Q.1) Fission reactors can be divided roughly into two classes, depending on the energy of the neutrons that sustain the fission chain reaction: thermal reactors and fast neutron reactors. Consider the following statements.

1. Thermal reactors (the most common type of nuclear reactor) use slowed or thermal neutrons to keep up the fission of their fuel.
2. Fast neutron reactors use fast neutrons to cause fission in their fuel.
3. Breeder reactors operate with thermal neutrons.

Which of the above statements is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) All the above

Q.1) Solution (a)

Thermal reactors (the most common type of nuclear reactor) **use slowed or thermal neutrons to keep up the fission of their fuel.** These contain neutron moderator materials that slow neutrons. The moderator is often also the coolant, usually water under high pressure.

Fast neutron reactors use fast neutrons to cause fission in their fuel. They do not have a neutron moderator and use less-moderating coolants.

Boiling water reactors (BWR), Pressurized water reactors (PWR) and Heavy water reactors (HWR) operate **with thermal neutrons** [moderators used].

Breeder reactors operate with **fast neutrons [moderators are not required].**

Do you know?

- The light-water reactor (LWR) is a type of thermal-neutron reactor that uses NORMAL WATER, as opposed to heavy water, as both its coolant and neutron moderator.

THINK!

- Pressurized Water reactor
- Boiling water reactor

Q.2) Consider the following statements.

1. The Nuclear Fuel Complex manufactures fuel assemblies for pressurized heavy water reactors only.
2. Heavy Water Board not only produces heavy water but also undertakes the task of boron enrichment.

Which of the above statements is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) None

Q.2) Solution (b)

The Nuclear Fuel Complex at Hyderabad manufactures fuel assemblies for **pressurized heavy water reactors, boiling water reactors and fast breeder reactor.**

The Heavy Water Board has contributed successfully to the first stage of Nuclear Power Programme by producing heavy water for all Pressurized Heavy Water Reactors in a cost-effective manner enabling the department to provide nuclear power at an affordable cost to common man.

In consonance with the material input required for second stage of NPP based on FBRs, HWB, with its decades of experience of handling isotope separation process, took up development, demonstration and deployment of indigenous technologies for production of enriched boron. HWB has now acquired comprehensive capability in this area achieving enrichment levels beyond 95 per cent in multiple chemical forms. **To support the second stage of NPP, HWB has successfully delivered the entire quantity of enriched boron for the 1st core of PFBR.**

Do you know?

- Sodium is another important input for FBRs, used as coolant in the reactor. Networking with the Indian R&D organizations, HWB has developed indigenous and safer closed electrolytic cell technology for production of nuclear grade sodium. Successively larger size cells are tested with the ultimate intent of an industrial scale set up.

THINK!

- Nuclear Power Generation Programme

Q.3) Consider the following statements about The Indian Nuclear Power Programme.

1. In the first stage of the programme, natural uranium fueled pressurized heavy water reactors (PHWR) produce electricity while generating plutonium-239 as by-product.
2. The Stage II Fast Breeder Reactors are designed to "breed" more fuel than they consume.
3. The Stage III reactor or an Advanced nuclear power system involves a self-sustaining series of thorium-232-uranium-233 fueled reactors.

Which of the above statements is/are correct?

a) 1 and 2 only
b) 2 and 3 only
c) 3 only
d) All the above

Q.3) Solution (d)

In the first stage of the programme, natural uranium fuelled pressurised heavy water reactors (PHWR) produce electricity while **generating plutonium-239 as by-product.**

In the second stage, fast breeder reactors (FBRs) would use a mixed oxide (MOX) fuel made from plutonium-239, recovered by reprocessing spent fuel from the first stage, and natural uranium. In FBRs, plutonium-239 undergoes fission to produce energy, while the uranium-238 present in the mixed oxide fuel transmutes to additional plutonium-239. **Thus, the Stage II FBRs are designed to "breed" more fuel than they consume.** Once the inventory of plutonium-239 is built up thorium can be introduced as a blanket material in the reactor and transmuted to uranium-233 for use in the third stage.

A Stage III reactor or an Advanced nuclear power system involves a self-sustaining series of thorium-232-uranium-233 fuelled reactors. This would be a thermal breeder reactor, which in principle can be refueled – after its initial fuel charge – using only naturally occurring thorium. According to the three-stage programme, Indian nuclear energy could grow to about 10 GW through PHWRs fueled by domestic uranium, and the growth above that would have to come from FBRs till about 50GW. **The third stage is to be deployed only after this capacity has been achieved.**

Do you know?

- **Doubling time** refers to the time required to extract as output, double the amount of fissile fuel, which was fed as input into the breeder reactors. This metric is critical for understanding the time durations that are unavoidable while transitioning from the

second stage to the third stage of Bhabha's plan, because building up a sufficiently large fissile stock is essential to the large deployment of the third stage.

THINK!

- Advanced Heavy Water Reactor.

Q.4) Consider the following statements about applications of Nuclear science in agriculture.

