W-16

11 PHYSICS ATAR
TEST 3: HEATING AND COOLING

NAME: SOLUTIONS MARK: — / 34

DATA

Use the data sheet plus the following table.

Table of Specific Heats ($J\ kg^{-1}\ K^{-1}$)	
Water	4.18×10^3
Pewter	1.43×10^2
Steam	2.00×10^3
Glass	8.40×10^2
Ice	2.10×10^3
Aluminium	8.80×10^2
Ethylene Glycol	2.40×10^3
Air	1.00×10^3
Copper	3.90×10^2
Stainless Steel	4.45×10^2
Lead	1.30×10^2
Av. Human Body	3.50×10^3

1. (a) Antifreeze has a specific heat less than that of water. What ***disadvantage*** would there be in using antifreeze in the cooling system of a car instead of a mixture of water and antifreeze?

- Antifreeze has a lower specific heat.
  ⇒ It doesn't hold as much heat as water. (1)
- Hence it won't conduct heat away from the engine fast enough and it may overheat easier. (1)

(2)

(b) The radiator of a car is usually painted ***black***. It is placed at the ***front of the engine*** behind the grille, and is usually made with ***lots of thin fins*** so that the air moves through it.

Explain how the three points underlined above assist in making the radiator efficient at removing heat from the coolant of the engine.

(i) black

• Radiates heat faster than light colours.

(ii) front of engine

• Air can move through the radiator when the car is moving to remove heat.

(iii) lots of thin fins

• Increases the surface area to remove heat faster.

(3)

2. A 5.00 x 10^2 g frozen pie is taken from a freezer at -5.00 °C. It is heated in a 6.50 x 10^2 W microwave.

(a) ***Estimate*** the amount of heat required to ***thaw the pie completely***, assuming it is mainly made of water. ***State any assumptions you have made.***
(Note: The pie is thawed when the water inside is just melted.)

Assume $L_f = 3.34 \times 10^5 \text{ J kg}^{-1}$.

$$Q = m_i c_i \Delta T + m_i L_f \quad (1)$$

$$= (0.500)(2.10 \times 10^3)(0 - (-5.00)) + (0.500)(3.34 \times 10^5) \quad (1)$$

$$= \underline{1.72 \times 10^5 \text{ J}} \quad (1)$$

(3)

(b) ***Estimate*** how much energy is needed to bring the thawed pie from 0.0 °C up to 80.0 °C.

Assume $C_p = 4.18 \times 10^3 \text{ J kg}^{-1} \text{K}^{-1}$

$$Q = m_p C_p \Delta T$$
$$= (0.500)(4.18 \times 10^3)(80.0 - 0) \quad (1)$$
$$= 1.67 \times 10^5 \text{ J} \quad (1)$$

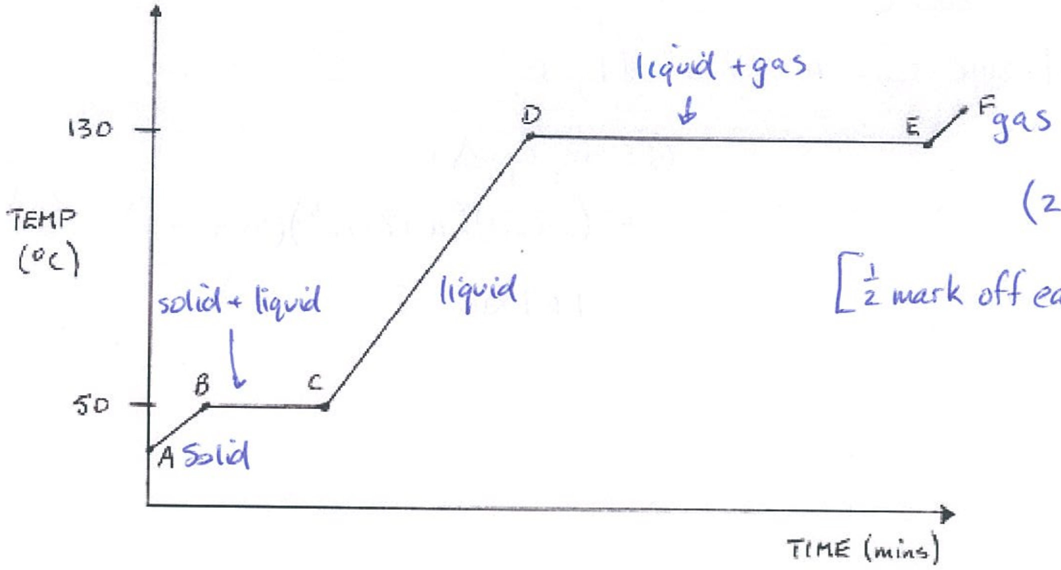
(2)

(c) Assuming all of the energy supplied by the microwave oven is used to thaw and cook the pie, how long should it be cooked?

$$P = \frac{Q_{needed}}{t}$$
$$\Rightarrow t = \frac{(1.72 \times 10^5 + 1.67 \times 10^5)}{6.50 \times 10^2} \quad (2)$$
$$= \underline{5.22 \times 10^2 \text{ s}} \quad (1)$$

(3)

3. The heating curve for a sample of wax is given below. Heat was added at a constant rate.



(2)

[½ mark off each error]

Use the Kinetic Theory of Matter to explain what is happening to the wax particles in the following questions.

