



2025 Sec 4 Physics Chapter 10

Thermal Physics - ANSWERS

1. Temperature

Example 1

373 K, 273 K, -173 K, 4727 K

Example 2: B

2. Kinetic Model of Matter

3. Thermal Processes

| Processes | Conduction | Convection | Radiation |
|--|---|--|---|
| Mechanism? How does it work | <u>vibration of particles</u> | <u>difference in density</u> | <u>medium</u> <u>infrared</u> |
| Factors which affect the rate of thermal energy transfer | <ul style="list-style-type: none"> • <u>type of particles</u> • <u>distance between particles</u> | <ul style="list-style-type: none"> • <u>position of heat source</u> | <ol style="list-style-type: none"> 1. <u>colour of surface</u> 2. <u>texture of surface</u> 3. <u>temperature of surface</u> 4. <u>surface area</u> <ul style="list-style-type: none"> • <u>faster</u> • <u>relative higher</u> |

Example 3

(a) Why does a stone floor feel cold to bare feet, but a floor mat in the same room feels warm?

- same temperature
- thermal conductor
- more rapidly

(b) Why is the heating coil of an electric kettle placed near the bottom inside the kettle?

- expands
- dense
- rise
- downwards
- convection

(c) What would happen if an air-conditioner is positioned near the floor instead of the ceiling?

- remain
- denser
- conduction
- poor

4. Thermal Properties of Matter

Example 4: D

Example 5: C

Example 6

(a) $C = Q / \Delta\theta = 12600 / 30 = 420 \text{ J } ^\circ\text{C}^{-1}$

(b) $C = 10 \times 420 = 4200 \text{ J } ^\circ\text{C}^{-1}$

Example 7

• $Q = m c \Delta\theta$

$c = Q / (m \Delta\theta) = 12\,000 \text{ J} / ((1.00 \text{ kg})(45 - 31)\text{K})$ - substitute with units!
 $= 12000 / 14 = 857.14 \approx 860 \text{ J kg}^{-1} \text{ K}^{-1}$ (2 s.f.) or $860 \text{ J kg}^{-1} (^\circ\text{C})^{-1}$

Example 8

Energy lost by brass = energy gained by parafin

$m_b c_b (100 - \theta) = m_p c_p (\theta - 30)$

$0.20 \times 380 \times (100 - \theta) = 0.50 \times 2000 (\theta - 30)$

$\theta = 35 \text{ } ^\circ\text{C}$

Example 9

• $Q = m L_v$

$L_v = Q / m = 45\,000 \text{ J} / (20/1000) \text{ kg} = 2.25 \times 10^6 \text{ J kg}^{-1}$
 Or $= 45\,000 \text{ J} / 20 \text{ g} = 2250 \text{ J g}^{-1}$

Example 10

Energy supplied by kettle = Energy gained by ethanol (to become a gas)

$P t = m L_v$
 $(2000 \text{ W})(5.0 \times 60 \text{ s}) = (0.20 \text{ kg}) L_v$

$c = 3.0 \times 10^6 \text{ J kg}^{-1}$

Example 11

Word equation: energy supplied by heating coil = energy gained by water

Math. equations: $Pt = m c \Delta\theta$

$V I t = m c \Delta\theta$

$(1980)(5.0 \times 60) = (2.0) c (100 - 30)$

$c = 4243 \approx 4240 \text{ J (kg } ^\circ\text{C)}^{-1}$

Example 12

Let θ be the final temperature (when thermal equilibrium is reached)

Assign $c = 4200 \text{ J (kg } ^\circ\text{C)}^{-1}$
 $L_f = 3.34 \times 10^5 \text{ J kg}^{-1}$

Word equation:

energy lost by lemonade = energy gained by ice to melt (constant temperature)
(temperature falls) + energy gained by water (temperature rises)

Math. equations:

$$\begin{aligned} Q &= m_1 c \Delta\theta & &= m_2 L_f + m_2 c \Delta\theta \\ (0.20)(4200)(30 - \theta) & & &= (0.050)(3.34 \times 10^5) + (0.050)(4200)(\theta - 0) \\ (840)(30 - \theta) & & &= 16700 + 210 \theta \\ 25200 - 840 \theta & & &= 16700 + 210 \theta \\ \theta & & &= (25200 - 16700) / (210 + 840) = 8.095 \\ \theta & \approx & & 8.1 \text{ } ^\circ\text{C} \end{aligned}$$

Example 13

Let θ be the final temperature (assume it is above $0 \text{ } ^\circ\text{C}$)

Convert all masses to "kg".

(a) energy transfer (by heating) when temperature of ice rises to $0 \text{ } ^\circ\text{C}$.

$$Q = m_1 c (0 - (-20)) = (0.01 \text{ kg})(2050 \text{ J (kg } ^\circ\text{C)}^{-1})(20^\circ\text{C}) = 410 \text{ J}$$

(b) energy transfer (by heating) when the ice melts completely at $0 \text{ } ^\circ\text{C}$.

$$Q = m_1 L_f = (0.01 \text{ kg})(3.34 \times 10^5 \text{ J kg}^{-1}) = 3340 \text{ J}$$

(c) energy transfer (by heating) when the temperature of water (from melted ice) rises to θ

$$Q = m_1 c_2 (\theta - 0) = (0.01 \text{ kg})(4200 \text{ J (kg } ^\circ\text{C)}^{-1}) \theta = 42 \theta$$

(d)

$$Q = m_2 c_2 (30 - \theta)$$

energy lost by water initially at $30 \text{ } ^\circ\text{C}$ =
(to fall from 30 to θ)

energy gained by ice (from -20 to $0 \text{ } ^\circ\text{C}$)
+ energy gained by ice (melting at $0 \text{ } ^\circ\text{C}$)
+ energy gained by water (from melted ice) (from 0 to θ)

$$\begin{aligned} (0.20 \text{ kg})(4200 \text{ J (kg } ^\circ\text{C)}^{-1})(30 \text{ } ^\circ\text{C} - \theta) & & &= 410 + 3340 + 42 \theta \\ 840(30 - \theta) & & &= 410 + 3340 + 42 \theta \\ \theta (42 + 840) & & &= 25200 - 410 - 3340 \\ \theta & & &= 24.32 \approx 24 \text{ } ^\circ\text{C} \end{aligned}$$

Example 14

Use the kinetic theory to explain

1. how evaporation occurs,

The liquid molecules are in constant random motion and collide with each other continuously.

Evaporation occurs when faster particles at the surface have enough energy to overcome the intermolecular forces of the liquid and push against the atmosphere to leave the liquid body.

2. why cooling occurs when a liquid evaporates.

During evaporation, the fastest-moving molecules leave the liquid. The average kinetic energy of the molecules remaining in the liquid is decreased.

Since temperature is directly proportional to the average kinetic energy of the molecules in the liquid, temperature falls, and hence cooling occurs.

Example 15

- Why is the horizontal section of the graph at the boiling point longer than that at the melting point?
The latent heat of vaporization is usually larger than the latent heat of fusion.
- Compare the gradients of the graph in each of the three states. What are they related to?
The gradients are related to the specific heat capacities of the substance when in those states.
In the cooling curve above, the specific heat capacity of the substance in solid state is lower than the specific heat capacity when in liquid state.
The steeper the graph, the lower the specific heat capacity.