1. Nitrogen-15 is used to assess soil quality.
2. Carbon-13 is used to know about how efficiently the crops use the nutrients.

Which of the above statements is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) None

Q.4) Solution (d)

To confirm the effectiveness of the integrated crop-livestock approach, scientists use nuclear techniques involving the nitrogen-15 and carbon-13 isotopes. Nitrogen-15 and carbon-13 are stable isotopes, and scientists are able to track these isotopes to measure, for example, how efficiently crops consume nitrogen.

Scientists do this by introducing samples of nitrogen-15 into the soil around the crops. Over several months they observe how much nitrogen-15 is absorbed by the plants. **This provides crucial information about how efficiently the crops use the nutrients.**

Similarly, scientists add samples of carbon-13 to the soil to assess soil quality. As nutrients are recycled in the soil, organic carbon content goes up. Scientists can measure the changes in organic carbon content by tracking the carbon-13.

Do you know?

- Stereotactic surgery or stereotaxy is a minimally invasive form of surgical intervention which makes use of a three-dimensional coordinate system to locate small targets inside the body and to perform on them some action such as ablation, biopsy, lesion, injection, stimulation, implantation, radiosurgery (SRS), etc.

- A robot based frameless stereotactic system is developed at BARC for performing neurosurgery which has accuracy and patient comfort level comparable to frame-based system.

THINK!

- Applications of Nuclear Science in Medicine.

(Source https://www.iaea.org/newscenter/news/integrated-farming-finds-success-in-india-with-help-of-nuclear-science)

Q.5) Consider the following statements.

1. Moderators slow down neutrons.
2. Moderators are composed of chemical elements such as boron, silver, indium and cadmium.
3. Control Rods absorb neutrons.

Which of the above statements is/are correct?

a) 1 and 2 only
b) 1 and 3 only
c) 3 only
d) All the above

Q.5) Solution (b)

A neutron moderator is a medium that reduces the speed of fast neutrons, thereby turning them into thermal neutrons capable of sustaining a nuclear chain reaction.

Commonly-used moderators include regular (light) water (in 74.8% of the world's reactors), solid graphite (20% of reactors), heavy water (5% of reactors).

The power output of the reactor is adjusted by controlling how many neutrons are able to create more fission. Control rods that are made of a neutron poison are used to absorb neutrons.

Control rods are composed of chemical elements such as boron, silver, indium and cadmium.

Do you know?

- A critical mass is the smallest amount of fissile material needed for a sustained nuclear chain reaction.

THINK!

- Neutron poison

Q.6) Which of the following are the types of energy that can be harnessed from sea/ocean?

1. Tidal energy
2. Marine current power
3. Ocean thermal energy
4. Osmotic power

Which of the above statements is/are correct?

a) 1, 2 and 3 only
b) 1 and 2 only
c) 1 and 3 only
d) All the above

Q.6) Solution (d)

Tidal Power. Quantitatively different from wave power, tidal generation makes use of moving masses of water as a whole. Although the technology is known, this form of renewable energy is not yet in widespread use due to relatively high cost and limited places with sufficiently strong tides, but experts believe it has the potential to be one of the most useful forms of sea-based renewable power, especially now the next generation of technology is coming through.

Marine current power. This form of renewable energy comes from harnessing of the kinetic energy of marine currents that can be found covering large swathes of the oceans, the Gulf Stream that keeps the UK warmer than Siberia is one such current. Marine current power is not widely in use at the moment but has great potential for the future, since marine currents are more reliable and regular than wind and solar energy.

Ocean thermal energy. Known as OTEC for short, this form of renewable energy exploits the difference between the cold water of the deep sea, and the warmer shallows to power a heat engine and produce electricity. Such temperature differentials, which increase the efficiency of a heat engine the greater they are, are at their best in the tropical oceans, with OTEC possessing the potential to offer energy levels up to 100 times greater than forms of

energy generation like wave or tidal power. They can also operate continuously and are not dependent on the weather.

Osmotic power. This is the most controversial of all the forms of sea-based renewable energy options. It works due to the difference in salt levels between sea and river water, using osmosis to create energy, according to laboratory tests which are now being converted to practical use in the Netherlands and Norway. However, there are serious concerns over the environmental impact of discharging large quantities of brackish fresh water into the sea, and vice versa. Osmotic power may well be renewable, but it sure isn't green!

Do you know?

- **Wave power.** Perhaps the best known of all forms of renewable energy from the sea, wave power involves harnessing the energy created by the ocean's surface waves to generate electricity, desalinate water or pump it into reservoirs.
- The machines used to exploit wave power are known as **wave energy converters (WECs),** which can be placed on the seashore itself, just off the shore and further out to sea. Once the wave energy has been captured at source, the power generated needs to be transferred to its point of use or connected to the national grid with power lines.

THINK!

- Geothermal energy.

