



Learning Science via Standards



PRESSURE COOKER



CM/L-XXXXXXXXXX

Lesson 18
May 2023



Nurturing Young Minds as Ambassadors of Quality and Standards



Foreword

Everything around us, whether natural phenomena or manmade products can be explained through science. The product which are used in our daily life are outcome of conscious efforts by the mankind to fulfil and exceed the needs of the present and demands of the future. Students are taught science as part of their school curriculum, to enable them to understand the various scientific laws and principles and also to inculcate the habit of exploring the world through the lens of science. Quality characteristics of any product or service are decided based on the stated and implied needs and are generally described in a document called 'Standard'. Science and standards are inseparable and integral aspect of any product.

Bureau of Indian Standards (BIS), the national standards body of India, is mandated for establishment and promotion of standards and creating a quality ecosystem in the country. This is achieved through developing Indian Standards on products and services through the active involvement of relevant stakeholders and dissemination of information of such standards for their use and implementation across all sectors of economy. Academia, as an important stakeholder of BIS, has been contributing towards development of standards through research activities and providing inputs related to technological advancements in product development, their characteristics and use as well as methods of tests. BIS, on its part has also been promoting standards in academia through a variety of programmes. This has since been institutionalized in the form of "Standards Clubs" which are being established in educational institutions across India to nurture the young minds as ambassadors of quality and standards and prepare them for dealing with these aspects in future.

In this initiative of BIS, called "Learning Science via Standards", a series of Lesson Plans are made elaborating the various scientific concepts, laws and principles to help students understand their practical applications via standards. The series comprises of a variety of subjects for insights into the scientific laws and principles and relating them to the quality characteristics of products used in day-to-day life. First 10 Lesson Plans in the series are released on the occasion of World Consumer Rights Day on 15 Mar 2023.

The Lesson Plans are expected to serve as a useful tool for the teaching fraternity for imparting knowledge on scientific laws and principles through their practical applications in activities and products around us and facilitate an interactive learning experience for the students.



Domestic Pressure Cooker

A domestic pressure cooker is a kitchen appliance that is commonly used for cooking food quickly and efficiently. It works on the principle of trapping steam inside a sealed pot, which raises the pressure and temperature inside the pot, leading to faster cooking times. Pressure cookers are commonly used for cooking grains, legumes, and meats, and are popular in households across the world.

Pressure cookers have come a long way since their inception in the 17th century. The first pressure cooker was invented by French physicist Denis Papin, who used a steam-powered piston to generate high pressure in a sealed pot in an attempt to reduce the cooking time of food. His airtight cooker used steam pressure to raise the water's boiling point, thus cooking food more quickly.

In the early 20th century, pressure cookers became more popular as they were developed for household use. Today, there are several types of pressure cookers available, including stovetop and electric models.

Pressure cookers are typically made of stainless steel or aluminum, which are both durable and efficient materials for conducting heat. The lid of the pressure cooker is equipped with a gasket, which helps to create a tight seal, and a pressure regulator, which allows the user to control the pressure inside the pot. The working principle of a pressure cooker is to increase the pressure and temperature of a sealed pot, which reduces the cooking time of certain foods. As the pot is heated, the liquid inside it boils, creating steam that increases the pressure and temperature inside the pot. The high pressure and temperature help to break down the fibers in the food being cooked, leading to faster cooking times.

Pressure cooking is considered to be one of the most energy-efficient methods of cooking. In addition, modern pressure cookers come with several safety features, including pressure release valves and locking mechanisms, which make them safe and easy to use in the kitchen.

Q. Is cooking time affected with change in altitude?

Answer: Yes, cooking time can be affected by changes in altitude. As altitude increases, atmospheric pressure decreases, which can affect the boiling point of water. At higher altitudes, water boils at a lower temperature, and this can result in longer cooking times for foods that require boiling, such as grains and legumes.

At sea level, the atmospheric pressure is higher, and the boiling point of water is 100°C (212°F). As you go up in altitude, the atmospheric pressure decreases, causing the boiling point of water to drop as well.

For example, at an altitude of 2,000 meters (6,560 feet), the boiling point of water is around 93°C (199°F). This means that it takes longer to cook food at this altitude than it would at sea level.



