

Physics

Thermal

Heat Heat Ca

**Heat Capacity 1** 

# **Heat Capacity 1**

## Essential Pre-Uni Physics G3.1

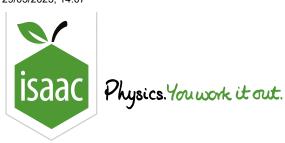


#### Data:

- Specific heat capacity of water:  $4180\,J\,kg^{-1}\,K^{-1}$
- Specific heat capacity of aluminium:  $880\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- Specific heat capacity of iron:  $435\,J\,kg^{-1}\,K^{-1}$
- Specific heat capacity of paraffin oil:  $2130\,\mathrm{J\,kg^{-1}\,K^{-1}}$

Complete the values in the table below. Give your answers to 2 sf.

Energy / J	Material	Mass / kg	Initial temperature / $^{\circ}\mathrm{C}$	Final temperature / °C
	Aluminium	0.290	15	82
45200	Paraffin	2.30	3.0	
81000	Water	1.50	11	



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# Essential Pre-Uni Physics G3.3



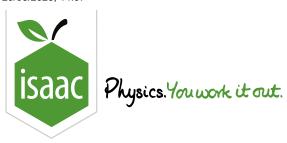
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These specific heat capacities can also be found within the hint tabs.

How much water can a shower head heat each second from  $12\,^{\circ}\mathrm{C}$  to  $41\,^{\circ}\mathrm{C}$  if the heater has a power of  $4200\,\mathrm{W}$ ? Assume that no heat is lost to the surroundings, and give your answer in kilograms.

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**STEM SMART Physics 27 - Heat and mixtures** 



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Essential Pre-Uni Physics G3.4

# Essential Pre-Uni Physics G3.4



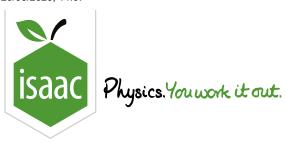
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These specific heat capacities can also be found within the hint tabs.

If  $0.024\,\mathrm{kg}$  of water gets trapped in the shower heater (the heater has a power of  $4200\,\mathrm{W}$ ) of <u>question G3.3</u>, the thermal sensor must stop the current before the water reaches  $80\,^\circ\mathrm{C}$ . Assuming that the water is at  $35\,^\circ\mathrm{C}$  when the fault occurs, how quickly must the thermal sensor act? Give your answer in seconds.

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# Essential Pre-Uni Physics G3.7



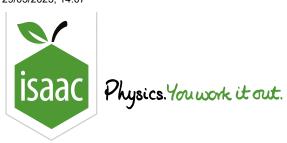
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These specific heat capacities can also be found within the hint tabs.

How much water at  $52\,^\circ\mathrm{C}$  must I add to  $19\,\mathrm{kg}$  of water at  $21\,^\circ\mathrm{C}$  to make it the right temperature,  $37\,^\circ\mathrm{C}$  for me to bath a baby?

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# Essential Pre-Uni Physics G3.8



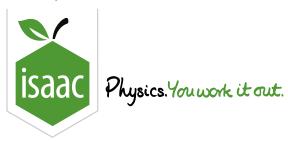
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These specific heat capacities can also be found within the hint tabs.

If I add  $210\,\mathrm{g}$  of rivets at  $303\,^\circ\mathrm{C}$  made of some unknown metal to  $500\,\mathrm{g}$  of water at  $15\,^\circ\mathrm{C}$ , and the final temperature is  $34\,^\circ\mathrm{C}$ , what is the specific heat capacity of the mystery metal? Give your answer to 2 significant figures.

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<u>Gameboard</u>

Physics

Thermal

Heat Capacity

Essential Pre-Uni Physics G4.1

# Essential Pre-Uni Physics G4.1



- ullet Specific heat capacity of water:  $4180\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific heat capacity of ice:  $2030\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific latent heat of fusion of ice:  $3.35 imes 10^5 \, J \, \mathrm{kg}^{-1}$
- ullet Specific latent heat of vaporization of water:  $2.26 imes 10^6 \, J \, kg^{-1}$

In all questions, assume that the heat capacities given above remain constant at all temperatures.

### Part A Frozen pipe

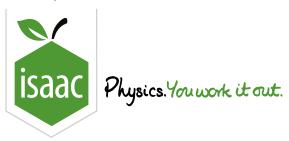
A frozen pipe contains  $5.60\,\mathrm{kg}$  of ice. How much energy is needed to melt it without changing its temperature?

### Part B Warming and melting

If the ice were initially at  $-3.5\,^{\circ}\mathrm{C}$ , how much energy would be taken to warm it to melting point and then melt it?

