Thermal Conductivity Chemistry Questions with Solutions

Q1: What is the Fourier's law of heat conduction?

Answer: The Fourier's law states that the rate of conduction is directly proportional to the area perpendicular to the direction of heat flow and also to the temperature gradient in the same direction.

$$Q = -kA\, dT/dx$$

Where dT/dx = temperature gradient with the unit = K m^{-1}
A = Area under measurement (m^2)
k = thermal conductivity (W m^{-1} K^{-1})
Q = heat transferred

Q2. The thermal conductivity of copper is 390 W m^{-1} K^{-1}. Calculate the rate of heat transfer through a copper wire with area 4.0 cm^2 and length 0.50 m. The temperature difference between both of the ends of the wire is 30 °C.

Answer: Given: k = 390 W m^{-1} K^{-1}
Area(A) = 4.0 x 1/ 10^4 m^2 = 4.0 x 10^{-4} m^2
Δθ = 30 °C
Length (x) = 0.50 m
Rate of heat transfer (Q/t) = ?
Hence,

$$\frac{Q}{t} = \kappa A.\frac{\Delta\theta}{x} = \frac{390.4 * 10^{-4}.30}{0.5} = 2.3\ W$$

Rate of heat transfer = 2.3 W

Q3. What is a Black Body?

Answer: A substance that can emit and absorb the radiations of all frequencies.

Q4. Gases have lower thermal conductivity than pure metals. Compare the thermal conductivities of copper and air.

Answer: The thermal conductivity of copper is around 10,000 times that of the thermal conductivity of air.
k_{air} = 0.026
k_{copper} = 384.1

Q5. Which factors can affect thermal conductivity?

Answer: The factors influencing the thermal conductivity are:

a. Humidity
b. Temperature
c. Thermal Anisotropy
d. Phase change
e. Magnetic Field
f. Electrical Conductivity

Q6. How does the thermal conductance take place in solid and gaseous phase substances?

Answer: In solids, the thermal conductance can occur in two ways:

a. By the motion of free electrons, in case of metals
b. By the lattice vibrations or phonons, in case of non- metals

While in the case of gases, thermal conductance takes place via discrete molecular collisions of gaseous particles/ molecules.

Q7. A wall with a surface area of 1 m^2 and thickness of 0.6 m has thermal conductivity 0.65 W m^{-1} K^{-1}. If the inner and outer temperatures of the wall are 1640 ^oC and 340 ^oC respectively, calculate the rate of heat transfer of the wall.

Answer: From the Fourier law of heat conduction:

$$Q = \frac{\Delta T}{\frac{b}{\kappa A}}$$

Given: k = 0.65 W m^{-1} K^{-1}
$\Delta T = T_i - T_o$
T_i = 1640 ^oC and T_o = 340 ^oC
ΔT = 1640 -340 = 1300 ^oC
b = 0.6 m and A = 1 m^2
Hence,

$$Q = \frac{\Delta T}{\frac{b}{\kappa A}}$$

$$Q = \frac{1300}{\frac{0.6}{0.65*1}} = 1408.3\ W$$

Thus, rate of heat transfer = 1408.3 W.

Q8. If an analogy is to be drawn in between the heat flow and the electricity flow in the circuits, the heat flow will be equated against the _____ in the electrical circuit.

a. Voltage
b. Resistance
c. Charge
d. Current

Answer: (d.)

Explanation: The heat flow in solid substances is due to the flow of electrons. The flow of electrons corresponds to current.

Q9. Which substance has the highest thermal conductivity of all?

Answer: The thermal conductivity of a substance depends strongly on its molecular arrangement and the temperature of the medium. Hence, Diamond has the highest value of thermal conductivity i.e. 2200 $W\ m^{-1}\ K^{-1}$.

Q10. Which is cooler at night- sea or land?

Answer: Since land has higher thermal conductivity than the sea, it cools off quickly before the sea does. Hence, the land is cooler than the sea at night.

Q11. Which of the following behaves as a conductor or insulator based on the temperature provided?

a. TiO
b. TiO_3
c. SiO_2
d. MgO

Answer: (b.)

Explanation: The energy gap between the valence band and the conduction band of TiO_3 varies with temperature.

Q12. Why does a brass tumbler feel cooler than a wooden tray during winters?

Answer: As brass is a metal and a good conductor of heat, when one touches a brass tumbler during winters or on any chilly day, the heat from the body gets conducted to the brass tumbler, and the temperature of the body decreases. This is why the brass tumbler feels cold.
While wood is not a good conductor of heat, which is why wood does not conduct heat from the body. Thus, the temperature of the body does not reduce and the wood feels hot.

Q13. How does the water in the earthen pot stay cool?

Answer: This is because the earthen pot has a very large number of tiny pores on its surface. Due to these tiny pores, the water from inside the earthen pot continuously keeps coming out of the walls of the earthen pot. The water on the surface of the pot vaporizes continuously and takes the latent heat required for the vaporization from the material of the pot surface. Thus, in this way, the temperature of the pot and hence the water inside the pot decreases.

Q14. Name a metal which is the best conductor of heat.

Answer: Copper has the highest thermal conductivity (386 K m^{-1} K^{-1}). Hence, copper is the best conductor of heat.

Q15. What is the difference between the terms: air-conditioning and refrigeration?

Answer: The differences in between air-conditioning and refrigeration are listed below:

Air-conditioning	Refrigeration
It circulates the cold air, pushing it away within the desired space.	It keeps the air close within the smaller space.
It maintains the temperature of the air at a certain level below the room temperature.	Refrigeration oftens reduces the temperature to around 0 ^{o}C.
Air-conditioning uses coolants and atmospheric air.	Refrigeration uses only coolants.

Practise Questions on Thermal Conductivity

Q1. Which among the following will cool most quickly?

a. Fe
b. Cu
c. Zn
d. Au

Answer: (b.)

Explanation: Cu has the highest thermal conductivity. Hence, Cu will heat and then cool down most quickly.

Q2. Write some generalized applications of thermal conductivity.

Answer: The substances with higher thermal conductivity are used in heat-sink applications; while the substances with lower thermal conductivity are used as thermal insulators.

Q3. Why is the thermal conductivity of ice greater than that of water?

Answer: This is because the molecules of ice are systematically arranged. While the molecules in water are free to flow and have spaces between them. As thermal conductivity increases with the close-packing of the substance, the thermal conductivity of ice is more than water.

Q4. Name the 4 commonly used refrigerants.

Answer: 4 commonly used refrigerants are:

a. Ammonia (NH_3)
b. Freon
c. CO_2
d. SO_2

Q5. What are the different modes of heat transfer?

Answer: There are 3 modes of heat transfer:

a. Conduction
b. Convection
c. Radiation