Pressure cookers can help compensate for the lower boiling point at high altitudes by increasing the internal pressure and temperature, which reduces cooking time. It's important to follow cooking instructions carefully and make necessary adjustments for altitude to ensure that food is cooked properly and safely.



Questions for Discussion

- *Why do we use pressure cooker for cooking?*
- *What is the relationship between vapour pressure and boiling point?*
- *Why Steam at 100°C causes more severe burns than water at 100°C?*
- *What Does a Pressure Cooker's Safety Valve Do?*
- *What Precautions Should we take While using a Pressure Cooker?*

1. Pressure Cooker

A pressure cooker is a kitchen appliance used for cooking food quickly by creating high pressure and temperature inside a sealed pot. This allows food to cook more quickly and with less water and energy than with standard cooking methods. The pressure cooker has a tightly fitting lid that traps steam and raises the pressure inside the pot, which leads to faster cooking times for food. A closed domestic pressure-cooking vessel for use with external heat source and capable of maintaining nominal cooking steam pressure up to 1.0 kgf/cm² gauge nominal (100 kN/m² approximately).

Manufacturing and design defects in pressure cookers could be serious. If the pressure cooker is not manufactured or designed properly, it could fail during use, leading to dangerous situations such as explosions, scalding, or burns. Some common defects include faulty safety valves, pressure regulating devices, fitment of lid and weak gaskets. These defects can lead to the build up of pressure beyond safe levels, resulting in sudden release of steam or even explosion.

2. Different Parts of Pressure Cooker

Following are the different parts of Pressure cooker:

1. Pressure regulator
2. Lid Plastic Handle with Screw
3. Steam vent/vent tube
4. Latch
5. Lid Metal Handle
6. Sealing Ring
7. Lid
8. Safety Valve with Washer
9. Short Body Handle



10. Long Body Handle

11. Long Body Handle Bracket with rivets



3. Glossary of Key Terms

- a) **Vapour Pressure** — Pressure exerted by the vapours of a liquid when equilibrium is established between the liquid and the vapour is called its vapour pressure. An example of vapour pressure is the pressure exerted by the water vapour in the air above a swimming pool.
- b) **Boiling point** — Boiling point can be defined as the temperature at which the vapour pressure of a liquid is equal to the external pressure acting on the liquid. In simple words it is Temperature at which a substance changes from liquid to gas at a given pressure. An example of boiling point is the temperature at which water boils at sea level, which is 100 degrees Celsius.
- c) **Sensible heat** — Sensible heat refers to the heat energy transferred to or from a substance that results in a change in temperature. An example of sensible heat is the heat absorbed by a pot of water when it is heated on a stove, which causes its temperature to increase.
- d) **Latent heat** — An example of latent heat is the heat absorbed by water when it changes from liquid to vapour during boiling, without changing its temperature.
- e) **Pressure Regulating Device** — Pressure regulating device in a cooker control the steam pressure by releasing it periodically, maintaining the required and safe pressure for proper cooking.



- f) **Safety Relief Device** — Device which prevents the pressure cooker from exceeding the safety pressure. It prevents dangerous levels of pressure from building up in a cooker by releasing steam automatically to maintain a safe cooking environment.



Questions for Answers

i) Q. Why Steam at 100°C (212°F) causes more severe burns than water at 100°C?

A. When steam at 100 °C comes into contact with skin, it condenses and releases its latent heat as well as sensible heat. While in case of water at 100 °C, water loses its sensible heat to skin. Steam loses more heat because of the phase change from steam to water (i.e. Latent heat)

ii) Q. What is the relationship between the vapour pressure and boiling point?

A. The relationship between the vapour pressure and boiling point is that both are inversely proportional. The more volatile liquid evaporates fast as compared to the less volatile liquid at a low temperature because the volume increases with respect to temperature so it has a low boiling point.

Example - If acetone and water are placed at the same temperature in which acetone evaporates first because it has a low molecular force of attraction so it requires less heat to evaporate. Acetone has high vapour pressure and a low boiling point.

4. Working of a Pressure Cooker

The working principle of a pressure cooker is based on the principles of thermodynamics and atmospheric pressure.