Q.7) Which of the following best describes 'Uranium enrichment'?

a) Increasing the concentration of U-235 isotope in the fuel.
b) Increasing the concentration of U-238 isotope in the fuel
c) Increasing the concentration of thorium in the fuel.
d) All the above

Q.7) Solution (a)

The nuclear fuel used in a nuclear reactor needs to have a higher concentration of the U-235 isotope than that which exists in natural uranium ore. **U-235 when concentrated (or "enriched") is fissionable in light-water reactors (the most common reactor design in the USA).**

Do you know?

- When uranium is mined, it consists of approximately 99.3% uranium-238 (U238), 0.7% uranium-235 (U235), and < 0.01% uranium-234 (U234).

THINK!

- Energy from Bio-resources.

Q.8) In recent times, there is a rise in the exploration works of the shale gas. Which of the following statements are correct regarding 'Shale Gas'?

1. It is predominantly Methane trapped in Shale rock formations.
2. The source of formation of shale gas is somewhere else and it travels through the permeable shale rocks and gets trapped in the pores.
3. Hydraulic Fracturing is the technique used for extraction of Shale gas.

Which of the above statements are correct?

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) All of the above

Q.8) Solution (c)

Shale Gas

Shale gas refers to natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas.

Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce.

Hydraulic Fracturing

Hydraulic fracturing (commonly called "fracking" or "hydrofracking") is a technique in which water, chemicals, and sand are pumped into the well to unlock the hydrocarbons trapped in shale formations by opening cracks (fractures) in the rock and allowing natural gas to flow from the shale into the well. When used in conjunction with horizontal drilling, hydraulic fracturing enables gas producers to extract shale gas at reasonable cost. Without these techniques, natural gas does not flow to the well rapidly, and commercial quantities cannot be produced from shale.

Shale Gas vs. Conventional Gas

Conventional gas reservoirs are created when natural gas migrates toward the Earth's surface from an organic-rich source formation into highly permeable reservoir rock, where it is trapped by an overlying layer of impermeable rock. In contrast, shale gas resources form within the organic-rich shale source rock. The low permeability of the shale greatly inhibits the gas from migrating to more permeable reservoir rocks. Without horizontal drilling and hydraulic fracturing, shale gas production would not be economically feasible because the natural gas would not flow from the formation at high enough rates to justify the cost of drilling.

Q.9) Consider the following statements regarding hydrogen fuel cells:

1. It is a clean energy device which converts chemical energy into electrical energy.
2. The byproduct of hydrogen fuel cell is Carbon dioxide.

Which of the above statements is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q.9) Solution (a)

Hydrogen Fuel cells

A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge.

Hydrogen is high in energy, yet an engine that burns pure hydrogen produces almost no pollution. NASA has used liquid hydrogen since the 1970s to propel the space shuttle and other rockets into orbit. Hydrogen fuel cells power the shuttle's electrical systems, producing a clean byproduct - pure water, which the crew drinks.

Fuel cells are a promising technology for use as a source of heat and electricity for buildings, and as an electrical power source for electric motors propelling vehicles. Fuel cells operate best on pure hydrogen. But fuels like natural gas, methanol, or even gasoline can be reformed to produce the hydrogen required for fuel cells.

Think

- Extraction of Hydrogen
- Reforming

Q.10) Lithium air battery is set to revolutionalise the feasibility and efficiency of electric vehicles. Which of the following statements are correct regarding Lithium air battery?

1. It produces much more energy as compared to Lithium ion battery.
2. In this process, Lithium reacts with oxygen to produce energy.
3. One exhausted, lithium air battery cannot be recharged.

Select the code from following:

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) All of the above

Q.10) Solution (a)

Lithium Air batteries

Li-O2 batteries have great potential, providing up to five times more energy than the lithium-ion batteries. It may even be possible to have a rechargeable battery of up to 1,000 watt-hours per kilogram, and all it will need is oxygen. Such a battery could be used to fuel electric automobiles and store the electricity generated by solar panels and wind turbines.

Li-O2 batteries consist of a lithium metal anode whose atoms supply the electrons for the electric circuit when it is being used. The residual Li+ ions then migrate across an electrolyte to the cathode where the incoming electrons from the circuit attach to oxygen (O2) from the atmosphere, forming peroxide ions, O22–. The overall chemical process is:

$2Li + O_2 \rightarrow Li_2O_2$.

When the battery is recharged, the reverse reaction occurs. Lithium metal atoms and O2 are regenerated, with the oxygen being retained in a closed system or supplied anew in an open system. Although the chemistry seems simple, there are hurdles to be overcome.

One obvious problem with lithium-air batteries is lithium itself. This is a reactive metal and yet it needs to be in contact with an electrolyte with which it must not react. Nor must its ions react with the peroxide ions that are formed.

The cathode, too, has its problems. There has to be easy diffusion of oxygen from the air into this so it has to be porous and yet not allow H2O and CO2 to gain access as these will react to form lithium hydroxide (LiOH) and lithium carbonate (Li2CO3), both of which will not regenerate the lithium when the battery is recharged. An oxygen-differentiating polymer membrane is therefore needed to prevent these atmospheric gases gaining access.

Q.11) China has built the first solar powered Highway in the World. Which of the following statements regarding the Highway are correct?

