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# China Restricts Helium Exports Amid West Asian Tensions, Highlighting Strategic Importance of the Critical Industrial Resource

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## Recent Developments:

- **China** has temporarily restricted **helium exports** following escalating **West Asian geopolitical tensions** and attacks affecting **Qatar's helium production facilities**.
- The move aims to secure domestic helium supplies amid concerns that disruptions in the **Strait of Hormuz** could interrupt global shipments from **Qatar**, one of the world's largest helium producers.
- The development has renewed global attention on **helium** as a **critical mineral resource** essential for semiconductors, aerospace, healthcare, quantum computing and advanced scientific research.

## Helium as a Strategic Resource:

### *About Helium:*

- **Helium (He)** is a **non-renewable**, naturally occurring **noble gas** and the **second lightest element** in the periodic table.
- It is a finite resource that cannot be commercially synthesised and is practically irreplaceable for several advanced technological applications requiring **ultra-low temperatures**.
- Owing to its unique physical and chemical properties, helium has emerged as a strategically important resource for both economic development and national security.

### *Why Helium is Strategically Important:*

- Helium is indispensable for **semiconductor manufacturing**, **quantum computing**, **space technology**, **medical diagnostics**, **nuclear research** and **defence applications**.
- Many of these sectors have no technically or economically viable substitute for helium.
- Growing demand for advanced electronics and artificial intelligence infrastructure has significantly increased the strategic importance of helium.

## Physical and Chemical Properties of Helium:

### *Ultra-Low Boiling Point:*

- Helium possesses the **lowest boiling point** among all known elements at approximately **?269°C (4.2 K)** under standard atmospheric pressure.
- It remains liquid even near **absolute zero**, making it indispensable for cryogenic applications.

### *Chemical Inertness:*

- As a **noble gas**, helium is chemically non-reactive and does not readily form compounds.

- Its inert nature provides a contamination-free environment during high-precision industrial manufacturing.

***High Thermal Conductivity:***

- Helium transfers heat rapidly and efficiently, making it ideal for cooling sensitive scientific instruments and industrial equipment.

***Small Atomic Size:***

- Helium atoms are extremely small and lightweight.
- Their ability to penetrate microscopic openings makes helium highly suitable for precision leak detection in industrial systems.

**Formation and Occurrence of Helium:**

***Natural Formation:***

- Helium is produced naturally over millions of years through the **radioactive alpha decay** of heavy elements such as **uranium** and **thorium** within the Earth's crust.
- The emitted alpha particles capture electrons and become stable helium atoms.

***Accumulation in Natural Gas Reservoirs:***

- Helium gradually migrates upward through geological formations and becomes trapped within underground **natural gas reservoirs**.
- Commercial extraction becomes economically viable when helium concentration is sufficiently high in natural gas deposits.

***Extraction Process:***

- Helium is separated from natural gas using **cryogenic fractional distillation**, which exploits differences in the boiling points of constituent gases.
- Commercial extraction generally requires helium concentrations of around **0.3% or higher** in natural gas, although economic viability varies depending on project conditions.

**Major Strategic Applications of Helium:**

***Semiconductor Manufacturing:***

- Helium is used in **Extreme Ultraviolet (EUV) Lithography**, plasma etching and wafer cooling during advanced semiconductor fabrication.
- It ensures temperature stability and contamination-free manufacturing of high-performance microchips.

***Quantum Computing:***

- Superconducting quantum computers operate at temperatures close to **absolute zero**, maintained using liquid helium.
- Helium preserves **qubit stability**, enabling reliable quantum computation.

***Space and Aerospace Sector:***

- **ISRO**, **NASA** and other space agencies use helium for **rocket fuel tank pressurisation**, purging fuel systems and maintaining propulsion safety.

- Helium is also used during satellite launch operations and cryogenic propulsion.

***Medical Diagnostics:***

- **Magnetic Resonance Imaging (MRI)** systems use liquid helium to cool superconducting magnets.
- Continuous cryogenic cooling enables accurate, high-resolution medical imaging.

***Scientific Research:***

- Helium is widely used in **particle accelerators**, **fusion research**, **low-temperature physics** and advanced laboratory instrumentation.

