1. What are rare earth metals? What are their applications? What are the issues with its extractions? Discuss

Approach

A simple and straightforward question where in the candidate needs to explain what are rare earth metals along with their applications in the first part of the answer while discussing the issues with the extractions of these metals in the second part of the answer.

Introduction

Rare earth metals are metals obtained from a group of 15 elements referred to as the lanthanide series in the periodic table of elements. Scandium and yttrium, while not true rare earth elements, are also included. REEs are key components in many electronic devices that we use in our daily lives, as well as in a variety of industrial application.

Body

Rare earth metals comprise seventeen chemical elements — anthanum, cerium, praseodymium, neodymium, promethium, etc. Despite their classification, most of these elements are not really "rare". One of the Rare Earths, promethium, is radioactive. As essential and functional materials, rare earth elements have been named "**The Vitamins of Modern Industry**". In this regard, their applications can be seen from the following points –

1. The manufacturing of permanent magnets represents the single largest and most important end use for REMs, accounting for 38% of total forecasted demand.
2. Permanent magnets are an essential component of modern electronics used in cell phones, televisions, computers, automobiles, wind turbines, jet aircraft and many other products.
3. They are used as phosphors in many consumer displays and lighting systems, and are also used in fluid cracking catalysts and catalytic converters in the oil and automotive industries and medical industry.
4. Rare Earth metals are used in space shuttle components, jet engine turbines, and drones. Cerium, the most abundant Rare Earth element, is essential to NASA's Space Shuttle Programme.
5. REE are also vital for many defence technologies, including precision guided munitions, targeting lasers, communications systems, airframes and aerospace engines, radar systems, optical equipment, sonar, and electronic counter measures.
6. Scandium is used in televisions and fluorescent lamps, and yttrium is used in drugs to treat rheumatoid arthritis and cancer.

According to the Rare Earth Technology Alliance (RETA), the estimated size of the Rare Earth sector is between $10 billion and $15 billion. In this regard, some issues with regards to its extraction can be seen from the following points –

- **Low Concentration:** Global rare-earth reserves are at more than 130 million metric tons. However, most of those reserves either are too low in concentration to be extracted economically, or they are not readily accessible, such as metals locked away in deep-sea manganese-based nodules or hydrothermal deposits.
- **Extraction Costs:** REMs are found in a variety of minerals, but not all are equally suitable for economic development. REMs are generally found in concentrations below what is economically viable for extraction at current prices using available technology.
- **Environmental factors:** Extraction and mining of rare earth metals involves similar land-use exploitation, environmental damage and ecological burden as any other mining operation. They are mined using extremely energy-intensive processes, spewing carbon emissions into the atmosphere and toxins into the ground.
- **Geopolitical Issues:** China is the world's largest producer of REEs, accounting for over 60% of global annual production, estimated at 132,000 tonnes for 2019. It withheld the supply of Rare Earths to Japan after their dispute over Senakaku Islands, which alerted the world to use of rare earths for geopolitical purposes.
- **Supply Monopoly:** China remains virtually the only producer of the valued heavy REMs. China imposed export restrictions on REE between 2010 and 2014, resulting in dramatic increases in REE prices during those years. This leads to uneconomical trends in other countries for rare earth extraction.
- China's intents of hegemony, non-solidarity with other nations does not augur well for the environment in general, as well as for geo-politics and global renewable energy usage and scenarios. Its intents on doing the same with its vast rare earth reserves will be detrimental.

Way Forward –

- Recycling of these rare earth metals for continuous usage for various technologies is a good option that can be considered.
- Diversifying the supply chain of Rare Earth Metals around the world, especially focusing on the same in India.

Conclusion

Rare earths have become indispensable and, in many cases, irreplaceable components of materials that are essential in modern life. Thus the usage of these metals, which form a critical part of the renewable energy revolution should be handled with careful, sincere and cleaner measures if the way forward has to be greener and environment-friendly.

