Specific Latent Heat Space School

Specific latent heat of fusion of materials

Material	Specific latent heat of fusion in $J\,kg^{-1}$
Alcohol	0.99×10^5
Aluminium	3.95×10^5
Carbon Dioxide	1.80×10^5
Copper	2.05×10^5
Iron	2.67×10^5
Lead	0.25×10^5
Water	3.34×10^5

Melting and boiling points of materials

Material	Melting point in °C	Boiling point in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Lead	328	1737
Iron	1537	2737
Water	–	100

Specific latent heat of vaporisation of materials

Material	Specific latent heat of vaporisation in $J\,kg^{-1}$
Alcohol	11.2×10^5
Carbon Dioxide	3.77×10^5
Glycerol	8.30×10^5
Turpentine	2.90×10^5
Water	22.6×10^5

1.

a) State the boiling point of aluminium.

b) State the specific latent heat of fusion for lead

c) State specific latent heat of vaporisation for water.

2.

a) Determine the heat energy required to change 0.1 kg of water at 100°C into steam at 100°C

b) State whether the temperature of water increases during the change of state.

3.

a) Determine the amount of heat energy required to change a 200 g solid block of carbon dioxide into a gas.

b) Explain why the temperature does not change during the change of state.

4.

Determine the heat energy required to melt a 2 kg block of iron.

5.

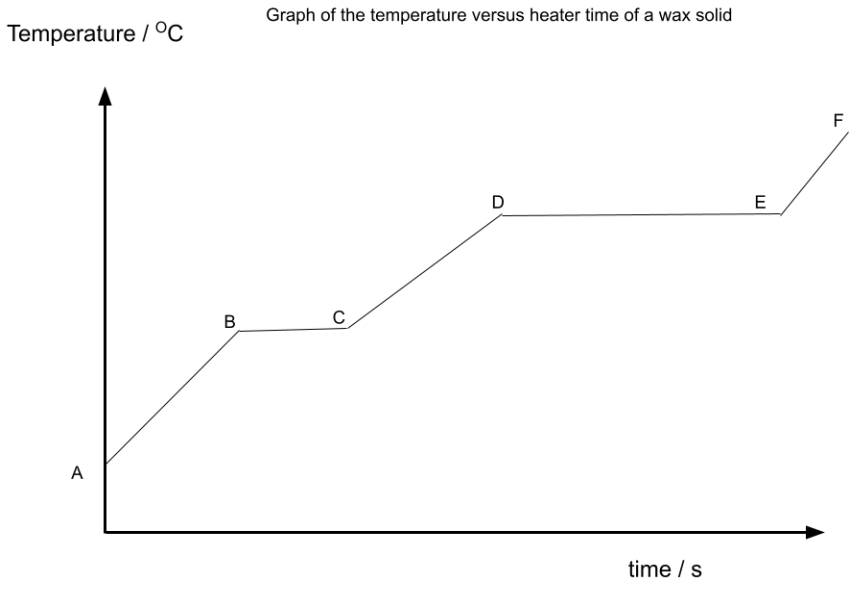
Determine the heat energy required to melt 50 g of ice.

6.

Aluminium melts at 660 ^{O}C. How much heat is required at this temperature to melt 1.5 g of the metal.

7. Determine the mass of copper at melting point 1077 ^{O}C which will melt after absorbing 164,000 J	**8.** Find the mass of turpentine vaporised after absorbing 580,000 J at its boiling point.	**9.** Determine the mass of alcohol that is condensed after giving out 5,600 J of energy.

10. An electric heater delivers energy into a wax solid. The temperature is recorded against the time since the heater was switched on.
    The graph is shown below:



