

Rewrite the equation in exponential form.

1.  $\log_2 8 = 3$   $2^3 = 8$

2.  $\log_5 25 = 2$   $5^2 = 25$

3.  $\log_3 27 = 3$   $3^3 = 27$

4.  $\log_7 49 = 2$   $7^2 = 49$

5.  $\log_2 16 = 4$   $2^4 = 16$

6.  $\log_6 6 = 1$   $6^1 = 6$

Evaluate the expression without using a calculator.

7.  $\log_2 4 = 2$

8.  $\log_2 32 = 5$

9.  $\log_8 64 = 2$

10.  $\log_{10} 100 = 2$

11.  $\log_7 1 = 0$

12.  $\log_8 8 = 1$

Use a calculator to evaluate the expression. Round the result to three decimal places.

13.  $\log 6 = 0.778$

14.  $\log(0.4) = -0.398$

15.  $\log 3.72 = 0.571$

16.  $\ln 8 = 2.079$

17.  $\ln(0.23) = -1.470$

18.  $\ln(6.12) = 1.812$

Simplify the expression.

19.  $7^{\log_7 x} = x$

20.  $27^{\log_27 x} = x$

21.  $13^{\log_{13} x} = x$

22.  $\log_3(3^x) = x$

23.  $\log_{15}(15^x) = x$

24.  $\log_{221}(221^x) = x$

Rewrite the equation in exponential form.

1.  $\log_4 16 = 2$   $4^2 = 16$

2.  $\log_3 81 = 4$   $3^4 = 81$

3.  $\log_2 1 = 0$   $2^0 = 1$

4.  $\log_9 3 = \frac{1}{2}$   $9^{\frac{1}{2}} = 3$

5.  $\log_5 \frac{1}{5} = -1$   $5^{-1} = \frac{1}{5}$

6.  $\log_2 \frac{1}{8} = -3$   $2^{-3} = \frac{1}{8}$

Evaluate the logarithm without using a calculator.

10.  $\log_3 27 = 3$

11.  $\log_4 1 = 0$

12.  $\log_2 \frac{1}{2} = -1$

13.  $\log_8 2$

14.  $\log_5 5^{2/3}$

15.  $\log_6 (-1)$

$8^x = 2$   
 $2^{3x} = 2^1$   
 $x = \frac{1}{3}$

$\frac{2}{3}$

~~0~~  
No solution

Rewrite the equation in exponential form.

1.  $\log_5 125 = 3$   $5^3 = 125$

2.  $\log_8 2 = \frac{1}{3}$   $8^{\frac{1}{3}} = 2$

3.  $\log_3 \frac{1}{27} = -3$   $3^{-3} = \frac{1}{27}$

Use a calculator to evaluate the expression. Round the result to three decimal places.

4.  $\ln 3 + 1$  2.099

5.  $\frac{\ln 2.5}{10}$  0.092

6.  $\frac{\log 4 - 3}{2}$  -1.199

Evaluate the expression without using a calculator.

7.  $\log_2 \frac{1}{32}$  -5

8.  $\log \frac{1}{1000}$  -3

9.  $\log_8 4$   $\frac{2}{3}$

10.  $\log_{16} 8$

11.  $\log_{27} \frac{1}{9}$

12.  $\log_{100} \frac{1}{1000}$

$16^x = 8$

$2^{4x} = 2^3$

$x = \frac{3}{4}$

$27^x = \frac{1}{9}$

$3^{3x} = 3^{-2}$

$x = -\frac{2}{3}$

$100^x = \frac{1}{1000}$

$10^{2x} = 10^{-3}$

$x = -\frac{3}{2}$

### VOCABULARY

#### Properties of Logarithms

Let  $b$ ,  $u$ , and  $v$  be positive numbers such that  $b \neq 1$ .

**Product Property**  $\log_b uv = \log_b u + \log_b v$

**Quotient Property**  $\log_b \frac{u}{v} = \log_b u - \log_b v$

**Power Property**  $\log_b u^n = n \log_b u$

**Change-of-Base Formula** Let  $u$ ,  $b$ , and  $c$  be positive numbers with

$b \neq 1$  and  $c \neq 1$ . Then:  $\log_c u = \frac{\log_b u}{\log_b c}$

In particular,  $\log_c u = \frac{\log u}{\log c}$  and  $\log_c u = \frac{\ln u}{\ln c}$

Expand the expression.

