Physical Science 20 Heat Review Answers

1. **What are the three states of matter? Explain how they differ using kinetic molecular theory.**
   Solids: particles vibrate around fixed positions transferring energy as they bump into each other
   Liquids: Particles move carrying energy with them throughout the substance. There is still some intermolecular bonding that holds particles close
   Gases: Particles move independently of each other carrying their energy with them
2. **Discuss how temperature differs from heat.**
   Temperature is a measure of the average kinetic energy of particles (thermal energy averaged over the number of particles) in a substance while heat refers to the transfer of thermal energy between two objects.
3. **What has more thermal energy: a 355 mL can of pop, or a 2 L bottle of pop, both at 288 K? Why?**
   The 2 L bottle of pop has more thermal energy because it contains more particles then the 355 mL of pop.
4. **What are the three modes of heat transfer?**
   Conduction: Heat transfer through solids. This is heat transfer by direct contact.
   Convection: Heat transfer through liquids and gases. Heat moves as the fluids move.
   Radiation: Heat transfer through electromagnetic waves and does not require a material to transfer the energy
5. **You touch a wooden tabletop and a metal table leg. Which one feels cooler? Why?**
   Metal leg feels cooler. It is a better thermal conductor so heat is transferred quickly away from fingertips. Metal has a low heat capacity so it absorbs heat quickly and also loses it quickly.
6. **What type of system does a calorimeter model? If a piece of gold is cooled, then placed in a calorimeter filled with water, explain what happens using the concept of conservation of energy.**
   A calorimeter models an isolated system because it is insulated from the surroundings. If a cold piece of gold is placed in a calorimeter filled with water, the water loses heat while the gold gains heat. Without loss of energy to the surroundings, energy is conserved and both substances are at thermal equilibrium.
7. **Why is there no temperature increase or decrease during changes of state?**
   The energy put into the system goes into overcoming the forces of attraction between particles and does not increase the kinetic energy hence no temperature change.

8. **Why do railroad tracks have gaps in them?**

To allow for thermal expansion (linear expansion) as temperatures increase so tracks do not bend.

9. **How is water different from other substances when it comes to volume expansion?**

Most substances expand when heated and contract when cooled, but water does the opposite for a small temperature range. When cooled from 4 to 0 degrees water expands allowing ice to float and warm oxygenated water to stay below ice allowing plants and animals to live.

10. a. Convert 50°F to Kelvin.

① $°C = (°F - 32) \times \frac{5}{9} = 10°C$ ② $K = °C + 273 = 10 + 273 = \boxed{283\ K}$

b. Convert 22°C to Kelvin.

$K = 22°C + 273 = \boxed{295\ K}$

11. How much heat is needed to raise the temperature of 50.0 g of water from 4.5°C to 83.0°C?

$Q = ?$

$m = 50.0\,g \times \left(\frac{1\,kg}{1000\,g}\right) = 0.0500\,kg$

$T_i = 4.5°C$

$T_f = 83.0°C$

$C = 4180 \frac{J}{kg°C}$

$Q = mC\Delta T = (0.0500\,kg)\left(4180 \frac{J}{kg°C}\right)(83.0 - 4.5°C)$

$= 16406.5\ J$

$= \boxed{1.6 \times 10^4\ J}$

12. A 10.0 kg piece of zinc at 71.0°C is placed in a container of water. The water has a mass of 20.0 kg and a temperature of 10.0°C before the zinc is added. What is the final temperature of the water and the zinc?

