OCR A A Level Thermal Physics 1 worksheet

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

Specification points covered

- 5.1.1(a) Define thermal equilibrium.
- 5.1.1(b) Understand that the absolute thermodynamic scale is independent of the property of any particular substance.
- 5.1.1(c-d) Measure temperature in °C and K, and use T(K) = θ(°C) + 273.
- 5.1.2(a-c) Describe solids, liquids and gases using particle spacing, ordering and motion; use kinetic models; describe and explain Brownian motion.
- 5.1.2(d-g) Define internal energy; understand absolute zero; explain changes in internal energy during heating and phase change.
- 3.2.4(a) Define and use density, ρ = m / V. (Module 3 retrieval)

Asteria sample-return mission

An engineering team tests an asteroid-sample return capsule in a thermal-vacuum chamber. A sealed canister holds a solid rock sample and a liquid coolant jacket protects it.
Use 0 °C = 273 K. Show working and give units for every calculation.

1. Absolute temperature and thermal equilibrium

1. The asteroid sample is initially at -43 °C. Convert this temperature to kelvin. [1 mark]

2. The coolant controller displays 315 K. Convert this temperature to °C. [1 mark]

3. A technician claims that 40 °C is twice 20 °C. Use absolute temperature to evaluate this claim. [2 marks]

4. Define thermal equilibrium. [1 mark]

2. Energy transfer and the particle model

5. The outer chamber wall is at 320 K and the sample canister is at 250 K. State the direction of net thermal energy transfer and the condition needed for the net transfer to become zero. **[2 marks]**

6. The kelvin scale is an absolute thermodynamic scale. State what is meant by this. **[1 mark]**

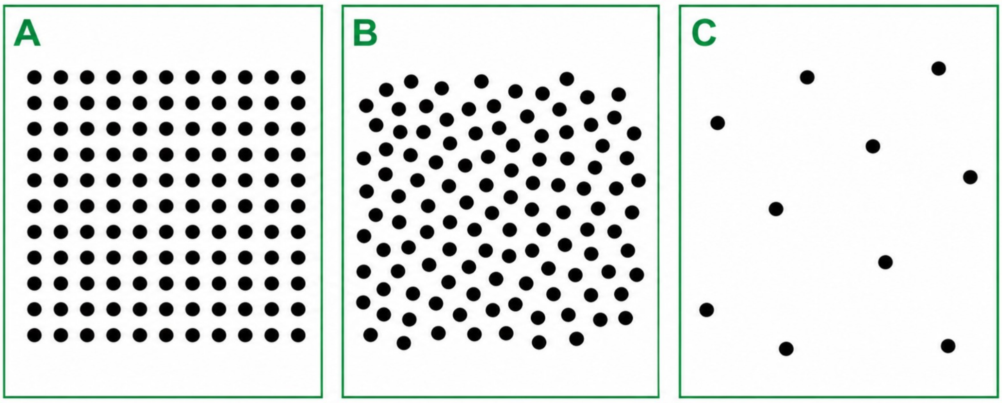

Figure 1: three particle arrangements

7. Figure 1 shows three particle arrangements. Identify the state of matter represented by A, B and C. **[3 marks]**

8. Describe the arrangement and motion of the particles in the solid asteroid sample. **[2 marks]**

9. Describe the arrangement and motion of the particles in the liquid coolant. **[2 marks]**

10. Use the particle model to explain why the gas in a filled test chamber takes the shape and volume of the chamber, whereas the liquid coolant has a fixed volume. **[2 marks]**