1. It is a 1 km long road built in Jinan.
2. It is made of three layers with transparent concrete on the top, photovoltaic panel in the middle and insulation on the bottom.
3. The electricity generated will be used to power street lights and snow melting system on the road.

Select the code from following:

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) All of the above

Q.11) Solution (d)

Photovoltaic Highway

In Jinan, the capital of the northeastern Shandong province, China has built the world's first photovoltaic highway.

Extending for 1 km (0.6 miles), the stretch is made of three layers: transparent concrete on the top, photovoltaic panels in the middle, and insulation on the bottom. The area covered comes out to 5,875 square meters (63,200 sq ft).

China is billing the project as the world's first photovoltaic highway. In late 2016, a village in France opened what it claimed was the world's first solar-panel road, running for about the same length as China's new stretch though covering about half the area. In 2014, the Netherlands built a bike path embedded with solar panels.

The expressway could handle 10 times more pressure than the normal asphalt variety and in a year generate 1 million kWH of electricity, which will be used to power street lights and a

snow-melting system on the road. It's also designed to supply power to charging stations for electric vehicles, should those be added in the future.

Q.12) Which of the following statements correctly defines cold fusion?

a) It is fusion of two molten metals at room temperature.
b) It refers to a nuclear fusion reaction taking place at cryogenic temperatures.
c) It refers to nuclear fusion reaction taking place at room temperature.
d) It refers to nuclear fusion reaction in the stars.

Q.12) Solution (c)

Cold Fusion

Cold fusion is a hypothesized type of nuclear reaction that would occur at, or near, room temperature. This is compared with the "hot" fusion which takes place naturally within stars, under immense pressure and at temperatures of millions of degrees, and distinguished from muon-catalyzed fusion. There is currently no accepted theoretical model that would allow cold fusion to occur.

Think

- Difference between Fusion and Fission

Q.13) Which of the following statements are correct regarding different generations of bio – fuels?

1. First-generation biofuels are those which are made from feedstocks that can also be consumed as human food.
2. Second-generation fuels are produced from sustainable feedstock but these feedstocks are *not* normally used for human consumption.
3. Third generation fuels are obtained from algae.

Which of the above statements are correct?

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) All of the above

Q.13) Solution (d)

Biofuels are broken down into generations, so here we talk about the three main categories under which biofuels fall: First-, second-, and third-generation biofuels.

First Generation Biofuels

first-generation biofuels are those which are made from feedstocks that can also be consumed as human food. Whether it is sugar, starch, or vegetable oil, all of them are also human food products which makes them a first-generation fuel. The feedstocks that typically top this list for first-generation fuels include food crops like corn, sugarcane, sugar beet, wheat and sorghum.

Since they are easily extracted using conventional technology, they are also known as "conventional biofuels."

Most common first-generation biofuels include:

- Biodiesel - extraction of vegetable oils, with or without esterification, from the seeds of plants like soybean, rape (canola) and sunflower
- Ethanol - fermentation of simple sugars from sugar crops (sugarcane) or starch crops (corn, wheat)
- Biogas - anaerobic fermentation of organic waste and crop residues as energy crops

As with any industry, certain concerns (in this case related to cost and inefficiency) arose out of first-generation biofuel production. This evolution naturally led to second-generation biofuels.

Second Generation Biofuels

Like first-generation fuels, second-generation fuels are also produced from sustainable feedstock but, in this case, these feedstocks are *not* normally used for human consumption. That is, no second-generation feedstock is also a food crop, though certain food crops *may become* second-generation fuels if and when they're no longer useful for consumption.

Second-generation non-food feedstocks include woody crops and agricultural residues or waste, which are a little more difficult to extract. For this reason, advanced conversion technologies are needed in the process, which is also why second-generation biofuels are known as "advanced biofuels."

Second-generation technologies cover a wider range of biomass resources, from agriculture to forestry and waste materials. One well-known second-generation technology is called **lignocellulosic processing,** which uses forest materials.

The plus side of second-generation biofuels is the increased efficiency that uses the vast majority of the biomass feedstock which avoids the waste seen in first-generation bioful production.

Third Generation Biofuels

And now we come to the latest phase in the biofuels story: Third-generation. The key word in third-generation fuels is **algae.**

Algae's use in biofuel production was formerly relegated to second generation, but there exist some key differences that have warranted its own separate category. These are, mainly:

- Impressive diversity: Algae can produce such fuels as biodiesel, butanol, gasoline (petrol), ethanol, and even jet fuel!
- Higher yields: Algae is capable of producing much more than its other feedstock counterparts, and with lower resource inputs. By some estimates, algae can produce *10-fold* what even the best conventional feedstocks can generate.

The capital and operating costs of third-generation production are the highest. This sub-sector requires additional research and development to reach the point of being a sustainable method of consistent biofuel production on a commercial scale, but the potential is highly promising.

Q.14) A new concept of Space Based Solar Power (SBSP) is an idea under consideration to generate clean energy. Which of the following statements is/are correct regarding SBSP?