a. Describe what is happening to the wax along BC of the graph

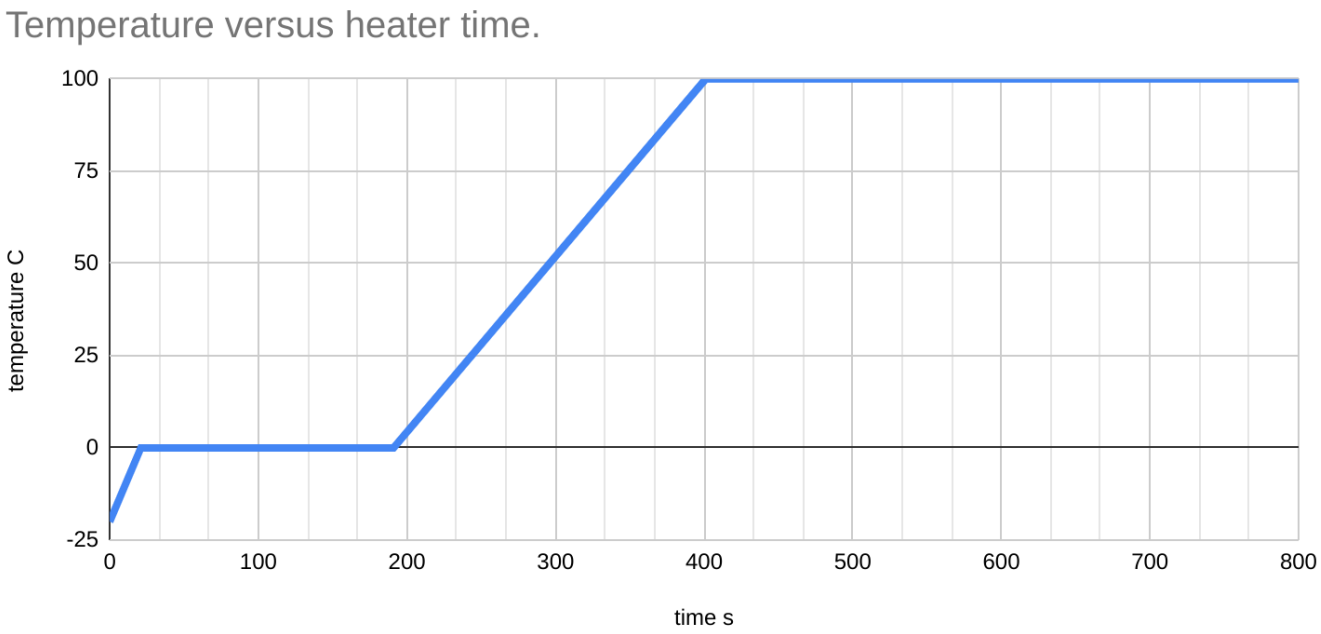
b. Describe what is happening to the wax along CD of the graph

c. There is no increase in the temperature of the wax along DE of the graph.
   Describe what is happening to the wax and explain why the temperature does not rise even though the heater is still delivering energy to the wax.

d. The specific latent heat of fusion of the wax is 176,000 J kg^{-1}. How much heat energy is required to melt 0.02 kg of the wax.

e. State and justify, from looking at the graph, if the specific latent heat of vaporisation is bigger or smaller than the wax's specific latent heat of fusion.

11. The graph below shows the temperature versus the time a 1 kW heater was switched on in a beaker containing 500 g of ice at a temperature of -25°C



a. State which of these statements is true or false:
   i. At precisely 100 seconds there is only liquid in the beaker
   ii. At precisely 600 seconds there is a mixture of water and steam.
   iii. Between 200 s and 400 s there is only ice in the beaker.

b. It takes 170 s to completely melt the ice in the beaker. From this information determine the specific latent heat of fusion of ice.

12. 200 kg of aluminium powder is preheated to a temperature of 200°C. The powder is placed in a furnace.
The specific heat capacity of aluminium is 902 J / kg ^{O}C.

