physicsUK
Smarter practice. Stronger understanding

WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Thermal Properties of Matter worksheet

35-40 minutes independent practice + 15-20 minutes review

Specification points covered

- 5.1.3(a) Define and use specific heat capacity c using E = mcΔθ.
- 5.1.3(b)(i-ii) Determine specific heat capacity by an electrical method.
- 5.1.3(c) Define and use specific latent heat of fusion and vaporisation using E = mL.
- 5.1.3(d)(i-ii) Determine specific latent heat by an electrical method.
- 5.1.2(f-g) Relate temperature and changes of state to changes in internal energy.

Firewatch drone thermal-protection trial

A research drone samples gases above a volcanic vent. Its electronics are protected by a housing, a phase-change cartridge and an evaporative emergency cooler.
Use the values supplied in each question. Show working and give an appropriate unit for every numerical answer.

1. Thermal properties

1. Define specific heat capacity. [1 mark]

2. Define specific latent heat and distinguish between the specific latent heat of fusion and the specific latent heat of vaporisation. [2 marks]

3. A 0.420 kg aluminium electronics housing has a specific heat capacity of 900 J kg^{-1} K^{-1}. Calculate the energy required to raise its temperature from 18.0 °C to 52.0 °C. [1 mark]

4. The drone electronics transfer thermal energy to the housing at a constant rate of 36.0 W. Calculate the minimum time taken to produce this temperature rise if no energy is transferred to the surroundings. [1 mark]

2. Protecting the electronics

Housing test

The same 0.420 kg housing is tested first in aluminium and then in a high-heat-capacity polymer.

5. In a field test the same temperature rise takes 420 s. Calculate the mean rate at which energy is transferred from the housing to the surroundings. [2 marks]

6. The same energy calculated in question 3 is transferred to a 0.420 kg polymer housing with specific heat capacity 1500 J kg^{-1} K^{-1}. Calculate the temperature rise of the polymer housing. [1 mark]

7. Using only thermal considerations, decide which housing would slow the temperature rise of the electronics more effectively. Explain your choice. [2 marks]

3. The phase-change cartridge

Controlled melting

The cartridge contains a material that absorbs energy as it warms and melts. During melting it remains at 48.0 °C.
Treat each energy transfer as a sequence of separate stages.

8. A 0.250 kg phase-change cartridge is already at its melting temperature. Its specific latent heat of fusion is 1.80×10^5 J kg^{-1}. Calculate the energy absorbed when the cartridge melts completely. [1 mark]

9. During flight, energy enters this cartridge at a net rate of 28.0 W. Calculate the time taken to melt it completely. Give your answer in minutes. [1 mark]

10. A second cartridge contains 0.300 kg of solid material initially at 20.0 °C. Its melting temperature is 48.0 °C and its specific heat capacity as a solid is 2100 J kg^{-1} K^{-1}. Calculate the energy needed to heat the solid to its melting temperature. [1 mark]

11. The second cartridge receives a total of 60.0 kJ. Its specific latent heat of fusion is 1.65×10^5 J kg^{-1}. Calculate the mass that melts after the cartridge reaches 48.0 °C. [2 marks]

12. Calculate the mass of material that remains solid after the 60.0 kJ transfer. [1 mark]

4. Severe heating and evaporative cooling

13. In a more severe test the second cartridge receives 80.0 kJ. Its specific heat capacity after melting is 2500 J kg^{-1} K^{-1}. Calculate its final temperature. Assume that it melts completely and that no energy is transferred to the surroundings. [3 marks]

14. A separate evaporative cooler removes water vapour at 6.0 g min^{-1}. The specific latent heat of vaporisation of water is 2.3×10^6 J kg^{-1}. Calculate the mean thermal power removed by evaporation. [2 marks]

15. Explain why the temperature of a pure substance stays constant while it changes state, even though its internal energy increases. [2 marks]

5. Electrical determination of specific heat capacity

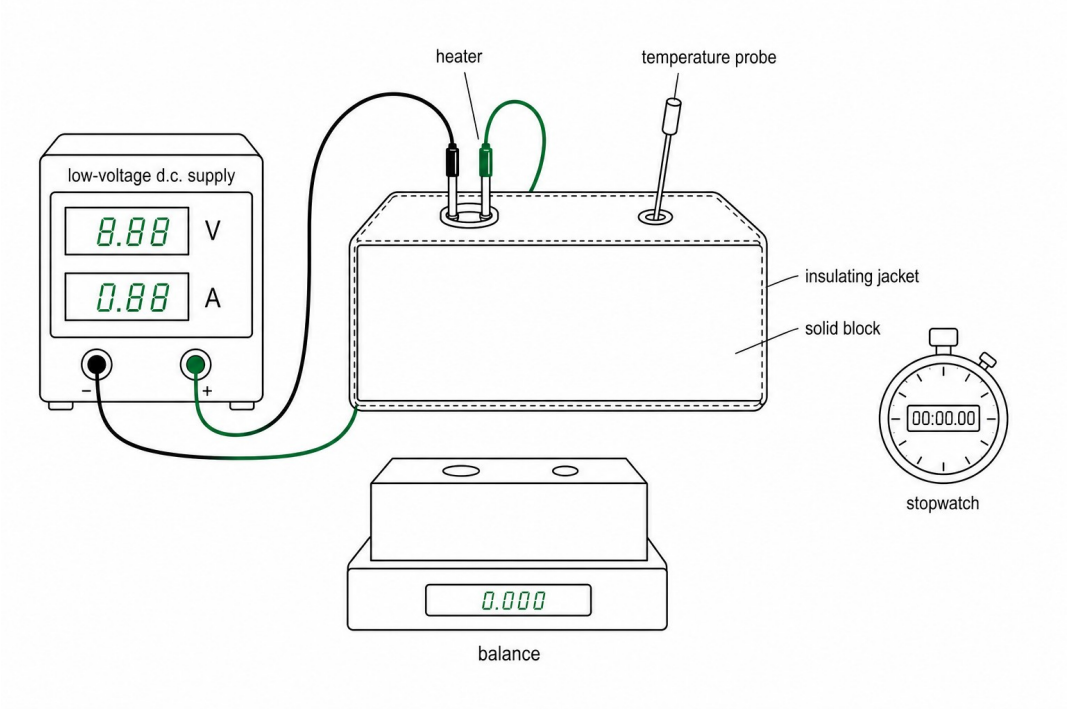

Figure 1: electrical heating apparatus

16. Figure 1 shows apparatus used to determine the specific heat capacity of a prototype alloy block. State the purpose of the insulating jacket and explain why the block is weighed before the heater and probe are fitted. [2 marks]

17. During one trial, V = 12.0 V, I = 2.40 A and t = 360 s. Calculate the electrical energy supplied by the heater. [1 mark]

6. Analyse, evaluate and plan

18. The block has mass 0.850 kg and its temperature increases from 19.4 °C to 30.6 °C. Use your answer to question 17 to calculate the specific heat capacity of the block. [2 marks]

19. The calculated value is greater than the accepted value. Explain how energy transfer to the surroundings could cause this result. [2 marks]

20. Using Figure 1 and your work in questions 16–19, describe a complete electrical method to determine the specific heat capacity of the block as accurately as possible. Include the measurements, procedure, analysis, improvements and one relevant safety precaution. [6 marks]

Review and improve

- □ I separate heating, melting and further heating into distinct energy stages.
- □ I use $E = mc\Delta\theta$ and $E = mL$ with SI units and explain what happens to the energy.
- □ I can describe an electrical method and explain how heat loss affects the calculated value.