21 Why are liquids virtually incompressible? There is very little free space between the molecules of a liquid, and as they get closer, nuclear-nuclear repulsion prevents them from getting closer together.

22 What is surface tension? What is the relationship between intermolecular forces and surface tension? How does surface tension change with temperature? Surface tension is the amount of energy required to stretch or increase the surface of a liquid by one unit area. Substances with strong intermolecular forces also have high surface tension. Surface tension decreases with increasing temperature.

23 Despite the fact that stainless steel is much denser than water, a stainless-steel razor blade can be made to float on water. Why? The surface tension in the water is sufficient to support the weight of the razor blade.

24 Use water and mercury to compare adhesion and cohesion: Water is strongly attracted to the walls of its container due to similarities in polarity, creating strong adhesive forces responsible for the positive meniscus between water and glass. Mercury is not attracted as strongly to the container as to itself, so cohesive forces dominate and this creates the negative meniscus.

25 Why can a glass of water be filled slightly above the rim? The surface tension attracts molecules at the surface to internal molecules.

26 Explain and draw diagrams showing the capillary action of:
(a) water (red): the water will rise up the capillary tube because the forces of adhesion are greater than cohesion. The thinner the tube, the higher the water will rise.

(b) mercury (blue): the level of mercury will be lower in the capillary tube than on the outside because the forces of cohesion are greater than adhesion. The thinner the tube the lower the mercury level in the tube.

27 What is viscosity? What is the relationship between intermolecular forces and viscosity? Viscosity is the resistance of a liquid to flow. Liquids with strong intermolecular forces will also have high viscosity.

28 Why does viscosity decrease with increasing temperature? Viscosity decreases as the temperature increases because the molecules have more kinetic energy and so can more easily break the intermolecular forces.

29 Why is ice less dense than liquid water? Ice is less dense than water because the structure of the solid ice expands to accommodate the hydrogen bonds.

30 Why are outside pipes drained in winter? If left in place, the freezing water would expand and burst the pipes.

31 Predict which of the following liquids has a greater surface tension: ethanol (C₂H₅OH) or dimethyl ether (CH₃OCH₃). Ethanol molecules can attract each other with strong hydrogen bonds; dimethyl ether molecules cannot (why?). The surface tension of ethanol is greater than that of dimethyl ether because of stronger intermolecular forces (the hydrogen bonds). Note that ethanol and dimethyl ether have identical molar masses and molecular formulas so attractions resulting from dispersion forces will be equal.
32 Predict the viscosity of ethylene glycol relative to that of ethanol and glycerol (see pg. 444 in the text). Ethylene glycol has two –OH groups, allowing it to exert strong intermolecular forces through hydrogen bonding. Its viscosity should fall between ethanol (1 OH group) and glycerol (3 OH groups).

60 What is the equilibrium vapor pressure of a liquid? How is it measured and how does it change with temperature?
The equilibrium vapor pressure is the pressure due to the vapor that forms above a liquid in a closed container after it has reached equilibrium. (The amount of vapor is constant because the rate of evaporation is equal to the rate of condensation at equilibrium.) It can be measured with a manometer or a pressure gauge, and it increases with increasing temperature.

64 What can we learn about the intermolecular forces in a liquid from the molar heat of vaporization? When intermolecular forces are strong, it means that the molar heat of vaporization is high. (It takes more energy to vaporize.)

65 Is the statement, “The greater the molar heat of vaporization of a liquid, the greater its vapor pressure” True or False? Explain False; higher ΔH_vap will result in a lower vapor pressure at a given temperature.

72 The vapor pressure of a liquid in a closed container depends on which of the following? Explain.
a) the volume above the liquid—NO; liquid will evaporate to fill the container to the correct pressure (as long as some liquid remains)
b) the amount of liquid present—NO; as long as there is enough liquid to reach the correct pressure.
c) the temperature—YES; as T increases, more mlcls have enough energy to enter the gas phase, so the rate of evaporation increases; P_vap must increase so that the rate of condensation is equal to the rate of evaporation.
d) intermolecular forces between the molecules in the liquid—YES; with stronger IMFs, the rate of evaporation is lower, so P_vap does not need to be as high for the rate of condensation to equal the rate of evaporation.

77 Calculate the amount of heat (in kJ/mol) required to convert 74.6 g of water to steam at 100°C (the molar heat of vaporization for H_2O is 40.79 kJ/mol).

\[
q = \frac{74.6 \text{ g } H_2O \times 1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{40.79 \text{ kJ}}{1 \text{ mol } H_2O} = 169 \text{ kJ}
\]

79 How is the rate of evaporation affected by the following? Explain.
(a) Temperature: Other factors being equal, liquids evaporate faster at higher temperatures since more mlcls have enough KE to overcome IMFs.
(b) Surface area of the liquid exposed to air: The greater the surface area, the greater the rate of evaporation be more mlcls with sufficient KE are exposed to the atmosphere.
(c) Intermolecular forces: Weak intermolecular forces imply a high vapor pressure and rapid evaporation be more mlcls have sufficient energy to overcome IMFs.

97 At –35°C, liquid HI has a higher vapor pressure than liquid HF. Explain The HF molecules are held together by strong intermolecular hydrogen bonds. Therefore, liquid HF has a lower vapor pressure than liquid HI. (The HI molecules do not form hydrogen bonds with each other.)