22. A 1024 Hz tuning fork is held up to a closed air column (closed at one end and open at the other) at 30.0°C. What is the minimum length of an air column that would resonate with this frequency?

23. Organ pipes, open at one end, resonate best at their first resonant length. Two pipes have length 23.0 cm and 30.0 cm respectively.
- **a)** What is the wavelength of the sound emitted by each pipe?
- **b)** What are the respective frequencies if the speed of sound is 341 m/s?
- **c)** What is the air temperature in this church?

24. One of the tubes in Pan's flute measures 10 cm from one open end to the other. The air temperature is 20.0°C.
- **a)** What is the fundamental wavelength of the note that is heard?
- **b)** What is the corresponding frequency?

25. A tuning fork was sounded over an adjustable closed air column. It was found that the difference between the second and fifth resonant length was 90.0 cm. What was the frequency of the tuning fork if the experiment was done in a lab with air temperature 25.0°C?

26. Hollow tube chimes are made of metal and are open at each end. These columns resonate best at their third resonant length. One chime is 2.5 m long and the air temperature is 25.0°C.
- **a)** What is the speed of sound?
- **b)** What is the wavelength of the sound produced?
- **c)** What is the frequency of the sound that is heard?

27. A guitar string is struck and found to have a frequency of 2048 Hz. If both the tension and the length are doubled, what is the new frequency of the string?

28. A string that is 90.0 cm long with a diameter of 0.75 mm and a tension of 60.0 N has a frequency of 1000 Hz. What new frequency is heard in each of the following situations?
- **a)** The length is increased to 100.0 cm.
- **b)** The tension is increased to 80.0 N
- **c)** The diameter is increased to 0.77 mm.
- **d)** Both factors in parts a) and b) are done together.

29. A fundamental frequency of 550 Hz is played on a guitar string.
- **a)** What is the first harmonic frequency of the string?
- **b)** The tension of the string is doubled. What is the new fundamental frequency of the string?

30. The distance between the first and third nodes of a standing wave in a violin string is 4.0 cm.
- **a)** Draw a scale diagram to illustrate the string.
- **b)** What is the wavelength of the sound wave that is produced?
- **c)** What is the frequency of the note that is heard if the speed of sound is 345 m/s?

31. A string under a tension of 170 N has a frequency of 300 Hz. What will its frequency become if the tension is increased to 340 N?

32. Two steel strings of equal diameter and tension have a length of 0.75 m and 0.95 m respectively. If the frequency of the first string is 250 Hz, what is the frequency of the second string?

14.7 Music

33. In your notebook, draw a simple sketch of a wave form that illustrates the characteristics of sound indicated in each box in Fig. 14.42. Start with a single wavelength. Under each sketch, write a brief description of the waveform you have drawn.