Heat Energy Questions – NAT 5

1) A student carries out an experiment to find out which mug is best at keeping drinks hot.

Each mug is made from a different material and they all contain hot water with the same volume and temperature.

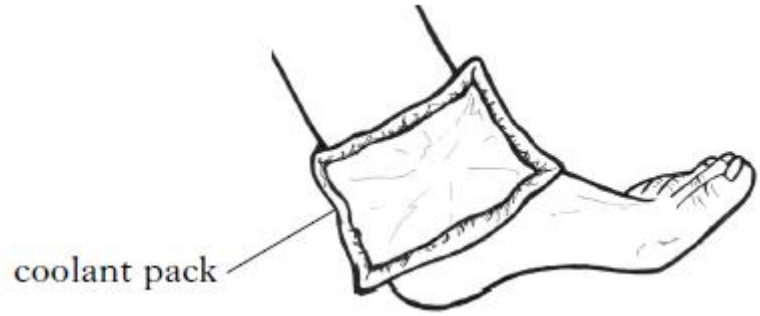
plastic metal ceramic

a) Describe how the student will carry out the experiment.

The description should include the **apparatus**, **measurements** made and a **conclusion**.

b) How could the heat energy lost from the mugs be reduced?

2) A footballer is treated with a coolant pack after suffering an injury during a match.



Before use, the coolant pack is stored at 2°C in a fridge. The coolant inside the pack changes from a liquid to a solid.

The coolant has a melting point of 7°C and a mass of 0.5kg.

The coolant is removed from the fridge and placed on the players injured ankle.

a) Calculate the energy required to raise the temperature of the coolant from 2°C to its melting point.(shc of coolant = 2100Jkg$^{-1^{\circ}}$ C^{-1})

b) Where does the energy to raise the temperature of the coolant pack come from?

c) When the coolant reaches its melting point, it remains at that temperature for 12 minutes. What is happening to the coolant during this time?

d) The Physiotherapist suggests that the injured player should wrap his ankle and coolant in a towel. **Explain** why this suggestion is a good idea?

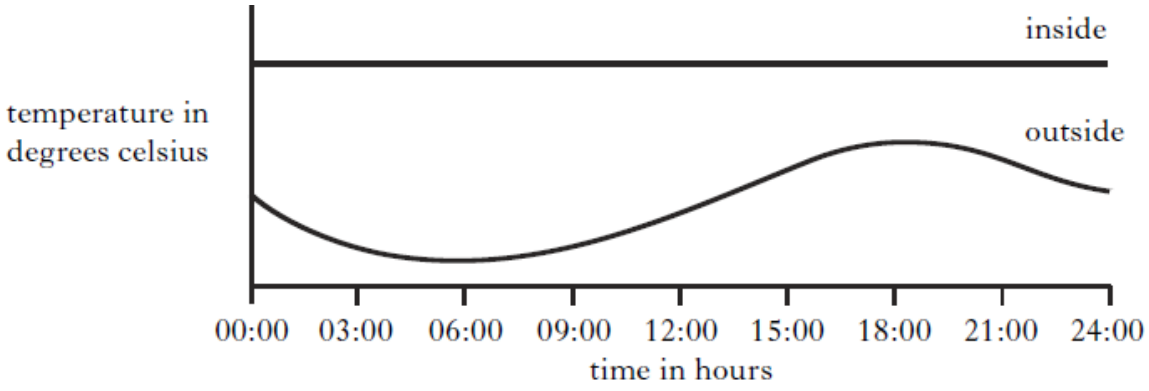
3) Modern houses are designed to conserve as much energy as possible. Insulation is used to reduce the heat energy lost by a variety of different means.

a) Match the type of insulation with each type of heat energy loss.

foil-backed plasterboard	**double glazing**	**loft insulation**

Type of heat loss	*Correct insulation*
Conduction	
Convection	
Radiation	

b) The temperature inside the house stays constant using a thermostat, while the temperature outside changes over a 24 hour period as shown in the graph below.



