1. $\pm 1, \pm 2; 1$

2. $\pm 1, \pm 2, \pm 3, \pm 6; 1, -2, -3$

3. $\pm 1, \pm 2, \pm 4; -1$

4. $\pm \frac{1}{2}, \pm 1, \pm 2, \pm 4, \pm 8$; no rational roots

5. $\pm 1, \pm 2, \pm 4, \pm 8, \pm 16; -2$

6. $\pm 1, \pm 3, \pm 5, \pm 15$; no rational roots

7. $2, \pm i\sqrt{5}$

8. $5, \pm i\sqrt{7}$

9. $-3, 1, \frac{7}{2}$

10. $-5, \frac{1 \pm \sqrt{3}}{2}$

11. $\pm \frac{1}{2}, \pm 3$

12. $1, -2, \frac{1 \pm \sqrt{7}}{3}$

13. $-\sqrt{5}, \sqrt{13}$

14. $4 + \sqrt{6}, -\sqrt{3}$

15. $1 + \sqrt{10}, 2 - \sqrt{2}$

16. $1 - i, 5i$

17. $2 - 3i, -6i$

18. $4 + i, 3 - 7i$

19. $x^3 - x^2 + 9x - 9 = 0$

20. $x^3 + 3x^2 - 8x + 10 = 0$

21. $x^3 - 2x^2 + 16x - 32 = 0$

22. $x^3 - 3x^2 - 8x + 30 = 0$

23. $x^3 - 6x^2 + 4x - 24 = 0$

24. $x^3 - x^2 + 2 = 0$

25. $\pm \frac{1}{12}, \pm \frac{1}{6}, \pm \frac{1}{4}, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{2}{3}, \pm \frac{3}{4}, \pm 1, \pm \frac{3}{2}, \pm 2, \pm 3, \pm 6; \frac{1}{2}, \frac{3}{2}, \frac{2}{3}$

26. $\pm \frac{1}{10}, \pm \frac{1}{5}, \pm \frac{2}{5}, \pm \frac{1}{2}, \pm \frac{4}{5}, \pm 1, \pm 2, \pm \frac{5}{2}, \pm 4, \pm 5, \pm 10, \pm 20; 2, \frac{2}{5}, \frac{5}{2}$

27. $\pm \frac{7}{3}, \pm \frac{1}{6}, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{7}{6}, \pm 1, \pm \frac{3}{2}, \pm 3, \pm \frac{7}{2}, \pm 7, \pm \frac{21}{2}, \pm 21; \frac{1}{3}, -\frac{7}{2}, 1, 3$

28. $\pm \frac{1}{4}, \pm \frac{5}{4}, \pm \frac{1}{2}, \pm \frac{3}{4}, \pm \frac{1}{8}, \pm \frac{5}{8}, \pm \frac{3}{8}, \pm \frac{15}{4}, \pm \frac{5}{2}, \pm 1, \pm \frac{3}{2}, \pm \frac{15}{8}, \pm \frac{15}{2}, \pm 15, \pm 3, \pm 5; -\frac{1}{2}, \frac{3}{2}, \frac{5}{2}$

29. $x^4 - 6x^3 + 14x^2 - 24x + 40 = 0$

30. $x^4 - 2x^3 - x^2 + 6x - 6 = 0$

31. $x^4 - 6x^3 + 2x^2 + 30x - 35 = 0$

32. Never true; 5 is not a factor of 8, so by the Rational Root Theorem, 5 is not a root of the equation.

33. Sometimes true; since -2 is a factor of 8, -2 is a possible root of the equation.

34. Always true; use the Rational Root Theorem with $p = a$ and $q = 1$.

35. Sometimes true; since $\sqrt{5}$ and $-\sqrt{5}$ are conjugates, they can be roots of a polynomial equation with integer coefficients.

36. Never true; since $2 + i$ and $-2 - i$ are not conjugates, they cannot be the only imaginary roots of a polynomial equation with integer roots. If their conjugates were also roots, there would be four roots and the equation would have to be of fourth degree.

37. D

38. If $2i$ is a root, then so is $-2i$.

39. Answers may vary. Sample: $x^4 - x^2 - 2 = 0$; roots are $\pm\sqrt{2}$ and $\pm i$.

40. **a.** 2 real, 2 imaginary; 4 imaginary; 4 real

b. 5 real; 3 real, 2 imaginary; 4 imaginary, 1 real

c. Answers may vary. Sample: It has an odd number of real solutions, but it must have at least one real solution.

41. Answers may vary. Sample: You cannot use the Irrational Root Theorem unless the equation has rational coefficients.

42. $x^2 + (-2 + i)x + 12 - 8i = 0$

43. **a–c. Answers may vary. Sample:**

a. $x - 1 - \sqrt{2} = 0$

b. $x^2 - 2(1 + \sqrt{2})x + (1 + \sqrt{2})^2 = 0$

c. -1