

Simplificación de radicales

EJERCICIO 1

$$1. \sqrt{18} = \sqrt{2 \cdot 3^2} = 3\sqrt{2}$$

$$2. 3\sqrt{48} = 3\sqrt{3 \cdot 2^4} = 3 \cdot 2^2 \cdot \sqrt{3} = 12\sqrt{3}$$

$$3. \sqrt[3]{16} = \sqrt[3]{2 \cdot 2^3} = 2\sqrt[3]{2}$$

$$4. \frac{1}{2}\sqrt[3]{128} = \frac{1}{2}\sqrt[3]{2^6 \cdot 2} = \frac{1}{2} \cdot 2^2 \sqrt[3]{2} = 2\sqrt[3]{2}$$

$$5. 2\sqrt[4]{243} = 2\sqrt[4]{3^4 \cdot 3} = 2 \cdot 3 \sqrt[4]{3} = 6\sqrt[4]{3}$$

$$6. \sqrt{50a^2b} = \sqrt{2 \cdot 5^2 a^2 b} = 5a\sqrt{2b}$$

$$7. 3\sqrt{81x^3y^4} = 3\sqrt{9^2 \cdot x^2 xy^4} = 3 \cdot 9xy^2 \sqrt{x} = 27xy^2 \sqrt{x}$$

$$8. \frac{1}{2}\sqrt{108a^5b^7} = \frac{1}{2}\sqrt{2^2 \cdot 3^2 \cdot 3 \cdot a^4 ab^6 b} \\ = \frac{2}{2} \cdot 3a^2 b^3 \sqrt{3ab} = 3a^2 b^3 \sqrt{3ab}$$

$$9. \frac{3}{5}\sqrt{125mn^6} = \frac{3}{5}\sqrt{5^2 \cdot 5mn^6} = \frac{3 \cdot 5}{5} n^3 \sqrt{5m} = 3n^3 \sqrt{5m}$$

$$10. 2a\sqrt{44a^3b^7c^9} = 2a\sqrt{2^2 \cdot 11a^2 ab^6 bc^8 c} \\ = 2 \cdot 2a \cdot ab^3 c^4 \sqrt{11abc} = 4a^2 b^3 c^4 \sqrt{11abc}$$

$$11. 2\sqrt[3]{16x^2y^7} \\ = 2\sqrt[3]{2^3 \cdot 2x^2y^6y} = 2 \cdot 2y^2 \sqrt[3]{2x^2y} = 4y^2 \sqrt[3]{2x^2y}$$

$$12. \frac{2}{3}\sqrt[3]{27m^2n^8} \\ = \frac{2}{3}\sqrt[3]{3^3 m^2 n^6 n^2} = \frac{2 \cdot 3}{3} n^2 \sqrt[3]{m^2 n^2} = 2n^2 \sqrt[3]{m^2 n^2}$$

$$13. 5a\sqrt[3]{160x^7y^9z^{13}} \\ = 5a\sqrt[3]{2^3 \cdot 20x^6xy^9z^{12}z} \\ = 5 \cdot 2ax^2y^3z^4 \sqrt[3]{20xz} = 10ax^2y^3z^4 \sqrt[3]{20xz}$$

$$14. \sqrt[4]{80a^4b^5c^{12}} = \sqrt[4]{2^4 \cdot 5a^4b^4bc^{12}} = 2abc^3 \sqrt[4]{5b}$$

$$15. 3\sqrt[4]{5x^8y^{14}z^{16}} = 3\sqrt[4]{5x^8y^{12}y^2z^{16}} = 3x^2y^3z^4 \sqrt[4]{5y^2}$$

$$16. \frac{2}{5}\sqrt[5]{32x^2y^{11}} \\ = \frac{2}{5}\sqrt[5]{2^5 x^2y^{10}y} = \frac{2 \cdot 2}{5} y^2 \sqrt[5]{x^2y} = \frac{4y^2}{5} \sqrt[5]{x^2y}$$

$$17. 2xy\sqrt[3]{128x^2y^8} \\ = 2xy\sqrt[3]{2^6 \cdot 2x^2y^6y^2} \\ = 2 \cdot 2^2 xy^2 \sqrt[3]{2x^2y^2} = 8xy^3 \sqrt[3]{2x^2y^2}$$

$$18. \frac{1}{3a}\sqrt{27a^3m^7} \\ = \frac{1}{3a}\sqrt{3^2 \cdot 3a^2 am^6 m} = \frac{3am^3}{3a} \sqrt{3am} = m^3 \sqrt{3am}$$

19. $\frac{3}{5x} \sqrt[3]{375a^8b}$
 $= \frac{3}{5x} \sqrt[3]{5^3 \cdot 3a^6a^2b} = \frac{3 \cdot 5a^2}{5x} \sqrt[3]{3a^2b} = \frac{3a^2}{x} \sqrt[3]{3a^2b}$

20. $\frac{1}{3} \sqrt[4]{81a^4b} = \frac{1}{3} \sqrt[4]{3^4 a^4 b} = \frac{3}{3} a \sqrt[4]{b} = a \sqrt[4]{b}$

21. $\sqrt{9a+18b} = \sqrt{9(a+2b)} = \sqrt{3^2(a+2b)} = 3\sqrt{a+2b}$

22. $\sqrt{3a^3b^2 - 3a^2b^2}$
 $= \sqrt{3a^2b^2(a-1)} = ab\sqrt{3(a-1)} = ab\sqrt{3a-3}$