At which time is the heat energy loss:

i) Greatest

ii) Smallest.

4) An electric kettle of power rating 2kW is used to heat 400g of water.

a) Calculate the heat energy required to increase the temperature of the water from 15°C to its boiling point.

b) The automatic switch on the kettle is not working. The kettle is switched off 5 minutes after it is switched on.

i) Calculate how much electrical energy is converted into heat energy in this time.

ii) Calculate the mass of water changed into steam in this time.

For Water

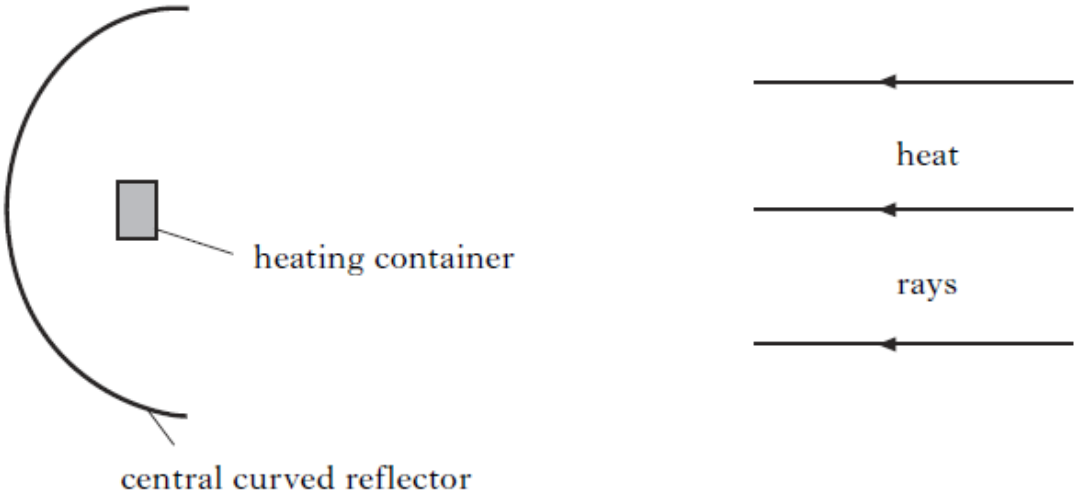
($L_v = 22.6 \times 10^5 Jkg^{-1}$ and $shc = 4180 Jkg^{-1}{}^{\circ}C^{-1}$)

5) A solar furnace consists of an array of mirrors which reflect heat radiation on to a central curved mirror.

A heating container is placed at the focus of the central covered mirror. Metals placed in the container are heated until they melt.

The diagram below shows the heat rays after reflection by the mirrors on the hillside.

a) Complete the diagram to show the effect of the central curved reflector on the heat rays.



b) 8000kg of pre-heated pellets at a temperature of 160°C are place in the container. Aluminium has a shc of 902Jkg^{-1}$^{\circ}$C^{-1}, L_f = 3.95x10^{5}Jkg^{-1}and a melting point of 660°C. Calculate the heat energy required to heat the aluminium to its melting point.

c) i) Calculate how much extra energy is required to melt the aluminium pellets.

ii) The power of the furnace is 800kW. Calculate how long it will take for this extra energy to be supplied.

iii) **Explain** why it takes longer, in practice, to melt the aluminium.

6) On the planet Mercury, the surface temperature at night is -173°C.

The surface temperature during the day is 307°C. A rock lying on the surface of the planet has a mass of 60kg.

a) The rock absorbs 2.59 x 10^7J of heat energy from the Sun during the day.

Calculate the specific heat capacity of the rock.

b) Heat energy is released at a rate of 1440Js^{-1} at night.

Calculate the time taken to release 2.59 x 10^7J of heat energy.

c) Energy from these rocks could be used to heat a base on the surface of Mercury.

How many 60kg rocks would be needed to supply a 288kW heating system.

