Heat – Latent Heat (+ a bit of specific heat) — A Physics

1. a) A hungry sports studies student gets 400g of frozen curry sauce out of the freezer at −18°C, and heats it until it simmers at 100°C. How much heat energy does this take? (5)

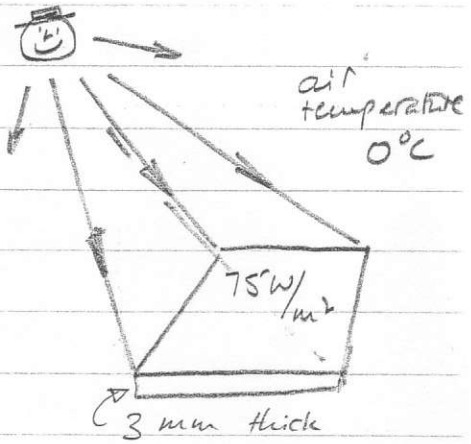
b) He uses a microwave set at medium (120 W). How long does it take? (2)

c) Suggest a name for the curry sauce. (1)

Water ...
- Specific heat capacity 4.2 J/g/k
- Latent heat .... (melting)
- of fusion 3.3×10^5 J/kg
- evaporation 2.3×10^6 J/kg
- Density of ice 0.96 g/cm³

Specific heats of curry
- frozen 4 kJ/kg
- liquid 5 kJ/kg.

2. The sun is shining on a 3mm thick layer of ice at 0°C

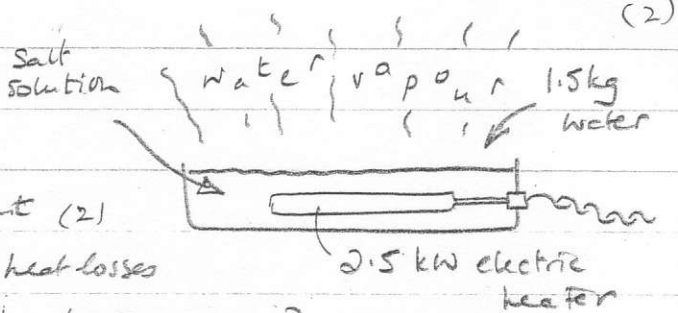


a) Show that the mass of 1 m² of ice is 2.88 kg. (Use the formula Mass = density × volume + watch the units!) (3)

b) If the sunlight delivers 75 W/m² of heat energy, how long does it take to melt the ice? (3)

c) In fact 90% of the sunlight is reflected. How long does it take now? (2)

3. The diagram shows a pan for boiling off water to obtain salt



a) How much heat energy is needed just to boil off 1.5 kg of water – ignore heat losses (2)

b) How long would this take, with the heater shown? (2)

c) In fact this takes 41 min. Calculate the average rate of heat loss from the hot solution to the surroundings (4)

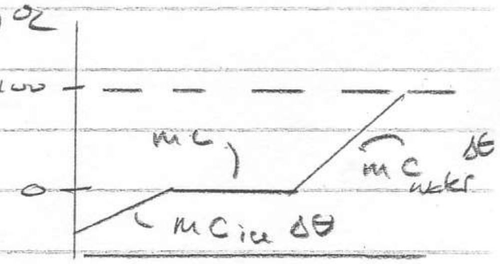
d) On one occasion, the heater failed with 1.2 kg of water STILL in it. Sketch a graph of temperature against time for the cooling solution. (4)

e) What was the approximate rate of temperature drop soon after the heater failed? (3) (Ignore the heat capacity of the pan and salt!)

Latent Heat Answers

A Physics

1 a) Total Heat energy $= mc\Delta\theta$ (frozen) + mL (melt) + $mc\Delta\theta$ (liquid) ① ① ①



$= (0.4 \times 4000 \times 18)$

① kg! ↗ $+ (0.4 \times 3.3 \times 10^5)$

$+ (0.4 \times 5000 \times 100)$

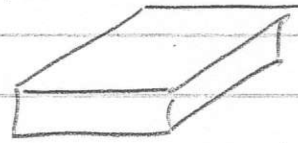
$= 28{,}800 + 132{,}000 + 200{,}000 = 360{,}800$ J $=$ 361 kJ ①

b) time $= 360{,}800 / 120$ ① $=$ 3007 sec ① ($=$ 50 min)

c) Korma, Dhansak ① Tikka Masala, Vindaloo (0) /8

2. a) for 1 m² of ice Vol, $V = 1 \times 1 \times 3 \times 10^{-3}$ ①

$= 3 \times 10^{-3}$ m³ ①



Mass = density × volume

$= 0.96 \times 3000$

$= 2880$ grams! ①

$= 2.88$ kg !

