Answers to End of unit questions 5

1. For net heat flow, there must be a temperature difference between two places or between the two ends of the material. It is not necessary to have a heat-conducting material for heat transfer.
2. Net heat flow from one object to another object stops when the two objects attain thermal equilibrium. At thermal equilibrium, two objects may exchange energy, but net heat flow is zero.
3. Spontaneously heat flows towards the cooler region.
4. Whenever a body absorbs heat, it becomes hotter, and when it releases heat, it becomes colder provided that no phase change takes place. When a body absorbs heat, the average kinetic energy of its particles rises, by then causing the body's temperature to rise. If no phase shift occurs, the heat provided to a body is exactly proportional to its temperature change. That is, heat (Q) = mass (m) × specific heat capacity (c) × change in temperature (ΔT). If the potential energy in the gas is neglected (the gas is assumed to be ideal gas), its internal energy depends only on temperature.
5. Temperature is proportional to the average kinetic energy of atoms and molecules in a substance. Internal energy of a system or a body with well defined boundaries is the sum of the total kinetic energy of its molecules and the total intermolecular potential energy. Therefore, increasing temperature or average molecular kinetic energy keeping intermolecular potential energy constant increases the internal energy of the system.
6. Heat is the energy in transit whenever temperature differences exist. The internal energy is equal to the sum of internal kinetic energy due to molecular motion and internal potential energy due to molecular attractive forces. A hot body has more internal energy than an identical cold body. When heat is supplied to an inflated balloon, the balloon expands by then doing work on the surrounding and the gas in the balloon gets hotter by then increasing the internal energy.
7. The three heat transfer mechanisms:

- ▷ Conduction heat transfer is the transfer of heat through matter (i.e., solids, liquids, or gases) by collisions between particles of the medium but without molecular drift or without bulk motion of the medium. On the other hand, heat transfer in solids is due to the combination of lattice vibrations of the molecules and the energy transport by free electrons.
- ▷ Convection heat transfer occurs partly due to molecular movement and partly as a result of mass transfer.
- ▷ Radiation is the method of transferring heat from one body to another without engaging the medium's molecules. Radiation heat transfer does not rely on the medium.

The general mode of heat transfer in solids, in liquids and gases:

- ▷ The general mode of heat transfer in solids is conduction.
- ▷ The general mode of heat transfer in liquids and gases is convection.

8. The ambient temperature is uniform on the cylinder's periphery, and the temperature is uniform. As a result, it only happens in the radial direction.
9. The boiling point of water can be changed in several ways such as by adding solutes such as sugar, salt and other non-volatile solutes. The important factor which changes the boiling point of water, and is the primary focus of this topic is that the boiling point of water or any fluid can be changed by changing the pressure.

10. Given: $T_0 = 20.0^{o}C$, $A_0 = 100.0cm \times 50.0cm = 5000.0cm^2$, $\alpha = 11\times10^{-6}\,{}^{o}C^{-1}$, $T = 100.0^{o}C$

Change in area

$$\Delta A = A_0 \alpha \Delta T = 5000.0cm^2 \times 11\times10^{-6}\,{}^{o}C^{-1} \times \left(100.0^{o}C - 20.0^{o}C\right) = 4.4cm^2$$

Area at $T = 100.0^{o}C$,

$$A = A_0 + A_0\alpha\Delta T = 5000.0cm^2 + 4.4cm^2 = 5004.4cm^2$$

11. Given: $\Delta T = 10.0°C$, $Q = 9000$ J, $m = 1000$ g=1kg

The specific heat capacity of the metal, c, can be calculated from $Q = mc\Delta T$, as

$$c = \frac{Q}{m\Delta T} = \frac{9000J}{1kg \times 10.0°C} = 900J / kg.°C;$$

The metal is Aluminium.

12. Thermal energy is part of internal energy, but not internal energy. The thermal energy of a system is the average kinetic energy of the system's constituent particles due to their motion.
13. A phase diagram is a graphical representation of the phases present in the system of materials at various temperatures, and pressures. It can be used to determine the melting temperature of various phases, the range of solidification, and so on.
14. At 374°C, particles of water in the gas phase are moving very, very rapidly. At any temperature higher than that, the gas phase cannot be made to liquefy, no matter how much pressure is applied to the gas. The critical pressure (P_c) is the pressure that must be applied to the gas at the critical temperature in order to turn it into a liquid. For water, the critical pressure is very high, 217.7 atm. The critical point is the intersection point of the critical temperature and the critical pressure.

15. Given: $m_m = 200\ g = 0.2kg$, $T_0 = 20°C$, T = 105 °C, P= 20W, t = 100s

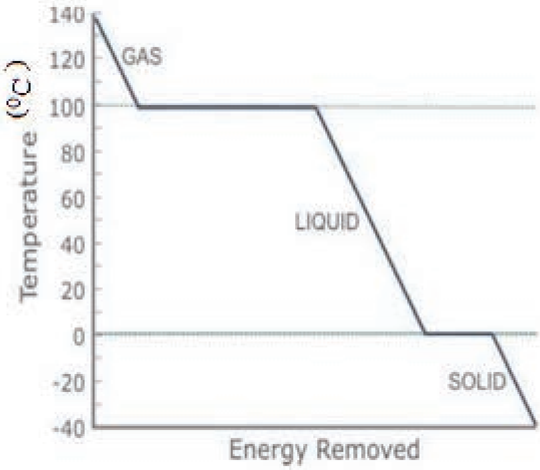
Use the principle of calorimetry,

$$Pt = m_m c_m \left(T - T_0\right)$$

After some rearrangements, we obtain

$$c_m = \frac{Pt}{m_m\left(T - T_0\right)} = \frac{20W \times 100s}{0.2kg \times \left(105°C - 20°C\right)} = 11.76\ J / kg.°C$$

16. The cooling curve for water is given below.



17. **Given**: $m_s = 0.5\text{kg}$, $T_s = 100.0°C$, $m_c = 0.2\text{kg}$, $T_w = 30.0°C$, $T = 80.0°C$, $c_w = 4200.0\text{J/kg.K}$, $c_{Cu} = c_c = 420.0\text{J/kg.K}$, $L_{v,w} = 2.26 \times 10^6\text{J/kg}$

▷ Fall in temperature of steam: $T_s - T = -\Delta T_s = 100.0°C - 80.0°C = 20.0°C$

▷ Rise in temperature of water + calorimetry: $T - T_w = 80.0°C - 30.0°C = 50.0°C$

▷ Heat lost by steam:

$$Q_s = m_s L_{v,w} + m_s c_w (T_s - T)$$
$$Q_s = 0.5\text{kg} \times 2.26 \times 10^6 \text{J/kg} + 0.5\text{kg} \times 4200.0\text{J/kg.°C} \times 20°C$$
$$Q_s = 1.172 \times 10^6 \text{ J}$$

▷ Heat gained by water + calorimeter:

$$Q_{w+c} = m_c c_c \Delta T_w + m_w c_w \Delta T_w$$
$$Q_{w+c} = 0.2\text{kg} \times 420.0\text{J/kg.°C} \times 50.0°C + m_w \times 4200.0\text{J/kg.°C} \times 50.0°C$$
$$Q_{w+c} = 4200.0\text{J} + 210000.0\text{J/kg} \times m_w$$

▷ We know heat lost by steam is equal to heat gained by water and calorimetry. Substituting values in to $Q_s = Q_{w+c}$ and solving for m_w, we obtain

$$m_w = 5.56\text{kg}$$