23. $\sqrt{8x^2y^4 + 16xy^4}$
 $= \sqrt{2^2 \cdot 2xy^4(x+2)} = 2y^2\sqrt{2x(x+2)} = 2y^2\sqrt{2x^2+4x}$

24. $\sqrt{2x^2 - 4xy + 2y^2}$
 $= \sqrt{2(x^2 - 2xy + y^2)} = \sqrt{2(x-y)^2} = (x-y)\sqrt{2}$

25. $\sqrt{(a-b)(a^2-b^2)}$
 $= \sqrt{(a-b)(a-b)(a+b)}$
 $= \sqrt{(a-b)^2(a+b)} = (a-b)\sqrt{a+b}$

26. $\sqrt{2am^2 + 4amn + 2an^2}$
 $= \sqrt{2a(m^2 + 2mn + n^2)} = \sqrt{2a(m+n)^2} = (m+n)\sqrt{2a}$

27. $\sqrt{9a^3 - 36a^2 + 36a}$
 $= \sqrt{3^2a(a^2 - 2a + 4)}$
 $= 3\sqrt{a(a-2)^2} = 3(a-2)\sqrt{a} = (3a-6)\sqrt{a}$

EJERCICIO 2

1. $\sqrt{\frac{1}{5}} = \sqrt{\frac{1 \cdot 5}{5 \cdot 5}} = \sqrt{\frac{5}{5^2}} = \frac{1}{5}\sqrt{5}$

2. $\sqrt{\frac{3}{8}} = \sqrt{\frac{3 \cdot 2}{8 \cdot 2}} = \sqrt{\frac{6}{2^4}} = \frac{1}{2^2}\sqrt{6} = \frac{1}{4}\sqrt{6}$

3. $2\sqrt{\frac{1}{2}} = 2\sqrt{\frac{2 \cdot 1}{2 \cdot 2}} = 2\sqrt{\frac{2}{2^2}} = \frac{2}{2}\sqrt{2} = \sqrt{2}$

4. $3\sqrt{\frac{1}{6}} = 3\sqrt{\frac{1 \cdot 6}{6 \cdot 6}} = 3\sqrt{\frac{6}{6^2}} = \frac{3}{6}\sqrt{6} = \frac{1}{2}\sqrt{6}$

5. $\frac{1}{2}\sqrt{\frac{2}{3}} = \frac{1}{2}\sqrt{\frac{2 \cdot 3}{3 \cdot 3}} = \frac{1}{2}\sqrt{\frac{6}{3^2}} = \frac{1}{2 \cdot 3}\sqrt{6} = \frac{1}{6}\sqrt{6}$

6. $\sqrt{\frac{a^2}{8x}} = \sqrt{\frac{a^2x}{2^2 \cdot 2x^2}} = \frac{a}{2x}\sqrt{\frac{x}{2}} = \frac{a}{2x}\sqrt{\frac{2x}{2}} = \frac{a}{4x}\sqrt{2x}$

7. $\frac{3}{2}\sqrt{\frac{4a^2}{27y^3}} = \frac{3}{2}\sqrt{\frac{3 \cdot 2^2 a^2 y}{3^4 y^4}} = \frac{3 \cdot 2a}{2 \cdot 3^2 y^2} \sqrt{3y} = \frac{a}{3y^2} \sqrt{3y}$

8. $5\sqrt{\frac{9n}{5m^3}} = 5\sqrt{\frac{3^2 \cdot 5mn}{5^2 m^4}} = \frac{5 \cdot 3}{5m^2} \sqrt{5mn} = \frac{3}{m^2} \sqrt{5mn}$

9. $6\sqrt{\frac{5a^3}{24x^2}} = 6\sqrt{\frac{5 \cdot 6a^3}{2^4 \cdot 3^2 x^2}} = \frac{6}{2^2 \cdot 3x} \sqrt{30a^2 a} = \frac{a}{2x} \sqrt{30a}$

10. $\sqrt[3]{\frac{2}{3}} = \sqrt[3]{\frac{2 \cdot 3^2}{3^3}} = \frac{1}{3}\sqrt[3]{18}$

11. $5\sqrt[3]{\frac{1}{5}} = 5\sqrt[3]{\frac{5^2}{5^3}} = \frac{5}{5}\sqrt[3]{5^2} = \sqrt[3]{25}$

12. $\sqrt[3]{\frac{8}{9x^2}} = \sqrt[3]{\frac{2^3 \cdot 3x}{3^3 x^3}} = \frac{2}{3x}\sqrt[3]{3x}$

13. $2b^2\sqrt[3]{\frac{125}{4b^5}} = 2b^2\sqrt[3]{\frac{5^3 \cdot 2b}{2^3 b^6}} = \frac{2 \cdot 5b^2}{2b^2}\sqrt[3]{2b} = 5\sqrt[3]{2b}$

14. $\frac{2}{3}\sqrt[3]{\frac{27x^2}{16a^2b^4}} = \frac{2}{3}\sqrt[3]{\frac{3^3 \cdot 4ab^2x^2}{2^6 a^3b^6}} = \frac{2 \cdot 3}{3 \cdot 2^2 ab^2}\sqrt[3]{4ab^2x^2} = \frac{1}{2ab^2}\sqrt[3]{4ab^2x^2}$

15. $2xy\sqrt[4]{\frac{81a^2}{4x^3y}} = 2xy\sqrt[4]{\frac{3^4 \cdot 2^2 a^2 xy^3}{2^4 x^4 y^4}} = \frac{2 \cdot 3xy}{2xy}\sqrt[4]{4a^2 xy^3} = 3\sqrt[4]{4a^2 xy^3}$