Here's how it works:

- i) The food and liquid are placed inside the pressure cooker and the lid is closed.
- ii) The pressure cooker is heated, causing the liquid inside to boil and produce steam.
- iii) The pressure inside the cooker increases, as the steam is trapped inside and cannot escape. This increased pressure raises the boiling point of the water, allowing the food to be cooked at a higher temperature. Food is cooked at around 120 °C .
- iv) The pressure inside the cooker is regulated by a pressure release valve, which allows the pressure to escape if it becomes too high.
- v) The food is cooked under pressure until it is fully cooked.
- vi) After cooking, the pressure is released from the pressure cooker before the lid is opened. This can be done by using a pressure release valve or by running the cooker under cold water.



The combination of increased pressure, higher boiling point, and trapped steam results in the food being cooked faster and more efficiently than with conventional cooking methods. The pressure cooker also helps to retain the flavor and nutrients of the food, making it a convenient and healthy cooking option.



5. Science Behind Pressure Cooker

Water boils at a higher temperature in a pressure cooker due to an increase in pressure inside the cooker. When the water is heated, the pressure inside the cooker also increases, which increases the boiling point of the water.

a) Water Boils at Higher Temperature in a pressure cooker

The only way to increase the temperature of boiling water as it converts to steam is to increase the surrounding pressure. This can be achieved by trapping the steam in an enclosed space. As water transforms into steam, it expands in volume. If the volume is not allowed to increase, the pressure (and therefore temperature), will increase.

Thus water boils at a higher temperature in a pressure cooker due to an increase in pressure inside the cooker.

b) **The ideal gas law**, also called the general gas equation, is the equation of state of a hypothetical ideal gas. The ideal gas law is often written in an empirical form:

$$pV = nRT$$

where p , V and T are the pressure, volume and temperature; n is the amount of substance; and R is the ideal gas constant.

c) **The law of Gay-Lussac** is a variant of the ideal gas law where the volume of gas is held constant. The pressure of a gas is directly proportional to its temperature while the volume is kept constant. $P / T = \text{constant}$ is the standard calculations for Gay-Lussac's law.

Thus according to the Ideal Gas Law and Gay-Lussac's Law, the pressure and temperature of a gas are directly proportional to each other at constant Volume. Pressure cooker is also a closed container with fixed volume, as the pressure increases inside the cooker, the temperature also increases, allowing the water to reach a higher boiling point. This higher temperature helps to cook the food faster and more efficiently, making the pressure cooker a popular kitchen appliance for cooking a variety of dishes.



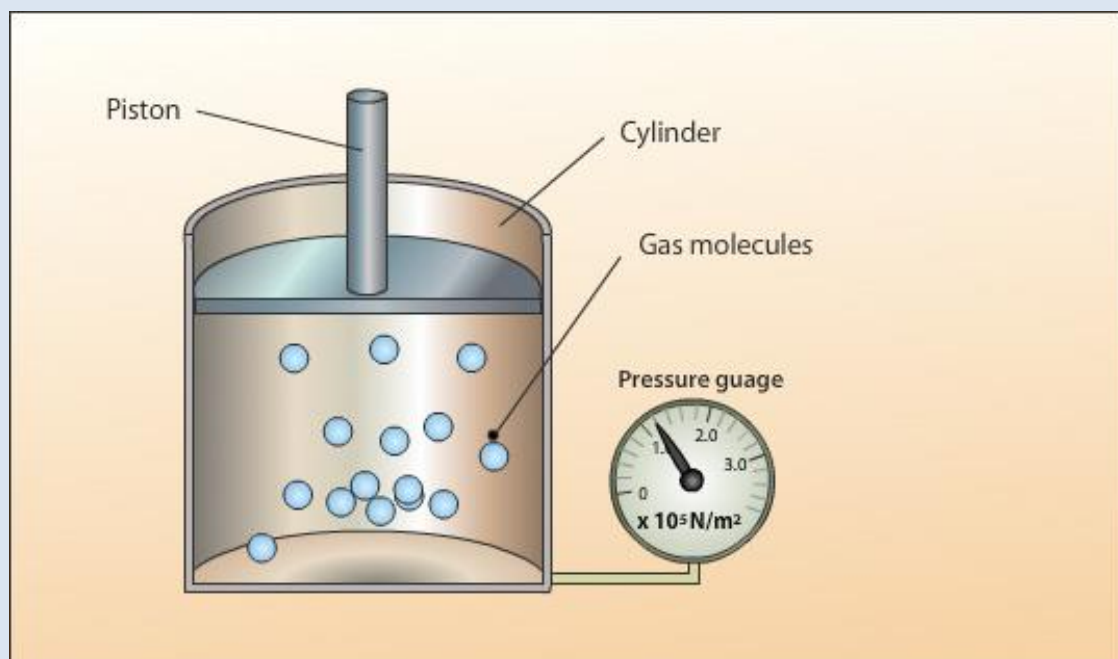
- d) **Pressure Regulating Devices:** A pressure cooker's pressure regulating device is responsible for maintaining a safe and consistent pressure level inside the cooker during the cooking process. The pressure regulating device works in conjunction with the safety pressure relief device to ensure that the pressure inside the cooker never exceeds a safe limit.