$m_z = 10.0\,kg$

$C_z = 388 \frac{J}{kg°C}$

$T_{iz} = 71.0°C$

$m_w = 20.0\,kg$

$C_w = 4180 \frac{J}{kg°C}$

$T_{iw} = 10.0°C$

$T_f = ?$

$m_w C_w (T_f - T_{iw}) = -m_z C_z (T_f - T_{iz})$

$m_w C_w T_f - m_w C_w T_{iw} = -m_z C_z T_f + m_z C_z T_{iz}$

$+ m_z C_z T_f \qquad - m_z C_z T_f$

$+ m_w C_w T_{iw} \qquad + m_w C_w T_{iw}$

$m_w C_w T_f + m_z C_z T_f = m_z C_z T_{iz} + m_w C_w T_{iw}$

$\frac{T_f (m_w C_w + m_z C_z)}{(m_w C_w + m_z C_z)} = \frac{(m_z C_z T_{iz} + m_w C_w T_{iw})}{(m_w C_w + m_z C_z)}$

$T_f = \frac{(10.0\,kg)(388 \frac{J}{kg°C})(71.0°C) + (20.0\,kg)(4180 \frac{J}{kg°C})(10.0°C)}{(20.0\,kg \times 4180 \frac{J}{kg°C} + 10.0\,kg \times 388 \frac{J}{kg°C})}$

$= \boxed{12.7\ °C}$

$m = 10.0\,g\left(\frac{1\,kg}{1000\,g}\right) = 0.0100\,kg$

13. How much heat is added to 10.0 g of ice at -20.0°C to convert it to steam at 120.0°C?

Q_1 = heat: -20.0°C to 0.0°C
Q_2 = heat of fusion
Q_3 = heat: 0.0°C to 100.0°C
Q_4 = heat of vaporization
Q_5 = heat: 100.0° to 120°C

$Q_{TOTAL} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$Q_1 = m\,C_{ice}\,\Delta T_1 = 0.01\,kg \times 2060\,\frac{J}{kg\,°C} \times 20.0°C = 412\,J$

$Q_2 = m\,H_f = 0.01\,kg \times 3.34 \times 10^5\,\frac{J}{kg} = 3340\,J$

$Q_3 = m\,C_{water}\,\Delta T_2 = 0.01\,kg \times 4180\,\frac{J}{kg\,°C} \times 100.0°C = 4180\,J$

$Q_4 = m\,H_v = 0.01\,kg \times 2.26 \times 10^6\,\frac{J}{kg} = 22600\,J$

$Q_5 = m\,C_{steam}\,\Delta T_3 = 0.01\,kg \times 2020\,\frac{J}{kg\,°C} \times 20°C = 404\,J$

$Q_{TOTAL} = 1.06 \times 10^4\,J$

14. A metal bar of length 8.024 m undergoes a temperature increase of 123°C. Its length increases by 0.020 m. Determine the metal's coefficient of linear expansion during the temperature change.

$L_0 = 8.024\,m$
$\Delta L = 0.020\,m$
$\Delta T = 123°C$
$\alpha = ?$

$\frac{\Delta L}{L_0 \Delta T} = \frac{L_0 \alpha \Delta T}{L_0 \Delta T}$

$\frac{0.020\,m}{(8.024\,m)(123°C)} = \alpha$

$2.0 \times 10^{-5}\,°C^{-1} = \alpha$

15. Coffee having a volume of 272 mL completely fills a cup made of Pyrex glass. The coffee and cup are at 21°C, and are placed in a microwave oven and heated to 89°C. Assuming coffee and water have the same coefficient of volume expansion, find the volume of coffee that overflows from the cup.

$V_{0C} = 272\,mL$
$T_i = 21°C$
$T_f = 89°C$
$V_{0G} = 272\,mL$
$V_{spilled}$
$\beta_C = \beta_W = 210 \times 10^{-6}\,°C^{-1}$
$\beta_G = 9 \times 10^{-6}\,°C^{-1}$

$\Delta V = V_0 \beta \Delta T$

coffee $\Delta V_C = 272\,mL \times 210 \times 10^{-6}\,°C^{-1} \times (89 - 21°C) = 3.88\,mL$

Pyrex glass $\Delta V_G = 272\,mL \times 9 \times 10^{-6}\,°C^{-1} \times (89 - 21°C) = 0.166\,mL$

$V_{spilled} = 3.88\,mL - 0.166\,mL = 3.7\,mL$