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A Level Physics – Edexcel

Topic 9 – Thermodynamics

Specific Heat Capacity and **Specific Latent Heat**

Topic 9 – Thermodynamics

Specific Heat Capacity and **Specific Latent Heat**

Paper 2 – Thermal Physics – Specific Heat Capacity – Edexcel

2017

11 An electric iron rated at 2600 W contains a steel plate which is heated to a working temperature of 215 °C. Room temperature is 18 °C.

Deduce whether the plate could reach its working temperature in less than 1 minute.

mass of steel plate = 890 g

specific heat capacity of steel = $450\,\mathrm{J\,kg^{-1}\,K^{-1}}$

(3)

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(Total for Question 11 = 3 marks)

2023

12 A student placed a metal block of mass 220 g in boiling water at 100 °C for several minutes.

The student then transferred the metal block into 300 g of water at 19 °C inside a glass container of mass 50 g. The final temperature of the water was 23 °C.

The table shows specific heat capacity values for copper and tin.

Metal	copper	tin
Specific heat capacity / $J\,kg^{-1}\,K^{-1}$	390	230

Deduce whether the metal block was made from copper or tin.

specific heat capacity of water = $4200\,J\,kg^{-1}\,K^{-1}$
specific heat capacity of glass = $840\,J\,kg^{-1}\,K^{-1}$

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(Total for Question 12 = 5 marks)

5 A data book contains the following information for ethanol.

latent heat of fusion = $109\,\text{kJ}\,\text{kg}^{-1}$

latent heat of vaporisation = $838\,\text{kJ}\,\text{kg}^{-1}$

545 J is transferred from a sample of ethanol when it condenses.

Which of the following shows how to calculate the mass of ethanol that condenses?

☒ **A** $545 \div 109\,000$

☒ **B** $545 \div 838\,000$

☒ **C** $109\,000 \div 545$

☒ **D** $838\,000 \div 545$

(Total for Question 5 = 1 mark)

2019

11 A wet handkerchief is dried in 56 s using a hot iron rated at 2400 W.

Determine whether energy is transferred to the water in the handkerchief at a greater rate than it is transferred to the iron.

initial temperature of wet handkerchief = 18 °C

initial mass of wet handkerchief = 35.9 g

final mass of dry handkerchief = 18.2 g

specific heat capacity of water = $4.19 \times 10^{3}\ \text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$

specific latent heat of vaporisation of water = $2.26 \times 10^{6}\ \text{J}\,\text{kg}^{-1}$

(5)

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2021

12 Latte is a type of coffee made with hot frothy milk. The milk is heated by pumping steam into it.

Calculate the maximum mass of milk that could be warmed to a temperature of 65 °C by absorbing 15 g of steam at 100 °C.

initial temperature of milk = 4.0 °C
specific heat capacity of milk = $3900\,\mathrm{J\,kg^{-1}\,K^{-1}}$
specific heat capacity of water = $4200\,\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat of vaporisation of water = $2.3 \times 10^{6}\,\mathrm{J\,kg^{-1}}$

Maximum mass = ...

(Total for Question 12 = 4 marks)

2022

15 Aluminium is one of the most widely recycled metals. Aluminium cans are heated from room temperature until all the aluminium has melted. The molten aluminium is then used to make new cans. This process uses only 5% of the energy needed to extract aluminium from raw materials.

On a website it is claimed that recycling one aluminium can of mass 14 g saves enough energy to listen to music on a mobile phone continuously for 7 days.

Assess the validity of this claim.

melting point of aluminium = 660 K
specific heat capacity of aluminium = 902 $\text{J kg}^{-1}\,\text{K}^{-1}$
specific latent heat of aluminium = 396 kJ kg^{-1}
room temperature = 293 K
mobile phone p.d. = 3.7 V
mobile phone current = 120 mA

(Total for Question 15 = 6 marks)

Question Number	Acceptable answers		Additional guidance	Mark
11	• use of $\Delta E = mc\Delta\theta$ • use of $P = E/t$ • Correct calculation of an appropriate quantity **and** comment consistent with their value.	(1) (1) (1)	**MP2** Candidates need to calculate either a time, a final temperature, an energy or a power Examples: Yes, because t = 30 s, which is less than one minute **Or** Yes, because it could reach temperature of 408 °C in one minute **Or** Yes, because it would transfer 156 000 J in one minute **Or** Yes, because the power required is 1.3 kW <u>Example of calculation</u> ΔE = 0.89 kg × 450 J kg^{-1} K^{-1} × (215 °C - 18 °C) = 78 900 J t = 78 900 J ÷ 2600 W = 30 s	3

