**1.1 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"?**

**Ans:**

The complex physical world involves different orders of magnitudes in space, time and mass. Despite this, nearly all physical phenomena can be expressed in terms of a few basic laws. By this view, Einstein's statement, "The most incomprehensible thing about the world is that it is comprehensible", becomes very clear.

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

**Ans:**
One of the general observations in our daily life is that light travels in a straight line. When Huygens propounded his wave theory, it was a heresy. However, soon it became dogma as interference patterns, refraction, etc., could be successfully explained on the basis of wave theory.
It was believed that light was only energy, but when the photoelectric effect was discovered, it was proposed that light had a particle nature, too; this was greatly debated and treated as heresy. However, Einstein finally proved it with his quantum theory of light. Henceforth, it has been treated as a dogma.

**1.3 "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**

**Ans:**

Politicians make anything and everything possible to win votes. Science is a systematic study of observation. Scientists and researchers study these observations and then work out certain laws from them. There is a multitude of natural phenomena taking place in this universe, and all of them can be explained in terms of some basic laws. For e.g., F = mg is true for you and me and also for a star. Thus, in science, we see that various phenomena are related, and they are soluble and can be explained with similar or the same law. This goes on to justify that science is the art of the soluble, just as politics is the art of the possible.

**1.4 Though India now has a large base in science and technology, which is fast expanding, it is still a long way from realising 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.**

**Ans:**
Here are some important factors that have obstructed the growth of science in India:

- Lack of infrastructure and funds for quality research work in science.
- Poor pay scales and other facilities for scientists as compared to administrators.
- Science education is neither properly oriented nor directed. It needs specific directions depending on our requirements. Industrialists are the actual consumers of new technology and research. The industrialists of this country have little confidence in the ability of Indian scientists. There is practically no coordination between the researchers and the industrialists.
- Rural-based science education is nearly non-existent, so the majority of the population is deprived of the benefits of advancements in technology and science.

**1.5 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?**

**Ans:**

Even though an electron has never been 'seen', its effects have been observed, and its practical evidence has been tested and proved, for e.g., electricity. However, regarding spirits and ghosts, even though there are many claims and sightings, standardised scientific reading and evidence have never been observed or successfully tested. Thus, we really cannot state with a cent per cent surety that they exist.

**1.6 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, immortalised 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 honour to their dead hero, set free any crab shell caught by them that accidentally had a shape resembling the face of a Samurai. Consequently, the particular shape of the crab shell survived longer and therefore, in the course of time, the shape was genetically propagated. This is an example of evolution by artificial selection. [Note: This interesting illustration is taken from Carl Sagan's 'The Cosmos' and highlights the fact that often strange and inexplicable facts that at first sight appear 'supernatural' actually turn out to have simple scientific explanations. Try to think of other examples of this kind].**

**Ans:**

**(a)** More logical and scientific.

**1.7 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?**

**Ans:**

The rise of modern science and the industrial revolution are closely connected to each other. The other profound impact effect that Science had on the development of modern science is that the application of Science to solve industrial problems garnered public support and interest in Science.

Some of the key discoveries and their uses are listed below:

- The application of thermodynamics and heat to form the steam engine are some of the key advances in Science and technology during the period of the industrial revolution.
- The implementation and discovery of electricity helped in the invention of motors and dynamos. Likewise, the study of gravitation led to the study of motion, which further led to the development of cannons and guns. This invention gave power to the hands of western countries, and they ruled over the rest of the world.
- The discovery of explosives not only helped the army but also helped in mineral exploration.

These were a few examples of scientific breakthroughs that helped England and Europe to have their prominent positions in the world.

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

**Ans:**

Some key contemporary areas of technology and Science, which are chiefly responsible for a new industrial revolution taking place now and likely to take place in the near future, are

- Artificial intelligence

- Design of super-fast computers
- Biotechnology
- Development of superconducting materials at room temperature
- Advancements in the field of

→ Electronics

→ Information technology

→ Nanotechnology

→ Developments in the field of Space Sciences

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

**Ans:**
In the 22nd century, humans will be able to create wormholes allowing people to travel to distant places in the universe. We will be in contact with aliens and have established human settlements outside the earth as well. With advancements in quantum Physics, we shall be more aware and understanding of the true nature of our universe and existence. Our technology will not pollute and degrade the earth. Artificial intelligence and humans could have some clashes.

**1.10 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 human society. How, if at all, will you resolve your dilemma?**

**Ans:**
A scientist works for the truth. Every scientific discovery reveals a certain truth about nature. So, any discovery, bad or good for humankind, must be made public.
But with that being said, we cannot afford to be blind to the consequences. Before disclosing it, we must ascertain the degree of good or bad consequences it will have. If we know that a certain discovery has nothing but dangerous consequences to offer to the mass, the discovery is best kept limited only to the knowledge of the scientist and researchers working on it. This way, the discovery can help societies in the long run without completely destroying them now.

**1.11 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 categorised.**

**(a) Mass vaccination against smallpox to curb and finally eradicate this disease from the population. (This has already been successfully done in India.)**
**(b) Television for the eradication of illiteracy and mass communication of news and ideas.**
**(c) Prenatal sex determination.**
**(d) Computers for the 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**

**Ans:**

**(a)** Good. Mass vaccination helped eradicate the dreaded diseases from the Earth.

**(b)** Good. Television helps in the literacy campaign and is an effective method of mass communication and entertainment.

**(c)** Bad. Prenatal sex determination is considered bad because it gives rise to the practice of abortion in the case of the female foetus.

**(d)** Good. Computer increases work efficiency.

**(e)** Good. Artificial satellites help in the worldwide communication process.

**(f)** Bad. Nuclear weapons, if misused, may cause the mass destruction of humankind.

**(g)** Bad. These techniques may be misused for destructive purposes.

**(h)** Good. Purified water improves the health of people.

**(i)** Neither good nor bad. Plastic surgery is something which can't be classified as either good or bad because it helps to remove a certain types of deformations in needy persons.

**(j)** Bad. Cloning has the potential to ruin the normal family life of human society.

**1.12 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?**

**Ans:**

In order to popularise scientific explanations of everyday phenomena, mass media like

→ Internet

→ Newspapers

→ Television

→ Radio

should be used. Knowledge of science should be educated to the masses so that they learn about the real causes of phenomena, allowing their superstitious beliefs to wash away.

**1.13 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.**

**Ans:**

No difference is noticed in the ability of women and men as far as work, intelligence, decision making is concerned. Nature makes little difference in the anatomy and feeling of men and women. The nutrition content of prenatal and postnatal diets contributes a lot towards the development of the human body. If equal opportunities are provided to both women and men, then the female mind and body will be just as efficient as a man's. The list of great women who have excelled in their respective fields is enormous. Names of

→ Madame Curie

→ Indira Gandhi

→ Florence Nightingale

→ Margaret Thatcher

→ Mother Teresa

→ Sarojini Naidu

→ Kalpana Chawla

been taken from fields varying from Sociology to Science, and they are very well-known for their contribution to the world. Reflecting on the contribution being made to each and every sphere of life in the country, it can be positively debated that women are no less essential to society than men.

**1.14 "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. Criticise this statement. Look out for some equations and results in this book which strike you as beautiful.**

**Ans:**

Dirac's belief holds true. Equations which represent entire concepts and hold up against experimental results are automatically simple, small and symmetrical, making them truly beautiful. Some examples of beautiful equations are:
$E = mc^2$, E = hv, F = mg, P.E = mgh