5. GDP in the advanced economies may _____ 7 percent this year, whereas the full-year GDP in this country is projected to grow this year and further rebound（反弹）by 7.9 percent next year.
6. FAST (Five-hundred-meter Aperture Spherical radio Telescope) not only needed to be _____ and sensitive in its applications, but it should also be beautiful to look at.
7. It was the _____ stage that she successfully achieved through slow but steady steps.
8. We must make plans that take all factors into consideration and simultaneously implement multiple comprehensive measures to ensure that our efforts to build an ecological civilization _____ all fields, regions and processes.
9. Tension here is _____, as we await the final result.
10. Using a telescope, Galileo discovered stars that were _____ to the naked eye.

Exercise 8

Choose a suitable phrase in the box to complete each sentence. Change the form where necessary.

give off	take up	climb up
pass through	keep...in mind	when it comes to
attach...to	a compilation of	

1. The Chinese dishes will _____ around 30 percent of the total, and the rest will be Western food.
2. It sold slightly better in its second week, _____ to $8.
3. _____ climate change, the actions of some countries disregard the future of all mankind as they seek all their own short-term interests.
4. The waves _____ each other without being disturbed.
5. It must _____ great importance _____ science and technology and allow technological innovation to play a key role and crucial role in the process.

6. The second kind, in which nuclear（核子的）particles _____ electrons, forms a bridge between nuclear matter (neutrons for example) and non-nuclear matter such as electrons.
7. This book is _____ his articles and new chapters.
8. Long term energy security and environmental goals need to be _____ for a sustainable development.

Word Formation

In this unit, we mainly focus on the roots: ***cess*** and ***ven***.

1. cess

There are often spelling variants to a primary root word. The root word ***cess*** meaning "to go," present in the words *success* and *access*, has variant spellings of ***cede*** and ***ceed***. We can figure out the meaning of the words with the root ***cess*** and its variants. Here are some examples.

Root (Base)	Meaning	Word Example	Definition
cess (*cede*, *ceed*)	to go	process (proceed)	a series of things that "go" for a result
		access	"go" towards
		excess (exceed)	"go" out of normal amount
		recession (recede)	act of "going" backward
		success (succeed)	"going" to a higher position or a best result
		ancestor	the one who has "gone" before you

2. ven

The Latin root word ***ven*** and its variant ***vent*** both mean "to come." These roots are the word origin of many English vocabulary words, including *prevent*, *invent*, *venue*, *convenient*, etc.

Root (Base)	Meaning	Word Example	Definition
ven (*vent*)	to come	eventually	"coming" out in the end
		venue	place where people "come"
		convenient	of a pleasant condition to "come" together
		intervene	to "come" between two things
		convention	a "coming" - together of people
		invent	to "come" to the world for the first time

Exercise 9

Please use the appropriate form of the above "cess" and "ven" root words to fill in the blanks in the following sentences.

1. The pandemic will not truly end until everyone has _____ to vaccines, including people in the poorest countries.
2. Two enterprises in this city will be punished for _____ discharge of pollutants.
3. The success and glory of the past does not guarantee that we will always _____ in the future.
4. Residents, waiting for the waters to _____, are staying in temporary shelters, provided by the local government, or in tents along the road.
5. A ceremony paying tribute（致敬）to the _____ of the Chinese nation, Huangdi, or Yellow Emperor, is held to mark the Qingming Festival.
6. In view of the weightless environment, vacuum（真空）storage bags, special bags to deal with trash, are a necessary _____.
7. They hope to provide early detection and _____ for children who have psychological difficulties and improve the overall mental health of those under 18.

8. Researchers made a new _____ to solve the counterfeit（伪造的）problem in the whiskey market.
9. These so-called "special _____ images" allow audiences to walk straight into a digitally projected world and interact with them in real time.
10. They have delegated him to represent their city at the _____.

Exercise 10

The root word "pose", together with its variant "posit", means "to place or put." Please try to figure out the meaning of the following words formed with "pose" or "posit."

Root (Base)	Meaning	Word Example	Meaning
pose (*posit*)	to place, to put	deposit	
		oppose	
		suppose	
		propose	
		compose	
		impose	
		dispose	

Writing

Writing a Comparison and Contrast Essay

If you focus on finding out the similarities and differences between two subjects while writing an academic article, you are working on writing a comparison and contrast essay. The essence of this type of essay lies in finding out the similarities and differences of two or more objects, places, events, people, etc. However, you can give

a different writing piece with an approach you use while working on it. Let's look into different approaches to writing a comparison and contrast essay.