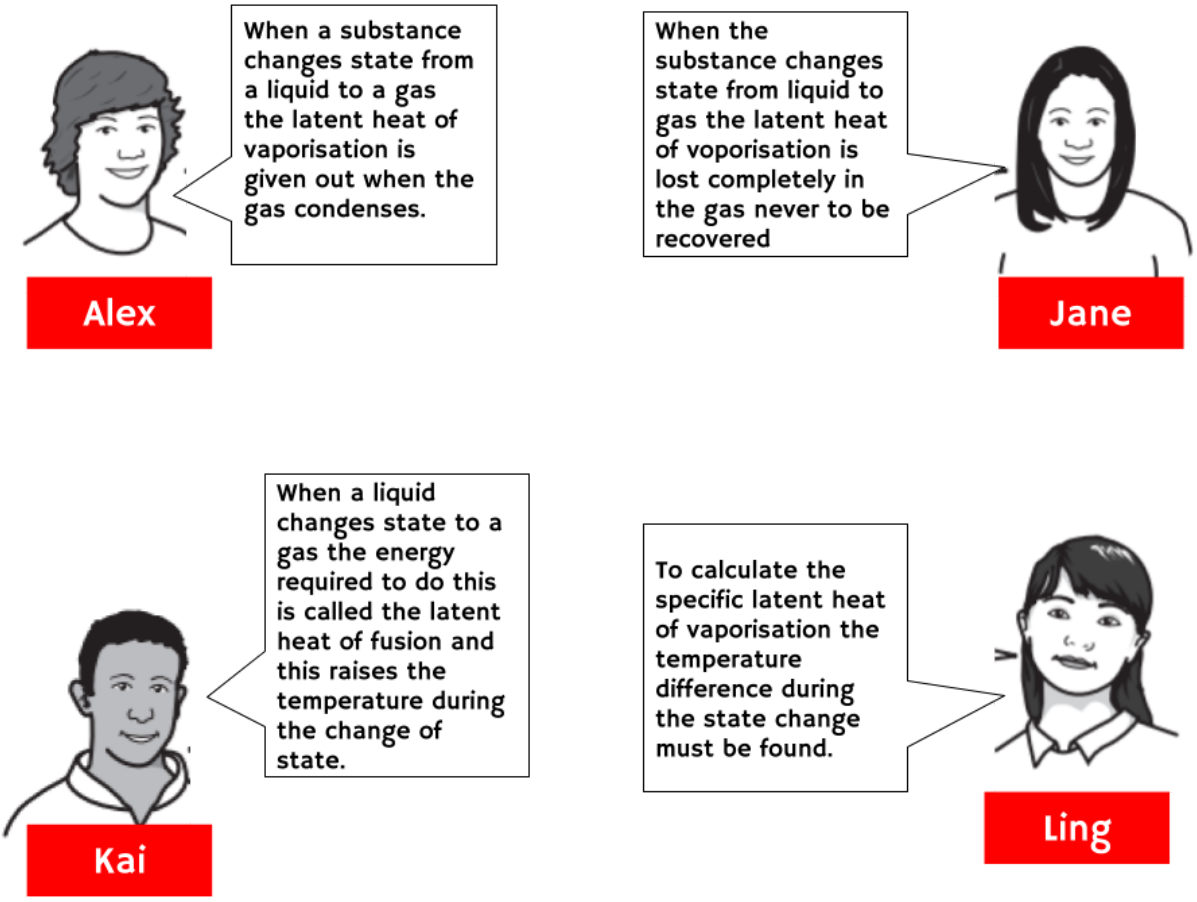
a. Find the melting point of aluminium from the data tables.
How much heat energy is required to heat the aluminium to its melting point?

b. How much extra energy is required to melt the 200 kg of aluminium?

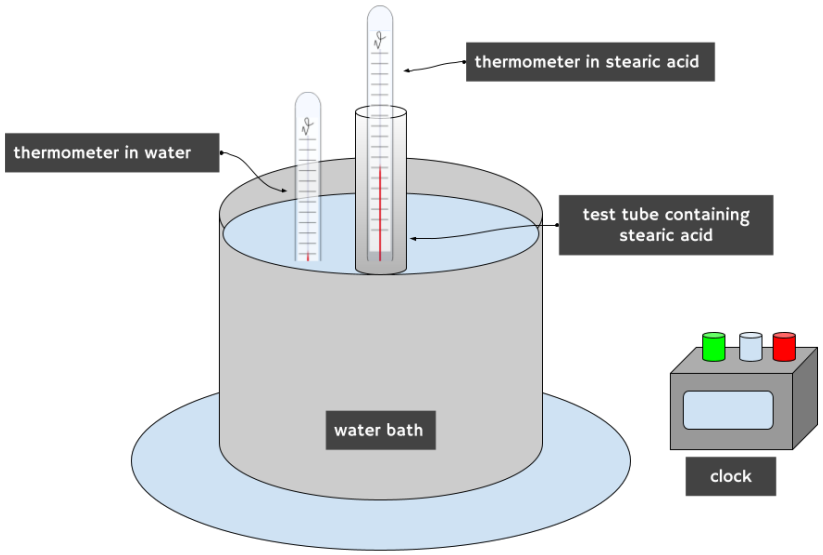
c. The furnace heater has a power of 500 kW. How long will it take the aluminium to melt?

d. Explain why it takes longer than calculated to melt the aluminium.

