Showing all working, convert the following temperature values to the scale indicated:

3. Convert 50^{o}C to Kelvin

4. Convert 300K to Celsius

5. Convert 400K to Fahrenheit

6. A weather report gives the temperature in Atlanta, Georgia, USA as being 72^{o}F. What is the Celsius equivalent?

7. A job procedure states that the melting point of soft solder to be used is about 183^{o}C, and that the soldering iron should be set to about 260^{o}C. The soldering iron thermostat scale is graduated from 100^{o}F to 700^{o}F. What should the thermostat be set to?

Showing all working, carry out the calculations necessary to answer the following questions:

1. A 5 litre container of water is to be heated to a temperature of 80^oC.   Calculate the heat energy required when the initial temperature is 15^oC.

2. A 10 litre container of water is to be heated to a temperature of 60^oC.   Calculate the heat energy required when the initial temperature is:

   (a) 15^oC

   (b) 40^oC

3. Express each of the values of heat energy calculated in Q2 above in terms of electrical energy (kWh)

   (a)

   (b)

The following table gives the approximate specific heat at 25^{o}C for some common materials:

Material	**Specific Heat** (kJ/kg.^{o}C)
Air	1.010
Aluminium	0.900
Ethyl Alcohol	2.450
Gold	0.130
Granite	0.800
Iron	0.450
Olive Oil	2.000
Silver	0.240
Stainless Steel	0.510
Water	4.185
Wood	1.760

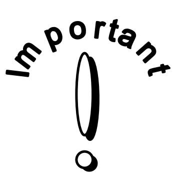
Note that of this list, water has the highest specific heat, while gold has the lowest specific heat.   Therefore, if the same mass of water and gold absorbed the same amount of heat, the temperature of gold would be much higher than that of water.

Latent Heat

When sufficient heat is added to water, the temperature rises until the water begins to boil at 100^{o}C (at sea level).   The temperature remains at a constant 100^{o}C until all of the water has changed state from liquid to vapour (steam).

Similarly, when sufficient heat is removed from water, the temperature falls until the water begins to freeze at 0^{o}C (at sea level).   The temperature remains at a constant 0^{o}C until all of the water has changed state from liquid to solid (ice).

The heat required to be added or removed from a matter to bring about a change of state is called *Latent Heat*.



The Latent Heat of a material is expressed in terms of the heat energy (kJ) required to change the state of one kilogram (kg) of the material.

If water is boiling to steam at 100^{o}C, the heat that is absorbed without changing the temperature of the water is the latent heat.   This latent heat energy expended in changing the water to steam is not lost, but is then stored as energy in the steam; this latent energy is released when the steam is condensed to form water.

The latent heat gained or absorbed during vaporisation is equal to that lost or given off during condensation.   Vaporisation and condensation occur at the same temperature at a given pressure.   In the case of water, this is 100^{o}C at atmospheric pressure (101.3kPa) at sea level.

For each of the following examples, indicate whether the means of heat transfer is MAINLY Conduction, Convection or Radiation:

(Select the main means only, even though other means may be involved)

1. Transfer of heat from a hot car engine to the cooling water

   . . . .

2. Transfer of heat from a heat lamp to a person's body

   . . . .

3. Transfer of heat from the water at the bottom of a heated pan to the rest of the water

   . . . .

4. Transfer of heat from the bottom of a heated saucepan to the end of the metal handle

   . . . .

5. Prevention of excess heat behind a bar heater by using a reflector to direct the heat forward

   . . . .

Give five common examples of heat conducting materials and five common examples of heat insulating materials:

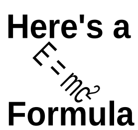
Heat Conducting Materials	**Heat Insulating Materials**
. . . .	. . . .
. . . .	. . . .
. . . .	. . . .
. . . .	. . . .
. . . .	. . . .

