

Rare Earth Elements, Properties, Application, UPSC Prelims 2026

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RARE EARTH ELEMENTS



The Rare Earth Elements (REEs) are 17 metals in **Group 3** of the Periodic Table comprising Lanthanide series elements and Scandium and Yttrium (due to similar physical properties and found in the same ores and deposits). Contrary to their name, they are moderately abundant in nature but not concentrated enough to make them economically exploitable. India has the fifth-largest rare earth resource globally, with mainly concentrated in its monazite minerals.

Rare Earth Elements are important components in **over 200 products**, spanning applications in consumer **electronics, electric vehicles, defence** systems, and many more. Demand for REEs is expected to rise with a focus on renewable energy, Electric Vehicles, and niche sectors like communications and nuclear energy.

What are Rare Earth Elements?

Scandium, Yttrium and the 15 Lanthanides, lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu) are considered as the **Rare Earth Elements**.

Period	Group																18															
1	1 H 1.008																	2 He 4.003														
2	3 Li 6.941	4 Be 9.012											13 B 10.81	14 C 12.01	15 N 14.01	16 O 16	17 F 19	18 Ne 20.18														
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95														
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.9	36 Kr 83.8														
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3														
6	55 Cs 132.9	56 Ba 137.3	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173	71 Lu 175	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	90 Th 232	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (271)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116 Uuh (292)	117 Uus 0	118 Uuo 0

- **Types:** Based on the atomic weight, Rare Earth Elements are divided into two groups - **light REEs**, those with atomic numbers from 57 to 63 (La, Ce, Pr, Nd, Pm, Sm and Eu) and **heavy REEs**, those with atomic numbers from 64 to 71 (Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu).
 - **Scandium and Yttrium**, although light, have been placed with the heavy REEs group due to their similar chemical and physical properties.
- **Characteristics:** REEs are characterised by **high density, high melting point, high conductivity** and **high thermal conductance**.
 - Rare Earth Elements share a trivalent charge (+3) and similar ionic radii, hence similar properties.
- **Sources:** The principal sources of REE are **bastnaesite** (a fluorocarbonate which occurs in carbonatites and related igneous rocks), **xenotime** (yttrium phosphate) commonly found in mineral sand deposits, **loparite** which occurs in alkaline igneous rocks and **monazite** (a phosphate).
 - Several rare-earth minerals contain thorium and uranium in variable amounts, but they do not constitute essential components in the composition of the minerals.
 - Cerium is the most abundant rare earth, approximately the same as that of Copper.
- **Significance:** Rare Earth Elements are very important for futuristic technology.
 - They have wide applications in clean energy, high-end electronics, defence, etc with no equal substitutes.

Applications of Rare Earth Elements

The versatile nature of rare earth elements is evident in their applications. Some of them are as follows:

- **Permanent magnet:** Neodymium magnets (Nd-Fe-B magnets) are permanent magnets made of neodymium, iron and boron.

- They have the highest magnetic properties of all permanent magnets and can withstand temperatures as high as 230 degrees C.
- They are used in automobiles for anti-lock brakes, in computer hard disk drives, CD-ROMs, digital cameras, etc.
- These magnets are also used in a variety of conventional automotive subsystems, such as **power steering, electric windows, power seats, and audio speakers.**
- **Electronics and Displays:** Rare Earth Elements are used in high-technology devices such as smartphones, hard disks, digital cameras, fluorescent and light-emitting-diode lights, computer monitors and electronic displays.
 - Some rare earth elements have **phosphorescent properties**, which makes them to be used in the **manufacture of flat television screens and computer monitors.**
 - Lanthanum makes up as much as 50 per cent of digital camera lenses, including cell phone cameras.
 - Eu, Y, and Tb are used in the manufacturing of phosphors (substances that emit luminescence) to be used in many types of ray tubes and flat panel displays for screens that range in size from smartphone displays to stadium scoreboards.
 - Erbium is used to make fibre optic cables and laser repeaters.
- **Green Technologies:** They play a critical role in green technologies such as wind turbines and electric vehicles that are going to support net zero carbon emissions goals.
 - Nickel-metal hydride batteries are built with **lanthanum-based** alloys as anodes which are used in electric vehicles.
 - **Cerium**-based catalysts are used in automotive **catalytic converters.**
 - Lanthanum acts as a hydrogen absorber in rechargeable batteries and is an important element in hybrid car batteries.
- **Petroleum Refining: Lanthanum** is used as a **catalyst** for petroleum refining processes.
- **Glass Industry:** The glass industry is the largest consumer of REE raw materials, using them for **glass polishing** and as **additives** that provide colour and special optical properties.
- **Water purifiers:** Cerium shows a strong affinity for elements like phosphorus, hence used in water purifiers.
- **Healthcare:** REEs are also used in advanced medical technologies like **MRIs, laser scalpels**, non-irritating antiseptic dressings, and even some **cancer drugs.**
- **Defence and Space:** They are used in **satellite** communications, **guidance systems** and **aircraft** structures.
- **Steel Making:** **Cerium, lanthanum, neodymium, and praseodymium**, commonly in the form of a mixed oxide known as **mischmetal**, are used in steel making to remove impurities and in the production of special alloys.
- **Other applications:** The rare earth elements like **promethium, samarium, and europium** serve specific functions in applications such as **beta radiation sources, high-temperature magnets, and fluorescent lighting**, respectively.