There are two main types of pressure regulating devices used in pressure cookers:

i) **Weighted Valve:** The weighted valve is a simple and commonly used type of pressure regulating device. It consists of a small metal weight that sits on top of the pressure cooker's steam vent. As the pressure inside the cooker increases, steam is released through the vent, which lifts the weight and allows excess steam to escape.

The design of a pressure cooker's weighted valve is based on the following laws of science:

- **Boyle's Law:** which states that the pressure and volume of a gas are inversely proportional to each other at a constant temperature.



As the temperature inside the pressure cooker increases during the cooking process, the volume of the steam and air inside the cooker decreases, which increases the pressure.

The weighted valve is designed to regulate this pressure increase by controlling the amount of steam that is released from the cooker. The small metal weight on top of the steam vent is calibrated to a specific pressure level, and once the pressure inside the cooker reaches that level, the weight is lifted and excess steam is released through the vent. This maintains a consistent pressure level inside the cooker and prevents it from exceeding a safe limit.

- **Pascal's Law:** states that pressure applied to a fluid is transmitted uniformly in all directions. This principle is used in the design of the pressure release valve in a pressure cooker.

The pressure release valve in a pressure cooker is designed to release steam and pressure from the cooker when the pressure inside the cooker exceeds a certain level. When the pressure inside the cooker reaches a critical point, the valve is lifted off its seat, allowing steam to escape from the cooker and reducing the pressure inside.

The design of the valve is based on Pascal's Law, which ensures that the pressure inside the cooker is transmitted uniformly in all directions. As the pressure inside the cooker increases, it exerts a force on the valve, pushing it upwards and allowing steam to escape. This ensures that the pressure is released uniformly and safely from the cooker, without the risk of an explosion or other dangerous event.

Overall, Pascal's Law is a critical principle used in the design of the pressure release valve in a pressure cooker, ensuring that the valve operates safely and efficiently to release excess pressure from the cooker.

- **Concept of gravity:** The design of the weighted valve also incorporates the concept of gravity. The weight is heavy enough to remain in place when the pressure inside the cooker is low, but light enough to be lifted by the steam when the pressure increases. This design ensures that the valve operates reliably and consistently, even in the presence of slight variations in pressure.

Overall, the design of the weighted valve in a pressure cooker is based on the principles of Boyle's Law and gravity, which allow for accurate and reliable pressure regulation during the cooking process.

ii) Spring-loaded Valve: The spring-loaded valve is a more advanced type of pressure regulating device that is used in some high-end pressure cookers. It consists of a spring that is calibrated to a specific pressure level and a valve that opens when the pressure inside the cooker reaches that level. The spring-loaded valve provides more accurate pressure control than the weighted valve, and some models may even have multiple spring-loaded valves to provide even more precise control.

Regardless of the type of pressure regulating device used, its primary function is to maintain a safe and consistent pressure level inside the pressure cooker during the cooking process. This ensures that food is cooked evenly and quickly, while also preventing the risk of the pressure cooker exploding due to excess pressure.