2. With the help of suitable examples, discuss the applications of robotics in agriculture.

Approach

Candidates are expected to write about use of robotics in agriculture and then with the suitable examples discuss the application of robotics in agriculture.

Introduction

Agriculture is quickly becoming an exciting high-tech industry technology it is developing rapidly, not only advancing the production capabilities of farmers but also advancing robotics and automation technology as we know it.

Body

Robotics in agriculture:

- An agricultural robot is a robot deployed for agricultural purposes. Agricultural robots automate slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields.
- Harvesting and picking is one of the most popular robotic applications in agriculture due to the accuracy and speed that robots can achieve to improve the size of yields and reduce waste from crops being left in the field.
- Many agricultural robotic advancements use machine vision technology to avoid hazards, identify crops, and even determine if they are ready to be harvested.

Applications of the robotics in the agriculture:

- Weeding: Combatting weeds and making sure crops have room to grow is a constant struggle for farmers. For example Using computer vision and a variety of mechanical tools, the robot plucks out individual weeds instead of using chemicals.
- Spraying: Similar to manual weeding robots, smart sprayers are typically paired with computer vision cameras to identify weeds for targeted herbicide applications. For example Sophisticated systems can even identify specific plants and activate only the relevant application nozzles. This means less waste, reduced herbicide resistance, and more efficient application across fields.
- Picking: Strawberries, like many berries and tender fruits/veggies, demand a very intensive harvesting program. Harvesting these crops require a lot of labour and time, both of which are often in short supply. The harvest process is quite intense, and farmers often run short of workers due to the backbreaking nature of the harvest.
- Seeding: Automated drone seeders are mostly used in forestry industries right now, but the potential for more widespread use is on the horizon. They are also able to plant much more efficiently with a team of two operators and ten drones capable of planting 400,000 trees a day.

- Robotic Harvesting: The robotic system utilizes soft-touch robotics and a lidar sensing system to detect ripe apples, leaving out unripe fruits during the picking process. For example AI-enabled robots are being widely deployed on tomato farms in Japan, and have reduced the on-field labour time by 20%.
- Other applications: Nursery planting, crop analysis, animal husbandry, dairy farming, drone service, harsh terrain resilient farming etc.
- PAAMA Agrico under Made-in-India Agri-Equipments has designed the world-class soil titling blades used in rotovators and cultivators. It enables a Robot to weld blades enabling the precision function ensuring uniformity in production while facilitating repeatability function each time.
- GRoboMac indigenously developed Robot has been designed in such a way that the computerised vision detects and locates the precise 3D coordinates of the bloomed cotton from the images of the cotton plant. A robotic arm uses these coordinates to pick the cotton and the arm, then uses a vacuum for precision picking of cotton and avoids picking any other contaminant.

Shortcomings of such applications in India:

- It will also reshape the definition of farmworkers Substitution of technology may put farmers out of their jobs and render difficulties to the already suffering state of unemployment.
- The capital-intensive nature of Robotics. And high cost of procuring imported hardware components as well as training personnel.
- It runs on increasing further Inequality among small and large landowners.
- Loss of various traditional, yet effectively resilient methods suitable for Indian agriculture.

Conclusion

Embracing new technologies like robotic will be a key factor in the changing face of Indian agriculture. Therefore, any policy measure on this front needs to be carefully designed and implemented. It is important to consider all stakeholders and have collaborated measures in making robotics and other technologies in agriculture affordable sustainable and properly understood by the end users and the farmer.

3. What are the potential applications of artificial intelligence in the field of medicine? Discuss.

Approach- Question is straight forward. Candidate is required to give application of AI in medicine with the help of suitable examples and answer can be concluded with predicting use of AI in various fields.

