

Thermal physics: mock test

Time: 60 minutes. Total: 60 marks. Calculator, ruler and sharp pencil allowed. Write your answers in the spaces provided. Equations are not given; 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 36 marks out of 60, that is 60 %: if you have completed all of them, you pass.

I Multiple choice**[12]**

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

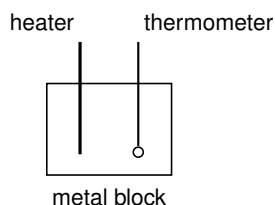
1. Two beakers hold 200 g and 100 g of water, both at 50 °C. Which statement is correct?  [1]
 - A The 200 g beaker has the higher temperature.
 - B The 100 g beaker has the higher temperature.
 - C The temperatures are equal, but the 200 g beaker holds more thermal energy.
 - D The temperatures are equal and the thermal energy is also equal.
2. A sample is at −23 °C. What is this temperature in kelvin?  [1]
 - A 23 K
 - B 250 K
 - C 296 K
 - D −250 K
3. Which change makes a liquid-in-glass thermometer more sensitive?  [1]
 - A A wider tube
 - B A smaller bulb
 - C Thicker glass walls
 - D A narrower tube
4. A copper rod 2.0 m long expands by 0.60 mm when its temperature rises by 25 °C. A copper rod 3.0 m long is heated by 50 °C. By how much does it expand?  [1]
 - A 0.90 mm
 - B 1.2 mm
 - C 1.5 mm
 - D 1.8 mm
5. When a solid cube is heated, each edge becomes 0.20 % longer. Approximately by what percentage does its volume increase?  [1]
 - A 0.80 %
 - B 0.60 %
 - C 0.40 %
 - D 0.20 %

6. Smoke particles in air, seen under a microscope, move along zigzag paths. What causes this motion?  [1]
- A The smoke particles are alive.
 - B Currents of warm air in the room.
 - C Unequal collisions with fast-moving air particles.
 - D Gravity acting on the smoke particles.
7. The pressure of a gas in a sealed rigid container rises when the gas is heated. Why?  [1]
- A The particles move faster, so they hit the walls harder and more often.
 - B The particles become larger.
 - C The particles repel each other more.
 - D More particles are produced.
8. Why does the evaporation of a liquid cool the liquid that remains?  [1]
- A All the particles slow down equally.
 - B The slowest particles escape, leaving the fastest ones behind.
 - C Energy is created inside the liquid.
 - D The most energetic particles escape, so the average kinetic energy of the remaining particles falls.
9. The same energy is supplied to 1.0 kg of metal X and to 1.0 kg of metal Y. The temperature of X rises by 12 °C and that of Y by 30 °C. Which statement is correct?  [1]
- A X has the larger specific heat capacity.
 - B Y has the larger specific heat capacity.
 - C X and Y have the same specific heat capacity.
 - D Y absorbed more energy than X.
10. How much energy is needed to raise the temperature of 0.40 kg of water by 5.0 K? (Specific heat capacity of water: 4200 J/(kg °C).)  [1]
- A 840 J
 - B 8400 J
 - C 84 000 J
 - D 2100 J
11. A 2.0 kW heater is switched on for 3.0 min. How much energy does it transfer?  [1]
- A 6.0 kJ
 - B 36 kJ
 - C 360 kJ
 - D 6000 kJ
12. In a vacuum flask, the vacuum between the double walls mainly reduces energy transfer by  [1]
- A conduction and convection.
 - B radiation only.
 - C conduction only.
 - D evaporation.

II Alternative to practical

[24]

A student investigates how the temperature of a metal block rises when it is heated at a constant rate. The block has a mass of 0.80 kg. An electric heater of power 60 W is placed in a hole in the block. A thermometer with 1 °C divisions is placed in a second hole, filled with a little oil. The student switches the heater on and records the temperature every 100 s.



Time t / s	Temperature T / °C
0	20.0
100	28.5
200	36.5
300	40.0
400	52.5
500	60.5

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

⚙️ [2]

- (b) One of the temperature readings is anomalous. State the time at which it was taken.

⚙️ [1]

- (c) Give one reason for your choice in (b).

