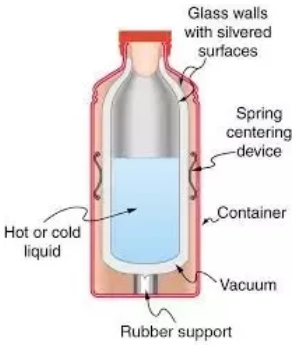
SPH3UB **Unit 3 MUST DO Practice**

3.1-Heat Transfer



1. Is bubble wrap more effective on a warm or cool day?
2. Why do you hear creaking and groaning sounds in a house, particularly at night as the air temperature drops?
3. Updrafts of air allow hawks and eagles to glide effortlessly, all the while gaining altitude. What causes these updrafts?
4. Two bowls of soup with identical temperature are placed on a table. One bowl has a metal spoon in it, the other does not. After a few minutes, how do the soup temperatures compare?
5. Using what you know about conduction, convection, and radiation, explain the design of a thermos bottle.
6. A glass window 0.35 cm thick measures 84 cm by 36 cm. How much heat flows through this window per minute if the inside and outside temperatures differ by 15°C? (49)
7. One of the windows in a house has the shape of a square 1.0 m on a side. The glass in the window is 0.50 cm thick.
    a. How much heat is lost through this window in one day if the temperature in the house is 21 °C?
    b. Suppose all the dimensions of the window -height, width, thickness, are doubled. If everything else remains the same, by what factor does the heat flow change?

ANSWERS

1-5- Talk to me or your classmates!

6- 65 kJ/min

7- a.) 3.0×10^8 J b.) 2Q

3.2-Black Body Radiation

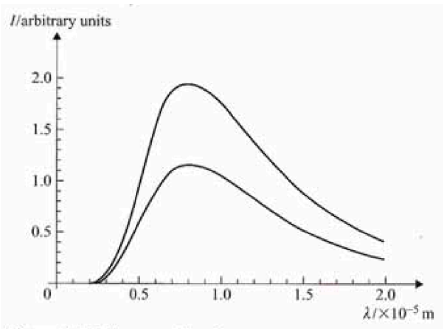
1. If one assumes that the Sun is a perfect black body with a surface temperature of 6000 K, calculate the power radiated from its surface. Assume the radius of the sun is 7.0×10^8 m.

2. By what factor does the rate of radiation from a body increase when the temperature is increased from 50°C to 100°C?

3. ATTEMPT THIS QUESTION AFTER 3.4 HEAT CAPACITY/LATENT HEAT.

It takes 2×10^{11} J of thermal energy to heat 50 m^2 of the Earth by 10 K. Determine the surface heat capacity of the Earth.

4. The graph to the right show the variation with wavelength of the intensity of radiation emitted by two bodies of identical shape.



(a) How do you know that the temperature of both bodies is the same? What is that temperature?

(b) If the upper graph is a black body, what is the **emissivity** of the other body?

5.

(a) ATTEMPT THIS QUESTION AFTER 3.4 HEAT CAPACITY/LATENT HEAT. Radiation of intensity 340 W m^{-2} is incident on a lake of depth 50 m. How much time is needed to increase the water temperature by 1 K? (density ρ_{water}= 1000 kg m^{-3}; c_{water}=4180 J kg^{-1} K^{-1})

(b) Estimate the heat capacity of the entire body of water on Earth. (Use an average depth of 300 m and an Earth radius of 6.4 x 10^6 m).

(c) Estimate the time needed to increase the water temperature by 1 K if solar radiation of intensity 340 W m^{-2} were incident on the water.

ANSWERS

1. 4.52 x 10^{26} W
2. Increase by 78%
3. 4 x 10^8 J m^2 K^{-1}
4. (a) 360 K
   (b) 0.6
5. (a) 171 h
   (b) 6.5 x 10^{23} J K^{-1}
   (c) 4 x 10^7 s

3.3-Global Warming

1. The cylindrical tungsten filament of a pyrometer (instrument for measuring high temperature thermal radiation) has a length of 0.50 m and a diameter of 5.0 x 10^{-5} m. The power rating is 60 W. Estimate the steady temperature of the filament. Assume that the radiation from the filament is the same as a perfect black body radiator at that steady temperature, and that heat only escapes through the curved side of the filament.

2. If the long-wave radiation flux from the surface of the Earth has an average value of 240 W m^{-2} and the average temperature somewhere in the atmosphere is 255 K, determine the incoming and outgoing radiation of the Earth. Assume the global albedo is 0.3.

3. The radius of earth's orbit suddenly decreases by 5%.

(a) By what factor will the intensity of the incoming solar radiation change?
(b) By what factor will the Earth's temperature change?