5.  $\log 9x$   $\log 9 + \log x$

6.  $\log_2 6x^3$   $\log_2 6 + 3 \log_2 x$

7.  $\log_6 \frac{2}{3}$   $\log_6 2 - \log_6 3$

8.  $\log_3 \frac{4x}{5}$   $\log_3 4 + \log_3 x - \log_3 5$

9.  $\ln 2xy$   $\ln 2 + \ln x + \ln y$

10.  $\ln \frac{2x^2}{y}$   $\ln 2 + 2 \ln x - \ln y$

Condense the expression.

11.  $\log_4 12 + \log_4 5$   $\log_4 60$

12.  $\log x - \log y$   $\log \frac{x}{y}$

13.  $\ln 3 + \ln 6 - \ln 9$   $\ln 2$

14.  $3 \log_2 3$   $\log_2 27$

15.  $6 \log_2 x + 3 \log_2 x$   $\log_2 x^6 \cdot x^3$   $\log_2 x^9$

16.  $\ln 24 - 3 \ln 2$   $\ln 24/8$   $\ln 3$

Use the change-of-base formula to evaluate the expression.

17.  $\log_3 30$   $\frac{\log 30}{\log 3} \approx 3.096$

18.  $\log_4 13$   $\frac{\log 13}{\log 4} \approx 1.850$

19.  $\log_2 17$   $\frac{\log 17}{\log 2} \approx 4.087$

20.  $\log_5 10$   $\frac{\log 10}{\log 5} \approx 1.431$

Use the properties of logarithms to rewrite the expression in terms of  $\log 2$  and  $\log 7$ . Then use  $\log 2 \approx 0.301$  and  $\log 7 \approx 0.845$  to approximate the expression.

1.  $\log 4$   
 $\log 2^2 = 2 \log 2$   
 $= 2(0.301)$   
 $= 0.602$

4.  $\log\left(\frac{2}{7}\right)$   
 $\log 2 - \log 7$   
 $0.301 - 0.845$   
 $= -0.544$

Expand the expression.

7.  $\log_2(3x)$   
 $\log_2 3 + \log_2 x$

10.  $\log_6\left(\frac{6}{x}\right)$   
 $\log_6 6 - \log_6 x$   
 $1 - \log_6 x$

13.  $\log \sqrt[3]{x}$   
 $\frac{1}{3} \log x$

2.  $\log 14$   
 $\log 2 + \log 7$   
 $0.301 + 0.845$   
 $= 1.146$

5.  $\log 7^{-3}$   
 $-3 \log 7$   
 $-3(0.845)$   
 $= -2.535$

3.  $\log\left(\frac{7}{2}\right)$   
 $\log 7 - \log 2$   
 $0.845 - 0.301$   
 $= 0.544$

6.  $\log 49$   
 $\log 7^2$   
 $2 \log 7$   
 $2(0.845)$   
 $= 1.69$

8.  $\log_3(9x)$   
 $\log_3 9 + \log_3 x$   
 $2 + \log_3 x$

11.  $\log_3 x^5$   
 $5 \log_3 x$

14.  $\log_2 \sqrt{2x}$   
 $\frac{1}{2} \log 2x$   
 $\frac{1}{2} \log 2 + \frac{1}{2} \log x$

9.  $\log\left(\frac{x}{5}\right)$   
 $\log x - \log 5$

12.  $\ln x^{-3}$   
 $-3 \ln x$

15.  $\log_3(27x)^2$   
 $2 \log_3 27 + 2 \log_3 x$   
 $2(3) + 2 \log_3 x$   
 $6 + 2 \log_3 x$

Condense the expression.

16.  $\log 3 + \log 5$   
 $\log 15$

19.  $\log 4 - \log x$   
 $\log \frac{4}{x}$

22.  $\ln 2 - \ln(x+2)$   
 $\ln\left(\frac{2}{x+2}\right)$

17.  $\log_2 x + \log_2 7$   
 $\log_2 7x$

20.  $\ln x - \ln 3$   
 $\ln \frac{x}{3}$

23.  $\log_3(x+5) + \log_3 4$   
 $\log_3((x+5)(4))$   
 $\log_3 4x + 20$

18.  $\log_3 14 + \log_3 y$   
 $\log_3 14y$

21.  $\log(x-1) - \log 6$   
 $\log \frac{x-1}{6}$

24.  $2 \log x + \log 8$   
 $\log 8x^2$

Use the change-of-base formula to rewrite the expression. Then use a calculator to evaluate the expression. Round your result to three decimal places.

