Specific heat capacity and specific latent heat

Worked solutions

GCSE science calculations

This topic online

1 Jack heats 2 kg of water in a saucepan. The temperature of the water rises by 30 °C.

The specific heat capacity of water is 4200 J/kg °C.

Calculate the change in thermal energy of the water. (2 marks)

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta E = 2 \times 4200 \times 30$

$\Delta E = 252000 \text{ J}$

252000 J

2 A block of ice of mass 0.5 kg is at 0 °C. It melts completely into water at 0 °C.

The specific latent heat of fusion of ice is 334 000 J/kg.

Calculate the thermal energy needed to melt the ice. (2 marks)

Thermal energy for a change of state = mass × specific latent heat

$E = 0.5 \times 334000$

$E = 167000 \text{ J}$

167000 J

3 An aluminium block has a mass of 3 kg. It is heated and its temperature rises by 15 °C.

The specific heat capacity of aluminium is 900 J/kg °C.

Calculate the change in thermal energy of the block. (2 marks)

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta E = 3 \times 900 \times 15$

$\Delta E = 40500 \text{ J}$

40500 J

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4 Zainab makes a cup of tea. She heats 250 g of water from 20 °C to 100 °C.
The specific heat capacity of water is 4200 J/kg °C.
Calculate the energy needed to heat the water. (3 marks)

Change in thermal energy = mass x specific heat capacity x temperature change

250 g = 0.25 kg

$\Delta\theta = 100 - 20 = 80\ ^{\circ}C$

$\Delta E = 0.25 \times 4200 \times 80$

$\Delta E = 84000\ J$

84000 J

5 A pan of water is boiling on a hob. 40 g of the water turns into steam.
The specific latent heat of vaporisation of water is 2 260 000 J/kg.
Calculate the thermal energy needed to turn this water into steam. Give your answer in kJ. (3 marks)

Thermal energy for a change of state = mass x specific latent heat

40 g = 0.04 kg

$E = 0.04 \times 2260000$

$E = 90400\ J$

÷ 1000 to change J to kJ

$E = 90.4\ kJ$

90.4 kJ

6 The copper base of a frying pan has a mass of 800 g. On the hob its temperature rises by 25 °C.
The specific heat capacity of copper is 385 J/kg °C.
Calculate the change in thermal energy of the copper. (3 marks)

Change in thermal energy = mass x specific heat capacity x temperature change

800 g = 0.8 kg

$\Delta E = 0.8 \times 385 \times 25$

$\Delta E = 7700\ J$

7700 J

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7 In a Year 10 practical, Oliver uses an electric heater to heat a 1.0 kg metal block. The heater transfers 12 600 J of energy to the block. The temperature of the block rises from 21 °C to 35 °C.

Calculate the specific heat capacity of the metal. (3 marks)

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta\theta = 35 - 21 = 14\ ^\circ C$

$12600 = 1.0 \times c \times 14$

$12600 = 14 \times c$

$c = 12600 \div 14$

$c = 900\ J/kg\ ^\circ C$

900 J/kg °C

8 An immersion heater transfers 630 000 J of energy to 5 kg of water. The water starts at 15 °C.

The specific heat capacity of water is 4200 J/kg °C. Assume all the energy is transferred to the water.

Calculate the final temperature of the water. (3 marks)

Change in thermal energy = mass × specific heat capacity × temperature change

$630000 = 5 \times 4200 \times \Delta\theta$

$630000 = 21000 \times \Delta\theta$

$\Delta\theta = 630000 \div 21000$

$\Delta\theta = 30\ ^\circ C$

$final = 15 + 30$

$final = 45\ ^\circ C$

45 °C

9 In a lab, Nadia melts 0.15 kg of solid stearic acid at its melting point. It takes 29 850 J of thermal energy to melt all of it.

Calculate the specific latent heat of fusion of stearic acid. (3 marks)

Thermal energy for a change of state = mass × specific latent heat

$29850 = 0.15 \times L$

$L = 29850 \div 0.15$

$L = 199000\ J/kg$

199000 J/kg

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10 Water in a kettle is boiling at 100 °C. The kettle transfers a further 452 000 J of thermal energy to the water.

The specific latent heat of vaporisation of water is 2 260 000 J/kg. Assume all this energy is used to turn water into steam.

Calculate the mass of water turned into steam. Give your answer in grams. (3 marks)

Thermal energy for a change of state = mass × specific latent heat

$452000 = m \times 2260000$

$m = 452000 \div 2260000$

$m = 0.2 \text{ kg}$

× 1000 to change kg to g

$m = 200 \text{ g}$

200 g

11 Ice cubes of total mass 0.5 kg are taken out of a freezer at −10 °C. They warm up to 0 °C and then all melt.

The specific heat capacity of ice is 2100 J/kg °C. The specific latent heat of fusion of ice is 334 000 J/kg.

Calculate the total thermal energy needed. Give your answer in standard form to 2 significant figures. Show your working. (4 marks)

Stage 1: warm the ice to 0 °C

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta\theta = 0 - (-10) = 10 \text{ °C}$

$\Delta E = 0.5 \times 2100 \times 10$

$\Delta E = 10500 \text{ J}$

Stage 2: melt the ice

Thermal energy for a change of state = mass × specific latent heat

$E = 0.5 \times 334000$

$E = 167000 \text{ J}$

Add the two stages

$\text{total} = 10500 + 167000$

$\text{total} = 177500 \text{ J}$

Standard form, 2 significant figures

1.8×10^5 J

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12 Kemi fills a 2.0 kW kettle with 1.2 kg of water at 18 °C. She forgets to switch it off, so the water heats to 100 °C and then 0.1 kg of it boils away.

The specific heat capacity of water is 4200 J/kg °C. The specific latent heat of vaporisation of water is 2 260 000 J/kg. Assume all the energy from the kettle is transferred to the water.

a. Calculate the energy needed to heat the water from 18 °C to 100 °C.

b. Calculate the total time the kettle was switched on. Give your answer to 2 significant figures. Show your working.

(5 marks)

a)

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta\theta = 100 - 18 = 82\ ^{\circ}C$

$\Delta E = 1.2 \times 4200 \times 82$

$\Delta E = 413280\ J$

413280 J

b)

Thermal energy for a change of state = mass × specific latent heat

$E = 0.1 \times 2260000$

$E = 226000\ J$

$total = 413280 + 226000$

$total = 639280\ J$

Energy transferred = power × time

2.0 kW = 2000 W

$639280 = 2000 \times t$

$t = 639280 \div 2000$

$t = 319.64\ s$

Round to 2 significant figures

320 s

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13 A tray of ice cubes at 0 °C has a total mass of 0.30 kg. The ice melts in a cool box and becomes water at 0 °C.

The specific latent heat of fusion of ice is 334 000 J/kg. The specific latent heat of vaporisation of water is 2 260 000 J/kg.

Calculate the thermal energy needed to melt all the ice. (2 marks)

Melting, so use the latent heat of fusion, not vaporisation

Thermal energy for a change of state = mass × specific latent heat

$E = 0.30 \times 334\,000$

100 200 J

14 A saucepan of mass 0.35 kg contains 1.5 kg of soup. Yusuf heats the soup from 20 °C to 80 °C.

The specific heat capacity of the soup is 3800 J/kg °C.

Calculate the energy needed to heat the soup. (3 marks)

Use the mass of the soup (1.5 kg), not the saucepan

$\Delta\theta = 80 - 20 = 60\ ^{\circ}C$

Change in thermal energy = mass × specific heat capacity × temperature change

$\Delta E = 1.5 \times 3800 \times 60$

342 000 J

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