[1]

- (d) Calculate the energy supplied by the heater in 500 s.

[1]

- (e) On the graph sheet, plot a graph of temperature T (vertical axis) against time t (horizontal axis). Label both axes with the quantity and the unit, and choose scales that use more than half of the grid in each direction.

⚙️ [2]

- (f) Plot the six points, each with a small cross.

[3]

- (g) 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]

- (h) Determine the gradient of your line, in °C/s. Show the triangle you use on the graph.

[2]

- (i) The block gains energy Q and its temperature rises by ΔT . Write the equation for Q in terms of m , c and ΔT , and the equation for the energy supplied by the heater in a time t .

⚙️ [1]

- (j) Use these equations to show that the gradient of the graph is equal to $P/(mc)$.

[1]

- (k) Rearrange gradient = $P/(mc)$ to make c the subject.

⚙️ [1]

- (l) Calculate the specific heat capacity c of the metal.

[2]

(m) Use the table of data to identify the metal.

[1]

(n) Suggest why the value of c you calculated is larger than the value in the table.

[1]

(o) Suggest one improvement to the method that would make the value of c more reliable.

[1]

(p) Using the specific heat capacity from the table, calculate the temperature rise expected in 500 s if no energy is lost. Compare it with the measured rise.

[2]

III Structured questions

[12]

1. A scientist uses the particle model to describe 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

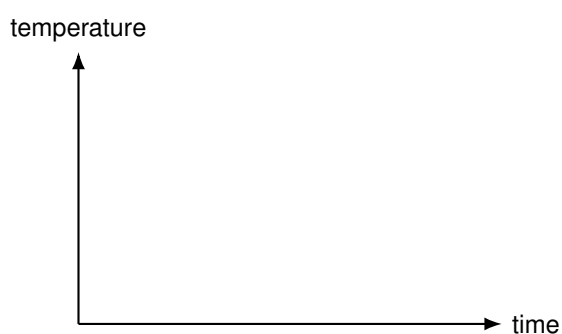
(b) Explain, using the particle model, why the pressure of a gas in a sealed rigid container rises when the gas is heated.

[2]

2. A solid is heated steadily until it has melted and then boiled.

(a) On the axes, sketch the graph of temperature against time for this process.

[3]



(b) Explain, using the particle model, why the temperature does not change while the solid is melting.

[2]

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

(a) From the Sun to the Earth.

[1]

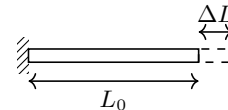
(b) Through the base of a metal pan on a hob.

[1]

IV Problems

[12]

1. A steel section of a bridge is 120 m long at -5°C . In summer its temperature reaches 35°C . For steel, $\alpha = 1.2 \times 10^{-5}/^{\circ}\text{C}$.



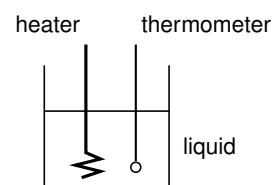
(a) Write, in symbols, the equation for linear expansion and say what each symbol means.

[2]

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

[2]

2. An immersion heater of power 500 W heats 2.0 kg of water from 20°C to 35°C .



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

[1]

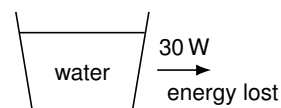
(b) Write, in symbols, the equation linking energy, power and time.

[1]

(c) Calculate the time taken, assuming that no energy is lost.

[2]

3. A cup holds 0.30 kg of tea at 85°C . The tea loses energy to the surroundings at an average rate of 30 W. Assume that tea has the same specific heat capacity as water.



(a) Combine the equations in symbols to obtain an expression for the time t taken for the temperature to fall by ΔT .

[2]

(b) Calculate the time taken for the temperature to fall by 15°C . Give your answer in minutes.

[2]

Data and constants

Specific heat capacity of water

4200 J/(kg °C)

Specific heat capacity of metals

lead 130; copper 390; iron 450; aluminium 900 J/(kg °C)

Linear expansion coefficient α

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

Conversion

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

Nome _____ Cognome _____ Data ____/____/____

Graph sheet: Section II