4. A researcher uses the following data for a simple climatic model of an Earth without an atmosphere:

Incident solar radiation = 350 W m^{-2}

Absorbed solar radiation = 250 W m^{-2}

a) Make an energy-flow (Sankey) diagram for these data.
b) Determine the average albedo for the Earth that is to be used in the modelling.
c) Determine the intensity of the outgoing long-wave radiation.
d) Estimate the temperature of the Earth according to this model, assuming a constant Earth temperature.

ANSWERS

1. 1900 K
2. Incoming = 340 W m^{-2}
   Outgoing = 240 W m^{-2}
3. a) increase by 11%
   b) increase by 2.6%
4. b) 0.29
   c) 250 W m^{-2}
   d) 258 K

3.4-Heat Capacity and Latent Heat

1. A 25.0 g piece of lead, originally at 300°C, is placed in a cold water bath, and its temperature is reduced to 100°C. How much energy was lost by the piece of lead during the cooling process?

2. A 100.0 g aluminum coffee cup at 15.0°C is filled with 250.0 g of piping hot coffee (about the same heat capacity as water) at 95.0°C. After all the heat transfer between the coffee and the cup is completed, what is the final temperature of the coffee (and the cup)? The specific heat capacity of aluminum is 0.9 J g^{-1} °C^{-1}

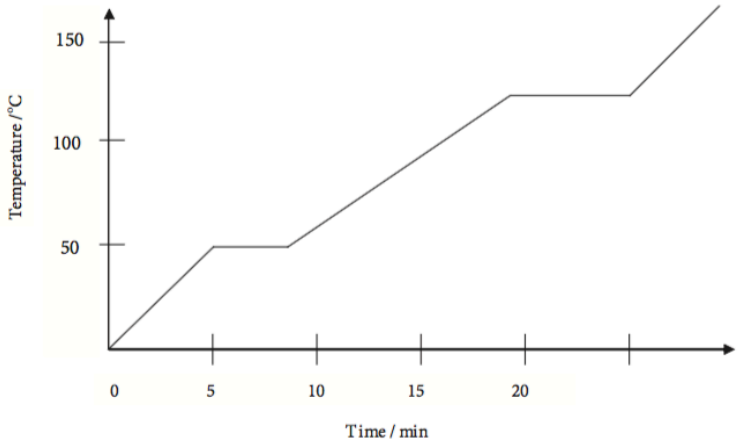
3. Julio wants to take a bath and he fills the tub with 50.0 L of water at a temperature of 38.0°C. After taking a phone call from his friend Bob, the bath water had cooled by 10.0°C. How much more hot water at 80.0°C must Julio add to return the bath to the desired temperature? (the density of water is 1 kg/L)

4. A 0.200 kg block of ice at -15°C is placed into a pan on a stove, heated to a liquid, and then to vapour with a final temperature of 115°C. Calculate the total amount of heat required for this process.

5. What mass of copper at 87.0°C, when added to 300 g of water at 17.0°C in a calorimeter, would yield a final temperature of 26.0°C?

6. A 0.700 kg piece of an unknown metal is heated to 100°C in boiling water and quickly placed into a calorimeter that contains 0.200 kg of water at 20.0°C. The final temperature of the calorimeter was determined to be 54.4°C. What is the specific heat capacity of the metal? Can you identify the metal?

7. The graph on the right shows the temperature of an unknown substance of mass 10.0 kg as heat is added at a constant rate of 1050 W. The substance is a solid at 0°C.



a) Determine the specific heat capacity of the substance when it is a solid.

b) Determine the specific latent heat of vaporization of the substance.

ANSWERS

1. 650 J
2. 88.6°C

3. 12 kg
4. 6.1×10^5 J
5. 0.487 kg
6. 9.05×10^2 J kg^{-1} $°C^{-1}$ (aluminum)
7. a) 630 J $kg^{-1}°C^{-1}$ b) 3.8×10^4 J kg^{-1}

3.5-Gas Laws

1. Estimate how many molecules there are in a gas of temperature 320 K, volume 0.025 m^3 and pressure 480 kPa.
2. A container of hydrogen with volume 0.10 m^3 and temperature 25°C contains 3.2×10^{23} molecules. Calculate the pressure of the container.
3. A fixed quantity of gas of volume 3.0×10^{-3} m^3, pressure 300 kPa and temperature 300 K expands to a volume of 4.0×10^{-3} m^3 and a pressure of 600 kPa. Calculate the new temperature of the gas.
4. The Kelvin temperature of a gas is doubled. By what factor does the average speed increase?
5. Calculate the ratio of the average speed of oxygen (O_2) to carbon dioxide (CO_2) molecules, when both gasses are at the same temperature.
6. Calculate the average speed of a helium (${}_2^4He$) atom at a temperature of -15°C. ($m_{He}=6.6 \times 10^{-27}$ kg)

ANSWERS

1. 2.7×10^{24}
2. 13 kPa
3. 800 K
4. by a factor of $\sqrt{2}$
5. 1.2 to 1
6. 1.3×10^3 m s^{-1}