

Thermal physics: midterm test

Time: 70 minutes. Total: 50 marks. Calculator, ruler and sharp pencil allowed. Write your answers in the spaces provided. A sheet of equations (not labelled: you must decide which one to use) and the data and constants are on the page before the graph sheet. If you work on a computer, type your answers in a separate document, numbering each answer as in the paper (for example II(c)), write equations in plain text (for example $Q = m \cdot c \cdot dT$), and describe in words any drawing or sketch that is asked for. The graph is always drawn by hand on the printed graph sheet and handed in.

Lifebuoy.  The parts marked with the lifebuoy symbol are worth 30 marks out of 50, that is 60 %: if you have completed all of them, you pass.

I Multiple choice

[10]

Choose one letter for each question. Each question is worth 1 mark.

1. Energy is transferred from a cup of hot tea to the cooler air around it. What is this energy transfer called?

 [1]

- A temperature
- B heat
- C pressure
- D expansion

2. A sample is at 47 °C. What is this temperature in kelvin?

 [1]

- A 226 K
- B 47 K
- C 320 K
- D 310 K

3. Two liquid-in-glass thermometers are identical, except that thermometer P has a narrower tube than thermometer Q. Which statement is correct?

 [1]

- A P is more sensitive: its liquid column moves further for each degree.
- B Q is more sensitive, because its liquid expands more.
- C They have the same sensitivity, because the liquid is the same.
- D P has a larger range than Q.

4. A steel rod 1.0 m long expands by 0.50 mm when heated by 40 °C. A steel rod 2.0 m long is heated by the same temperature change. By how much does it expand?

 [1]

- A 0.25 mm
- B 0.50 mm
- C 0.75 mm
- D 1.0 mm

5. Why does a solid rod become longer when it is heated?

 [1]

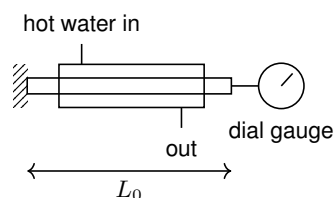
- A Its particles become larger.
- B New particles are formed inside it.
- C Its particles vibrate more and, on average, move slightly further apart.
- D Its particles stop vibrating.

6. What causes the pressure of a gas on the walls of its container? [1]
- A Collisions of the gas particles with the walls.
 - B The weight of the gas particles.
 - C The gas particles repelling the walls.
 - D The gas particles becoming larger.
7. What does the specific heat capacity of a material tell us? [1]
- A The energy stored in 1 kg of the material.
 - B The energy needed to raise the temperature of 1 kg of the material by 1 °C.
 - C The temperature at which the material melts.
 - D The rate at which the material conducts energy.
8. How much energy is needed to raise the temperature of 2.0 kg of water by 10 K? (Specific heat capacity of water: 4200 J/(kg °C).) [1]
- A 8400 J
 - B 42 000 J
 - C 21 000 J
 - D 84 000 J
9. A 1000 W heater is switched on for 60 s. How much energy does it transfer? [1]
- A 16.7 J
 - B 1000 J
 - C 60 000 J
 - D 60 J
10. Two identical cans of hot water stand in a cool room. One can is matt black and the other is shiny silver. Which statement is correct? [1]
- A The matt black can cools faster, because it is a better emitter of infrared radiation.
 - B The shiny silver can cools faster, because it is a better emitter of infrared radiation.
 - C The cans cool at the same rate, because they contain the same water.
 - D The matt black can cools slower, because it absorbs more radiation.

II Alternative to practical

[20]

A student investigates how the length of a copper rod changes when it is heated. The rod has a length $L_0 = 0.800$ m at 20 °C. Hot water at different temperatures flows through a jacket around the rod, and a dial gauge measures the increase in length ΔL . The temperature rise ΔT is the temperature of the water minus 20 °C. The dial gauge reads to 0.01 mm.



