ICSE CLASS 10 · PHYSICS

Chapter 11 : CALORIMETRY

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20) · $Q = mc\Delta T$ · $Q = mL$ · heat lost = heat gained · $c_{water} = 4.2\ J\ g^{-1}\ °C^{-1}$ · $L_{ice} = 336\ J\ g^{-1}$ · $L_{steam} = 2260\ J\ g^{-1}$

Marks for each step are shown in square brackets on the right. Parts added in the solution diagrams are drawn in red.

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(a)** J kg^{-1} K^{-1}	Specific heat capacity c = Q ÷ (m Δt), so the unit is joule per kilogram per kelvin.
(ii)	**(c)** 42000 J	Q = mcΔT = 2 × 4200 × 5 = 42000 J.
(iii)	**(c)** remains constant	During a change of state the heat supplied is used to change the state (latent heat), so the temperature stays constant.
(iv)	**(d)** water	Water has a specific heat capacity of about 4200 J kg^{-1} K^{-1}, much greater than lead, copper or iron.
(v)	**(c)** Both (A) and (R) are true, and (R) is the correct explanation for (A).	Both are true: condensing steam releases latent heat in addition to the heat released by water at the same temperature; (R) explains (A).
(vi)	**(b)** 16800 J	Q = mL = 50 × 336 = 16800 J.
(vii)	**(c)** 1000 J K^{-1}	Heat capacity = mc = 2 × 500 = 1000 J K^{-1}.
(viii)	**(a)** energy	Heat lost by hot bodies = heat gained by cold bodies is the law of conservation of energy.

Question 2 [6 marks]

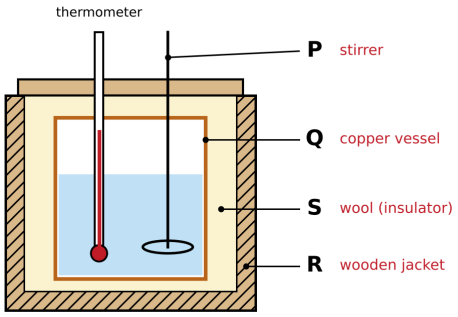
(a) **Specific heat capacity** of a substance is the heat energy required to raise the temperature of unit mass (1 kg) of the substance by 1 K (1 °C). [1] **[2]**

S.I. unit: **J kg^{-1} K^{-1}**. [1]

(b) (i) P is the **stirrer** and Q is the **copper vessel** (calorimeter). The stirrer is used to stir the liquid so that its temperature is uniform throughout. [1] **[3]**

(ii) R is the **wooden jacket** and S is the **wool (felt) packing**. Both are bad conductors of heat, so they reduce the loss of heat to the surroundings. [1]

(iii) Copper is a good conductor of heat and has a low specific heat capacity, so it quickly attains the temperature of its contents and absorbs little heat itself. [1]



Solution to Q2(b)

(c) The S.I. unit of heat capacity is **J K^{-1}** (joule per kelvin). [1] **[1]**

Question 3 [6 marks]

(a) Given: m = 500 g, ΔT = 70 − 20 = 50 °C, c = 4.2 J g^{-1} $°C^{-1}$, P = 700 W. **[3]**

(i) Q = mcΔT = 500 × 4.2 × 50 = **105000 J**. [1]

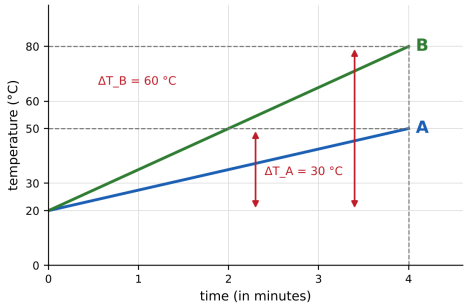
(ii) t = Q ÷ P = 105000 ÷ 700 = **150 s**. [1]

(iii) Heat capacity = mc = 500 × 4.2 = **2100 J $°C^{-1}$**. [1]

(b) (i) Both liquids receive the same heat in 4 min, but the rise in temperature of A (30 °C) is less than that of B (60 °C). So **A** has the greater specific heat capacity, since c ∝ 1 ÷ ΔT for equal mass and heat. [1] **[3]**

(ii) $c_A \div c_B = \Delta T_B \div \Delta T_A = 60 \div 30 =$ **2 : 1**. [1]

(iii) Heat supplied in 4 min = Pt = 50 × 240 = 12000 J; m = 0.4 kg. $c_A = Q \div (m\Delta T) = 12000 \div (0.4 \times 30) =$ **1000 J kg^{-1} K^{-1}**. [1]



Solution to Q3(b)

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) **Specific latent heat of fusion** is the heat energy required to change unit mass of a solid into liquid at its melting point without any change in temperature. [1] **[3]**

For ice, it is **336 J g^{-1}**. [1]

Q = mL = 25 × 336 = **8400 J**. [1]

(b) (i) Water has a high specific heat capacity, so it can absorb a large amount of heat from the engine with only a small rise in its own temperature. [1] **[3]**

(ii) The heat supplied is used up as latent heat of fusion to change the ice into water, not to raise the temperature, until all the ice has melted. [1]

(iii) The land has a smaller specific heat capacity than the sea, so it gets hotter faster during the day; the warm air over land rises and cooler air from the sea moves in. [1]