Suma y resta de radicales

EJERCICIO 3

1. $7\sqrt{2} - 15\sqrt{2} = (7-15)\sqrt{2} = -8\sqrt{2}$
2. $4\sqrt{3} - 20\sqrt{3} + 19\sqrt{3} = (4-20+19)\sqrt{3} = 3\sqrt{3}$
3. $\sqrt{5} - 22\sqrt{5} - 8\sqrt{5} = (1-22-8)\sqrt{5} = -29\sqrt{5}$
4. $\sqrt{2} - 9\sqrt{2} + 30\sqrt{2} - 40\sqrt{2} = (1-9+30-40)\sqrt{2} = -18\sqrt{2}$
10. $3x\sqrt{y} + (a-x)\sqrt{y} - 2x\sqrt{y}$
 $= (3x+a-x-2x)\sqrt{y} = a\sqrt{y}$
11. $(x-1)\sqrt{3} + (x-3)\sqrt{3} + 4\sqrt{3}$
 $= (x-1+x-3+4)\sqrt{3} = 2x\sqrt{3}$
12. $\frac{1}{3}\sqrt[3]{2} - \frac{2}{3}\sqrt[3]{2} + 2\sqrt[3]{2}$
 $= \left(\frac{1}{3} - \frac{2}{3} + 2\right)\sqrt[3]{2} = \left(\frac{1-2+6}{3}\right)\sqrt[3]{2} = \frac{5}{3}\sqrt[3]{2}$
13. $\frac{3}{5}\sqrt[3]{2} - \frac{1}{4}\sqrt[3]{2} + \frac{1}{6}\sqrt[3]{2} = \left(\frac{36-15+10}{60}\right)\sqrt[3]{2} = \frac{31}{60}\sqrt[3]{2}$
14. $x\sqrt[3]{a^2} - (a-2x)\sqrt[3]{a^2} + (2a-3x)\sqrt[3]{a^2}$
 $= (x-a+2x+2a-3x)\sqrt[3]{a^2} = a\sqrt[3]{a^2}$
5. $\frac{3}{4}\sqrt{2} - \frac{1}{2}\sqrt{2} = \left(\frac{3}{4} - \frac{1}{2}\right)\sqrt{2} = \left(\frac{3-2}{4}\right)\sqrt{2} = \frac{1}{4}\sqrt{2}$
6. $\frac{3}{5}\sqrt{3} - \sqrt{3} = \left(\frac{3}{5} - 1\right)\sqrt{3} = \left(\frac{3-5}{5}\right)\sqrt{3} = -\frac{2}{5}\sqrt{3}$
7. $2\sqrt{5} - \frac{1}{2}\sqrt{5} + \frac{3}{4}\sqrt{5}$
 $= \left(2 - \frac{1}{2} + \frac{3}{4}\right)\sqrt{5} = \left(\frac{8-2+3}{4}\right)\sqrt{5} = \frac{9}{4}\sqrt{5}$
8. $\frac{1}{4}\sqrt{3} + 5\sqrt{3} - \frac{1}{8}\sqrt{3}$
 $= \left(\frac{1}{4} + 5 - \frac{1}{8}\right)\sqrt{3} = \left(\frac{2+40-1}{8}\right)\sqrt{3} = \frac{41}{8}\sqrt{3}$
9. $a\sqrt{b} - 3a\sqrt{b} + 7a\sqrt{b} = (a-3a+7a)\sqrt{b} = 5a\sqrt{b}$

Multiplicación de radicales de igual índice

EJERCICIO 4

1. $\sqrt{3} \cdot \sqrt{6} = \sqrt{18} = \sqrt{3^2 \cdot 2} = 3\sqrt{2}$
2. $5\sqrt{21} \cdot 2\sqrt{3} = 10\sqrt{63} = 10\sqrt{3^2 \cdot 7} = 30\sqrt{7}$
3. $\frac{1}{2}\sqrt{14} \cdot \frac{2}{7}\sqrt{21} = \frac{1}{7}\sqrt{294} = \frac{1}{7}\sqrt{7^2 \cdot 6} = \sqrt{6}$
4. $\sqrt[3]{12} \cdot \sqrt[3]{9} = \sqrt[3]{108} = \sqrt[3]{3^3 \cdot 4} = 3\sqrt[3]{4}$
5. $\frac{5}{6}\sqrt[3]{15} \cdot 12\sqrt[3]{50} = 10\sqrt[3]{750} = 10\sqrt[3]{5^3 \cdot 6} = 50\sqrt[3]{6}$
6. $x\sqrt{2a} \cdot \frac{1}{a}\sqrt{5a} = \frac{x}{a}\sqrt{10a^2} = x\sqrt{10}$
7. $5\sqrt{12} \cdot 3\sqrt{75} = 15\sqrt{900} = 15\sqrt{2^2 \cdot 3^2 \cdot 5^2} = 450$
8. $\frac{3}{4}\sqrt[3]{9a^2} \cdot 8\sqrt[3]{3ab} = 6\sqrt[3]{27a^3b} = 6a\sqrt[3]{3^3b} = 18a\sqrt[3]{b}$
9. $3\sqrt{6} \cdot \sqrt{14} \cdot 2\sqrt{35} = 6\sqrt{2 \cdot 940} = 6\sqrt{2^2 \cdot 7^2 \cdot 15} = 84\sqrt{15}$
10. $\frac{1}{2}\sqrt{21} \cdot \frac{2}{3}\sqrt{42} \cdot \frac{3}{7}\sqrt{22}$
 $= \frac{1}{7}\sqrt{19 \cdot 404} = \frac{1}{7}\sqrt{2^2 \cdot 7^2 \cdot 3^2 \cdot 11} = 6\sqrt{11}$
11. $3\sqrt[4]{45} \cdot \frac{1}{6}\sqrt[4]{15} \cdot 4\sqrt[4]{20} = 2\sqrt[4]{13 \cdot 500} = 2\sqrt[4]{5^3 \cdot 3^3 \cdot 4} = 30\sqrt[4]{4}$
12. $\frac{5}{6}\sqrt{\frac{7}{8}} \cdot \frac{3}{5}\sqrt{\frac{4}{7}} = \frac{1}{2}\sqrt{\frac{1}{2}} = \frac{1}{2}\sqrt{\frac{2}{2^2}} = \frac{1}{4}\sqrt{2}$
13. $\frac{2}{x}\sqrt{a^2x} \cdot \frac{3}{2}\sqrt{\frac{1}{a^3}} = \frac{3}{x}\sqrt{\frac{x}{a}} = \frac{3}{x}\sqrt{\frac{ax}{a^2}} = \frac{3}{ax}\sqrt{ax}$
14. $\frac{1}{3}\sqrt{\frac{x}{y^2}} \cdot 6\sqrt{\frac{2}{y}} = 2\sqrt{\frac{2x}{y^3}} = 2\sqrt{\frac{2xy}{y^4}} = \frac{2}{y^2}\sqrt{2xy}$

