

Problem Set 2: Heat Transfer

- 2.1 This material reduces heat transfer by radiation. Because the surface of the aluminium sheet is shiny it reflects heat back into the house in winter and reflects heat from outside the house away from the house in summer.
- 2.2 The water at the surface of the pool is heated by the Sun's radiation and as hot water is less dense than cold water will remain at the surface. This means there will be no heat transfer by convection. The only method of heating the water is by conduction which will be slow as water is a poor conductor.
- 2.3 The cold air in the freezer is denser than the hot air around it and will not rise, remaining in the freezer and limiting convection currents. The only way for heat to be gained is by radiation and conduction which will occur slowly.
- 2.4 Your feet feel cold as heat flows from them into the concrete floor which is a better conductor than carpet. This means more heat will flow from your feet. The carpet will reach thermal equilibrium with your feet resulting in no more heat flow.
- 2.5 Metals are better conductors than plastic so a metal fork will take heat away from your hand more quickly than a plastic fork, effectively making the metal fork feel colder.
- 2.6 [a] The electricity supplied by the energy company causes the particles in the internal metal wire to vibrate more violently causing the wire to become hot. This hot wire emits red light as infrared radiation which is reflected by the shiny backing around the element ensuring that most of the heat energy is directed in the desired direction (into the room). There is also some heating due to convection, but as bar heaters are usually mounted high up, this hot air rises to the ceiling of the room, having little effect in heating the room.
[b] Forced convection by the fan moves warm air horizontally for some distance instead of allowing it to rise straight up. This makes the user feel warmer without using significantly more power.
- 2.7 Dull, black objects are the best absorbers of heat radiated by the sun whereas light or white coloured clothing reflects this radiated heat away.
- 2.8 Clothes trap layers of air between your body and the surrounding environment. As air is an excellent insulator, it limits the heat lost from your body through conduction. This layer of air is also fairly well trapped which reduces heat lost through convection. In the absence of clothing, this layer of air close to the skin is being constantly replaced by air through wind and draughts that has not been warmed by your body heat.
- 2.9 Glass is a poor conductor of heat. In addition to the air between the fibres is an even poorer conductor. The air cannot transmit heat energy by convection because it is trapped and cannot move. While some heat is transferred by radiation, this can be reduced by covering the pads with aluminium foil or a similar shiny material.
- 2.10 The curtains are insulators and absorb radiation from the hot objects in the room and re-emit that as heat as heat energy which is retained in the room. The curtains also trap a layer of air between them and the window which also limits the heat lost from the room.
- 2.11 A thermal is the result of localised heating of air over hot spots on the ground, predominantly darker areas such as wheat fields, towns or sunlit hillsides. The hot air is less dense than the air above it so it rises. As it rises, it expands and cools until its density again matches that of the air around it. At this point it stops rising.

Heating Processes

- 2.12 The hotter the tea is compared to the temperature of the surrounding environment, the faster it will cool. Therefore, it would be better to add the milk immediately, in order to slow down this cooling process. However, if too much milk is added, then the tea will cool significantly on adding the milk. So it all depends on the amount of milk added.
- 2.13 Dull, black objects are the best absorbers of heat transferred by radiation such as the heat radiated by hot coals or burning wood, whereas shiny materials will tend to reflect this radiated heat away.
- 2.14 [a] Like water, glycol has a high specific heat capacity however it is not as corrosive as water.
[b] The radiator is made of a good conductor, in addition to having a large surface area and narrow water tubes which allow the water to cool quickly.
[c] The fan creates a forced convection component which increases the mass of cooler air flowing over the hot radiator.
[d] The engine operates more efficiently when it is hot. The thermostat acts like a switch would and activates at a particular temperature. The coolant does not circulate when the engine is cold as it does not need to, it only circulates when the engine is hot to avoid overheating.
[e] Relatively good conductor, high specific heat capacity, low coefficient of expansion when hot, strong enough so it does not break as fuel burns and expansion moves the pistons.
- 2.15 [a] Evaporation occurs from the surface of the material. When the tea is poured into a saucer it has a greater surface area which allows more evaporation to occur. As the molecules evaporate, they take their latent heat of vaporisation from the remaining liquid which cools it.
[b] Blowing onto the tea removes vaporised molecules more quickly near the surface of the liquid. It is a form of forced convection which prevents the immediate area of air from becoming saturated. This prevents the molecules from recondensing and allows more molecules to evaporate from the surface of the tea. As the molecules evaporate, they take their latent heat of vaporisation from the remaining liquid, cooling it.
- 2.16 [a] Infrared radiation is radiated from the hot bricks. There are also some convection currents produced immediately above the brick surface.
[b] The Sun's fusion reactions at its core cause very high temperatures, which in turn cause the emission of infrared, visible and ultra-violet electromagnetic radiation. The ultra-violet radiation is stopped by the Earth's atmosphere, but the remaining radiation travels through the atmosphere where most of it is absorbed by the wall.
- 2.17 Double glazing has a trapped layer of air between the two glass panels. This trapped layer of air acts as a good insulator and since glass is more of a conductor than air, very little heat will enter this gap which will result in fewer convection currents being produced.
- 2.18 Aluminium is a better conductor of heat than either glass or plastic. Thus, for the same temperature difference between the drink and the surrounding environment, more heat will be conducted through the can thereby warming the drink faster than that in the bottle.
- 2.19 Unless your water comes from a partly frozen water source such as from an alpine stream or frozen lake, it would be better to wrap the bottle in a cloth and wet the cloth with water from the bucket. In this situation, the water evaporates and cools the bottle and its contents below the temperature of the water in the bucket.