

1 **a** = 64 **b** = 216 **c** = 1
d = 625 **e** = -243 **f** = $\frac{1}{16}$
g = $\frac{8}{27}$ **h** = $-\frac{1}{64}$ **i** = $(\frac{4}{3})^2 = \frac{16}{9}$ or $1\frac{7}{9}$
j = $(\frac{3}{2})^4 = \frac{81}{16}$ or $5\frac{1}{16}$ **k** = 0.000 01 **l** = -0.008

2 **a** 2^8 **b** 2^7 **c** 2^0 **d** 2^4 **e** 2^9 **f** 2^{14}

3 **a** = $8p^7$ **b** = x^{10} **c** = $6n^5$ **d** = y^{12}
e = $2b$ **f** = p^4q^3 **g** = x^3y **h** = $6r^2s^3$
i = $2x^3y^7$ **j** = $4a^5b^8$ **k** = $125r^3s^6 \div 100r^2s^2$ **l** = $15p^3q$
= $\frac{5}{4}rs^4$

4 **a** = $\frac{1}{3^2} = \frac{1}{9}$ **b** = 1 **c** = $\frac{1}{(-2)^6} = \frac{1}{64}$
d = $6^2 = 36$ **e** = $(\frac{3}{2})^{-3} = (\frac{2}{3})^3 = \frac{8}{27}$ **f** = $\sqrt{9} = 3$
g = $\sqrt[4]{16} = 2$ **h** = $\sqrt[3]{-27} = -3$ **i** = $\sqrt{\frac{1}{49}} = \frac{1}{7}$
j = $\sqrt[3]{125} = 5$ **k** = $\sqrt{\frac{4}{9}} = \frac{2}{3}$ **l** = $\frac{1}{\sqrt{36}} = \frac{1}{6}$
m = $\frac{1}{\sqrt[4]{81}} = \frac{1}{3}$ **n** = $\frac{1}{\sqrt[3]{-64}} = -\frac{1}{4}$ **o** = $\sqrt[5]{32} = 2$
p = $\sqrt[3]{-\frac{8}{125}} = -\frac{2}{5}$ **q** = $\sqrt{\frac{9}{4}} = \frac{3}{2}$ or $1\frac{1}{2}$ **r** = $(\frac{27}{8})^{-\frac{1}{3}} = \sqrt[3]{\frac{8}{27}} = \frac{2}{3}$

5 **a** = $(\sqrt{4})^3 = 2^3 = 8$ **b** = $(\sqrt[3]{27})^2 = 3^2 = 9$
c = $(\sqrt[4]{16})^3 = 2^3 = 8$ **d** = $(\sqrt[3]{-125})^2 = (-5)^2 = 25$
e = $(\sqrt{9})^5 = 3^5 = 243$ **f** = $\frac{1}{(\sqrt[3]{8})^2} = \frac{1}{2^2} = \frac{1}{4}$
g = $\frac{1}{(\sqrt{36})^3} = \frac{1}{6^3} = \frac{1}{216}$ **h** = $(\sqrt[3]{\frac{1}{8}})^4 = (\frac{1}{2})^4 = \frac{1}{16}$
i = $(\sqrt{\frac{4}{9}})^3 = (\frac{2}{3})^3 = \frac{8}{27}$ **j** = $(\sqrt[3]{216})^2 = 6^2 = 36$
k = $(\sqrt{\frac{16}{9}})^3 = (\frac{4}{3})^3 = \frac{64}{27}$ or $2\frac{10}{27}$ **l** = $(\sqrt[3]{-\frac{27}{64}})^4 = (-\frac{3}{4})^4 = \frac{81}{256}$
m = $\sqrt{\frac{4}{100}} = \frac{2}{10} = \frac{1}{5}$ or 0.2 **n** = $(\frac{9}{4})^{-\frac{3}{2}} = (\sqrt{\frac{4}{9}})^3 = (\frac{2}{3})^3 = \frac{8}{27}$
o = $(\sqrt[3]{\frac{64}{1000}})^2 = (\frac{4}{10})^2 = \frac{4}{25}$ or 0.16 **p** = $(\frac{25}{16})^{-\frac{3}{2}} = (\sqrt{\frac{16}{25}})^3 = (\frac{4}{5})^3 = \frac{64}{125}$
q = $(\frac{81}{16})^{\frac{3}{4}} = (\sqrt[4]{\frac{81}{16}})^3 = (\frac{3}{2})^3 = \frac{27}{8}$ or $3\frac{3}{8}$ **r** = $(\frac{64}{27})^{-\frac{4}{3}} = (\sqrt[3]{\frac{27}{64}})^4 = (\frac{3}{4})^4 = \frac{81}{256}$