13. Four pupils discuss latent heat in their physics class. Decide who is correct.



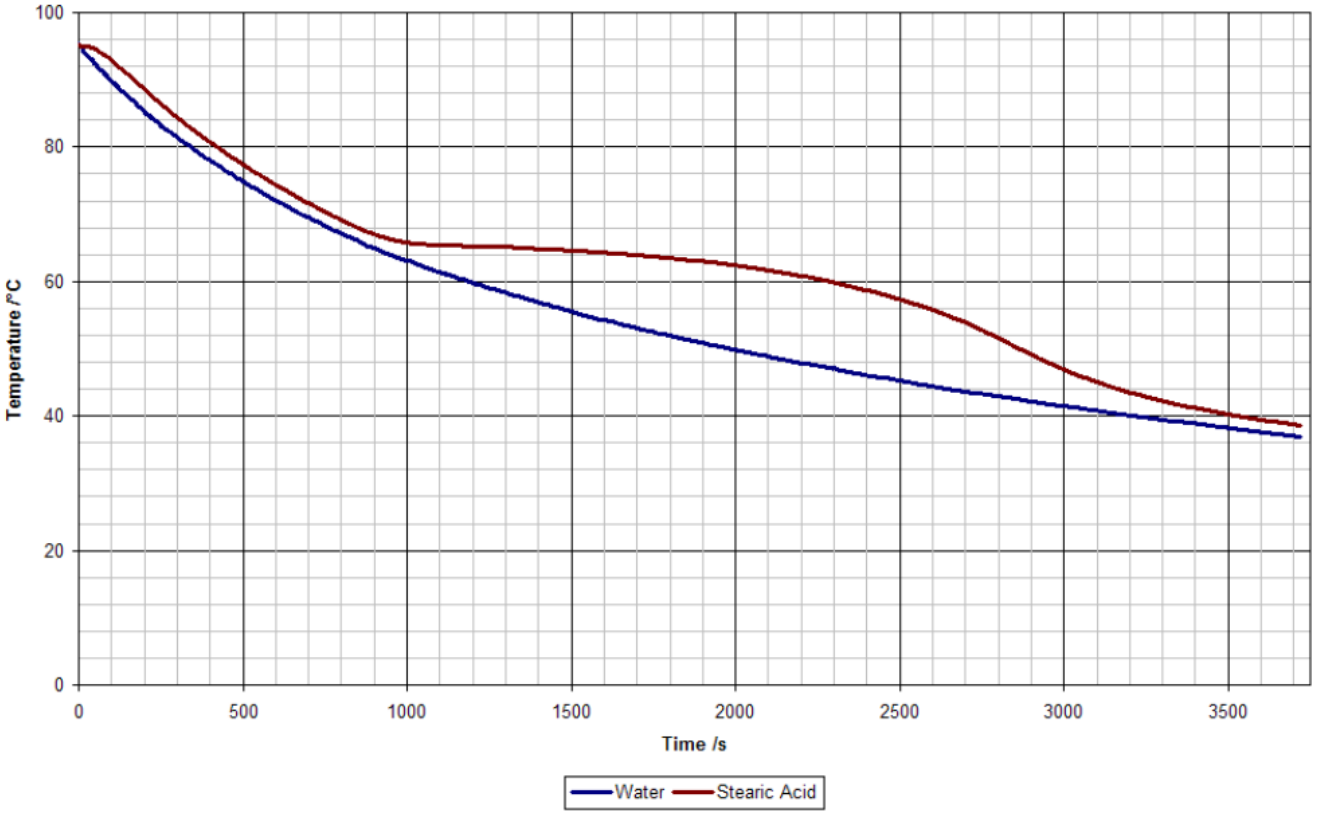
14. An experiment designed to compare the cooling curves of water and a waxy substance called stearic acid is shown below:



continued/

The water in the water bath is heated and this in turn melts the stearic acid.
A clock is started and the water bath heater is switched off. The temperature of the water bath and the stearic acid are noted over a given time interval.

The temperatures of the water and stearic acid as they cool are displayed on the graph below:



a. State the temperature of both the water and stearic acid at the start of the experiment.

b. The cooling curve of the stearic acid levels off between 1000 s and 2000 s.
Explain what is happening to the stearic acid during this time.