3. Heat transfer in the test chamber

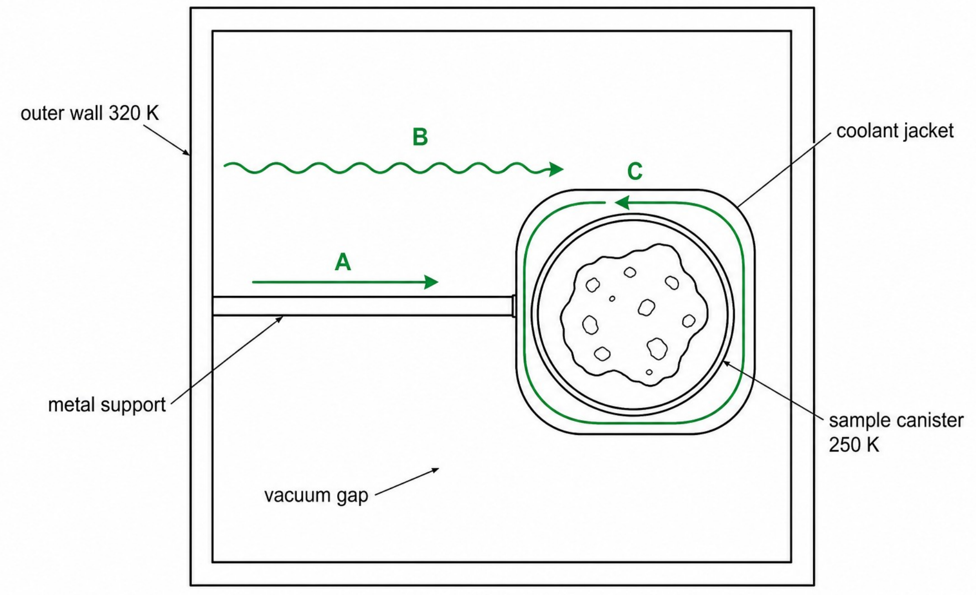

Figure 2: simplified thermal-vacuum test chamber

11. Figure 2 shows three energy-transfer processes in the test chamber. Name the process represented by A, B and C. [3 marks]

12. Explain why conduction and convection cannot transfer energy across the vacuum gap, but process B can. [2 marks]

13. Explain how the circulating current shown by C can form in the liquid coolant. Use density in your answer. [3 marks]

4. Density and evidence for the particle model

14. The asteroid sample has mass 1.84 kg and volume 6.80 × 10^{-4} m^3. Calculate its density. [2 marks]

15. The coolant has density 1050 kg m^{-3}. A test uses 3.20 litres of coolant. Calculate the mass of coolant. 1 litre = 1.00 × 10^{-3} m^3. [2 marks]

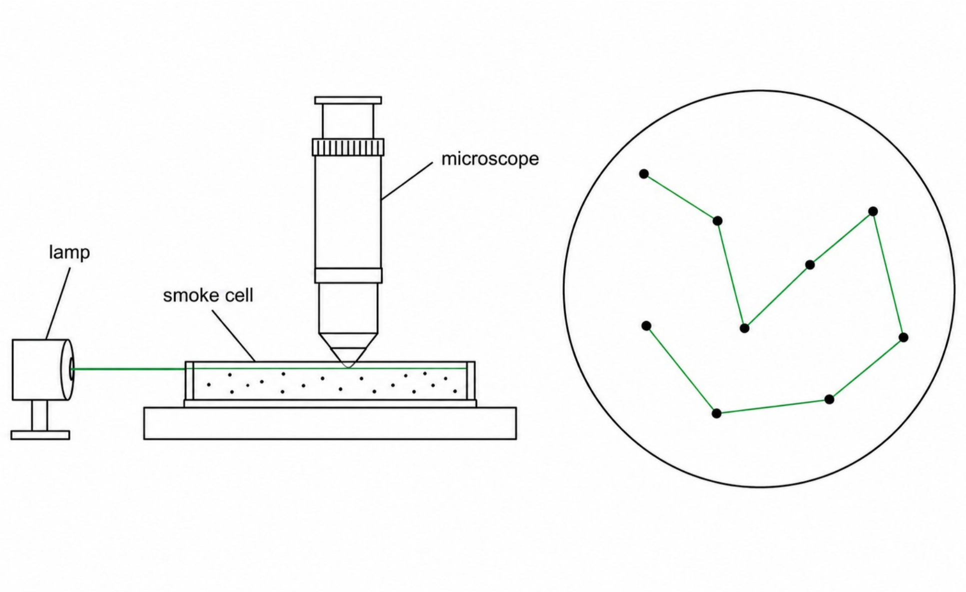

Figure 3: smoke-cell apparatus and two recorded particle tracks

16. Figure 3 shows the tracked paths of two smoke particles at equal time intervals. Describe the pattern of motion using two precise words. [1 mark]

17. Explain what causes the observed motion of the smoke particles. [3 marks]

5. Internal energy and absolute zero

18. Define the internal energy of a system. [2 marks]

19. The solid sample is first warmed from 250 K to 280 K without changing state. It is then heated while it melts at constant temperature. For each stage, describe the changes in the particles' average random kinetic energy and intermolecular potential energy, and hence the change in internal energy. [4 marks]

20. What does absolute zero mean for internal energy? Give its value in K and °C. [2 marks]

Review and improve

- □ I can use kelvin when comparing temperatures and identify thermal equilibrium.
- □ I can describe solids, liquids and gases using spacing, ordering and motion.
- □ I can explain Brownian motion and internal-energy changes using precise particle language.