The Spark Is Burning Metal: Lanthanoids in Everyday Technology

A lighter "flint" is not stone but mischmetall, about 95% lanthanoid metals (mostly cerium) and 5% iron; scraped shavings catch fire in air, so the spark is burning metal. Lanthanoids are silvery-white, soft metals that tarnish rapidly in air; hardness increases with atomic number (samarium is steel-hard); they conduct heat and electricity. They are very reactive (early members like calcium, later ones like aluminium; E° about −2.2 to −2.4 V): they burn in O_2 (Ln_2O_3; Ce gives CeO_2) and halogens (LnX_3), react with water ($Ln(OH)_3 + H_2$) and dilute acids (H_2), and on heating form LnN, Ln_2S_3, LnC_2 (2773 K) and hydrides. Their oxides and hydroxides are basic. Most Ln^{3+} ions are coloured because of f electrons; La^{3+} ($4f^0$) and Lu^{3+} ($4f^{14}$) are colourless. Uses: alloy steels (best single use), mischmetall in Mg alloys for bullets, shells and lighter flint, mixed oxides as petroleum-cracking catalysts, oxides as TV phosphors, and $Nd_2Fe_{14}B$ magnets in phones. Rare earths are not rare: cerium is as common as copper.

Name: Date: Score: ____ / 24

A. Fill in the blanks

1. A lighter "flint" is the alloy called ____.

2. Mischmetall contains about ____ % lanthanoid metals and about 5 % iron.

3. The lanthanoid that is steel-hard is ____.

4. Heated with carbon at 2773 K, lanthanoids form the carbide ____.

5. The two colourless Ln^{3+} ions are La^{3+} and ____.

B. True or False

6. Lanthanoid metals are hard and do not tarnish in air. True / False

7. Hardness of the lanthanoids increases with atomic number. True / False

8. Lanthanoid hydroxides $Ln(OH)_3$ are acidic. True / False

9. Lanthanoids liberate hydrogen from dilute acids. True / False

10. Rare earths are rarer in the crust than silver. True / False

C. Assertion and reason

11. Assertion (A): Assertion: La^{3+} and Lu^{3+} are colourless. Reason: they have $4f^0$ and $4f^{14}$ configurations.
Reason (R): Both true; the reason explains the assertion: no f–f excitation is possible.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

12. Assertion (A): Assertion: The sparks of a lighter are burning metal. Reason: shavings of cerium alloy ignite in air at only about 150–180 °C.
Reason (R): Both true; the reason explains the assertion.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

D. Choose the correct option

13. Burning a lanthanoid in oxygen generally gives:

(a) Ln_2O_3 (b) LnO_2
(c) LnO (d) Ln_3O_4
Answer: _____

14. The product of a lanthanoid with water is:

(a) $Ln(OH)_3 + H_2$ (b) $Ln_2O_3 + O_2$
(c) LnH_3 (d) no reaction
Answer: _____

15. Heated with nitrogen, lanthanoids form:

(a) LnN (b) Ln_3N_4
(c) $Ln(NO_3)_3$ (d) no reaction
Answer: _____

16. Early lanthanoids react most like:

(a) calcium (b) aluminium
(c) sodium (d) iron
Answer: _____

17. Mixed oxides of lanthanoids are used as:

(a) petroleum-cracking catalysts (b) fertilisers
(c) antacids (d) dyes
Answer: _____

18. The magnet in a phone speaker is mainly:

(a) $Nd_2Fe_{14}B$ (b) Fe_3O_4
(c) CeO_2 (d) $SmCl_3$
Answer: _____

E. Numerical problems

19. Mischmetall is 95 % lanthanoids by mass. How many grams of lanthanoids are in a 2.0 g flint?

20. Thulium is ~0.52 ppm and silver ~0.075 ppm in the crust. How many times more common is thulium?

F. Short answer questions

21. Write balanced equations for a lanthanoid (Ln) reacting with (a) oxygen, (b) chlorine.

22. Write the products of a lanthanoid heated with N_2, S, C (2773 K) and H_2.

23. Give four uses of the lanthanoids.

G. Match the columns

24. Match each item in Column A with the correct item in Column B.

Column A	Column B	Your answer
1. Mischmetall	(a) −2.2 to −2.4 V (Eu −2.0 V)	1 → ____
2. $E°(Ln^{3+}/Ln)$	(b) ≈ 95 % Ln + ≈ 5 % Fe (+ S, C, Ca, Al)	2 → ____

Detailed solutions

1. mischmetall

2. 95

3. samarium

4. LnC_2

5. Lu^{3+}

6. False. They are soft and tarnish rapidly.

7. True. Samarium is steel-hard.

8. False. They are basic, like alkaline-earth hydroxides.

9. True. $2Ln + 6H^+ \rightarrow 2Ln^{3+} + 3H_2$.

10. False. Even thulium (~0.5 ppm) beats silver (~0.075 ppm).

11. (a) Colour comes from f electrons.

12. (a) Pyrophoric alloy.

13. (a) Ln_2O_3. Cerium is the exception (CeO_2).

14. (a) $Ln(OH)_3 + H_2$. Slow in cold, faster when hot.

15. (a) LnN. NCERT Fig. 4.9.

16. (a) calcium. Later ones behave more like Al.

17. (a) petroleum-cracking catalysts. La/Ce in zeolite catalysts.

18. (a) $Nd_2Fe_{14}B$. A neodymium magnet.

19. 0.95 × 2.0. **Answer: 1.9 g**

20. 0.52 / 0.075. **Answer: ≈ 7 times**

21. (a) $4Ln + 3O_2 \rightarrow 2Ln_2O_3$ (b) $2Ln + 3Cl_2 \rightarrow 2LnCl_3$

22. LnN; Ln_2S_3; LnC_2 (also Ln_3C, Ln_2C_3); a hydride such as LnH_2.

23. Alloy steels for plates and pipes; mischmetall in Mg alloys for bullets, shells and lighter flint; mixed oxides as petroleum-cracking catalysts; oxides as phosphors in TV screens.

24. 1 → (b), 2 → (a).