- e) **Safety Pressure Relief Device:** Safety valves are a crucial component of pressure cookers and play a vital role in ensuring the safe operation of the appliance. There are



typically two types of safety valves found in pressure cookers: pressure regulating device and overpressure plugs.

- **Pressure release valves:** These valves are designed to release excess pressure that builds up inside the cooker. They work by allowing steam to escape from the cooker, preventing the pressure from building to dangerous levels. Some pressure cookers have multiple release valves to ensure that pressure is released even if one valve becomes blocked.



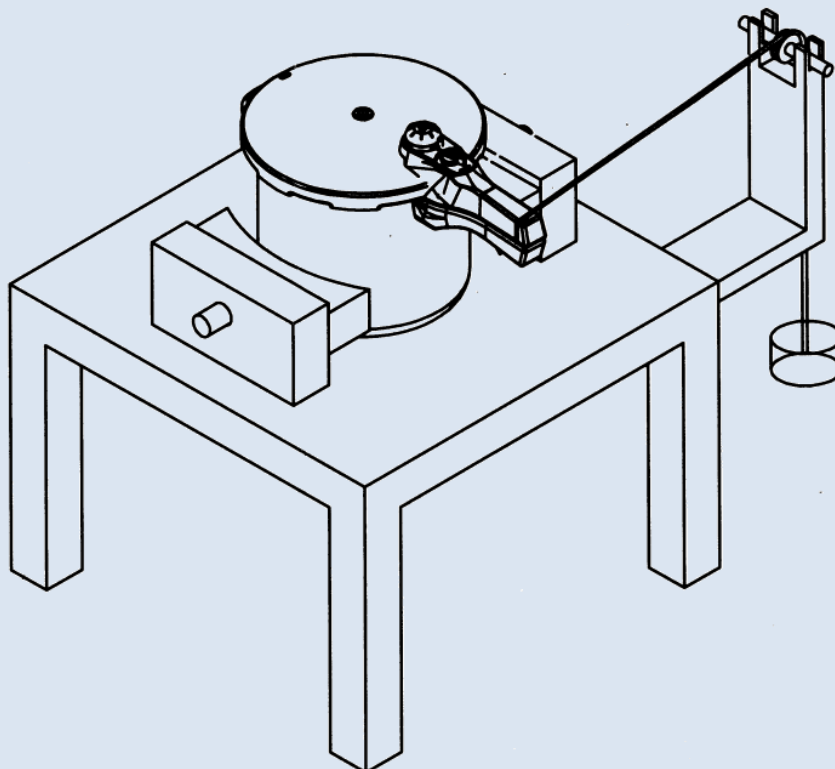
- **Overpressure safety plugs:** Overpressure plugs are safety devices that are designed to relieve pressure in the event that the pressure release valves become blocked or fail. These plugs are made of a material that melts at a specific temperature, allowing excess pressure to escape if the pressure inside the cooker becomes too high. Pallet type fusible plugs consist of a metal disk or pallet that is placed over a vent in the lid of the pressure cooker. The metal disk is typically made of a low-melting-point alloy, such as lead, tin, or bismuth, which melts at a relatively low temperature. When the pressure inside the cooker exceeds a safe limit, the temperature of the metal disk increases, causing it to melt and allow steam to escape through the vent. This reduces the pressure inside the cooker and prevents it from exploding.

The main advantage of pallet type fusible plugs is that they can be easily replaced. It is important to regularly check these safety features and ensure that they are functioning properly to prevent any accidents or damage to the cooker.

- f) **Pressure Leakage:** The pressure cooker works on the principle that increase in pressure increases boiling point of the water inside, thereby increasing the temperature of medium(water) being used for cooking. In case if any leakage of air exists in the pressure cooker, the pressure cannot be built up during the cooking. Hence it is important to check for any leakages in the pressure cooker. For this, air is pressurized into the cooker at a pressure of 0.4 kgf/cm² and then slowly raised to a pressure of 1.0 kgf/cm², during the process there should not be any leakages or drop in pressure of the cooker.
- g) **Burst Pressure:** Pressure coooker is provided with a pressure regulating device for regulating the pressure between 0.8 to 1.2 kg/cm² and also provided with safety features like safety pressure relief device which operates between 2 to 3 kg/cm². To ensure proper working of these features, it is ensured that the pressure cooker is capable of bearing a pressure of atleast 6 kg/cm² so that the safety pressure releief device gets enough time for its working in case of any unwanted pressure build up.