**Major Industrial Applications:**

***Optical Fibre and Silicon Manufacturing:***

- Helium provides a chemically stable atmosphere for producing high-purity optical fibres and silicon wafers.

***Rocket Technology:***

- Helium purges propellant lines, pressurises cryogenic fuel tanks and protects propulsion systems during launch operations.

***Weather Balloons and Airships:***

- Helium serves as a safe, non-flammable lifting gas for meteorological balloons and specialised airships.

***Industrial Leak Detection:***

- Helium is injected into pipelines, vacuum chambers and pressure systems to detect microscopic leaks with high precision.

***Advanced Welding:***

- Helium acts as a shielding gas during **Gas Tungsten Arc Welding (GTAW)** of specialised metals such as aluminium, titanium and magnesium.

**Challenges Associated with Helium:**

***Finite and Non-Renewable Resource:***

- Helium forms naturally over geological timescales and cannot be replenished within human timescales.
- Once released into the atmosphere, helium eventually escapes Earth's gravitational field into outer space.

***Transportation Challenges:***

- Liquid helium requires specialised vacuum-insulated cryogenic containers for storage and transportation.
- Maintaining extremely low temperatures significantly increases logistics costs.

***Boil-Off Losses:***

- Due to its exceptionally low boiling point, stored liquid helium gradually evaporates during transport and storage.
- This limits storage duration and increases operational losses.

***Highly Concentrated Global Supply:***

- Global helium production is concentrated in a few countries, with the **United States**, **Qatar** and **Algeria** accounting for a major share of global supply.
- Supply concentration exposes global industries to geopolitical and production risks.

***Geopolitical Vulnerability:***

- A substantial proportion of Qatar's helium exports transit through the **Strait of Hormuz**, making global supply vulnerable to regional conflicts.
- Export restrictions and geopolitical tensions can rapidly disrupt global supply chains.

**India and Helium Security:**

***Strategic Importance for India:***

- India's expanding **semiconductor ecosystem**, **space programme**, **medical sector** and **high-technology manufacturing** require secure helium supplies.
- Dependence on imports increases vulnerability to international supply disruptions.

***Domestic Potential:***

- Helium recovery from domestic **natural gas fields**, particularly those containing measurable helium concentrations, offers an opportunity to strengthen strategic resilience.
- Expansion of domestic exploration, recovery and recycling infrastructure can reduce import dependence.

***Need for Recycling:***

- Helium recycling systems in hospitals, research laboratories and semiconductor industries can substantially improve resource efficiency and reduce wastage.

**Way Forward:**

***Diversify Supply Sources:***

- Countries should reduce excessive dependence on a limited number of supplier nations through diversified import strategies.

***Promote Domestic Recovery:***

- Investment in helium exploration and recovery from indigenous natural gas reserves should be accelerated.

***Strengthen Strategic Reserves:***

- Establishing strategic helium reserves can help cushion temporary disruptions arising from geopolitical crises.

***Encourage Recycling Technologies:***

- Large-scale helium recovery and recycling systems should become an integral component of research institutions, hospitals and high-technology industries.

***Strengthen International Cooperation:***

- Long-term supply agreements and international collaboration can improve resilience against global supply shocks.

**Value Addition for UPSC:**

***Important Cryogenic Applications:***

- **Cryogenic Rocket Engines** use extremely low-temperature propellants such as **Liquid Hydrogen** and **Liquid Oxygen**, while helium is used for tank pressurisation and system purging.
- **Superconductivity** occurs when certain materials exhibit zero electrical resistance at extremely low temperatures maintained using liquid helium.
- **Magnetic Resonance Imaging (MRI)** relies on superconducting magnets cooled by liquid helium for advanced diagnostic imaging.

***Related Strategic Concepts:***

- **Critical Minerals:** Minerals essential for economic security, strategic industries and clean technologies that face significant supply risks.
- **Supply Chain Resilience:** Building diversified, reliable and sustainable supply networks for critical resources.
- **Strategic Resource Security:** Ensuring uninterrupted availability of essential materials required for defence, technology and economic stability