1. It is the concept of collecting solar power in outer space and distributing it to Earth.
2. Solar collectors will collect the light in space and beam it back to earth as microwaves.

Select the code from following:

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q.14) Solution (c)

Space-based solar power (SBSP)

Space-based solar power (SBSP) is the concept of collecting solar power in outer space and distributing it to Earth. Potential advantages of collecting solar energy in space include a higher collection rate and a longer collection period due to the lack of a diffusing atmosphere, and the possibility of placing a solar collector in an orbiting location where there is no night. A considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption.

Space-based solar power systems convert sunlight to microwaves outside the atmosphere, avoiding these losses and the downtime due to the Earth's rotation, but at great cost due to the expense of launching material into orbit. SBSP is considered a form of sustainable or green energy, renewable energy, and is occasionally considered among climate engineering proposals. It is attractive to those seeking large-scale solutions to anthropogenic climate change or fossil fuel depletion (such as peak oil).

Think

- Suntower concept

Q.15) Recently, an India-UK Joint Team won the Newton-Bhabha Fund for a project on –

a) Groundwater Arsenic Research in Ganga River Basin.
b) Tapping huge atomic mineral deposits in Kerala and to meet the energy needs of the country.
c) Mining precious metals trapped in magma on the seabed of the Indian Ocean.
d) Neutrino project in Theni district in Tamil Nadu.

Q.15) Solution (a)

An **India-UK Joint Team** won the Newton-Bhabha Fund for a project on **Groundwater Arsenic Research in Ganga River Basin**.

The Department of Science and Technology has undertaken the project with the Natural Environment Research Council, UK, to find solutions to the water challenges faced in the pervasively arsenic-affected Ganga River Basin.

Do you know?

The **Newton Bhabha Fund**, provided by the **British Council**, aims to bring together the UK and Indian scientific research and innovation sectors to find joint solutions to the challenges facing India in economic development and social welfare.

THINK!

- About Newton Bhabha Fund
- Why Arsenic Contamination is a high-profile problem in the Ganges Delta?

Q.16) Consider the below statements about neutrinos and identify the incorrect statement:

a) Neutrino is a tiny elementary particle, but it is not part of the atom.
b) Neutrino has a very tiny mass, no charge and spin half.
c) Natural neutrinos are harmful as they generate radiation and can cause diseases.
d) Neutrinos come from the sun (solar neutrinos) and other stars, cosmic rays that come from beyond the solar system, and from the Big Bang from which our Universe originated.

Q.16) Solution (c)

What are neutrinos?

Proton, neutron, and electron are tiny particles that make up atoms. The neutrino is also a **tiny elementary particle**, but it is **not part of the atom**. Such particles are also found to exist in nature. Neutrino has a **very tiny mass**, **no charge** and **spin half**. It interacts very weakly with other matter particles. So weakly that every second trillions of neutrinos fall on us and pass through our bodies unnoticed.

Neutrinos come from the sun (solar neutrinos) and other stars, cosmic rays that come from beyond the solar system, and from the Big Bang from which our Universe originated. They can also be produced in the lab.

Neutrinos come in three types or "flavours" – **electron neutrino**, **tau neutrino** and **muon neutrino.**

They can change from one flavor to another as they travel. This process is called **neutrino oscillation** and is an unusual quantum phenomenon.

Do you know?

- Neutrino oscillation was established by **Sudbury Neutrino Observatory, Canada**, and **Super-Kamiokande experiment in Japan**. They studied Solar neutrinos, atmospheric neutrinos and man-made neutrinos.
- The India-based Neutrino Observatory (INO) will study atmospheric neutrinos only. Solar neutrinos have much lower energy than the detector can detect.

- Natural neutrinos are **harmless**, everyone knows millions of neutrinos pass through us every moment. But artificially produced "collimated" beams of neutrinos generate radiation and can cause diseases.
- Here, "collimated" simply means the beams of neutrinos travel in parallel lines. And all that is called radiation, in scientific usage, is not harmful. Even visible light is a form of radiation.

Source: http://www.thehindu.com/sci-tech/science/what-are-neutrinos-and-how-are-they-detected/article23546887.ece

https://www.thehindubusinessline.com/news/science/all-you-want-to-know-about-the-neutrino-controversy/article23554745.ece

THINK!

- How are neutrinos detected? What's special about locating the INO in the South?
- Why study neutrinos?

Q.17) Recently, scientists have observed a new class of quantum matter created at low temperatures, in which a very large atom contains other ordinary atoms in the space between the nucleus and the electrons. The new state of matter is termed as –

a) Bose Fermion
b) Higgs Boson
c) Rydberg polarons
d) Telluride

Q.17) Solution (c)

Scientists have observed a new class of quantum matter at the very smallest scales in one of the coldest environments ever made. This discovery could pave the way for new technologies including innovations in superconductivity and other cutting-edge fields.

The researchers examined the behavior of matter on the atomic and subatomic scales - known as "quantum matter" - where a large number of particles interact with each other.