- 6 **a** $= \sqrt{4} \times \sqrt[3]{27}$
 $= 2 \times 3 = 6$
- b** $= \sqrt[4]{16} + \sqrt{25}$
 $= 2 + 5 = 7$
- c** $= \frac{1}{\sqrt[3]{8}} \div \sqrt{36}$
 $= \frac{1}{2} \div 6 = \frac{1}{12}$
- d** $= \sqrt[3]{-64} \times (\sqrt{9})^3$
 $= -4 \times 27 = -108$
- e** $= 3^2 - \sqrt[3]{-8}$
 $= 9 - (-2) = 11$
- f** $= \sqrt{\frac{1}{25}} \times 4^2$
 $= \frac{1}{5} \times 16 = \frac{16}{5}$ or $3\frac{1}{5}$
- g** $= (\sqrt[4]{81})^3 - \sqrt{49}$
 $= 27 - 7 = 20$
- h** $= \sqrt[3]{27} \times (\sqrt{\frac{9}{4}})^3$
 $= 3 \times \frac{27}{8} = \frac{81}{8}$ or $10\frac{1}{8}$
- i** $= \sqrt{9} \times (\sqrt[5]{-32})^3$
 $= 3 \times (-8) = -24$
- j** $= \sqrt{121} + \sqrt[5]{32}$
 $= 11 + 2 = 13$
- k** $= \sqrt{100} \div (\sqrt{\frac{1}{4}})^3$
 $= 10 \div \frac{1}{8} = 80$
- l** $= \frac{1}{\sqrt[4]{16}} \times (\sqrt[5]{243})^2$
 $= \frac{1}{2} \times 9 = \frac{9}{2}$ or $4\frac{1}{2}$
- 7 **a** $= x^2$
- b** $= y^{-6}$
- c** $= 3p^{-4}$
- d** $= 8x^{-12}$
- e** $= y^{\frac{5}{2}}$
- f** $= 8b^{\frac{2}{3} + \frac{1}{4}} = 8b^{\frac{11}{12}}$
- g** $= x^{\frac{3}{5} - \frac{1}{3}} = x^{\frac{4}{15}}$
- h** $= a^{\frac{1}{2} - \frac{4}{3}} = a^{-\frac{5}{6}}$
- i** $= p^{\frac{1}{4} - (-\frac{1}{5})} = p^{\frac{9}{20}}$
- j** $= 9x^{\frac{4}{5}}$
- k** $= y^{1 + \frac{5}{6} - \frac{3}{2}} = y^{\frac{1}{3}}$
- l** $= \frac{1}{3}t$
- m** $= b^{2 + \frac{1}{4} - \frac{1}{2}} = b^{\frac{7}{4}}$
- n** $= y^{\frac{1}{2} + \frac{1}{3} - 1} = y^{-\frac{1}{6}}$
- o** $= 2x^{\frac{2}{3} + (-\frac{1}{6}) - \frac{3}{4}} = 2x^{-\frac{1}{4}}$
- p** $= \frac{1}{4}a^{1 + \frac{3}{4} - (-\frac{1}{2})} = \frac{1}{4}a^{\frac{9}{4}}$
- 8 **a** $x = 6^2 = 36$
- b** $x = 5^3 = 125$
- c** $x^{\frac{1}{2}} = \frac{1}{2}$
