Chapter 6: Thermal Energy and Society

Mini Investigation: Will It Pop?, page 269

A. Answers may vary. Sample answer:
For the water-filled balloon: water has a high heat capacity. This means that it takes lots of heat to increase the thermal energy of the water. When the temperature of the water increases, the liquid boils becoming a gas. The gas expands the balloon sides until the balloon bursts.
For the air-filled balloon: air has a low heat capacity. It is a ready conductor of heat. Heating the balloon quickly increases the thermal energy of the air, causing the gas to expand until the balloon bursts.

Section 6.1: Warmth and Coldness

Tutorial 1 Practice, page 273

1. (a) Given: $T_C = 32$ °C
Required: T_K
Analysis: $T_K = T_C + 273$
Solution:

$$T_K = T_C + 273$$
$$= 32 + 273$$
$$T_K = 305 \text{ K}$$

Statement: The temperature 32 °C is equal to 305 K.
(b) Given: $T_C = -10$ °C
Required: T_K
Analysis: $T_K = T_C + 273$
Solution:

$$T_K = T_C + 273$$
$$= -10 + 273$$
$$T_K = 263 \text{ K}$$

Statement: The temperature – 10 °C is equal to 263 K.
(c) Given: $T_C = 95$ °C
Required: T_K
Analysis: $T_K = T_C + 273$
Solution:

$$T_K = T_C + 273$$
$$= 95 + 273$$
$$T_K = 368 \text{ K}$$

Statement: The temperature 95 °C is equal to 368 K.
2. (a) Given: $T_K = 200$ K
Required: T_C
Analysis: $T_C = T_K - 273$
Solution:

$$T_C = T_K - 273$$
$$= 200 - 273$$
$$T_C = -73 \text{ °C}$$

Statement: The temperature 200 K is equal to –73 °C.
(b) Given: $T_K = 373$ K
Required: T_C
Analysis: $T_C = T_K - 273$
Solution:

$$T_C = T_K - 273$$
$$= 373 - 273$$
$$T_C = 100 \text{ °C}$$

Statement: The temperature 373 K is equal to 100 °C.
(c) Given: $T_K = 298$ K
Required: T_C
Analysis: $T_C = T_K - 273$
Solution:

$$T_C = T_K - 273$$
$$= 298 - 273$$
$$T_C = 25 \text{ °C}$$

Statement: The temperature 298 K is equal to 25 °C.

Mini Investigation: Film Canister Thermometer, page 273

A. The density of a liquid changes with temperature. This is the basis of any liquid thermometer. For a film canister thermometer, the density of liquid water decreases as the temperature of the water increases from 0 °C to room temperature. The density decreases because the volume of the liquid water increases as its temperature increases.
B. The distance the liquid rises will be noticeable but measurements will vary from student to student. Therefore, the thermometer cannot be very accurate.
C. The thermometer could be improved if narrower straws or very narrow hollow cylinders like capillary needles were used so that minute increases in the height of the water in the straw could be measured. Another improvement would be to use a liquid with a lower boiling point than water, like alcohol, but then the thermometer must be airtight to prevent evaporation of the alcohol.

D. The canister thermometer is not practical when measuring the temperature of a liquid because each student's thermometer will be calibrated a little differently, so the results will not all be the same.

Section 6.1 Questions, page 274

1. Temperature is a measure of the average kinetic energy of the particles in a substance. Thermal energy is the sum of the total potential energy and the total kinetic energy possessed by the particles in a substance.

2. The kinetic molecular theory states that as particles of matter gain kinetic energy, they move faster and further apart, raising the temperature and changing substances from a solid to a liquid or from a liquid to a solid. It also states that as particles of matter lose kinetic energy, they move more slowly and get closer together, lowering the temperature and changing a gas to a liquid or a liquid to a solid.

3. A temperature thermometer is a sealed glass tube containing liquid mercury (or coloured alcohol). When placed into a liquid or gas substance, the substance particles bump into the thermometer glass particles. When the temperature of the substance increases, the kinetic energy of the particles increases, causing a greater number of collisions with the glass particles. This increases the kinetic energy of the glass particles. The faster glass particles collide with the slower mercury particles inside the thermometer. This causes the mercury particles to move faster, making them collide more frequently with each other and to spread out. Therefore, the liquid rises up the thermometer. If the temperature of the mercury is lowered, the glass particles collide with the slower moving mercury particles. The glass particles slow down. The mercury particles, which are faster, transfer energy to the glass particles, slowing the mercury particles. The mercury particles have fewer collisions so the space between particles decreases, causing the mercury to go down the thermometer.

4.

Substance	Boiling point (°C)	Boiling point (K)
sodium	882.9	**1155.9**
helium	**–268.78**	4.22
copper	2567	**2840**
mercury	**357**	630

Sodium: Given: $T_C = 882.9$ °C
Required: T_K
Analysis: $T_K = T_C + 273$
Solution:

$$T_K = T_C + 273$$
$$= 882.9 + 273$$
$$T_K = 1155.9 \text{ K}$$

Statement: The boiling point of sodium is 1155.9 K.

Helium: Given: $T_K = 4.22$ K
Required: T_C
Analysis: $T_C = T_K - 273$
Solution:

$$T_C = T_K - 273$$
$$= 4.22 - 273$$
$$T_C = -268.78 \text{ °C}$$

Statement: The boiling point of helium is –268.78 °C.

Copper: Given: $T_C = 2567$ °C
Required: T_K
Analysis: $T_K = T_C + 273$
Solution:

$$T_K = T_C + 273$$
$$= 2567 + 273$$
$$T_K = 2840 \text{ K}$$

Statement: The boiling point of copper is 2840 K.

Mercury: Given: $T_K = 630$ K
Required: T_C
Analysis: $T_C = T_K - 273$
Solution:

$$T_C = T_K - 273$$
$$= 630 - 273$$
$$T_C = 357 \text{ °C}$$

Statement: The boiling point of mercury is 357 °C.

5. Answers may vary. Sample answer:
The caloric theory was disproved over a number of years and through experiments by James Prescott Joule and William Thomson (Lord Kelvin). One of Joule's experiments showed that heat was generated in a conductor, not transferred from another area. In another experiment, he measured the heat generated by compressing a gas. Both of these experiments disproved the caloric theory that heat moved from one object to another.

6. The volume of alcohol in a thermometer decreases when it is moved from a warm environment to a colder environment because the glass particles of the thermometer collide with the slower-moving particles of the alcohol,

transferring energy to them. This causes the glass particles to slow down. The particles of the alcohol in the thermometer collide with the glass, and transfer energy to them. The particles of the alcohol move more slowly and get closer to each other, decreasing in volume.

7. The freezing point and the melting point of most substances are the same.