This latest discovery reveals a new state of quantum matter called a "**Rydberg polaron**," a relatively giant particle containing many atoms that behaves in some ways like a single massive particle.

Do you know?

About Rydberg polaron

It is an exotic state of matter, created at low temperatures, in which a very large atom contains other ordinary atoms in the space between the nucleus and the electrons.

For the formation of this atom, scientists had to combine two fields of atomic physics: Bose-Einstein condensates and Rydberg atoms.

- Rydberg atoms are formed by exciting a single atom into a high-energy state, in which the electron is very far from the nucleus.
- Bose-Einstein condensates are a state of matter that is produced at temperatures close to absolute zero.

What will be the use of these Rydberg polarons?

A particularly interesting implication is for cosmology. Our universe is believed to be filled with a mysterious 'dark matter' which exerts a gravitational force on other matter.

Some theories of dark matter postulate that it is a cosmic Bose Einstein Condensate, perhaps composed of an as-yet-unknown type of particle. If we are indeed living in an invisible all pervading Bose Einstein Condensate, this experiment can suggest ways to detect it.

Source: http://www.thehindu.com/sci-tech/science/a-new-state-of-matter-created/article22967209.ece

Q.18) Consider the following statements about Noble Gases and identify the incorrect statement:

a) All of the elements in Group Zero are noble gases.
b) The list includes helium, neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn).
c) They are called noble gases because they are so majestic that, in general, they don't react with anything.
d) Among all noble gases, Neon is the most reactive and xenon is very unreactive.

Q.18) Solution (d)

Noble Gases

The noble gases (historically also the inert gases) make up a group of chemical elements with similar properties; under standard conditions, they are all odorless, colorless,

monatomic gases with very low chemical reactivity. The six noble gases that occur naturally are helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and the radioactive radon (Rn).

They traditionally have been labeled Group 0 in the periodic table because for decades after their discovery it was believed that they could not bond to other atoms; that is, that their atoms could not combine with those of other elements to form chemical compounds.

Do you know?

Scientists have actually split the noble gases up into two groups, with krypton, xenon, and radon considered to be relatively reactive, and argon, neon, and helium considered to be very unreactive.

Actually noble gases are least reactive but among all, Xenon is the most reactive and Neon is least reactive.

THINK!

- Oganesson (Og)
- What causes noble gases to be unreactive?

Q.19) Match List I with List II and select the correct answer using the code given below the Lists:

List I	***List II***
Neutrino Observatory experiment names	***Countries***
1. Daya Bay Reactor	A) China
2. Hyper- Kamiokande	B) Japan
3. NOvA	C) US
4. JUNO	D) India

Choose the correct match from below options:

1-2-3-4

a) A-B-C-D
b) C-A-D-B
c) C-B-A-D
d) A-B-C-A

Q.19) Solution (d)

1st Chinese Neutrino Experiment: Daya Bay Reactor Neutrino Experiment (DBRNE)

2nd Chinese Neutrino Experiment: JUNO (Jiangmen Underground Neutrino Observatory)

Hyper- Kamiokande in Japan

NOvA in the U.S.

India's Neutrino Experiment - INO (Indian Neutrino Observatory) - located in Theni, TN (Near Bodhi Hills)

Do you know?

Who else has a neutrino facility?

- Underground: SNO, Canada, Kamioka in Japan and Gran Sasso, Italy.
- Underwater: Amundsen-Scott South Pole Station, Antarctica. Antares - under Mediterranean sea off coast of Toulon, France.

Q.20) Consider the following statements with regard to Atomic Energy Regulatory Board (AERB)

1. AERB is engaged in the development of nuclear power technology, applications of radiation technologies in the fields of agriculture, medicine, industry, and basic research.
2. The safety standards formulated by AERB are at par with those recommended by the international organisations such as the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP).

Which of the statements given above is/are correct?

a) 1 only
b) 2 only
c) Both 1 and 2
d) Neither 1 nor 2

Q.20) Solution (b)

Department of Atomic Energy (not AERB), established in 1954 is engaged in the development of nuclear power technology, applications of radiation technologies in the fields of agriculture, medicine, industry, and basic research.

Do you know?

Atomic Energy Regulatory Board (AERB) is an independent body, the Atomic Energy Regulatory Board (AERB) monitors safety.

The safety standards formulated by AERB are at par with those recommended by the international organisations such as the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP).

THINK!

- Functions of AERB

Q.21) Nikolaus Otto was famous for his 1876 discovery of –

a) Nuclear fission
b) Modern internal combustion engine
c) Protactinium
d) Bijov, the most powerful laser in the world

Q.21) Solution (b)

OTTO was born on June 10, 1832 at Holzhausen, Germany. He was the son of a farmer and received meagre education. He left school when he was 16, to work in a merchant's office. Later he shifted to Cologne and became greatly interested in the **gas engine** pioneered by the Belgian, **Jean Lenoir** (1822-1900). This self- taught technologist brought to a successful conclusion two centuries of experiment **to harness the energy resulting from an explosion in a closed cylinder**.