25.  $\log_2 5$  2.322

28.  $\log_6 200$  2.957

26.  $\log_7 10$  1.183

29.  $\log_5 \frac{1}{2}$  -0.431

27.  $\log_3 17$  2.579

30.  $\log_4 1235$  5.135

Use the properties of logarithms to rewrite the expression in terms of  $\log 3$  and  $\log 4$ . Then use  $\log 3 \approx 0.477$  and  $\log 4 \approx 0.602$  to approximate the expression.

1.  $\log\left(\frac{3}{4}\right)$   
 $\log 3 - \log 4$   
 $0.477 - 0.602$

4.  $\log 16$   
 $2 \log 4$   
 $2(0.602)$   
 $1.204$

2.  $\log 12$   
 $\log 3 + \log 4$   
 $0.477 + 0.602$

5.  $\log \frac{1}{4}$   
 $-\log 4$   
 $-1(0.602)$   
 $-0.602$

3.  $\log 9$   
 $2 \log 3$   
 $2(0.477)$

6.  $\log\left(\frac{4}{27}\right)$   
 $\log 4 - 3 \log 3$   
 $0.602 - 3(0.477)$   
 $-0.829$

Expand the expression.

7.  $\log_6 3x$   
 $\log_6 3 + \log_6 x$

10.  $\log_4 \frac{xy}{3}$   
 $\log_4 x + \log_4 y - \log_4 3$

13.  $\log \frac{x^2}{4}$   
 $2 \log x - \log 4$

8.  $\log_2 \frac{x}{5}$   
 $\log_2 x - \log_2 5$

11.  $\log_3 \sqrt{xyz}$   
 $\frac{1}{2} \log_3 x + \frac{1}{2} \log_3 y + \frac{1}{2} \log_3 z$

14.  $\log \frac{10}{\sqrt{x}}$   
 $\log 10 - \frac{1}{2} \log x$   
 $1 - \frac{1}{2} \log x$

9.  $\log xy^2$   
 $\log x + 2 \log y$

12.  $\log_5 2\sqrt{x}$   
 $\log_5 2 + \frac{1}{2} \log_5 x$

15.  $\log_2 \frac{x^2 y}{z}$   
 $2 \log_2 x + \log_2 y - \log_2 z$

Condense the expression.

16.  $\log_3 7 - \log_3 x$   
 $\log_3 \frac{7}{x}$

18.  $\log_4 5 + \log_4 x + \log_4 y$   
 $\log_4 5xy$

20.  $\frac{2}{3} \log_2 x - 3 \log_2 y$   
 $\log_2 \left(\frac{x^{4/3}}{y^9}\right)$

17.  $2 \log_5 x + \log_5 3$   
 $\log_5 3x^2$

19.  $\frac{1}{2} \log x - \log 4$   
 $\log \left(\frac{\sqrt{x}}{4}\right)$

21.  $\log_3 4 + 2 \log_3 x - \log_3 5$   
 $\log_3 \left(\frac{4x^2}{5}\right)$

Expand the expression.

7.  $\log(8x)$   
 $\log 8 + \log x$

10.  $\ln \frac{x}{yz}$   
 $\ln x - (\ln y + \ln z)$

13.  $\ln \frac{3y}{\sqrt[4]{x}}$   
 $\ln 3 + \ln y - \frac{1}{4} \ln x$

8.  $\log_3 xyz$   
 $\log_3 x + \log_3 y + \log_3 z$

11.  $\log \sqrt{3xy}$   
 $\frac{1}{2} \log 3 + \frac{1}{2} \log x + \frac{1}{2} \log y$

14.  $\log(3xyz^2)^3$   
 $3 \log 3 + 3 \log x + 3 \log y + 6 \log z$

9.  $\log_4 \frac{2xy}{z}$   
 $\frac{1}{2} + \log_4 x + \log_4 y - \log_4 z$

12.  $\log_5 \frac{\sqrt{x}}{y}$   
 $\frac{1}{2} \log_5 x - \log_5 y$

15.  $\log_2 \frac{(xy)^4}{z^2}$   
 $4 \log_2 x + 4 \log_2 y - 2 \log_2 z$

Condense the expression.

16.  $\log 3 - \log 4 - \log 7$   
 $\log \frac{3}{28}$

18.  $3 \ln x - 2 \ln y - 4 \ln z$

20.  $\frac{1}{2} \log(x+5) - 2 \log x + \ln y$

17.  $\ln x - \ln y + \ln z + \ln 3$   
 $\ln \frac{3xz}{y}$

19.  $\log_2(x-4) + 5 \log_2(x+1) - 3 \log_2(x-1)$

21.  $3[\ln(x-2) + 2 \ln(x+1) - \ln(x+2) - 5 \ln(x-1)]$