Rare Earth Elements Concerns and Challenges

The Rare Earth Elements are very critical for the high-end modern technology but there are some environmental concerns and geopolitical challenges as well.

- **Rare Earth Dilemma:** Despite its applications in green and emerging technologies, the extraction of REEs causes environmental damage.
 - The extraction of REEs often results in large amounts of toxic waste, contaminating air, water, and soil.
 - For every ton of rare earth, 2,000 tons of toxic waste are produced.
 - Every year, China produces tens of millions of tons of wastewater.
 - This paradox is called the Rare earth Dilemma.
- **Health risks:** Rare earth ores are often laced with radioactive thorium and uranium, which can cause detrimental health effects while extracting.
- **Monopoly of China:** China has the largest reserves of REE, about 37% of the total global resources, followed by Brazil and Vietnam (18% each) and Russia (10%).
 - China is also the largest producer, followed by the United States.
 - Since the 1990s, China has provided 90-95 per cent of the world's REEs.
 - This gives China a monopoly over the supply chain of REEs.
 - However, in recent years, countries like **Australia, Brazil, Russia** and the **United States** have made strides in increasing their production capabilities to **reduce dependence on China**.

Country	Reserves in tonnes (in terms of REO)	% Share
Australia	3,400,000	2.56
Brazil	22,000,000	16.67
Canada	830,000	0.63
China	44,000,000	33.33
Greenland	1,500,000	1.14
India	6,900,000	5.23
Malaysia	30,000	0.02
Malawi	140,000	0.11
Russia	18,000,000	13.64
South Africa	860,000	0.65
Vietnam	22,000,000	16.67
USA	1,400,000	1.06
World Reserves	132,000,000	-

REO ¼ Rare Earth Element Oxide.

Rare Earth Elements in India

India is the fifth-largest rare earth resource globally, with significant deposits in the monazite minerals.

- **Resources:** There are around 13.07 million tonnes of REEs, mainly found in the monazite sand, which contains 55-60% total Rare Earth Elements oxide. These are found in:
 - Coastal beach placer monazite sands of Andhra Pradesh, Odisha, Kerala, Tamil Nadu, Maharashtra and Gujarat.
 - Inland placer deposits of Jharkhand, West Bengal and Tamil Nadu.
- **Types:** India contains **mainly Light REEs** while Heavy REEs are not available in extractable quantities.

- Only Neodymium and Praseodymium are available in India and are being extracted up to the 99.9 % purity level.
- **Mining: Indian Rare Earth Limited (IREL)** is a major player in mining and processing, producing rare earth compounds.
 - Foreign collaboration: Toyotsu Rare Earths India Limited, Visakhapatnam (Toyota Tsusho Corporation, Japan with IREL).
- **Challenges:** Despite abundant resources, India faces challenges in achieving self-sufficiency in rare earths.
 - **Economic Extraction:** The primary challenge lies in their extraction and processing. This is due to their dispersed nature.
 - **Industrial Scale Facility:** The existing **ecosystem from mining** to separation and **refining** in oxide form exists, but **industrial-scale facilities** for alloy and magnet production are **lacking**.
- **Initiatives:**
 - Initiatives like the setting up of a **Rare Earth Theme Park** and **joint ventures** aim to enhance India's position in this critical industry.
 - **RE and Titanium Theme Park** was developed by IREL to cater for the technologies developed by BARC.
 - India is actively exploring **collaborations**, and initiatives such as **Toyotsu Rare Earths India Limited in Visakhapatnam** to enhance efforts to refine rare earths through foreign collaboration.
 - Recently, a Carbonatite Deposit was found in Gujarat.
 - IREL processing plants have been established in Ganjam, Odisha and Aluva, Kerala.

Rare Earth Elements UPSC PYQs

Question 1: Consider the following statements: **(UPSC Prelims 2025)**

Statement I:

Some rare earth elements are used in the manufacture of flat television screens and computer monitors.

Statement II:

Some rare earth elements have phosphorescent properties.

Which one of the following is correct in respect of the above statements?

- a) Both Statement I and Statement II are correct and Statement II explains Statement I
- b) Both Statement I and Statement II are correct but Statement II does **not** explain Statement I
- c) Statement I is correct but Statement II is not correct
- d) Statement I is not correct but Statement II is correct

Ans: (a)

Source: <https://vajiramandravi.com/upsc-exam/rare-earth-elements/>

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