The principle employed was that of the double-acting steam engine. Instead of steam, gas and air were successively admitted at each end of the cylinder. This enabled induction, explosion and expansion to alternate with exhaustion on either side of the piston. Lenoir's engine patented in 1860 met the need of small industrialists and sold in hundreds. But it had defects of lack of compression and in complete expansion, which limited the range from 1/2 to 3 HP.

To overcome the above defects, Otto built in 1861 a small experimental engine. In 1864, he entered into a collaboration with Eugen Langen to form a company. He received valuable help from a former classmate Franz Reuleaux.

At the Paris Exhibition of 1867, the firm's product a vertical gas engine won a gold medal amongst 14 other gas engines displayed. A new factory, the Gasmotorenfabrik, was built in

1869 at Dentz near Cologne. Otto concentrated on the production side, leaving Langen to develop the engineering side. Gottlieb Daimler (1834-1900) and Wilhelm Maybach (1847-1929) joined the team.

Otto came out in 1876 with the patent for his **four-stroke engine**. This was in validated in 1886 as his competitors brought to notice the obscure pamphlet of Alphonse Bean de Rochas (1815- 1893), where the principle of the four-stroke cycle had already been enunciated.

Otto introduced in 1877 a horizontal engine, the operation of which was similar to Beau's cycle. However, Otto's much more efficient and relatively quiet engine - called the `silent Otto' - was well received and more than 30,000 engines were sold in the first ten years of manufacture. Otto died on January 26, 1891 at Cologne.

The Otto cycle

In the first stroke of the piston, the explosive mixture is drawn into the cylinder. It is compressed on the return stroke. Then ignition is effected and the burning mixture drives the piston during the third stroke. Finally, on the fourth stroke, the burnt gases are expelled out of the cylinder. The cycle is repeated.

The superiority of Otto's new engine over other types was soon recognised. Electric ignition was employed in the beginning; this was substituted by ignition by means of a flame drawn into the cylinder at the correct moment. A later innovation was the hot- tube method, in which a small tube of platinum (or other non- combustible mater) was inserted in the cylinder its outer being closed. The tube was kept at a bright red heat by an external gas flame, and upon compression a portion of the charge was forced into the tube and then ignited. The invention of the free-float carburettor by Wilhelm Maybach allowed petrol to be used as a fuel instead of gas.

Q.22) Which of the following is not a 'Multilateral Export Control Regime'?

a) Wassenaar Arrangement (WA)
b) Nuclear Suppliers Group (NSG)
c) Australia Group (AG)
d) North Atlantic Treaty Organization (NATO)

Q.22) Solution (d)

A Multilateral Export Control Regime is an international body that states use to organize their national export control systems.

There are currently four such regimes:

- The Wassenaar Arrangement (WA) on Export Controls for Conventional Arms and Dual-Use Goods and Technologies
- The Nuclear Suppliers Group (NSG), for the control of nuclear related technology
- The Australia Group (AG) for control of chemical and biological technology that could be weaponized
- The Missile Technology Control Regime (MTCR) for the control of rockets and other aerial vehicles capable of delivering weapons of mass destruction

India is a member of AG, MTCR and WA.

Q.23) Consider the following statements about 'Gross fixed capital formation (GFCF)'

1. It refers to the net increase in physical assets (investment minus disposals) within the measurement period
2. It does not account for the consumption (depreciation) of fixed capital, and also does not include land purchases

Select the correct statement

a) 1 Only
b) 2 Only
c) Both 1 and 2
d) Neither 1 nor 2

Q.23) Solution (c)

Gross fixed capital formation (GFCF)

- It is a macroeconomic concept used in official national accounts such as the United Nations System of National Accounts (UNSNA), National Income and Product Accounts (NIPA) and the European System of Accounts (ESA).
- The concept dates back to the National Bureau of Economic Research (NBER) studies of Simon Kuznets of capital formation in the 1930s, and standard measures for it were adopted in the 1950s.
- Gross fixed capital formation (GFCF) refers to the net increase in physical assets (investment minus disposals) within the measurement period.
- It does not account for the consumption (depreciation) of fixed capital, and also does not include land purchases.
- It is a component of expenditure approach to calculating GDP.

Source: http://www.thehindu.com/todays-paper/tp-opinion/getting-back-on-track/article21293417.ece

Q.24) Which of the following is/are correctly matched?

	Paintings	State
1.	Chitrakathi	Maharashtra
2.	Pattachitra	West Bengal
3.	Patua	Jammu & Kashmir

Select the correct code:

a) 1 Only
b) 2 Only
c) 1 and 2
d) 2 and 3

Q.24) Solution (a)

Chitrakathi

- Chitrakathi is a unique style of Painting, practised in Pinguli, a small village near Kudal, in the district of Sindhudurg in the Indian States of Maharashtra, dating back to the 17th century.
- Painting is done using paper, brush and hand-made colours and in the sequence, based on the story of Mahabhartha or Ramayana.
- The collection of pictures are used to narrate the whole story.
- The sutradhar (narrator) unfolds the tale in the form of songs supported by the music of the vina, the taal and the huduk.
- All paintings belonging to one story were kept in a bundle called pothi.
- The Theme of Chitrakathi paintings include stories on local versions of Ramayana and Mahabharata and mythical themes.