Ejercicios sobre raíz de una raíz

EJERCICIO 5

$$1. \sqrt[3]{\sqrt{a^2}} = \sqrt[6]{a^2} = (a)^{\frac{2}{6}} = a^{\frac{1}{3}} = \sqrt[3]{a}$$

$$2. \sqrt[3]{\sqrt{8}} = \sqrt[6]{8} = (2)^{\frac{3}{6}} = (2)^{\frac{1}{2}} = \sqrt{2}$$

$$3. \sqrt[4]{\sqrt{81}} = \sqrt[8]{81} = (3)^{\frac{4}{8}} = (3)^{\frac{1}{2}} = \sqrt{3}$$

$$4. \sqrt{\sqrt{3a}} = \sqrt[4]{3a}$$

$$5. \sqrt[3]{\sqrt{4a^2}} = \sqrt[6]{2^2 a^2} = (2a)^{\frac{2}{6}} = (2a)^{\frac{1}{3}} = \sqrt[3]{2a}$$

$$6. \sqrt[3]{2\sqrt{2}} = \sqrt[3]{\sqrt{2^2} \cdot 2} = \sqrt[6]{2^3} = (2)^{\frac{3}{6}} = (2)^{\frac{1}{2}} = \sqrt{2}$$

$$7. \sqrt[4]{\sqrt{25a^2}} = \sqrt[8]{5^2 a^2} = (5a)^{\frac{2}{8}} = (5a)^{\frac{1}{4}} = \sqrt[4]{5a}$$

$$8. \sqrt[3]{\sqrt[4]{27a^3}} = \sqrt[12]{3^3 a^3} = (3a)^{\frac{3}{12}} = (3a)^{\frac{1}{4}} = \sqrt[4]{3a}$$

$$9. \sqrt{3\sqrt{3}} = \sqrt{\sqrt[5]{3^5} \cdot 3} = \sqrt[10]{3^6} = (3)^{\frac{6}{10}} = (3)^{\frac{3}{5}} = \sqrt[5]{3^3} = \sqrt[5]{27}$$

$$10. \sqrt[4]{\sqrt{a^4 b^6}} = \sqrt[8]{a^4 b^4 b^2} = (ab)^{\frac{4}{8}} (b)^{\frac{2}{8}} = (ab)^{\frac{1}{2}} (b)^{\frac{1}{4}}$$

$$= \sqrt{ab} \cdot \sqrt[4]{b}$$

$$\Rightarrow \sqrt{ab} = \sqrt[4]{(ab)^2} = \sqrt[4]{a^2 b^2}$$

$$= \sqrt[4]{a^2 b^2} \sqrt[4]{b} = \sqrt[4]{a^2 b^3}$$

$$11. \sqrt[5]{\sqrt[3]{x^{10}}} = \sqrt[15]{x^{10}} = x^{\frac{10}{15}} = x^{\frac{2}{3}} = \sqrt[3]{x^2}$$

$$12. \sqrt[3]{\sqrt{(a+b)^2}} = \sqrt[6]{(a+b)^2} = (a+b)^{\frac{2}{6}} = (a+b)^{\frac{1}{3}} = \sqrt[3]{a+b}$$

Ejercicios sobre racionalización de monomios

EJERCICIO 6

$$1. \frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{\sqrt{3^2}} = \frac{\sqrt{3}}{3}$$

$$2. \frac{5}{\sqrt{2}} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \frac{5\sqrt{2}}{\sqrt{2^2}} = \frac{5\sqrt{2}}{2}$$

$$3. \frac{3}{4\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{3\sqrt{5}}{4\sqrt{5^2}} = \frac{3\sqrt{5}}{4 \cdot 5} = \frac{3\sqrt{5}}{20}$$

$$4. \frac{2a}{\sqrt{2ax}} \cdot \frac{\sqrt{2ax}}{\sqrt{2ax}} = \frac{2a\sqrt{2ax}}{\sqrt{2^2 a^2 x^2}} = \frac{2a\sqrt{2ax}}{2ax} = \frac{\sqrt{2ax}}{x}$$