Introduction

A broad spectrum of intelligent technologies like Artificial Intelligence has managed to penetrate into different industries in this information and technology-oriented era. Healthcare is no exception. It is witnessing the rapid integration of AI over a couple of years. According to a CB Insights Report, 86% of the life science companies, healthcare providers, and technology vendors are relying on Artificial Intelligence technologies. The healthcare systems will be spending $54 million on an average, on different AI projects.

Body

Potential applications of AI in medicine

1. Diagnose diseases
    - Machine Learning particularly Deep Learning algorithms– have recently made huge advances in automatically diagnosing diseases, making diagnostics cheaper and more accessible.
    - Machine Learning algorithms can learn to see patterns similarly to the way doctors see them. A key difference is that algorithms need a lot of concrete examples – many thousands – in order to learn.
    - So Machine Learning is particularly helpful in areas where the diagnostic information a doctor examines is already digitized. Detecting lung cancer or strokes based on CT scans.
    - Assessing the risk of sudden cardiac death or other heart diseases based on electrocardiograms and cardiac MRI images. Classifying skin lesions in skin images, Finding indicators of diabetic retinopathy in eye images.

2. Develop drugs faster
    - Developing drugs is a notoriously expensive process. Many of the analytical processes involved in drug development can be made more efficient with Machine Learning. This has the potential to shave off years of work and hundreds of millions in investments.
    - AI has already been used successfully in all of the 4 main stages in drug development-Identifying targets for intervention, Discovering drug candidates, Speeding up clinical trials, Finding Biomarkers for diagnosing the disease.
    - Machine Learning can speed up the design of clinical trials by automatically identifying suitable candidates as well as ensuring the

correct distribution for groups of trial participants. Algorithms can help identify patterns that separate good candidates from bad.

3. Personalize treatment
    - Different patients respond to drugs and treatment schedules differently. So personalized treatment has enormous potential to increase patients' lifespans. But it's very hard to identify which factors should affect the choice of treatment.
    - Machine Learning can automate this complicated statistical work – and help discover which characteristics indicate that a patient will have a particular response to a particular treatment. So the algorithm can predict a patient's probable response to a particular treatment.
    - The system learns this by cross-referencing similar patients and comparing their treatments and outcomes. The resulting outcome predictions make it much easier for doctors to design the right treatment plan.

4. Improve gene editing
    - Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), specifically the CRISPR-Cas9 system for gene editing, is a big leap forward in our ability to edit DNA cost effectively – and precisely, like a surgeon.
    - Machine Learning models have been proven to produce the best results when it comes to predicting the degree of both guide-target interactions and off-target effects for a given sgRNA. This can significantly speed up the development of guide RNA for every region of human DNA.

Conclusion

AI is already helping us more efficiently diagnose diseases, develop drugs, personalize treatments, and even edit genes. But this is just the beginning. The more we digitize and unify our medical data, the more we can use AI to help us find valuable patterns – patterns we can use to make accurate, cost-effective decisions in complex analytical processes.

4. How do cryptocurrencies work? What are the issues with their regulation? Comment.

Approach

Explain the working of cryptocurrencies. Also mention issues with their regulations. Comment means you have to give your views and support them with evidence.

Introduction:

Cryptocurrency is a kind of digital money that is designed to be secure and, in many cases, anonymous. It is a currency associated with the internet that uses cryptography, the process of converting legible information into an almost uncrackable code, to track purchases and transfers.

Body:

How do cryptocurrencies work?

- Cryptocurrencies use decentralized technology to let users make secure payments and store money without the need to use their name or go through a bank.
- They run on a distributed public ledger called block chain, which is a record of all transactions updated and held by currency holders.
- Units of cryptocurrency are created through a process called mining, which involves using computer power to solve complicated math's problems that generate coins.
- Users can also buy the currencies from brokers, then store and spend them using cryptographic wallets.