 $x = (\frac{1}{2})^2 = \frac{1}{4}$
- d** $x^{\frac{1}{4}} = 3$
 $x = 3^4 = 81$
- e** $x^{\frac{1}{2}} = \sqrt[3]{8} = 2$
 $x = 2^2 = 4$
- f** $x^{\frac{1}{3}} = \pm \sqrt{16} = \pm 4$
 $x = (\pm 4)^3 = \pm 64$
- g** $x^{\frac{1}{3}} = \pm \sqrt[4]{81} = \pm 3$
 $x = (\pm 3)^3 = \pm 27$
- h** $x^{\frac{3}{2}} = \frac{1}{27}$
 $x^{\frac{1}{2}} = \sqrt[3]{\frac{1}{27}} = \frac{1}{3}$
 $x = (\frac{1}{3})^2 = \frac{1}{9}$
- 9 **a** $= x^{\frac{1}{2}}$
- b** $= x^{-\frac{1}{3}}$
- c** $= x^2 \times x^{\frac{1}{2}} = x^{\frac{5}{2}}$
- d** $= \frac{x^{\frac{1}{4}}}{x} = x^{-\frac{3}{4}}$
- e** $= (x^3)^{\frac{1}{2}} = x^{\frac{3}{2}}$
- f** $= x^{\frac{1}{2}} \times x^{\frac{1}{3}} = x^{\frac{5}{6}}$
- g** $= (x^{\frac{1}{2}})^5 = x^{\frac{5}{2}}$
- h** $= x^{\frac{2}{3}} \times x^{\frac{3}{2}} = x^{\frac{13}{6}}$
- 10 **a** $4x^{-\frac{1}{2}}$
- b** $\frac{1}{2}x^{-1}$
- c** $\frac{3}{4}x^{-3}$
- d** $\frac{1}{9}x^{-2}$
- e** $\frac{2}{5}x^{-\frac{1}{3}}$
- f** $\frac{1}{3}x^{-\frac{2}{3}}$
- 11 **a** $= (2^3)^2 = 2^6$
- b** $= (2^{-2})^{-2} = 2^4$
- c** $= (2^{-1})^{\frac{1}{3}} = 2^{-\frac{1}{3}}$
- d** $= (2^4)^{-\frac{1}{6}} = 2^{-\frac{2}{3}}$
- e** $= (2^3)^{\frac{2}{5}} = 2^{\frac{6}{5}}$
- f** $= (2^{-5})^{-3} = 2^{15}$
- 12 **a** $= (3^2)^x = 3^{2x}$
- b** $= (3^4)^{x+1} = 3^{4x+4}$
- c** $= (3^3)^{\frac{x}{4}} = 3^{\frac{3}{4}x}$
- d** $= (3^{-1})^x = 3^{-x}$
- e** $= (3^2)^{2x-1} = 3^{4x-2}$
- f** $= (3^{-3})^{x+2} = 3^{-3x-6}$
- 13 **a** $= 2 \times 2^x = 2y$
- b** $= 2^{-2} \times 2^x = \frac{1}{4}y$
- c** $= (2^x)^2 = y^2$
- d** $= (2^3)^x = 2^{3x} = (2^x)^3 = y^3$
- e** $= 2^3 \times 2^{4x} = 8y^4$
- f** $= (2^{-1})^{x-3} = 2^3 \times 2^{-x} = \frac{8}{y}$