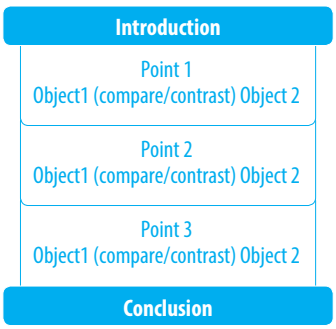
1. The structure of a comparison and contrast essay

The three approaches to writing this type of essay are:

- ▶ Point by point method
- ▶ Block structure
- ▶ Venn diagram

A. Point by point method

This method focuses on comparing or contrasting various points of the same object. You can refer to the following outline:



To demonstrate what this method is about, let's try to compare eating out and eating at home. Let's say we can compare or contrast three main aspects: expense, quality of food, and atmosphere in three paragraphs, each of which is dedicated to only one point.

e.g.

Topic: Eating Out *vs* Eating at Home

Introduction

Main body paragraph 1: Expense

Higher when dinning out (e.g. choices on how to spend money; extra charges)

Lower when eating at home (e.g. keeping an eye out for sales on foods)

Main body paragraph 2: Quality of food

Typically lower with no exceptions whening dining out (e.g. offer examples of the cleanliness of foods, etc.)

Typically higher at home (e.g. the precise selection of ingredients, etc.)

Main body paragraph 3: Atmosphere

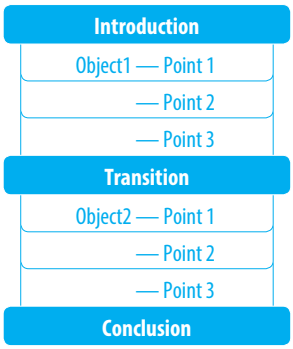
Comfortable and relaxing when eating at home

Having a pleasurable social experience when dining out

Conclusion

B. Block Structure

With this approach, you take the first object to be compared and describe it in the first paragraph from certain points. Then, in the second paragraph, you proceed to describe the second object from the points of the same category as in the first paragraph. Throughout the process, features or qualities are examined step by step. You may refer to the following structure.



Let's see what the block structure would look like with the same topic "Eating Out *vs* Eating at Home."

e.g.

Topic: Eating Out *vs* Eating at Home

Introduction

Main body paragraph 1: Eating out

Advantage: Showing many things unexpected

Social norm: Providing a pleasurable social experience (dressing up, etc.)

Feeling: Offering an exciting feeling

Main body paragraph 2: Eating at home

Advantage: Ensuring cleanliness

Social norm: No dress code and no worry of being too loud

Feeling: Relaxing and comfortable

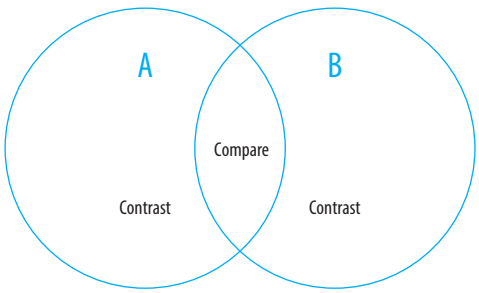
Conclusion

C. Venn diagram

If you ever make up your mind on employing this tool for one of the comparison and contrast essay topics, you can refer to the following steps.

▶ Simply draw two or more circles (depending on the number of objects you're comparing).

▶ Write down things that have common characteristics inside the intersection of these circles with the differences left on the outside.



The same writing topic "Eating Out *vs* Eating at Home" can be developed with this structure as follows.

e.g.

Topic: Eating Out *vs* Eating at Home

Introduction

Main body paragraph 1: Similarities

Offering a variety of delicious foods

Providing a precious opportunity to get together with family members

Main body paragraph 2: Differences

Different health and safety consideration

Providing different social experiences

Economic factors

Conclusion

These are the three main methods used to craft a comparison and contrast essay. Just choose the one that you feel most comfortable using.

2. Transition words used in a comparison and contrast essay

Transition words are the key to smooth reading experience. Here are some transition words you can use when crafting a comparison and contrast essay.

Transitional Signals for Comparison	Transitional Signals for Contrast
in the same way	nonetheless
similarly	however
likewise	yet
by the same token	though
as well as	in contrast
coupled with	notwithstanding
in addition	on the contrary
identically	on the other hand
correspondingly	but
moreover	at the same time
together with	after all
also	
again	
comparatively	

Exercise 11

Write an essay of comparison and contrast on the topic "Types of Thermometers" with no less than 150 words.