Issues with their regulations:

- There are big concerns about digital coins as a source of fraud. They are also entirely unregulated and some are open to market manipulation.
- Speculators who buy digital coins should be aware they could lose all their money.
- While Bitcoin is decentralized, it is highly volatile at the same time.
- One of the most common practical uses of cryptocurrency is to finance illegal activities, such as buying illegal goods on the dark web.
- Many black market internet stores accept payments in cryptocurrency because they can be highly anonymous and do not require cash to change hands.
- Hackers have taken advantage of digital coins and can target exchanges and accounts, in one case crashing one of the world's largest cryptocurrency exchanges.

Conclusion:

Cryptocurrencies are known for being secure and providing a level of anonymity. Transactions in them cannot be faked or reversed and there tend to be low fees. Their decentralized nature means they are available to everyone, although they can be complicated to set up and few stores accept them for spending.

5. What are sounding rockets? How do they function? Discuss their applications.

Approach:

Question is very simple and straight forward in its approach students are expected to write about sounding rockets their functioning and applications with proper explanation.

Introduction:

Sounding rockets take their name from the nautical term "to sound," which means to take measurements. Since 1959, NASA-sponsored space and earth science research has used sounding rockets to test instruments used on satellites and spacecraft and to provide information about the Sun, stars, galaxies and Earth's atmosphere and radiation.

Body:

These rockets are basically divided into two parts: a solid-fuel rocket motor and a payload. Many of the motors used in sounding-rocket programs are surplus military motors, which keep down the cost of the rocket. The payload is the section that carries the instruments to conduct the experiment and sends the data back to Earth. These rockets produce higher-quality microgravity conditions for longer periods than airplanes, or drop towers, and tubes. An experiment is placed on the rocket, which is launched and then allowed to free-fall back to Earth.

Functioning and applications-

- A sounding rocket follows a parabolic arc, like the aircraft, but goes above the Earth's atmosphere, where air drag does not disturb microgravity conditions. The typical flight profile of a sounding rocket is the following: subsequent to a launch and as the rocket motor uses up its propellants it separates from the vehicle; the payload continues into space after separation from the motor and begins conducting the experiments; when the experiments are completed, the payload re-enters the atmosphere and a parachute is deployed, bringing the payload gently back to Earth; the payload is then retrieved (by retrieving the payload a considerable saving can be achieved because the payload or parts of the payload and experiments can be refurbished and flown again).

- The main difference between a sounding rocket and an orbital launch vehicle is the velocity reached. In fact, a sounding rocket does not reach the velocity (in terms of (km/s)) needed to go into orbit, and after achieving the maximum altitude comes back to Earth.
- The experiments experience several minutes of microgravity before the rocket re-enters the atmosphere. Acceleration levels are usually around 10−5 g.
- Therefore, sounding rockets provide a reasonably economical means of conducting engineering tests for instruments and devices used on satellites and other spacecraft, prior to their use in more expensive activities. Also, because of their low cost and short mission lead time, they are valuable tools for undergraduate and graduate students conducting research in the microgravity environment.
- They also serve as easily affordable platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites. With the establishment of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 at Thumba, a location close to the magnetic equator, there was a quantum jump in the scope for aeronomy and atmospheric sciences in India.
- ISRO started launching indigenously made sounding rockets from 1965 and experience gained was of immense value in the mastering of solid propellant technology. In 1975, all sounding rocket activities were consolidated under the Rohini Sounding Rocket (RSR) Programme. RH-75, with a diameter of 75mm was the first truly Indian sounding rocket, which was followed by RH-100 and RH-125 rockets. The sounding rocket programme was the bedrock on which the edifice of launch vehicle technology in ISRO could be built. It is possible to conduct coordinated campaigns by simultaneously launching sounding rockets from different locations. It is also possible to launch several sounding rockets in a single day.

Conclusion:

Not only are sounding rocket missions carried out at very low cost, but also the payload can be developed in a very short time frame -- sometimes as quickly as 3 months. This rapid response enables scientists to react quickly to new phenomena (such as observing the Shoemaker-Levy comet impact to Jupiter) and to incorporate the latest, most up-to-date technology in their experiments.