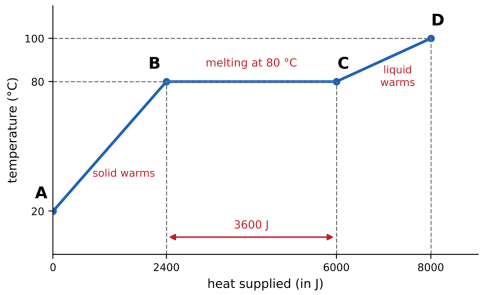
(c) Given: m = 100 g. **[4]**

(i) Melting point = **80 °C**; the part BC (horizontal) represents the **melting** of the solid at constant temperature. [1]

(ii) Heat for AB = 2400 J, ΔT = 60 °C: c = Q ÷ (mΔT) = 2400 ÷ (100 × 60) = **0.4 J g⁻¹ °C⁻¹**. [1]

(iii) Heat for BC = 6000 − 2400 = 3600 J: L = Q ÷ m = 3600 ÷ 100 = **36 J g⁻¹**. [1]

(iv) Heat for CD = 8000 − 6000 = 2000 J, ΔT = 20 °C: c = 2000 ÷ (100 × 20) = **1 J g⁻¹ °C⁻¹**. [1]



Solution to Q4(c)

Question 5 [10 marks]

(a) Any three (1 mark each): **[3]**

• Use a calorimeter made of copper (a good conductor with a low specific heat capacity) and keep it polished to reduce loss of heat by radiation.

• Place the calorimeter in an insulating jacket of wool or felt to reduce loss of heat to the surroundings.

• Stir the liquid continuously so that the temperature is uniform, and read the thermometer carefully.

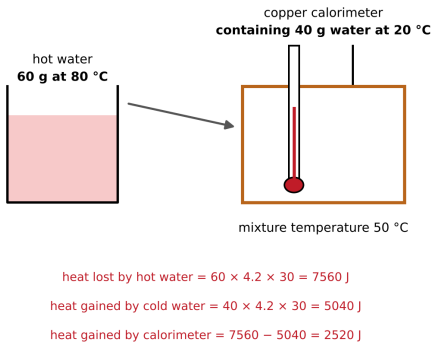
• Transfer the hot substance quickly into the calorimeter, and avoid splashing the liquid.

• Use enough liquid to cover the bulb of the thermometer and keep the initial temperature of the calorimeter below room temperature if possible.

(b) (i) Heat lost by hot water = mcΔT = 60 × 4.2 × (80 − 50) = **7560 J**. [1] **[3]**

(ii) Heat gained by cold water = 40 × 4.2 × (50 − 20) = **5040 J**. [1]

(iii) Heat gained by calorimeter = 7560 − 5040 = **2520 J**; its heat capacity = 2520 ÷ (50 − 20) = **84 J °C⁻¹**. [1]



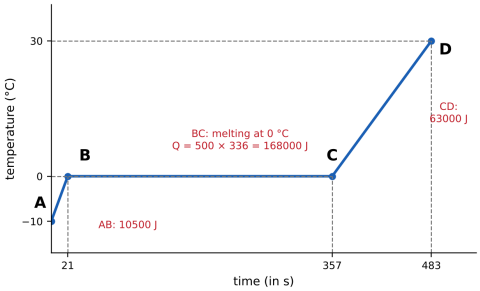
Solution to Q5(b)

(c) (i) Melting takes place along BC: time = 357 − 21 = **336 s**. [1] **[4]**

(ii) Heat supplied = Pt = 500 × 336 = **168000 J**. [1]

(iii) Q = mL, so m = 168000 ÷ 336 = **500 g**. [1]

(iv) Heat for AB = 500 × 21 = 10500 J, ΔT = 0 − (−10) = 10 °C: c = 10500 ÷ (500 × 10) = **2.1 J g⁻¹ °C⁻¹**. [1]



Solution to Q5(c)

Question 6 [10 marks]

(a) Given: m_1 = 150 g (metal), m_2 = 100 g (water). **[3]**

(i) Heat gained by water = 100 × 4.2 × (30 − 20) = **4200 J**. [1]

(ii) Fall in temperature of the block = 100 − 30 = **70 °C**. [1]

(iii) Heat lost by metal = heat gained by water: 150 × c × 70 = 4200, so c = **0.4 J g⁻¹ °C⁻¹** (400 J kg⁻¹ K⁻¹). [1]

(b) (i) **Specific latent heat of vaporisation** is the heat energy required to change unit mass of a liquid into vapour at its boiling point without any change in temperature. [1] **[3]**

(ii) Q = mL = 10 × 2260 = **22600 J**. [1]

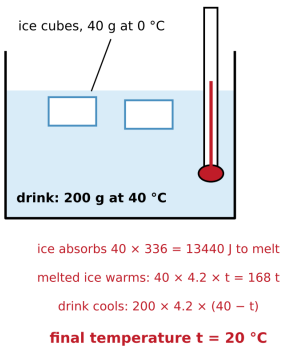
(iii) Cooling the water from 100 °C to 40 °C: 10 × 4.2 × 60 = 2520 J; total heat released = 22600 + 2520 = **25120 J**. [1]

(c) (i) Heat to melt the ice = 40 × 336 = **13440 J**. [1] **[4]**

(ii) Heat gained by ice (melting + warming) = heat lost by drink: 13440 + 40 × 4.2 × t = 200 × 4.2 × (40 − t). [1]

(iii) 13440 + 168 t = 33600 − 840 t, so 1008 t = 20160 and t = **20 °C**. [1]

(iv) Ice at 0 °C also absorbs the large latent heat of fusion (336 J g⁻¹) while melting, in addition to the heat gained on warming, so it takes much more heat from the drink than water at 0 °C. [1]



Solution to Q6(c)

Marks summary	
Section A: Q1 (8) + Q2 (2 + 3 + 1 = 6) + Q3 (3 + 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**