

**Question 1:**

Some of the most profound statements on the nature of science have come from Albert Einstein, one of the greatest scientists of all time. What do you think did Einstein mean when he said: “The most incomprehensible thing about the world is that it is comprehensible”?

**Solution 1:**

The Physical world around us is full of different complex natural phenomena so the world is in-comprehensible. But with the help of study and observations it has been found that all these phenomena are based on some basic physical laws and so it is comprehensible.

**Question 2:**

“Every great physical theory starts as a heresy and ends as a dogma”. Give some examples from the history of science of the validity of this incisive remark.

**Solution 2:**

The statement above is true. Validity of this incisive remark can be validated from the example of moment of inertia. It states that the moment of inertia of a body depends on its energy. But according to Einstein's mass-energy relation , energy depends on the speed of the body.

**Question 3:**

Politics is the art of the possible”. Similarly, "Science is the art of the soluble”. Explain this beautiful aphorism on the nature and practice of science.

**Solution 3:**

It is well known that to win over votes, politicians would make anything and everything possible even when they are least sure of the same. and in Science the various natural phenomena can be explained in terms of some basic laws. So as 'Politics is the art of possible' similarly 'Science is the art of the soluble.

**Question 4:**

Though India now has a large base in science and technology, which is fast expanding, it is still a long way from realizing its potential of becoming a world leader in science. Name some important factors, which in your view have hindered the advancement of science in India.

**Solution 4:**

Some important factors in our view which have hindered the advancement of science in India

are:

- Proper funds are not arranged for the development of research work and laboratories. The labs and scientific instruments are very old and outdated.
- Most of the people in India are uneducated and highly traditional. They don't understand the importance of Science.
- There is no proper employment opportunity for the science educated person in India.
- There are no proper facilities for science education in schools and colleges in India.

### Question 5:

No physicist has ever “seen” an electron. Yet, all physicists believe in the existence of electrons. An intelligent but superstitious man advances this analogy to argue that ‘ghosts’ exist even though no one has ‘seen’ one. How will you refute his argument?

### Solution 5:

No physicist has ever seen an atom but there are practical evidences which prove the presence of electron. Their size is so small, even powerful microscopes find it difficult to measure their sizes. But still its effects could be tested

On the other end there is no phenomena which can be explained on the basis of existence of ghosts.

### Question 6:

The shells of crabs found around a particular coastal location in Japan seem mostly to resemble the legendary face of a Samurai. Given below are two explanations of this observed fact. Which of these strikes you as a scientific explanation?

- a) A tragic sea accident several centuries ago drowned a young Samurai. As a tribute to his bravery, nature through its inscrutable ways immortalized his face by imprinting it on the crab shells in that area.
- b) After the sea tragedy, fishermen in that area, in a gesture of honor to their dead hero, let free any crab shell caught by them which accidentally had a shape resembling the face of a Samurai. Consequently, the particular shape of the crab shell survived longer and therefore in course of time the shape was genetically propagated. This is an example of evolution by artificial selection.
- c) [Note : This interesting illustration taken from Carl Sagan’s ‘The Cosmos’ highlights the fact that often strange and inexplicable facts which on the first sight appear ‘supernatural’

actually turn out to have simple scientific explanations. Try to think out other examples of this kind].

### **Solution 6:**

Explanation (b) is correct is a scientific explanation of the observed fact

### **Question 7:**

The industrial revolution in England and Western Europe more than two centuries ago was triggered by some key scientific and technological advances. What were these advances ?

### **Solution 7:**

More than two centuries ago, England and Western Europe invented steam engine, electricity, theory of gravitation and the explosives. Steam engines helped them in the field of heat and thermodynamics, theory of gravitation in field of motion and making guns and                      These progresses brought about industrial revolution in England and Western Europe.

### **Question 8:**

It is often said that the world is witnessing now a second industrial revolution, which will transform the society as radically as did the first. List some key contemporary areas of science and technology, which are responsible for this revolution.

### **Solution 8:**

Some of the key contemporary areas of science and technology which may transform the society radically are:

- Development of super-fast computers
- Internet and tremendous advancement in information technology
- Development in Biotechnology
- Development of super-conducting materials at room temperature
- Development of robots.

### **Question 9:**

Write in about 1000 words a fiction piece based on your speculation on the science and technology of the twenty-second century.

### **Solution 9:**

Imagine you alongwith your friends are in a spaceship which is moving towards Mars. The body of the spaceship is made of a specially designed matter which becomes more harder as its

temperature increases. The spaceship is using nuclear fuel and there are three nuclear power plants in a spaceship. Two of them work alternatively and the third is for emergency. The speed of the spaceship is very high and all of you are very happy. The energy produced in power plants is converted into electric energy which runs the motors of the spaceship. You along with your friends reach safely on Mars, collect data, take photographs and then return to the Earth. On the return journey, the spaceship collides with an object in the space due to which two power plants stop to work. Now, only one power plant is working and due to overheating its efficiency is decreasing continuously. You and your friends try to reduce the temperature of the power plant by flowing air in the plant and try to repair the fuse of the other power plants. Finally, fuse of one other plant is repaired and start to work before the first plant crosses the danger limit of an excess of temperature. Finally, you and your friends return safely to Earth

**Question 10:** Attempt to formulate your ‘moral’ views on the practice of science. Imagine yourself stumbling upon a discovery, which has great academic interest but is certain to have nothing but dangerous consequences for the human society. How, if at all, will you resolve your dilemma?