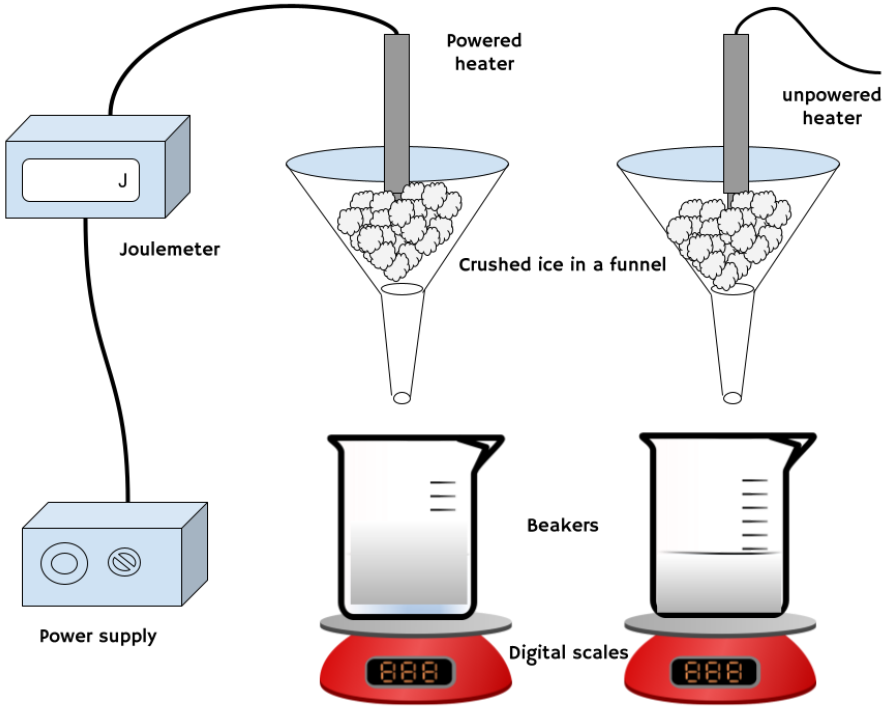
c. Explain why the stearic acid's temperature does not fall during this time.

d. Estimate, from the graph, the melting point of stearic acid.

e. The specific latent heat of fusion of stearic acid is 199,000 J kg^{-1}. Determine the heat energy released from 5 g of stearic acid during solidification.

15. When liquids evaporate energy is taken from the surroundings to provide for the latent heat of fusion.
Using your knowledge of evaporation and latent heat explain why your skin feels cold when perfume is sprayed on it.

16. A pupil sets up an experiment to determine the specific latent heat of fusion of ice.
A sketch of the experimental set up is shown below:



a. Explain why an identical mass of ice is placed in a funnel with an unpowered heater.

b. The pupil waits for 5 minutes after completing the setup before turning on the heater. Explain why the pupil does this.

c. The data collected from the experiment is given below:

Energy supplied to the ice = 10,000 J
Mass of water in the beaker collected by heater melting ice = 29.9 g
Mass of water in the beaker collected by switched off heater = 0.6 g.

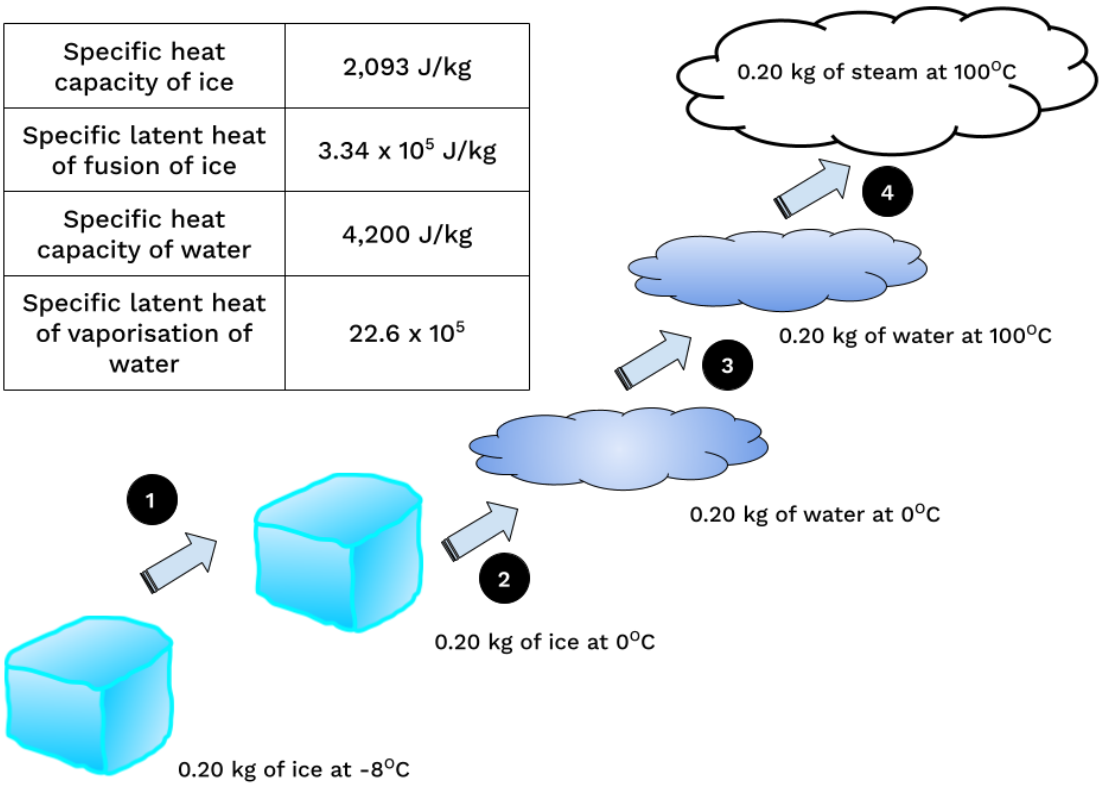
Using the data collected, determine the specific latent heat of fusion of ice.