or $V = 100 \times 100 \times 0.3$ ①

$= 3000$ cm³ ①

1 m³ = 1 000 000

$= 10^2 \times 10^2 \times 10^2$

$= 1 \times 10^6$ cm³

b) Heat energy to melt 1 m² = 2.88 kg ice

$= mL$ ① $= 2.88 \times 3.3 \times 10^5 = 950{,}400$ J ①

at 75 J/s this will take $950{,}400 / 75 = 12{,}672$ s ① ($=$ 211 min)

c) If you only get 10% of the light energy → heat

it takes 10 × as long ① $= 1.27 \times 10^5$ sec ①

3. a) Heat $= mL$ ① $= 1.5 \times 2.3 \times 10^6 = 3.45 \times 10^6$ J ①

b) time take $= 3.45 \times 10^6 / 2500$ ① $=$ 1380 sec ① ($=$ 23 min)

c) In 41 min = 2460 s produce $2460 \times 2500 = 6.15 \times 10^6$ J ①

This evaporates water + covers heat losses

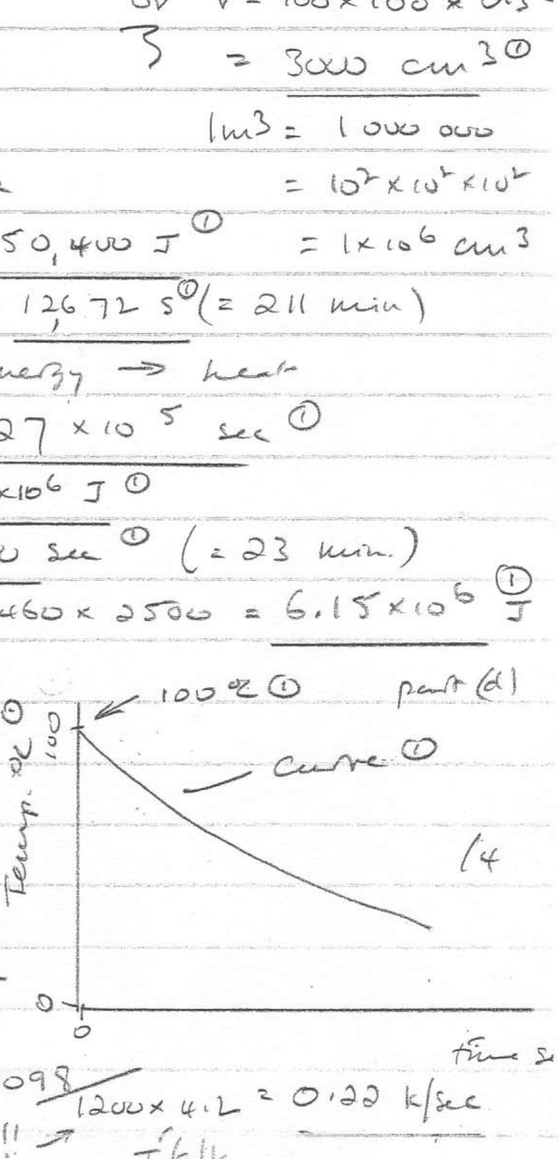
So Heat lost $= 6.15 \times 10^6 - 3.45 \times 10^6$

$= 2.7 \times 10^6$ J ①

This is lost in 41 mins

So rate of heat loss $= \frac{2.7 \times 10^6}{2460}$ ① $= 1098$ J/s ①

3/5, 2/8, 1/8, ... 7



(e) at 100 °C rate of heat loss

is 1098 J/s,

So in 1 second Heat loss $= mc\Delta\theta$ → $\Delta\theta$ (temp drop) $= \frac{1098}{1200 \times 4.2} = 0.22$ K/sec

in J !! → J/g/K

12.99 SJM