(a) What is occurring in sections BC and DE as heat is added to the wax?

BC : (½) melting – E_P of molecules is increasing. (1)

DE : (½) boiling – E_P of molecules is increasing.

(2)

(b) Why is DE much longer than BC?

- It takes a lot of energy to overcome the bonds between the wax molecules. (1)
- As the heat source is working at a constant rate, it will take longer to input the energy. (1)

(2)

(c) What is happening during CD as heat is added?

- A temperature change in the liquid is occurring. (1)
- The average E_K of the molecules is increasing. (1)

(2)

(d) Label the diagram with the following labels.

solid, liquid, gas, solid + liquid, liquid + gas

(2)

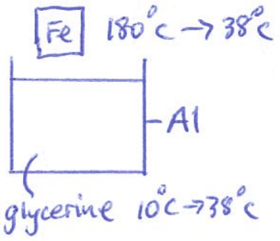
4. A young footballer twisted his ankle slightly during a match. The physiotherapist for the team sprayed a liquid from a can onto the ankle and the player immediately felt an intense cold. It lasted for about a minute until no fluid was visible on the skin.

Explain why the skin felt so cold so quickly.

- The liquid is very volatile - it easily turns into a gas. (1)
- Heat from the skin evaporates the liquid. (1)
- The liquid evaporates rapidly, removing heat quickly from the skin. (1)

(3)

5. During an experiment to determine the specific heat of glycerine, a 2.90 x 10^2 g piece of iron at 1.80 x 10^2 °C was placed carefully into a 1.00 x 10^2 g aluminium calorimeter containing 2.50 x 10^2 g of glycerine at 10.0 °C. The temperature rose to 38.0 °C. Determine the specific heat of the glycerine.



$$Q_{lost} = Q_{gained}$$

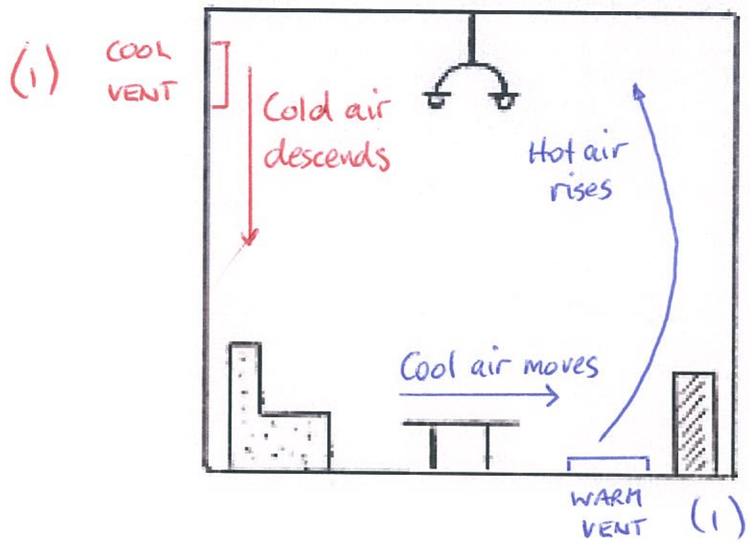
$$\Rightarrow m_{Fe} c_{Fe} \Delta T = m_g c_g \Delta T + m_{Al} c_{Al} \Delta T \quad (2)$$

$$\Rightarrow (0.290)(4.45 \times 10^2)(180 - 38.0) = (0.250) c_g (38.0 - 10.0) + (0.100)(8.80 \times 10^2)(38.0 - 10.0) \quad (1)$$

$$\Rightarrow c_g = \underline{2.27 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}} \quad (1)$$

(4)

6. Many homes are now heated and cooled by reverse-cycle air conditioners.



(a) On the diagram above, show where you should put a vent from the system so that the room is ***heated quickly and efficiently***. Explain the reasons behind your decision.

- Hot air becomes less dense and rises. (1)
- Cool air moves to take its place and sets up a convection current. (1)

(3)

(b) ***In a different colour***, do the same as part (a) so that the room is ***cooled quickly and efficiently***. Again, explain the reasons behind your decision.

- Cold air is more dense than warm air and sinks to the floor. (1)
- Warm air is pushed upwards, setting up a current. (1)

(3)