Pattachitra

- Pattachitra is a general term for traditional, cloth-based scroll painting, based in the eastern Indian state, Odisha.
- In the Sanskrit language, "Patta" literally means "cloth" and "Chitra" means "picture".

- These paintings are based on Hindu mythology and specially inspired by Jagannath and Vaishnava sect.
- Pattachitra is registered under the identity of Odisha Pattachitra. This ensures the high quality that the artisans of Odisha deliver.
- The geographical indication ensures that the real artists are not overshadowed by fake claims of pattachitra in the neighbouring regions.

Patua

- The birth of the Patua Paintings can be traced back to the 13th century.
- The word Patua is actually the corruption of a Bengali word Pota which literally translates to 'an engraver'.
- The Potas started out with being a community of Hindu idol makers in the Mindapur region of West Bengal, but most of them were islamized over time.
- With time, their art form evolved and Pota, or now the Patuas became Scroll Painters or Chitrakars, paying little heed to faith and instead, looking for patronage.
- They have made their mark in the Hindu, Islamic and Buddhist cultures.
- The subjects painted by the Patua artists are extremely varied. From something as minimal to a lobster eating a fish, to complex political themes of the French Revolution and, more recently the depiction of natural calamities in the form of scrolls.
- The scrolls are made from sheets of white paper. The pencil outline is drawn first of the story and the characters and is later filled in with colour.
- Once the paint dries off, its outlined with black paint, which is a distinguishing character of the Patua Paintings.
- After single panels have been painted, the segments of paper are sewn together and the seams seem to disappear in the scroll border.
- The entire scroll is then glued to a recyclable piece of cloth, usually a sari to make it durable.

Q.25) 'IFRS 9' is associated with

a) Financial Instrument
b) Bear and Bull Markets
c) Mezzanine Financing
d) JICA and LEAP

Q.25) Solution (a)

IFRS 9

- It is an International Financial Reporting Standard (IFRS) promulgated by the International Accounting Standards Board (IASB).
- It addresses the accounting for financial instruments. It contains three main topics: classification and measurement of financial instruments, impairment of financial assets and hedge accounting.
- It will replace the earlier IFRS for financial instruments, IAS 39, when it becomes effective in 2018.

Q.26) Which of the following is/are associated with 'Conflict Diamonds'?

a) Kimberly Process
b) Fowler Report
c) Both (a) and (b)
d) Neither (a) nor (b)

Q.26) Solution (c)

Kimberly Process Certification Scheme

- India was appointed as the Kimberly Process (KP) Vice Chair for 2018 & Chair for 2019 in the last plenary held in Dubai in November, 2016. The EU will be KP Chair for 2018.
- The Kimberley Process is a joint Government, International Diamond Industry and Civil Society initiative to stem the flow of Conflict Diamonds.
- "Conflict Diamonds" means rough diamonds used by rebel movements or their allies to finance conflict aimed at undermining legitimate governments.
- It is also described in the United Nations Security Council (UNSC) resolutions.
- The KPCS came to into effect from 1st January, 2003 and evolved into an effective mechanism for stopping the trade in conflict diamonds.
- India is the founding member of KPCS. At present, KPCS has 54 members representing 81 countries including the EU with 28 members.
- India is one of the founding members of the KPCS and was Chair of the KPCS for the year 2008.

The Fowler Report, released on March 14, 2000, is a United Nations report detailing how various companies, African and European governments, including that of Angola and the political wing of UNITA, violated the Lusaka Protocol as well as UN-imposed sanctions. Robert Fowler, Canada's ambassador to the United Nations, headed the commission that

compiled the report, which raised widespread international concern by highlighting the strong link between the illicit diamond trade and third world conflicts.

Q.27) Consider the following statements about 'Capital Adequacy Ratio (CAR)'

1. It measures a bank's capital in relation to its risk-weighted assets.
2. Under Basel III, the minimum capital adequacy ratio that banks must maintain is 4%.
3. It promotes financial stability and efficiency in economic systems throughout the world.

Select the correct statements

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) All of the above

Q.27) Solution (c)

Capital Adequacy Ratio (CAR)

- It is the ratio of a bank's capital in relation to its risk weighted assets and current liabilities. It is decided by central banks and bank regulators to prevent commercial banks from taking excess leverage and becoming insolvent in the process.
- It is measured as - Capital Adequacy Ratio = (Tier I + Tier II + Tier III (Capital funds)) /Risk weighted assets
- The risk weighted assets take into account credit risk, market risk and operational risk.
- The Basel III norms stipulated a capital to risk weighted assets of 8%.
- Banks are mandated to maintain minimum 9% capital adequacy ratio (CAR) plus a capital conservation buffer of 2.5%.

Source: http://www.thehindu.com/business/govt-injects-funds-into-6-public-banks/article22328348.ece