$$5. \frac{5}{\sqrt[3]{4a^2}} \cdot \frac{\sqrt[3]{2a}}{\sqrt[3]{2a}} = \frac{5\sqrt[3]{2a}}{\sqrt[3]{2^3 a^3}} = \frac{5\sqrt[3]{2a}}{2a}$$

$$6. \frac{1}{\sqrt[3]{9x}} \cdot \frac{\sqrt[3]{3x^2}}{\sqrt[3]{3x^2}} = \frac{\sqrt[3]{3x^2}}{\sqrt[3]{3^3 x^3}} = \frac{\sqrt[3]{3x^2}}{3x}$$

$$7. \frac{3}{\sqrt[4]{9a}} \cdot \frac{\sqrt[4]{3^2 a^3}}{\sqrt[4]{3^2 a^3}} = \frac{3\sqrt[4]{3^2 a^3}}{\sqrt[4]{3^4 a^4}} = \frac{3\sqrt[4]{9a^3}}{3a} = \frac{\sqrt[4]{9a^3}}{a}$$

$$8. \frac{6}{5\sqrt[3]{3x}} \cdot \frac{\sqrt[3]{3^2 x^2}}{\sqrt[3]{3^2 x^2}} = \frac{6\sqrt[3]{3^2 x^2}}{5\sqrt[3]{3^3 x^3}} = \frac{6\sqrt[3]{9x^2}}{15x} = \frac{2\sqrt[3]{9x^2}}{5x}$$

$$9. \frac{x}{\sqrt[4]{27x^2}} \cdot \frac{\sqrt[4]{3x^2}}{\sqrt[4]{3x^2}} = \frac{x\sqrt[4]{3x^2}}{\sqrt[4]{3^4 x^4}} = \frac{x\sqrt[4]{3x^2}}{3x} = \frac{\sqrt[4]{3x^2}}{3}$$

$$10. \frac{1}{\sqrt[5]{8a^4}} \cdot \frac{\sqrt[5]{2^2 a}}{\sqrt[5]{2^2 a}} = \frac{\sqrt[5]{4a}}{\sqrt[5]{2^5 a^5}} = \frac{\sqrt[5]{4a}}{2a}$$

$$11. \frac{5n^2}{3\sqrt{mn}} \cdot \frac{\sqrt{mn}}{\sqrt{mn}} = \frac{5n^2 \sqrt{mn}}{3\sqrt{m^2 n^2}} = \frac{5n^2 \sqrt{mn}}{3mn} = \frac{5n\sqrt{mn}}{3m}$$

$$12. \frac{1}{5a\sqrt[4]{25x^3}} \cdot \frac{\sqrt[4]{5^2 x}}{\sqrt[4]{5^2 x}} = \frac{\sqrt[4]{25x}}{5a\sqrt[4]{5^4 x^4}} = \frac{\sqrt[4]{25x}}{25ax}$$