- h) **Heat transfer & thermal conductivity:** The concept of heat transfer and thermal conductivity of materials is applicable to pressure cookers because it determines how efficiently heat is transferred from the heat source to the food. Materials with high thermal conductivity, such as copper or aluminum, are often used in the base of pressure cookers to ensure even and efficient heat distribution during cooking.
- i) **Convection:** The scientific concept used to ensure even heat distribution during cooking in a pressure cooker is convection. Convection occurs when heat is transferred through a fluid or gas, causing hot molecules to rise and cool ones to sink, creating a circular flow. In a pressure cooker, the design of the pot and the lid promote the circulation of hot air, ensuring that heat is distributed evenly throughout the cooking process.
- j) **Prevention of lid removal under pressure:** The removal of the lid of a pressure cooker while it is still under pressure is prevented by a variety of safety features that are built into the cooker. One of the most important of these is the locking mechanism, which prevents the lid from being opened while the cooker is still pressurized.

In addition, pressure cookers are also equipped with pressure release valves that allow excess pressure to be safely released before the lid can be opened.



Ergonomics: The scientific concept behind the design of the handles and knobs of a pressure cooker is ergonomics. Ergonomics is the science of designing products and systems that are optimized for human use, taking into account factors such as comfort, safety, and efficiency. In the case of pressure cookers, the handles and knobs are designed to be comfortable to grip, even when the cooker is hot or under pressure.

They are also designed to be durable and safe to use, to minimize the risk of accidents or injuries. The shape, size, and placement of the handles and knobs are carefully considered to ensure that they are optimized for human use, making the pressure cooker more user-friendly and efficient.

Q. What Does a Pressure Cooker's pressure regulating device Do?

A. When pressure supersedes predetermined levels, the disc starts to lift and opens up an outlet for the excess pressure to escape.

When the pressure decreases, the force of the safety valve's spring pushes the disc back into place and closes the outlet.

Is it possible to cook with a pressure cooker if it has a broken safety valve?

Both yes and no.

No, it's not possible to cook in a pressure cooker with a missing safety valve. Without the valve, the pressure cooker will not be able to reach and maintain enough pressure to cook a meal. The absence of the valve opens up an escape route for steam, which would otherwise be trapped in the cooker.

Yes, it's possible to cook in a pressure cooker with a flawed, damaged or defective safety valve as long as the valve is still shut and intact. I can't stress enough how bad of an idea this is. If the valve is damaged and the cooker reaches pressure levels above predetermined limits, the valve may not be able to release the excess pressure – which will cause the cooker to explode. Superheated steam will fly from the exploded cooker and burn anything in its path.

6. Capacities

The nominal capacity of pressure cookers shall be from 1 to 24 litre and shall be expressed only in complete or half litre units. No negative tolerances shall be allowed on the nominal capacity.

The capacity of the pressure cooker shall be filled with water up to the brim of vent pipe. The volume of the water shall be measured with the help of a measuring jar. This shall give the full water capacity of the pressure cooker.

NOTE — If the capacity of a cooker is not in complete or half litre unit, its nominal capacity shall be marked as the nearest lower complete or half litre units. For example, in the case of a cooker having a capacity of 4.9 litre, the nominal capacity to be marked shall be 4.5 litre.



7. Materials

All components of the cookers including the vessel, gasket, pressure regulating device and internal accessories which come in contact with food or steam shall be made of the materials satisfying the following requirements:

- a) They shall not discolour the food or spoil the flavour or odour of the cooked food in the cooker or cause it to become toxic; and
- b) They shall not be affected by contact with foods cooked in the cooker in such a way that the operational efficiency or safety of the cooker is impaired.