Question Number	Acceptable answers		Additional guidance	Mark
12	• Energy lost by block = energy gained by water and/ or glass • Use of $\Delta E = mc\Delta\theta\ldots$ • …using temperature change of block • c = 310 (J kg^{-1} K^{-1}) **Or** Required temperature change for tin = 103 K **Or** required starting temperature for tin = 126 °C • Block is copper with justification e.g. some energy transferred to surroundings (so causes an underestimate in c) **or** block not fully at 100°C (so causes an underestimate in c) **or** tin cannot produce the required temperature change	(1) (1) (1) (1) (1)	<u>Example of calculation:</u> $0.22\text{ kg} \times c \times (100 - 23)\text{K}$ $= 0.05\text{ kg} \times 840\text{ J kg}^{-1}\text{ K}^{-1} \times 4\text{ K} + 0.3\text{ kg} \times 4200\text{ J kg}^{-1}\text{ K}^{-1} \times 4\text{ K}$ 16.94 c = 168 + 5040 = 5208 J c = 307 J kg^{-1} K^{-1} MP1 may be awarded for approach comparing energy gained by water and/or glass with maximum energy lost by block without equating them	5

(Total for Question 12 = 5 marks)

5	**B – 545 ÷ 838 000** Incorrect Answers: Correct method: mass = energy transfer ÷ latent heat of vaporisation A – uses energy transfer ÷ latent heat of fusion C – uses latent heat of fusion ÷ energy transfer D – uses latent heat of vaporisation ÷ energy transfer	1

Question Number	Acceptable answers		Additional guidance	Mark
11	• Use of $\Delta Q = mc\Delta\theta$ • … for correct temperature change • Use of $\Delta Q = L\Delta m$ • Use of $P = E/t$ • It is not transferred faster because: 823 (W to water) < 2400 (W to iron) **Or** 46 100 (J to water) < 134 400 (J to iron) **Or** 19.2 (s to evaporate water at rate of 2400 W) < 56 (s taken)	**(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation mass of water = 0.0359 kg – 0.0182 kg = 0.0177 kg ΔQ = 0.0177 kg × 4190 J kg^{-1} K^{-1} × (100 °C − 18 °C) = 6100 J ΔQ = (0.0177 kg) × 2.26 × 10^{6} J kg^{-1} = 40 000 J P = (6100 J + 40 000 J) / 56 s = 823 W	5

Question Number	Acceptable answers		Additional guidance	Mark
12	• Use ofincrease in thermal energy of milk = latent heat energy released by steam + decrease in thermal energy of condensed steam • Use of $\Delta Q = mc\Delta\theta$ • Use of $\Delta Q = L\Delta m$ • m = 0.15 kg (150 g)	**(1)** **(1)** **(1)** **(1)**	Example of calculation $(mc\Delta\theta)_{milk} = (mc\Delta\theta)_{water} + L\Delta m_{steam}$ m × 3900 J kg^{-1} K^{-1} × (65.0 °C – 4.00 °C) = (0.015 kg × 4200 J kg^{-1} K^{-1} × (100 °C – 65.0 °C)) + (2.3 × 10^{6} J kg^{-1} × 0.015 kg) m = 0.15 kg	4

Question Number	Acceptable answers		Additional guidance	Mark
15	• Use of $\Delta E = mc\Delta\theta$ • Use of $\Delta E = L\Delta m$ • Apply 5% to calculate energy saved • Use of $P = VI$ **or** Use of $Q = It$ • Use of $P = \frac{W}{t}$ **or** Use of $E = QV$ • 2.69×10^5 J compared with 1.93×10^5 J for energy saved, and concludes claim invalid. **Or** a phone could run for 5 days compared to 7 days and conclusion claim invalid **Or** a phone could run for 433 900 s compared to 604 800 s and conclusion claim invalid	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation: For aluminium when being heated up to m.pt.: $\Delta E = 14 \times 10^{-3}\ \text{kg} \times 902\ \text{J kg}^{-1}\text{K}^{-1} \times (660 - 293)\text{K}$ $\Delta E = 4.63 \times 10^3$ J For aluminium when melting: $\Delta E = 14 \times 10^{-3}\ \text{kg} \times 396 \times 10^3\ \text{J kg}^{-1} = 5.54 \times 10^3$ J Energy saved $= \frac{0.95}{0.05} \times (4630 + 5540)$J Energy saved $= 1.93 \times 10^5$ J $P = 3.7\ \text{V} \times 120 \times 10^{-3}\ \text{A} = 0.444$ W $\Delta E = 0.444\ \text{W} \times 7 \times 24 \times (60 \times 60)\text{s} = 2.69 \times 10^5$ J	6

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