Ejercicios sobre racionalización de binomios

EJERCICIO 7

1. $\frac{3-\sqrt{2}}{1+\sqrt{2}} \cdot \frac{1-\sqrt{2}}{1-\sqrt{2}} = \frac{3-3\sqrt{2}-\sqrt{2}+\sqrt{2^2}}{1-\sqrt{2^2}} = \frac{3-4\sqrt{2}+2}{1-2} = \frac{5-4\sqrt{2}}{-1} = 4\sqrt{2}-5$
2. $\frac{5+2\sqrt{3}}{4-\sqrt{3}} \cdot \frac{4+\sqrt{3}}{4+\sqrt{3}} = \frac{20+5\sqrt{3}+8\sqrt{3}+2\sqrt{3^2}}{4^2-\sqrt{3^2}} = \frac{20+13\sqrt{3}+6}{16-3} = \frac{26+13\sqrt{3}}{13} = 2+\sqrt{3}$
3. $\frac{\sqrt{2}-\sqrt{5}}{\sqrt{2}+\sqrt{5}} \cdot \frac{\sqrt{2}-\sqrt{5}}{\sqrt{2}-\sqrt{5}} = \frac{\sqrt{2^2}-2\sqrt{2}\sqrt{5}+\sqrt{5^2}}{\sqrt{2^2}-\sqrt{5^2}} = \frac{2-2\sqrt{10}+5}{2-5} = \frac{7-2\sqrt{10}}{-3} = \frac{2\sqrt{10}-7}{3}$
4. $\frac{\sqrt{7}+2\sqrt{5}}{\sqrt{7}-\sqrt{5}} \cdot \frac{\sqrt{7}+\sqrt{5}}{\sqrt{7}+\sqrt{5}} = \frac{\sqrt{7^2}+\sqrt{35}+2\sqrt{35}+2\sqrt{5^2}}{\sqrt{7^2}-\sqrt{5^2}} = \frac{7+3\sqrt{35}+10}{7-5} = \frac{17+3\sqrt{35}}{2}$
5. $\frac{\sqrt{2}-3\sqrt{5}}{2\sqrt{2}+\sqrt{5}} \cdot \frac{2\sqrt{2}-\sqrt{5}}{2\sqrt{2}-\sqrt{5}} = \frac{2\sqrt{2^2}-\sqrt{10}-6\sqrt{10}+3\sqrt{5^2}}{2^2\sqrt{2^2}-\sqrt{5^2}} = \frac{4-7\sqrt{10}+15}{8-5} = \frac{19-7\sqrt{10}}{3}$
6. $\frac{19}{5\sqrt{2}-4\sqrt{3}} \cdot \frac{5\sqrt{2}+4\sqrt{3}}{5\sqrt{2}+4\sqrt{3}} = \frac{95\sqrt{2}+76\sqrt{3}}{5^2\sqrt{2^2}-4^2\sqrt{3^2}} = \frac{95\sqrt{2}+76\sqrt{3}}{50-48} = \frac{95\sqrt{2}+76\sqrt{3}}{2}$
7. $\frac{3\sqrt{2}}{7\sqrt{2}-6\sqrt{3}} \cdot \frac{7\sqrt{2}+6\sqrt{3}}{7\sqrt{2}+6\sqrt{3}} = \frac{21\sqrt{2^2}+18\sqrt{6}}{7^2\sqrt{2^2}-6^2\sqrt{3^2}} = \frac{42+18\sqrt{6}}{98-108} = \frac{42+18\sqrt{6}}{-10} = -\frac{21+9\sqrt{6}}{5}$
8. $\frac{4\sqrt{3}-3\sqrt{7}}{2\sqrt{3}+3\sqrt{7}} \cdot \frac{2\sqrt{3}-3\sqrt{7}}{2\sqrt{3}-3\sqrt{7}} = \frac{8\sqrt{3^2}-12\sqrt{21}-6\sqrt{21}+9\sqrt{7^2}}{2^2\sqrt{3^2}-3^2\sqrt{7^2}} = \frac{24-18\sqrt{21}+63}{12-63} = \frac{87-18\sqrt{21}}{-51} = \frac{6\sqrt{21}-29}{17}$
9. $\frac{5\sqrt{2}-6\sqrt{3}}{4\sqrt{2}-3\sqrt{3}} \cdot \frac{4\sqrt{2}+3\sqrt{3}}{4\sqrt{2}+3\sqrt{3}} = \frac{20\sqrt{2^2}+15\sqrt{6}-24\sqrt{6}-18\sqrt{3^2}}{4^2\sqrt{2^2}-3^2\sqrt{3^2}} = \frac{40-9\sqrt{6}-54}{32-27} = \frac{-14-9\sqrt{6}}{5} = -\frac{14+9\sqrt{6}}{5}$
10. $\frac{\sqrt{7}+3\sqrt{11}}{5\sqrt{7}+4\sqrt{11}} \cdot \frac{5\sqrt{7}-4\sqrt{11}}{5\sqrt{7}-4\sqrt{11}} = \frac{5\sqrt{7^2}-4\sqrt{77}+15\sqrt{77}-12\sqrt{11^2}}{5^2\sqrt{7^2}-4^2\sqrt{11^2}} = \frac{35+11\sqrt{77}-132}{175-176} = \frac{-97+11\sqrt{77}}{-1} = 97-11\sqrt{77}$
11. $\frac{\sqrt{5}+\sqrt{2}}{7+2\sqrt{10}} \cdot \frac{7-2\sqrt{10}}{7-2\sqrt{10}} = \frac{7\sqrt{5}-2\sqrt{50}+7\sqrt{2}-2\sqrt{20}}{7^2-2^2\sqrt{10^2}} = \frac{7\sqrt{5}-2\sqrt{5^2 \cdot 2}+7\sqrt{2}-2\sqrt{2^2 \cdot 5}}{49-40} = \frac{7\sqrt{5}-10\sqrt{2}+7\sqrt{2}-4\sqrt{5}}{9} = \frac{3\sqrt{5}-3\sqrt{2}}{9} = \frac{\sqrt{5}-\sqrt{2}}{3}$
12. $\frac{9\sqrt{3}-3\sqrt{2}}{6-\sqrt{6}} \cdot \frac{6+\sqrt{6}}{6+\sqrt{6}} = \frac{54\sqrt{3}+9\sqrt{18}-18\sqrt{2}-3\sqrt{12}}{6^2-\sqrt{6^2}} = \frac{54\sqrt{3}+9\sqrt{3^2 \cdot 2}-18\sqrt{2}-3\sqrt{2^2 \cdot 3}}{36-6} = \frac{54\sqrt{3}+27\sqrt{2}-18\sqrt{2}-6\sqrt{3}}{30} = \frac{48\sqrt{3}+9\sqrt{2}}{30} = \frac{16\sqrt{3}+3\sqrt{2}}{10}$

$$13. \frac{\sqrt{a}+\sqrt{x}}{2\sqrt{a}+\sqrt{x}} \cdot \frac{2\sqrt{a}-\sqrt{x}}{2\sqrt{a}-\sqrt{x}} \\ = \frac{2\sqrt{a^2}-\sqrt{ax}+2\sqrt{ax}-\sqrt{x^2}}{2^2\sqrt{a^2}-\sqrt{x^2}} = \frac{2a+\sqrt{ax}-x}{4a-x}$$

$$14. \frac{\sqrt{x}-\sqrt{x-1}}{\sqrt{x}+\sqrt{x-1}} \cdot \frac{\sqrt{x}-\sqrt{x-1}}{\sqrt{x}-\sqrt{x-1}} \\ = \frac{\sqrt{x^2}-2\sqrt{x}\sqrt{x-1}+\sqrt{(x-1)^2}}{\sqrt{x^2}-\sqrt{(x-1)^2}} \\ = \frac{x-2\sqrt{x^2-x}+x-1}{x-(x-1)} = 2x-1-2\sqrt{x^2-x}$$

