

3.1 Thermal Concepts

Question Paper

Course	DPIB Physics
Section	3. Thermal Physics
Topic	3.1 Thermal Concepts
Difficulty	Hard

Time allowed: 20
Score: /10
Percentage: /100

Question 1

1 kg of water at 20 °C cools to 0 °C and then freezes to form ice, also at 0 °C.

What is the energy released during this process?

You may use the following values:

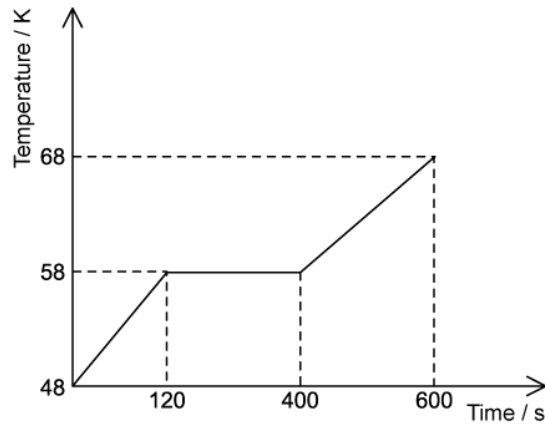
- Specific heat capacity of water = $4000 \text{ J kg}^{-1} \text{ K}^{-1}$
- Specific latent heat of fusion of ice = $3.4 \times 10^5 \text{ J kg}^{-1}$

- A. $1.1 \times 10^5 \text{ J}$
- B. $3.0 \times 10^5 \text{ J}$
- C. $4.2 \times 10^5 \text{ J}$
- D. $5.0 \times 10^5 \text{ J}$

[1 mark]

Question 2

Heat energy is supplied at a constant rate to a solid material with a specific heat capacity of $1.92 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$.



What is the specific latent heat of fusion of the substance?

- A. $2.6 \times 10^5 \text{ J kg}^{-1}$
- B. $9.6 \times 10^4 \text{ J kg}^{-1}$
- C. $4.48 \times 10^4 \text{ J kg}^{-1}$
- D. $1.92 \times 10^3 \text{ J kg}^{-1}$

[1 mark]

Question 3

The temperature of 500 g of water decreases by ΔT °C when placed in a fridge for 10 minutes. This container of water is then removed and a second container of mass 250 g and temperature 25 °C is placed in the same fridge for 20 minutes.

Assume that the containers holding the water are identical and do not emit or absorb energy. The specific heat capacity of water is $4200 \text{ J kg}^{-1} \text{ K}^{-1}$.

What is the final temperature of the second container of water after 20 minutes?

- A. $25 - 4\Delta T$
- B. $25 - 3\Delta T$
- C. $25 + 4\Delta T$
- D. $4\Delta T$

[1 mark]

Question 4

An engine goes through 6000 cycles every minute. To maintain a constant working temperature, 152 J of energy must be removed by a coolant during each complete cycle of the engine. The temperature of the coolant rises by 20 °C as it passes through the engine.

The specific heat capacity of the coolant is $3.8 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$ and the density is 1000 kg m^{-3} .

What is the volume of the coolant that flows through the engine in one second?

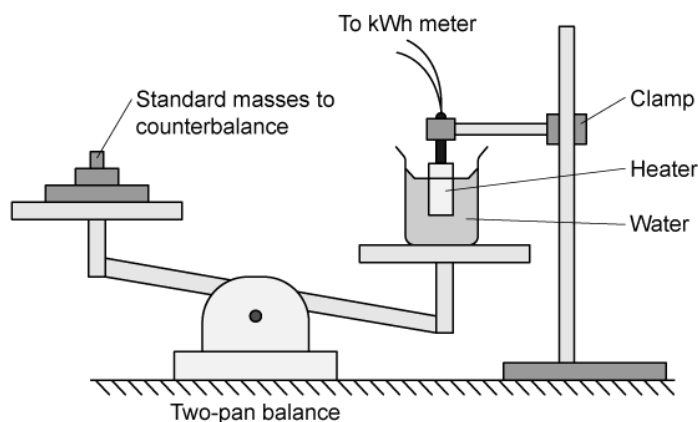
- A. $3 \times 10^{-5} \text{ m}^3$
- B. $\frac{1}{3} \times 10^{-8} \text{ m}^3$
- C. $12 \times 10^{-3} \text{ m}^3$
- D. $2 \times 10^{-4} \text{ m}^3$

[1 mark]

Question 5

A glass beaker of water contains an immersion heater completely submerged by the water and is placed on the right-hand side of a two-pan balance. The heater boils the water at $100\text{ }^{\circ}\text{C}$ and is connected to a kWh meter. When the water starts to boil standard masses are added to the left-hand side of the balance so it is in equilibrium with the water. At this moment the reading on the meter is 11.3 kWh.