**Solution 10:**

In our view a type of discovery which is of great academic interest but harmful for human society should not be made public because Science is for the society, society is not for science.

**Question 11:**

Science, like any knowledge, can be put to good or bad use, depending on the user. Given below are some of the applications of science. Formulate your views on whether the particular application is good, bad or something that cannot be so clearly categorized:

- (a) Mass vaccination against small pox to curb and finally eradicate this disease from the population. (This has already been successfully done in India).
- (b) Television for eradication of illiteracy and for mass communication of news and ideas.
- (c) Prenatal sex determination
- (d) Computers for increase in work efficiency
- (e) Putting artificial satellites into orbits around the Earth
- (f) Development of nuclear weapons
- (g) Development of new and powerful techniques of chemical and biological warfare.
- (h) Purification of water for drinking
- (i) Plastic surgery
- (j) Cloning

**Solution 11:**

- (k) Good
- (l) Good
- (m) Bad
- (n) Good
- (o) Good
- (p) Bad
- (q) Bad
- (r) Good
- (s) Good
- (t) Good

**Question 12:**

India has had a long and unbroken tradition of great scholarship - in mathematics, astronomy, linguistics, logic and ethics. Yet, in parallel with this, several superstitious and obscurantist attitudes and practices flourished in our society and unfortunately continue even today - among many educated people too. How will you use your knowledge of science to develop strategies to counter these attitudes?

**Solution 12:**

Poverty and illiteracy are the two major factors which make people superstitious in India. So to remove the superstitious and obscurantist attitude we have to first overcome these factors. Everybody should be educated, so that one can have scientific attitude. Knowledge of science can be put to use to prove people's superstitious wrong by showing them the scientific logic behind everything happening in our world.

**Question 13:**

Though the law gives women equal status in India, many people hold unscientific views on a woman's innate nature, capacity and intelligence, and in practice give them a secondary status and role. Demolish this view using scientific arguments, and by quoting examples of great women in science and other spheres; and persuade yourself and others that, given equal opportunity, women are on par with men.

**Solution 13:**

Some people in our society have the view that women do not have the innate nature, capacity and intelligence.

To demolish this view there are many examples of women who have proven their abilities in

Science and other fields.

Madam Curie, Mother Teresa, Indira Gandhi, Marget Thatcher, Rani Laxmi Bai, Florence Nightingale are some examples. So in this era women are definitely not behind man in any field.

#### Question 14:

“It is more important to have beauty in the equations of physics than to have them agree with experiments”. The great British physicist P. A. M. Dirac held this view. Criticize this statement. Look out for some equations and results in this book which strike you as beautiful.

#### Solution 14:

An equation which agrees with experiment must also be simple and hence beautiful. We have some simple and beautiful equations in Physics such as

$$E = mc^2 \text{ (Energy of light)}$$

$$E = h\nu \text{ (Energy of a photon)}$$

$$KE = 1/2mv^2 \text{ (Kinetic energy of a moving particle)}$$

$$PE = mgh \text{ (Potential energy of a body at rest)}$$

$$W = F.d \text{ (Work done)}$$

All have the same dimensions. One experiment shows dependency of energy on speed, the other shows dependency on frequency & displacement.

That's the beauty of equations in Physics coming from different experiments.

**Question 15:** Though the statement quoted above may be disputed, most physicists do have a feeling that the great laws of physics are at once simple and beautiful. Some of the notable physicists, besides Dirac, who have articulated this feeling, are : Einstein, Bohr, Heisenberg, Chandrasekhar and Feynman. You are urged to make special efforts to get access to the general books and writings by these and other great masters of physics. (See the Bibliography at the end of this book.) Their writings are truly inspiring !

**Solution 15:** It is absolutely true that great laws of physics are simple and beautiful. Few examples are given below.

- (i) Einstein's mass-energy equivalence relation  $E = mc^2$  is simple and beautiful.
- (ii) According to Max Planck's quantum, the energy of a photon is  $E = h\nu$ , is also a simple and beautiful equation.
- (iii) De-Broglie wavelength associated with a particle of mass  $m$  is given by  $\lambda = h/mv$ . It

is also a simple and beautiful equation.

**Question 16:** Textbooks on science may give you a wrong impression that studying science is dry and all too serious and that scientists are absent-minded introverts who never laugh or grin. This image of science and scientists is patently false. Scientists, like any other group of humans, have their share of humorists, and many have led their lives with a great sense of fun and adventure, even as they seriously pursued their scientific work. Two great physicists of this genre are Gamow and Feynman. You will enjoy reading their books listed in the Bibliography.

**Solution 16:** It is true that scientists like any other group of humans have their share of humorists. Two great physicists of this genre are Gamow and Feynman. Few other scientists whose name can be added in this list are CV Raman, Einstein, Bohr, former Indian president. APJ Abdul Kalam etc.

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