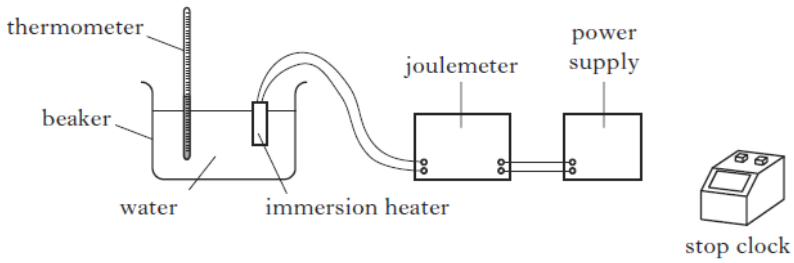
d) Would it be easier, the same or more difficult to lift rocks on Mercury compared to Earth?

(Gravitational field strength on Mercury = 4Nkg^{-1})

Explain your answer.

7) An experiment is used to determine the specific heat capacity of water.

The energy supplied to the water was measured with a joulemeter.



The following data was recorded.

Initial temperature of the water = 21°C

Final temperature of the water = 33°C

Initial reading on the joulemeter = 12kJ

Final reading on the joulemeter = 120kJ

Mass of water = 2.0kg

Time taken = 5 minutes.

a) i) Calculate the change in temperature of the water.

ii) Calculate the energy supplied by the immersion heater.

iii) Calculate the specific heat capacity of water obtained from the data recorded.

b) The accepted value for the specific heat capacity of water quoted is 4180J$kg^{-1}°C^{-1}$.

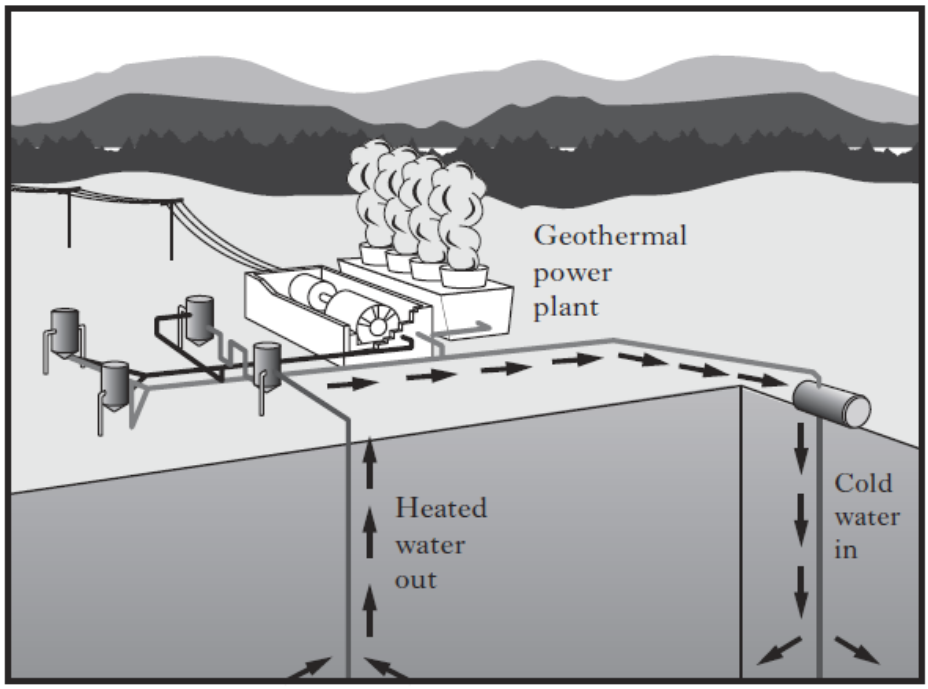
i) **Explain** the difference in the experimental value calculated and accepted value.

ii) How could the experiment be improved to reduce this difference?

c) Calculate the power rating of the immersion heater.

