**17.** Consider the image formed by a thin converging lens. Under what conditions will the image be

**a.** inverted?
**b.** upright?
**c.** real?
**d.** virtual?
**e.** larger than the object?
**f.** smaller than the object?

**18.** Repeat a–f of item 17 for a thin diverging lens.

**19.** Explain this statement: The focal point of a converging lens is the location of an image of a point object at infinity. Based on this statement, can you think of a quick method for determining the focal length of a positive lens?

### Conceptual Questions

**20.** If a glass converging lens is submerged in water, will its focal length be longer or shorter than when the lens is in air?

**21.** In order to get an upright image, slides must be placed upside down in a slide projector. What type of lens must the slide projector have? Is the slide inside or outside the focal point of the lens?

**22.** If there are two converging lenses in a compound microscope, why is the image still inverted?

**23.** In a Jules Verne novel, a piece of ice is shaped into the form of a magnifying lens to focus sunlight and thereby start a fire. Is this possible?

### Practice Problems

***For problems 24–26, see Sample Problem B.***

**24.** An object is placed in front of a diverging lens with a focal length of 20.0 cm. For each object distance, find the image distance and the magnification. Describe each image.

**a.** 40.0 cm
**b.** 20.0 cm
**c.** 10.0 cm

**25.** A person looks at a gem using a converging lens with a focal length of 12.5 cm. The lens forms a virtual image 30.0 cm from the lens. Determine the magnification. Is the image upright or inverted?

**26.** An object is placed in front of a converging lens with a focal length of 20.0 cm. For each object distance, find the image distance and the magnification. Describe each image.

**a.** 40.0 cm
**b.** 10.0 cm

## TOTAL INTERNAL REFLECTION, ATMOSPHERIC REFRACTION, AND ABERRATIONS

### Review Questions

**27.** Is it possible to have total internal reflection for light incident from air on water? Explain.

**28.** What are the conditions necessary for the occurrence of a mirage?

**29.** On a hot day, what is it that we are seeing when we observe a "water on the road" mirage?

**30.** Why does the arc of a rainbow appear with red colors on top and violet colors on the bottom?

**31.** What type of aberration is involved in each of the following situations?

**a.** The edges of the image appear reddish.
**b.** The central portion of the image cannot be clearly focused.
**c.** The outer portion of the image cannot be clearly focused.
**d.** The central portion of the image is enlarged relative to the outer portions.

### Conceptual Questions

**32.** A laser beam passing through a nonhomogeneous sugar solution follows a curved path. Explain.

**33.** On a warm day, the image of a boat floating on cold water appears above the boat. Explain.

**34.** Explain why a mirror cannot give rise to chromatic aberration.

**35.** Why does a diamond show flashes of color when observed under ordinary white light?