ELECTRIC HEATING

General Considerations

Heat is produced when an electric current flows through a conductor. Electric current is the movement of electrons, and heat is the result of raising the energy level of the atoms of the conducting material in the process of freeing electrons from their parent atoms. The amount of heat produced is:

- **proportional to square of the current flowing**
- **directly proportional to the resistance of the conducting path**
- **directly proportional to the time that the current flows**



To find the heat energy produced by a current flowing through a resistance for a period of time:

Heat Energy (J)

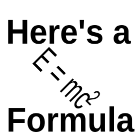
$$E = I^2Rt$$

Current (A)

Resistance (S)

Time (s)

Recall that power is the rate of doing work or expending energy. Recall also that the unit of energy, the joule (J), is equal to one watt.second (Ws) – one watt of power for one second. Therefore it follows that the power dissipated in watts (W) by an electric current flowing through a resistance is equal to the energy in joules (J) divided by the time in seconds (s).



To find the power dissipated by a current flowing through a resistance:

Power (W)

$$P = I^2R$$

Current (A)

Resistance (Ω)

Heat produced by an electric current may be desirable *(as in an appliance intended to produce heat)* **or undesirable** *(as in cables carrying current or electrical connections with relatively high resistance)*. **In any case, the relationships are the same, and the above formulae apply.**

Showing all working, carry out the calculations necessary to answer the following questions:

1. An electric heater has a resistance of 16Ω and operates on a 240V supply for a period of 30 minutes.

   (a) Calculate the energy in JOULES (J) used by the heater.

   (b) Calculate the energy in WATT-HOURS (Wh) used by the heater.

   (c) Calculate the power in WATTS (W) of the heater.

Showing all working, carry out the calculations necessary to answer the following questions:

2. An electric heater rated at 2kW operates on a 240V supply.

(a) Calculate the current in amperes (A) drawn by the heater.

(b) Calculate the resistance in ohms (Ω) of the heater element.

(c) If the heater operates for a period of 3 hours, calculate the energy in JOULES (J) used by the heater.

(d) If the heater operates for a period of 3 hours, calculate the energy in WATT-HOURS (Wh) used by the heater.

Answer the following questions relating to automatic control of electric heating:

1. “Automatic On/Off control” is a form of heating control where:

   (a) the quantity of current is varied smoothly

   (b) the quantity of current is varied in fixed steps

   (c) the current is switched off or on, determined by the actual temperature

   (d) the current is switched off or on, unrelated to the actual temperature

2. A bi-metal thermostat operates on the principle of:

   (a) variation of pressure in a bi-metal tube

   (b) bending of a bi-metal strip when current flows in it

   (c) expansion of a bi-metal strip with increase in temperature

   (d) bending of a bi-metal strip with increase in temperature

3. An expanding tube thermostat operates on the principle of:

   (a) bending of a bi-metal tube when current flows in it

   (b) expansion of a bi-metal tube with increase in temperature

   (c) variation of pressure in a bi-metal tube

   (d) expansion of a brass tube with increase in temperature

4. A capillary type thermostat operates on the principle of:

   (a) bending of a bi-metal capillary when current flows in it

   (b) expansion of a bi-metal capillary with increase in temperature

   (c) variation of pressure in a capillary tube

   (d) expansion of a capillary tube with increase in temperature

Answer the following questions relating heating controlled by a simmerstat:

1. A simmerstat provides a form of control described as:
   - **(a) open cycle manual control**
   - **(b) closed cycle automatic control**
   - **(c) open cycle automatic control**
   - **(d) closed cycle manual control**

2. In relation to the small internal heater element of a simmerstat, the heater load is:
   - **(a) connected in parallel with the internal heater element**
   - **(b) connected in series with the internal heater element**
   - **(c) connected with the internal heater element as required by the situation**
   - **(d) not connected in any way with the internal heater element**

3. With simmerstat control, the electrical energy to the heater load is controlled by:
   - **(a) smoothly varying the current flowing, determined by a pre-set setting**
   - **(b) on/off control of the current flowing, determined by a pre-set setting**
   - **(c) smoothly varying the current flowing, determined by the temperature output**
   - **(d) on/off control of the current flowing, determined by the temperature output**

4. The compensating bi-metal of a simmerstat ensures:
   - **(a) changes in ambient temperature will affect the output heat of the load**
   - **(b) changes in ambient temperature will not affect the output heat of the load**
   - **(c) heat of the load will affect the ambient temperature**
   - **(d) heat of the load will affect the input electrical energy**