8) An experimental geothermal power plant uses heat energy from deep underground to produce electrical energy. A pump forces water at high pressure down a pipe.

The water is heated and returns to the surface. At this high pressure the boiling point of the water is 180°C.



The plant is designed to pump 82kg of heated water to the surface each second. The shc of this water is 4320Jkg^{-1}°C^{-1}.

a) The water enters the ground at 20°C and leaves at 145°C.

Calculate the heat energy absorbed by the water each second.

b) The hot water is fed into a heat exchanger where 60% of this heat energy is used to vapourise another liquid into gas. This gas is used to drive a turbine which generates electrical energy. The specific latent heat of vapourisation for this liquid is 3.42 x 10 ^{5}Jkg^{-1}.

Calculate the mass of liquid which is vapourised each second.

c) Geothermal is a source of renewable energy.

i) State **one** other renewable energy source.

ii) State **one** advantage and one disadvantage of this source.

9) A pupil wishes to measure the amount of energy stored in a 5μF capacitor which is charged to a potential difference of 10V.

He discharges the capacitor through a heating coil which is immersed into a small quantity of oil.

The energy stored in the capacitor is calculated using the equation below:

$$\text{energy stored in capacitor} = \text{specific heat capacity of oil} \times \text{mass of oil} \times \text{rise in temperature of oil}$$

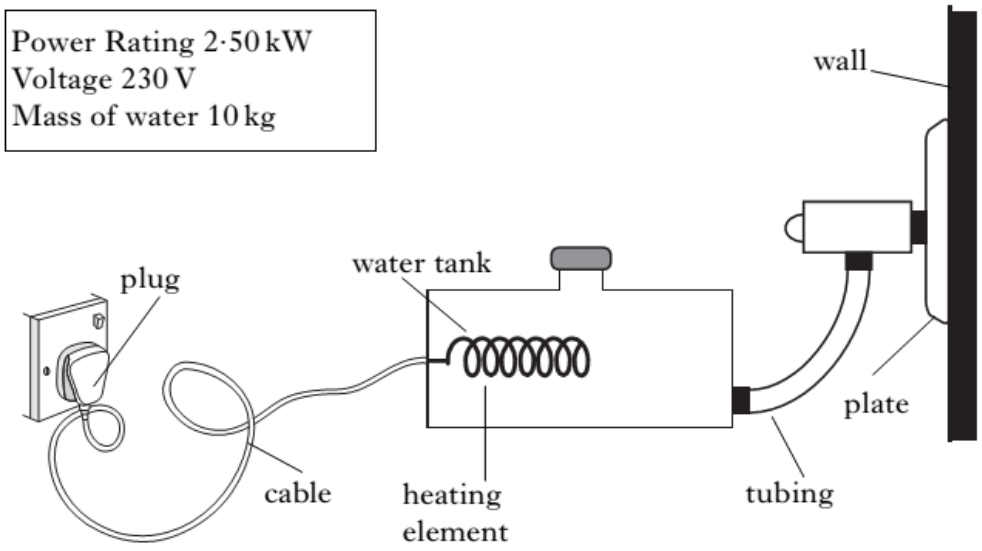
a) **State the assumption** made by the pupil in the equation.

b) By considering the energy stored in the capacitor, **explain w**hy the measurement of the rise in temperature of the oil is likely to be extremely inaccurate.

10)

A steam wallpaper stripper is used on the walls of a room.

Water is heated until it boils and produces steam. The plate is held against the wall and steam is released from the plate.



The tank is filled with water. The water has an initial temperature of 20 °C.

(*a*) (i) Calculate the energy required to bring the water to its boiling point.

(ii) Calculate the time taken for this to happen.

(iii) The actual time taken for this to happen was found to be longer than that calculated in (*a*) (ii). Explain why.

(*b*) Calculate the current required by the wallpaper stripper.

(*c*) After using the wallpaper stripper for some time, 1·2 kg of water is converted into steam. Calculate the energy used to do this.