A 400 g mass is then added to the left-hand side of the balance, causing it to tilt. As the water boils off the right pan rises until it is once again in equilibrium. When this happens the new reading on the meter is 11.5 kWh.



What is the specific latent heat of vapourisation of the steam if the heater is 50% efficient?

- A. $3.6 \times 10^5 \text{ J kg}^{-1}$
- B. 1800 J kg^{-1}
- C. $9 \times 10^5 \text{ J kg}^{-1}$
- D. 250 J kg^{-1}

[1 mark]

Question 6

A spring in a ball point pen has a mass of 0.10 g and a specific heat capacity of $400 \text{ J kg}^{-1} \text{ K}^{-1}$ and a spring constant $k = 200 \text{ N m}^{-1}$. To open or close the nib of the pen the spring is compressed by 8 mm. Upon release 5% of the elastic potential energy stored is converted into heat energy in the spring.

How many times must the spring be compressed and released to cause the temperature of the pen to increase by $2\text{ }^{\circ}\text{C}$?

Assume that no heat is lost from the pen.

- A. 250
- B. 80 000
- C. 250 000
- D. 100

[1 mark]

Question 7

An ice cube of mass m_i and temperature $-T_i$ is dropped into a glass of water of mass m_w and temperature T_w . The specific heat capacity of ice is c_i and the specific latent heat of fusion of ice is L_i . The specific heat capacity of water is c_w .

What is the final temperature of the water?

A.
$$\frac{m_w c_w T_w + m_i (c_i T_i + L_i)}{m_w c_w - m_i c_i}$$

B.
$$\frac{m_w c_w T_w - m_i (c_i T_i + L_i)}{m_w c_w + m_i c_w}$$

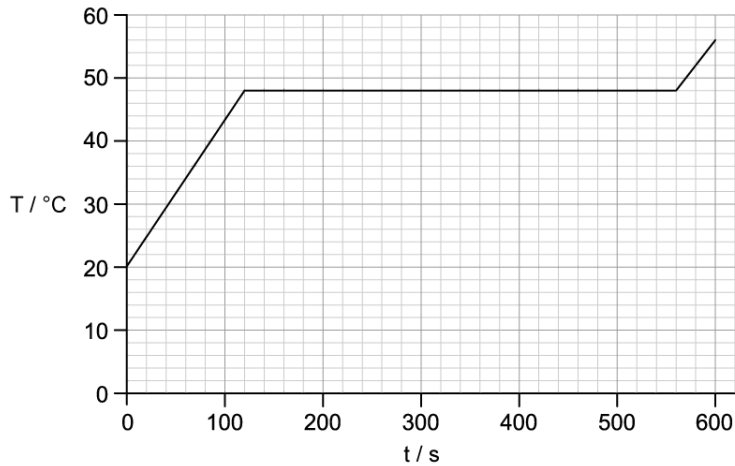
C.
$$\frac{m_w c_w T_w - m_i L_i}{m_w c_w + m_i c_i}$$

D.
$$\frac{m_w c_w T_w - m_i (c_i T_i + L_i)}{m_i c_i}$$

[1 mark]

Question 8

A sample of a solid is heated with a heater of constant power.



What is the power of the heater?

- A. $\frac{9mc}{30}$ W
- B. $\frac{7mc}{150}$ W
- C. $\frac{2mc}{5}$ W
- D. $\frac{7mc}{30}$ W

[1 mark]

Question 9

Two bodies of equal mass A and B are brought into thermal contact. Object A has a temperature of 0 °C and object B has a temperature of 100 °C. Object A has a specific heat capacity greater than object B. No other exchanges of heat take place.

Which statement is correct?

- A. $0 < T < 50$ °C
- B. $T = 50$ °C
- C. $T = 75$ °C
- D. 50 °C $< T < 100$ °C

[1 mark]

Question 10

Energy is provided to a solid at its melting rate of P joules per second. The rate at which the mass is melting away is α kg per second.

What is the specific latent heat of fusion of the solid?

A. $\frac{\alpha}{P}$

B. αP

C. $\frac{1}{\alpha P}$

D. $\frac{P}{\alpha}$

[1 mark]