WRITTEN EXERCISES

In Exercises 1–6, write each expression in terms of $\log M$ and $\log N$.

A **1.** $\log (MN)^2$ **2.** $\log \frac{M}{N^2}$ **3.** $\log \sqrt[3]{\frac{M}{N}}$ **4.** $\log M\sqrt[4]{N}$ **5.** $\log M^2\sqrt{N}$ **6.** $\log \frac{1}{M}$

Write each expression as a rational number or as a single logarithm.

7. $\log 2 + \log 3 + \log 4$

8. $\log 8 + \log 5 - \log 4$

9. $\frac{1}{2}\log_6 9 + \log_6 5$

10. $\log_2 48 - \frac{1}{3}\log_2 27$

11. $2 \ln 6 - \ln 3$

12. $\frac{1}{2}\ln 5 + 3 \ln 2$

13. $\log M - 3 \log N$

14. $4 \log M + \frac{1}{2}\log N$

15. $\log A + 2 \log B - 3 \log C$

16. $\frac{1}{2}(\log_b M + \log_b N - \log_b P)$

17. $\frac{1}{3}(2 \log_b M - \log_b N - \log_b P)$

18. $5(\log_b A + \log_b B) - 2 \log_b C$

19. $\log \pi + 2 \log r$

20. $\log 4 - \log 3 + \log \pi + 3 \log r$

21. $\ln 2 + \ln 6 - \frac{1}{2}\ln 9$

22. $\ln 10 - \ln 5 - \frac{1}{3}\ln 8$

Simplify each expression.

23. **a.** $\ln e^2$ **b.** $\ln e^3$ **c.** $\ln \frac{1}{e}$ **d.** $\ln \sqrt{e}$

24. **a.** $\ln e^4$ **b.** $\ln \frac{1}{e^3}$ **c.** $\ln \sqrt[3]{e}$ **d.** $\ln 1$

25. **a.** $\ln e^x$ **b.** $e^{\ln x}$ **c.** $e^{2 \ln x}$ **d.** $e^{-\ln x}$

26. **a.** $\ln e^{3x}$ **b.** $e^{3 \ln x}$ **c.** $e^{\ln \sqrt{x}}$ **d.** $e^{(-1/2) \ln x}$

27. **a.** $10^{\log 6}$ **b.** $10^{2 \log 6}$ **c.** $10^{3 + \log 4}$ **d.** $e^{3 + \ln 4}$

28. **a.** $10^{3 \log 5}$ **b.** $e^{3 \ln 5}$ **c.** $10^{1 + 2 \log x}$ **d.** $e^{1 + 2 \ln x}$

Express y in terms of x.

29. **a.** $\log y = 2 \log x$ **b.** $\log y = 3 \log x + \log 5$

30. **a.** $\ln y - \ln x = 2 \ln 7$ **b.** $\ln y = 2 \ln x - \ln 4$

31. **a.** $\log y = -\log x$ **b.** $\log y = 2 \log x + \log 2$

32. **a.** $\log y + \frac{1}{2}\log x = \log 3$ **b.** $\ln y = \frac{1}{3}(\ln 4 + \ln x)$

33. **a.** $\log y = 1.2x - 1$ **b.** $\ln y = 1.2x - 1$

34. **a.** $\log y = 3 - 0.5x$ **b.** $\ln y = 3 - 0.5x$