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Physics

Thermal Heat Capacity

Essential Pre-Uni Physics G4.2

# Essential Pre-Uni Physics G4.2



- ullet Specific heat capacity of water:  $4180\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific heat capacity of ice:  $2030\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific latent heat of fusion of ice:  $3.35 imes 10^5 \, J \, \mathrm{kg}^{-1}$
- ullet Specific latent heat of vaporization of water:  $2.26 imes 10^6 \, J \, kg^{-1}$

In all questions, assume that the heat capacities given above remain constant at all temperatures.

### Part A Initial temperature

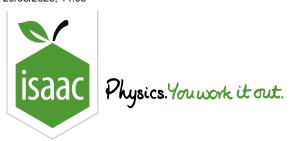
A certain quantity of ice requires  $10.0\,\mathrm{J}$  to warm it to melting temperature. It then requires  $100\,\mathrm{J}$  to melt it. Calculate the initial temperature of the ice in  $^{\circ}\mathrm{C}$ , assuming no heat loss to the surroundings.

#### Part B Final temperature

The water at freezing point in Part A is then heated using a further  $100\,\mathrm{J}$ . What is its final temperature? Give your answer in  $^\circ\mathrm{C}$ 

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**Physics** 

Thermal Heat Capacity

Essential Pre-Uni Physics G4.5

# Essential Pre-Uni Physics G4.5



- ullet Specific heat capacity of water:  $4180\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific heat capacity of ice:  $2030\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- ullet Specific latent heat of fusion of ice:  $3.35 imes 10^5 \, J \, \mathrm{kg}^{-1}$
- ullet Specific latent heat of vaporization of water:  $2.26 imes 10^6 \, \mathrm{J\,kg^{-1}}$

In all questions, assume that the heat capacities given above remain constant at all temperatures.

A mass of  $0.35\,\mathrm{kg}$  of ice at  $-15\,^{\circ}\mathrm{C}$  is lowered into an insulated beaker containing  $0.61\,\mathrm{kg}$  of water at  $59\,^{\circ}\mathrm{C}$ .

### Part A Equilibrium temperature

What is the temperature after equilibrium has been reached? Give your answer in °C

### Part B Minimum mass of water for $0.0\,^{\circ}\mathrm{C}$

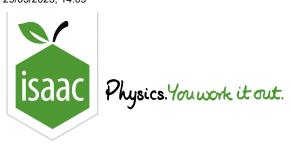
What is the minimum mass of water at  $59\,^{\circ}\mathrm{C}$  needed in the beaker to achieve a final temperature of  $0.0\,^{\circ}\mathrm{C}$ ?

#### Part C Maximum mass of water for $0.0\,^{\circ}\mathrm{C}$

What is the maximum mass of water at  $59\,^{\circ}\mathrm{C}$  that could be present in the beaker to achieve a final temperature of  $0.0\,^{\circ}\mathrm{C}$ ?

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## Sea Level Rise



### Part A Ocean heating

Sea level is currently observed to increase at a total rate of about  $3\,\mathrm{mm/year}$ . Out of this total rate, approximately  $1\,\mathrm{mm/year}$  is due to thermal expansion of the warming sea water. This is known as steric sea level change.

Assume that the ocean heating occurs uniformly over the top  $1000\,\mathrm{m}$  of the ocean at a rate of  $0.01\,^\circ\mathrm{C}\,\mathrm{year}^{-1}$ . Calculate the power required for this ocean heating.

Use the following information:

- ullet Assume that the Earth is a perfect sphere with radius  $6371\,\mathrm{km}$
- ullet The oceans cover  $70\,\%$  of the Earth's surface
- ullet The density of sea water is  $1025\,{
  m kg}\,{
  m m}^{-3}$
- ullet The heat capacity of sea water  $C_p = 4.006 imes 10^3 \, \mathrm{J\,kg^{-1}\,K^{-1}}$

### Part B Melting ice on land

For this question, we assume that the remaining  $2\,\mathrm{mm}\,\mathrm{year}^{-1}$  of sea level change occurs due to the melting of land-based ice.

Estimate the rate of melting of land-based ice (in  $kg \, year^{-1}$ ) needed to achieve the observed rate of sea level increase due to the **non-steric** effect. Assume that the area of the ocean remains constant.

## Part C Power of melting

Estimate the power required to account for the observed rate of melting, assuming that the ice is initially at  $T_{\rm ice}=-20\,^{\circ}{
m C}$ .

The heat capacity of ice is  $C_{\rm ice}=2100\,{
m J\,kg^{-1}\,K^{-1}}$  and the latent heat of fusion ofice is  $L_{\rm fusion}=330\,{
m kJ\,kg^{-1}}.$ 

Created for Isaac Physics by the Royal Meteorological Society.

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