Thermal Properties of Matter

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. 60 °C on the Fahrenheit scale is:
(a) 65.33 °F **(b)** 108 °F **(c)** 92 °F **(d)** 140 °F

2. A lead rod 37 m long is heated through 90 K. Its increase in length is ($\alpha = 2.9 \times 10^{-5}$ K^{-1}):
(a) 96.57 mm **(b)** 965.7 mm **(c)** 9.657 mm **(d)** 289.71 mm

3. How much heat raises the temperature of 0.1 kg of copper by 20 K? (specific heat 390 J/kg K)
(a) 7,800 J **(b)** 2 J **(c)** 39 J **(d)** 780 J

4. How much heat is needed to melt 2.9 kg of ice at 0 °C? ($L = 3.36 \times 10^5$ J/kg)
(a) 9.74×10^5 J **(b)** 6.55×10^6 J **(c)** 9.74×10^6 J **(d)** 1.22×10^6 J

5. The SI unit of temperature is the:
(a) kelvin **(b)** degree Fahrenheit
(c) joule **(d)** degree Celsius

6. 600 g of water at 60 °C is mixed with 600 g of water at 80 °C. The final temperature (no heat lost) is:
(a) 69 °C **(b)** 140 °C **(c)** 71 °C **(d)** 70 °C

7. Heat flows through a metal slab (k = 50 W/m K) of area 0.18 m^2 and thickness 0.1 m with a temperature difference of 95 K. The rate of heat flow is:
(a) 17,100 W **(b)** 8,550 W **(c)** 85.5 W **(d)** 90 W

8. Assertion (A): The coefficient of volume expansion of gold ($\alpha = 1.4 \times 10^{-5}$ K^{-1}) is about 4.2×10^{-5} K^{-1}. Reason (R): $\gamma = 2\alpha$, because a solid expands in two dimensions.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. Convert (a) −35 °C to °F and to K, (b) 419 °F to °C.

10. A square iron plate of side 80 cm is heated through 75 K. Find the increase in its area and the increase in the volume of an iron cube of side 80 cm. ($\alpha = 1.2 \times 10^{-5}$ K^{-1})

11. A 0.7 kg aluminium block at 75 °C is dropped into 1 kg of water at 10 °C. Find the final temperature (ignore heat lost to the surroundings). (c of aluminium = 900 J/kg K, c of water = 4200 J/kg K) (2 decimal places where needed.)

12. How much heat changes 0.7 kg of ice at −30 °C into steam at 100 °C? (c of ice 2100 J/kg K, c of water 4200 J/kg K, L_f 3.36 × 10^5 J/kg, L_v 2.26 × 10^6 J/kg)

13. A metal slab (k = 400 W/m K) of area 0.16 m^2 and thickness 0.17 m has its faces at a temperature difference of 70 K. How much heat flows through it in 10 minutes?

14. A body cools from 90 °C to 80 °C in 9 minutes in a room at 25 °C. Using Newton's law of cooling (with average temperatures), how long will it take to cool from 80 °C to 70 °C? (2 decimal places where needed.)

15. Copper bars 21 m long are laid at 20 °C. What gap must be left between them if the temperature can rise by 10 K? ($\alpha = 1.7 \times 10^{-5}$ K^{-1})

16. 20 g of ice at 0 °C is added to 440 g of water at 50 °C. Find the final temperature. (c of water 4.2 J/g K; L_f 336 J/g) (2 decimal places where needed.)

Section C — Word problems — 4 × 4 = 16 marks

17. An aluminium calorimeter of mass 0.3 kg contains 0.6 kg of water at 20 °C. A 0.1 kg aluminium block at 100 °C is dropped in. Find the final temperature. (c of aluminium 900 J/kg K; c of water 4200 J/kg K) (2 decimal places where needed.)

18. 2 kg of ice at 0 °C is heated steadily until it has all turned into steam at 100 °C. (a) Find the heat needed for each stage: melting, warming the water, boiling. (b) Sketch how the temperature changes with time, and explain the flat parts. (L_f 3.36 × 10^5 J/kg; c of water 4200 J/kg K; L_v 2.26 × 10^6 J/kg)

19. Two slabs of equal area, of thermal conductivities 400 and 100 W/m K and thicknesses 2 cm and 4 cm, are placed face to face. The outer faces are kept at 85 °C and 30 °C. Find the temperature of the junction in steady state. (2 decimal places where needed.)

20. A cup of tea cools from 85 °C to 75 °C in 10 minutes in a room at 20 °C. (a) State Newton's law of cooling. (b) Find the constant K (per minute), using the average temperature. (c) What is its rate of cooling when it is at 70 °C? (2 decimal places where needed.)

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Answer key

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Q	Answer	Working
1	**(d) 140 °F**	F = 9C/5 + 32
2	**(a) 96.57 mm**	ΔL = αLΔT
3	**(d) 780 J**	Q = mcΔT
4	**(a) 9.74×10^5 J**	Q = mL
5	**(a) kelvin**	—
6	**(d) 70 °C**	heat lost = heat gained
7	**(b) 8,550 W**	H = kAΔT/L
8	**(c) A is true, but R is false.**	A is true: $\gamma = 3\alpha = 4.2 \times 10^{-5}$ K^{-1}. R is false.
9	**(a) −31 °F, 238.15 K; (b) 215 °C**	F = 9C/5 + 32; K = C + 273.15
10	**ΔA = 11.52 cm^2; ΔV = 1,382.4 cm^3**	ΔA = 2αAΔT; ΔV = 3αVΔT
11	**18.48 °C**	heat lost by the block = heat gained by the water
12	**2.16×10^6 J**	44,100 + 235,200 + 294,000 + 1,582,000 J
13	**1.58×10^7 J (rate 26,352.94 W)**	H = kAΔT/L; Q = Ht
14	**10.8 minutes**	rate = K × (average temperature − 25); find K from the first part
15	**3.57 mm**	gap = αLΔT
16	**44.35 °C (all the ice melts)**	heat to melt the ice 6,720 J; heat the water can give out cooling to 0 °C 92,400 J
17	**22.5 °C**	heat lost by the block = heat gained by the water + calorimeter
18	**(a) Melting 6.72×10^5 J; warming 8.40×10^5 J; boiling 4.52×10^6 J; total 6.03×10^6 J. (b) The graph is flat during melting and boiling: the heat goes into changing the state, not raising the temperature.**	—
19	**78.89 °C**	the same heat flows through both: 400(85 − T)/2 = 100(T − 30)/4
20	**(a) The rate of cooling is proportional to the difference between the body's temperature and its surroundings. (b) K = 0.0167 per minute. (c) 0.83 °C per minute.**	10/10 = K × (80 − 20)

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