- 14** **a** $2^x = 2^6$
 $x = 6$
- b** $5^{x-1} = 5^3$
 $x - 1 = 3$
 $x = 4$
- c** $3^{x+4} = 27 = 3^3$
 $x + 4 = 3$
 $x = -1$
- d** $(2^3)^x = 2^{3x} = 2$
 $3x = 1$
 $x = \frac{1}{3}$
- e** $3^{2x-1} = 3^2$
 $2x - 1 = 2$
 $x = \frac{3}{2}$
- f** $16 = 4^2 = 4^{3x-2}$
 $2 = 3x - 2$
 $x = \frac{4}{3}$
- g** $(3^2)^{x-2} = 3^{2x-4} = 3^3$
 $2x - 4 = 3$
 $x = \frac{7}{2}$
- h** $(2^3)^{2x+1} = 2^{6x+3} = 2^4$
 $6x + 3 = 4$
 $x = \frac{1}{6}$
- i** $(7^2)^{x+1} = 7^{2x+2} = 7^{\frac{1}{2}}$
 $2x + 2 = \frac{1}{2}$
 $x = -\frac{3}{4}$
- j** $3^{3x-2} = (3^2)^{\frac{1}{3}} = 3^{\frac{2}{3}}$
 $3x - 2 = \frac{2}{3}$
 $x = \frac{8}{9}$
- k** $(6^{-1})^{x+3} = 6^{-x-3} = 6^2$
 $-x - 3 = 2$
 $x = -5$
- l** $(2^{-1})^{3x-1} = 2^{1-3x} = 2^3$
 $1 - 3x = 3$
 $x = -\frac{2}{3}$
- 15** **a** $2^{x+3} = (2^2)^x = 2^{2x}$
 $x + 3 = 2x$
 $x = 3$
- b** $5^{3x} = (5^2)^{x+1} = 5^{2x+2}$
 $3x = 2x + 2$
 $x = 2$
- c** $(3^2)^{2x} = 3^{4x} = 3^{x-3}$
 $4x = x - 3$
 $x = -1$
- d** $(4^2)^x = 4^{2x} = 4^{1-x}$
 $2x = 1 - x$
 $x = \frac{1}{3}$
- e** $(2^2)^{x+2} = (2^3)^x$
 $2^{2x+4} = 2^{3x}$
 $2x + 4 = 3x$
 $x = 4$
- f** $(3^3)^{2x} = (3^2)^{3-x}$
 $3^{6x} = 3^{6-2x}$
 $6x = 6 - 2x$
 $x = \frac{3}{4}$
- g** $6^{3x-1} = (6^2)^{x+2}$
 $6^{3x-1} = 6^{2x+4}$
 $3x - 1 = 2x + 4$
 $x = 5$
- h** $(2^3)^x = (2^4)^{2x-1}$
 $2^{3x} = 2^{8x-4}$
 $3x = 8x - 4$
 $x = \frac{4}{5}$
- i** $(5^3)^x = 5^{x-3}$
 $5^{3x} = 5^{x-3}$
 $3x = x - 3$
 $x = -\frac{3}{2}$
- j** $(3^{-1})^x = 3^{x-4}$
 $3^{-x} = 3^{x-4}$
 $-x = x - 4$
 $x = 2$
- k** $(2^{-1})^{1-x} = (2^{-3})^{2x}$
 $2^{x-1} = 2^{-6x}$
 $x - 1 = -6x$
 $x = \frac{1}{7}$
- l** $(2^{-2})^{x+1} = (2^3)^x$
 $2^{-2x-2} = 2^{3x}$
 $-2x - 2 = 3x$
 $x = -\frac{2}{5}$
- 16** **a** $= x^3 - 1$
- b** $= 2x^2 + 6x^3$
- c** $= 3 - x^2$
- d** $= 12x^3 + 8x$
- e** $= 3x^3 + 2x$
- f** $= 3 - 3x^2$
- g** $= 5x^{\frac{1}{2}} + x^2$
- h** $= 3x^2 - x^{-1}$
- i** $= x^6 + x^4 - 3x^2 - 3$
- j** $= 2x^9 + 6x^5 + x^5 + 3x$
 $= 2x^9 + 7x^5 + 3x$
- k** $= x^3 - 1 - 2 + 2x^{-3}$
 $= x^3 - 3 + 2x^{-3}$
- l** $= x^3 - x^{\frac{5}{2}} - x^{\frac{5}{2}} + x^2$
 $= x^3 - 2x^{\frac{5}{2}} + x^2$
- 17** **a** $= x^2 + 2$
- b** $= 2t^3 - 3t$
- c** $= x - 3x^{\frac{1}{2}}$
- d** $= \frac{y^5 - 6y^2}{3y}$
 $= \frac{1}{3}y^4 - 2y$
- e** $= p^{\frac{1}{4}} + p^{\frac{3}{4}}$
- f** $= 2w^{\frac{3}{2}} - \frac{1}{2}w$
- g** $= \frac{x^{\frac{1}{2}}(x+1)}{x+1}$
 $= x^{\frac{1}{2}}$
- h** $= \frac{t^{\frac{1}{2}} \times 2t(t^2 - 2)}{t^2 - 2}$
 $= 2t^{\frac{3}{2}}$