$\Delta T / ^\circ\text{C}$	$\Delta L / \text{mm}$
0	0.00
15	0.20
30	0.42
45	0.73
60	0.82

- (a) State the independent variable and the dependent variable of this experiment. [2]

- (b) One of the readings of ΔL is anomalous. State the value of ΔT at which it was taken. [1]

(c) Give one reason for your choice in (b). [1]

(d) On the graph sheet, plot a graph of ΔL (vertical axis) against ΔT (horizontal axis). The scales are printed. Label both axes with the quantity and the unit. [2]

(e) Plot the five points, each with a small cross. [3]

(f) Draw one straight line of best fit with a ruler. Do not join the points, and do not let the anomalous reading pull the line away from the other points. [2]

(g) Use your line to read the increase in length ΔL for $\Delta T = 45^\circ\text{C}$. [1]

(h) Determine the gradient of your line, in $\text{mm}/^\circ\text{C}$. Show the triangle you use on the graph. [2]

(i) Write, in symbols, the equation for linear expansion. The gradient of the graph is equal to αL_0 . [1]

(j) Calculate the linear expansion coefficient α of the rod, in $1/^\circ\text{C}$. Remember that the graph is in millimetres and L_0 is in metres. [3]

(k) Use the table of data to identify the metal of the rod. [1]

(l) Suggest one improvement to the method that would make the value of α more reliable. [1]

III Structured questions [10]

1. A student studies the particles in solids, liquids and gases.

(a) In the boxes, draw the arrangement of the particles in a solid, in a liquid and in a gas. Draw about 12 particles in each box. [3]



solid



liquid



gas

(b) Explain why a gas fills its container but a solid does not. [1]

2. Thermal energy is transferred in different ways.

(a) State the main process of energy transfer (conduction, convection or radiation) in each case.

(i) The handle of a metal spoon in hot soup becomes hot.

⚙️ [1]

(ii) A person sitting beside a fire feels warmth on the face.

⚙️ [1]

(b) Explain why metals conduct thermal energy better than plastics.

[2]

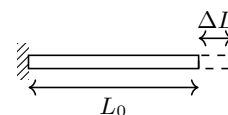
3. A student says: "The metal spoon has a lot of heat, which is why it feels hot." Explain what is wrong with this statement. Use the words *temperature*, *heat* and *energy*.

[2]

IV Problems

[10]

1. A copper bar is 2.00 m long at 15 °C. It is heated to 65 °C. For copper, $\alpha = 1.7 \times 10^{-5} / ^\circ\text{C}$.



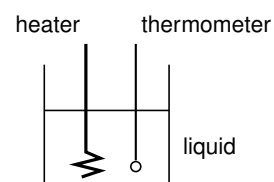
(a) Write, in symbols, the equation for linear expansion and say what each symbol means.

⚙️ [2]

(b) Calculate the increase in length. Give your answer in mm.

[2]

2. An electric heater of power 1.5 kW heats 2.0 kg of water from 15 °C to 45 °C. Assume that no energy is lost.



(a) Write, in symbols, the equation for the energy needed to heat the water.

⚙️ [1]

(b) Write, in symbols, the equation linking energy, power and time.

⚙️ [1]

(c) Combine the two equations to obtain an expression for the time t .

⚙️ [2]

(d) Calculate the time taken.

[2]

Equations

$$\Delta L = \alpha L_0 \Delta T$$

$$Q = m c \Delta T$$

$$E = P t$$

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273$$

Data and constants

Specific heat capacity of water

4200 J/(kg °C)

Linear expansion coefficient α

steel $1.2 \times 10^{-5}/^{\circ}\text{C}$; copper $1.7 \times 10^{-5}/^{\circ}\text{C}$; brass $1.9 \times 10^{-5}/^{\circ}\text{C}$;
aluminium $2.3 \times 10^{-5}/^{\circ}\text{C}$

Graph sheet: Section II