8. Safety precautions for using a pressure cooker

Safety precautions for using a pressure cooker include ensuring the lid is properly secured, avoiding overfilling the pot, and releasing pressure slowly after cooking. Some are listed below:

- a) Use the right amount of liquid in the pressure cooker. Too little liquid can cause the pressure cooker to boil dry, which can be dangerous.
- b) Never exceed the maximum fill line in the pressure cooker. Overfilling the pressure cooker can cause the food to block the pressure release valve, making it difficult to regulate the pressure.
- c) Always use a timer when cooking with a pressure cooker. Cooking for too long can cause the food to become overcooked and the pressure cooker to become over-pressurized.
- d) Never try to open the pressure cooker when it is still under pressure. Wait until the pressure has been released and the pressure indicator has dropped before opening the lid.
- e) If the pressure release valve becomes clogged, do not try to unclog it yourself. Release the pressure by running cold water over the pressure cooker or by using the manual release valve if one is available.



9. Some interesting facts about pressure cookers

- a) Pressure cookers were invented in the 17th century by French physicist Denis Papin, who was inspired by the idea of using steam to cook food quickly.
- b) Pressure cookers were first introduced to the United States in the early 1900s, and quickly became popular as a convenient and efficient way to cook food.
- c) They were once used as bombs during World War II.
- d) Pressure cookers are not only useful for cooking food, but also for sterilizing medical instruments, canning foods, and even making soap.
- e) Some modern pressure cookers are equipped with smart technology, such as Bluetooth connectivity and mobile apps, that allow users to control the cooker from their smartphone.
- f) In recent years, pressure cookers have become popular in the world of molecular gastronomy, where chefs use them to create new and innovative dishes by manipulating the cooking environment and pressure inside the cooker.



10. Questions and Answers

1. What scientific concept is used to determine the materials used in the base of a pressure cooker?

- a) Electrical conductivity
- b) Thermal conductivity
- c) Magnetic permeability
- d) Refractive index

Answer: b) Thermal conductivity

2. What is the purpose of the gasket or sealing ring in a pressure cooker?

- a) To keep the lid securely in place
- b) To prevent steam from escaping
- c) To regulate the pressure inside the cooker
- d) To evenly distribute heat throughout the cooker

Answer: b) To prevent steam from escaping

3. What is the main purpose of a pressure cooker?

- a) To cook food quickly
- b) To enhance the flavor of food
- c) To make food more tender
- d) To reduce the nutrient content of food

Answer: a) To cook food quickly

4. What happens if the pressure inside a pressure cooker exceeds the maximum pressure limit?

- a) The food will be overcooked
- b) The cooker will explode
- c) The cooker will stop functioning
- d) The food will not be cooked at all

Answer: b) The cooker will explode

5. Which of the following is an advantage of using a pressure cooker for cooking?

- a) It requires a lot of water
- b) It is time-consuming
- c) It preserves the nutrients in food
- d) It does not require electricity or gas

Answer: c) It preserves the nutrients in food



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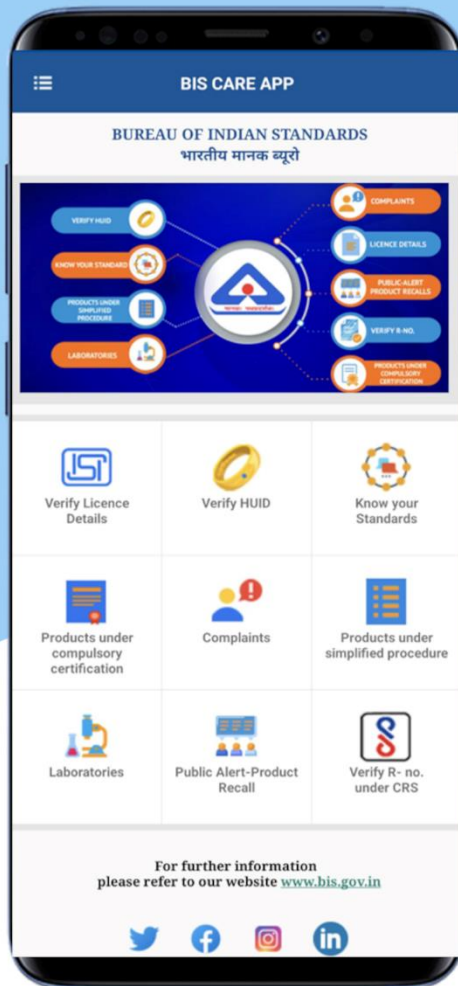
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