17. Explain why a damp cloth placed on a forehead reduces the temperature of a fever.

18. Sweating is vital to cooling down our bodies when we exercise in hot conditions.
Explain using the change of state from liquid to gas how sweat cools us down.

19. A poster showing the story of how 200 g of ice at a temperature of -8°C reaches steam at 100°C.

Specific heat capacity of ice	2,093 J/kg
Specific latent heat of fusion of ice	3.34 x 10^5 J/kg
Specific heat capacity of water	4,200 J/kg
Specific latent heat of vaporisation of water	22.6 x 10^5



a. Which of the stages 1,2,3 or 4 involve a change of state?

b. Determine the heat energy needed for each step.

c. State which step needs the most energy and explain why it needs the most energy.

d. Find the total energy needed to change 200 g of ice at -8°C to 200g of steam at 100°C

20. In the sci-fi series Star Trek Captain Kirk melts a lump of rock with his weapon called a phasor.
Assuming that 20 kg of granite is melted in 0.01 s and the rock is at an initial temperature of 25°C.

Using the data that granite has a specific heat capacity of 790 J/kg^{O}C , melting point of 1200 ^{O}C and a specific latent heat of fusion of 4.2 x 10^5 J/kg determine the energy required to do this and the power output of the phasor.

Comment on the power of the weapon compared to a nuclear power station.

Answers and hints:

1 a) 2470°C b) 0.25 x 10^5 J/kg c) 22.6 X 10^5 J/kg
2 a) 226,000 J b) Temperature does not change
3 a) 75,400 J b) Energy is being used to pull the molecules further apart.
4 534,000 J
5 16,700 J
6 593 J
7 0.8 kg
8 2.0 kg
9 5 g
10 a) Changing state solid to liquid.
b) The liquid is being heated and its temperature rises.
c) liquid wax is changing into a gas. During the change of state the energy is being used to pull the molecules apart increasing the potential energy rather than the kinetic energy.
d) 3,520 J
e) The specific latent heat of vaporisation is larger because the length of the time the heater is on during this part is longer which implies bigger energy input.
11 a) i) False. Liquid and solid present
ii) True. Water and steam present
iii) False. Water present only.
b) 340,000 J/kg

12 a) 660°C, 83 MJ
b) 79 MJ
c) 158 s
d) Some of the energy is lost to the surroundings.

13 Alex
14 a) 96 ^{O}C
b) Changing state from liquid to gas, evaporating.
c) The stearic acid is releasing its latent heat to the surroundings thus keeping the temperature up.
d) 68 ^{O}C
e) 995 J

15 Perfume consists of the scent and alcohol as the solvent. The alcohol evaporates taking heat energy from your skin. You then feel that part of your skin colder.

16 a) Determines the ice melted due to the surroundings.
b) To give a measurable control volume of melted ice.
c) 345,000 J/kg.

17 Heat energy is transferred from your hot forehead to evaporate the liquid in the cloth. The evaporated water carries away the heat energy and makes your forehead cooler.

18. The droplets of water evaporate from the skin. The energy needed for this change of state comes from the heat energy of the skin. The evaporated sweat then takes energy away from the skin reducing the temperature of the skin.

19. a) Stages 2 and 4

b) Step 1 = 3,349 J
Step 2 = 66,800 J
Step 3 = 84,000 J
Step 4 = 452,000 J

c) Step 4. Liquid to gas change of state needs a lot more energy needed to pull the molecules apart (almost ten times further apart) than solid to liquid.

d) Total energy = 606 149 J

20 Total energy required = 27 MJ
Power output = 859 MW
Typical power station output approximately 1,000 MW (Hunterston B).