$$15. \frac{\sqrt{a}-\sqrt{a+1}}{\sqrt{a}+\sqrt{a+1}} \cdot \frac{\sqrt{a}-\sqrt{a+1}}{\sqrt{a}-\sqrt{a+1}} \\ = \frac{\sqrt{a^2}-2\sqrt{a}\sqrt{a+1}+\sqrt{(a+1)^2}}{\sqrt{a^2}-\sqrt{(a+1)^2}} \\ = \frac{a-2\sqrt{a^2+a}+a+1}{a-(a+1)} \\ = \frac{2a+1-2\sqrt{a^2+a}}{-1} = 2\sqrt{a^2+a}-2a-1$$

$$16. \frac{\sqrt{x+2}+\sqrt{2}}{\sqrt{x+2}-\sqrt{2}} \cdot \frac{\sqrt{x+2}+\sqrt{2}}{\sqrt{x+2}+\sqrt{2}} \\ = \frac{\sqrt{(x+2)^2}+2\sqrt{x+2}\sqrt{2}+\sqrt{2^2}}{\sqrt{(x+2)^2}-\sqrt{2^2}} \\ = \frac{x+2+2\sqrt{2x+4}+2}{x+2-2} = \frac{x+4+2\sqrt{2x+4}}{x}$$

$$17. \frac{\sqrt{a+4}-\sqrt{a}}{\sqrt{a+4}+\sqrt{a}} \cdot \frac{\sqrt{a+4}-\sqrt{a}}{\sqrt{a+4}-\sqrt{a}} \\ = \frac{\sqrt{(a+4)^2}-2\sqrt{a+4}\sqrt{a}+\sqrt{a^2}}{\sqrt{(a+4)^2}-\sqrt{a^2}} \\ = \frac{a+4-2\sqrt{a^2+4a}+a}{a+4-a} = \frac{2a+4-2\sqrt{a^2+4a}}{4} \\ = \frac{a+2-\sqrt{a^2+4a}}{2}$$

$$18. \frac{\sqrt{a+b}-\sqrt{a-b}}{\sqrt{a+b}+\sqrt{a-b}} \cdot \frac{\sqrt{a+b}-\sqrt{a-b}}{\sqrt{a+b}-\sqrt{a-b}} \\ = \frac{\sqrt{(a+b)^2}-2\sqrt{a+b}\sqrt{a-b}+\sqrt{(a-b)^2}}{\sqrt{(a+b)^2}-\sqrt{(a-b)^2}} \\ = \frac{a+b-2\sqrt{a^2-b^2}+a-b}{a+b-a+b} = \frac{2a-2\sqrt{a^2-b^2}}{2b} = \frac{a-\sqrt{a^2-b^2}}{b}$$

EJERCICIO 8

$$1. \frac{\sqrt{3}}{\sqrt{2}+\sqrt{3}-\sqrt{5}} \cdot \frac{(\sqrt{2}+\sqrt{3})+\sqrt{5}}{(\sqrt{2}+\sqrt{3})+\sqrt{5}} \\ = \frac{\sqrt{6}+\sqrt{9}+\sqrt{15}}{(\sqrt{2}+\sqrt{3})^2-(\sqrt{5})^2} \\ = \frac{3+\sqrt{6}+\sqrt{15}}{2+2\sqrt{6}+3-5} = \frac{3+\sqrt{6}+\sqrt{15}}{2\sqrt{6}} \cdot \frac{2\sqrt{6}}{2\sqrt{6}} = \frac{6\sqrt{6}+2\sqrt{36}+2\sqrt{90}}{(2\sqrt{6})^2} = \frac{6\sqrt{6}+12+6\sqrt{10}}{24} = \frac{6(\sqrt{6}+2+\sqrt{10})}{24} = \frac{2+\sqrt{6}+\sqrt{10}}{4}$$

$$2. \frac{\sqrt{2}}{\sqrt{2}+\sqrt{3}+\sqrt{6}} \cdot \frac{(\sqrt{2}+\sqrt{3})-\sqrt{6}}{(\sqrt{2}+\sqrt{3})-\sqrt{6}} \\ = \frac{2+\sqrt{6}-\sqrt{12}}{(\sqrt{2}+\sqrt{3})^2-(\sqrt{6})^2} \\ = \frac{2+\sqrt{6}-2\sqrt{3}}{2+2\sqrt{6}+3-6} = \frac{2+\sqrt{6}-2\sqrt{3}}{2\sqrt{6}-1} \cdot \frac{2\sqrt{6}+1}{2\sqrt{6}+1} = \frac{4\sqrt{6}+2+12+\sqrt{6}-4\sqrt{18}-2\sqrt{3}}{(2\sqrt{6})^2-1} = \frac{5\sqrt{6}+14-12\sqrt{2}-2\sqrt{3}}{23}$$

$$\begin{aligned}
3. \quad & \frac{2-\sqrt{3}}{2+\sqrt{3}+\sqrt{5}} \cdot \frac{(2+\sqrt{3})-\sqrt{5}}{(2+\sqrt{3})-\sqrt{5}} \\
&= \frac{4-3-2\sqrt{5}+\sqrt{15}}{(2+\sqrt{3})^2-(\sqrt{5})^2} \\
&= \frac{1-2\sqrt{5}+\sqrt{15}}{4+4\sqrt{3}+3-5} \\
&= \frac{1-2\sqrt{5}+\sqrt{15}}{2+4\sqrt{3}} \cdot \frac{2-4\sqrt{3}}{2-4\sqrt{3}} \\
&= \frac{2-4\sqrt{3}-4\sqrt{5}+8\sqrt{15}+2\sqrt{15}-4\sqrt{45}}{2^2-(4\sqrt{3})^2} \\
&= \frac{2-4\sqrt{3}-4\sqrt{5}+10\sqrt{15}-12\sqrt{5}}{-44} \\
&= \frac{2(2\sqrt{3}+8\sqrt{5}-5\sqrt{15}-1)}{44} = \frac{2\sqrt{3}+8\sqrt{5}-5\sqrt{15}-1}{22}
\end{aligned}$$

$$\begin{aligned}
6. \quad & \frac{\sqrt{2}-\sqrt{5}}{\sqrt{2}+\sqrt{5}-\sqrt{10}} \cdot \frac{(\sqrt{2}+\sqrt{5})+\sqrt{10}}{(\sqrt{2}+\sqrt{5})+\sqrt{10}} \\
&= \frac{2-5+\sqrt{20}-\sqrt{50}}{2+2\sqrt{10}+5-10} \\
&= \frac{2\sqrt{5}-5\sqrt{2}-3}{2\sqrt{10}-3} \cdot \frac{2\sqrt{10}+3}{2\sqrt{10}+3} \\
&= \frac{4\sqrt{50}+6\sqrt{5}-10\sqrt{20}-15\sqrt{2}-6\sqrt{10}-9}{40-9} \\
&= \frac{20\sqrt{2}+6\sqrt{5}-20\sqrt{5}-15\sqrt{2}-6\sqrt{10}-9}{31} \\
&= \frac{5\sqrt{2}-14\sqrt{5}-6\sqrt{10}-9}{31}
\end{aligned}$$

$$\begin{aligned}
4. \quad & \frac{\sqrt{3}+\sqrt{5}}{\sqrt{2}+\sqrt{3}+\sqrt{5}} \cdot \frac{(\sqrt{2}+\sqrt{3})-\sqrt{5}}{(\sqrt{2}+\sqrt{3})-\sqrt{5}} \\
&= \frac{\sqrt{6}+\sqrt{10}+3-5}{(\sqrt{2}+\sqrt{3})^2-(\sqrt{5})^2} \\
&= \frac{\sqrt{10}+\sqrt{6}-2}{2+2\sqrt{6}+3-5} \\
&= \frac{\sqrt{10}+\sqrt{6}-2}{2\sqrt{6}} \cdot \frac{2\sqrt{6}}{2\sqrt{6}} \\
&= \frac{2\sqrt{60}+2\sqrt{36}-4\sqrt{6}}{(2\sqrt{6})^2} \\
&= \frac{4\sqrt{15}+12-4\sqrt{6}}{24} \\
&= \frac{4(\sqrt{15}+3-\sqrt{6})}{24} = \frac{\sqrt{15}+3-\sqrt{6}}{6}
\end{aligned}$$

$$\begin{aligned}
5. \quad & \frac{\sqrt{6}+\sqrt{3}+\sqrt{2}}{\sqrt{6}+\sqrt{3}-\sqrt{2}} \cdot \frac{(\sqrt{6}+\sqrt{3})+\sqrt{2}}{(\sqrt{6}+\sqrt{3})+\sqrt{2}} \\
&= \frac{6+3+2+2\sqrt{18}+2\sqrt{12}+2\sqrt{6}}{(\sqrt{6}+\sqrt{3})^2-(\sqrt{2})^2} \\
&= \frac{11+6\sqrt{2}+4\sqrt{3}+2\sqrt{6}}{6+2\sqrt{18}+3-2} \\
&= \frac{11+6\sqrt{2}+4\sqrt{3}+2\sqrt{6}}{2\sqrt{18}+7} \cdot \frac{2\sqrt{18}-7}{2\sqrt{18}-7} \\
&= \frac{22\sqrt{18}-77+12\sqrt{36}-42\sqrt{2}+8\sqrt{54}-28\sqrt{3}+4\sqrt{108}-14\sqrt{6}}{(2\sqrt{18})^2-49} \\
&= \frac{66\sqrt{2}-77+72-42\sqrt{2}+24\sqrt{6}-28\sqrt{3}+24\sqrt{3}-14\sqrt{6}}{72-49} \\
&= \frac{24\sqrt{2}-4\sqrt{3}+10\sqrt{6}-5}{23}
\end{aligned}$$

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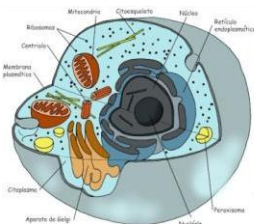
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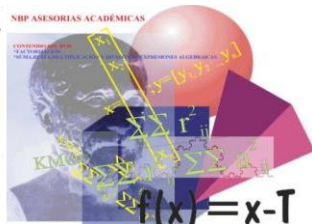


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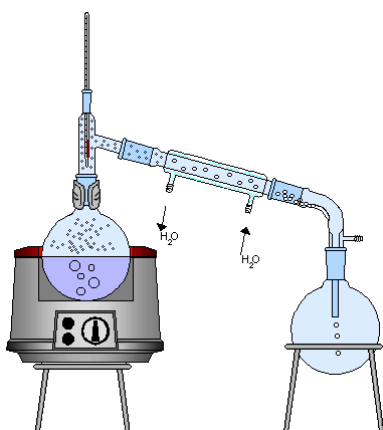
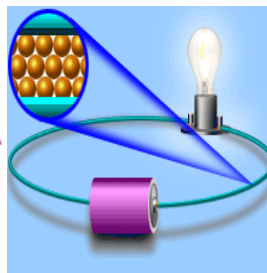
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