Physics. You work it out.

Home Physics Thermal Heat Heat Capacity 1

Heat Capacity 1

GCSE P P P A Level P P P

Essential Pre-Uni Physics G3.1

Data:

- Specific heat capacity of water: $4180\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- Specific heat capacity of aluminium: $880\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- Specific heat capacity of iron: $435\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- 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 / °C**	**Final temperature / °C**
	Aluminium	0.290	15	82
45200	Paraffin	2.30	3.0	
81000	Water	1.50	11	

Essential Pre-Uni Physics G3.3

GCSE C C C A Level P P P

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

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.

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G3.4

GCSE C C C A Level P P P

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

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 question G3.3, 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.

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G3.7

GCSE A Level

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

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?

Gameboard:
STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G3.8

GCSE A Level

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

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.

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G4.1

GCSE A Level

- Specific heat capacity of water: $4180\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- Specific heat capacity of ice: $2030\,\mathrm{J\,kg^{-1}\,K^{-1}}$
- Specific latent heat of fusion of ice: $3.35\times10^{5}\,\mathrm{J\,kg^{-1}}$
- Specific latent heat of vaporization of water: $2.26\times10^{6}\,\mathrm{J\,kg^{-1}}$

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?

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G4.2

GCSE A Level

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

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 $^\circ\mathrm{C}$

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Essential Pre-Uni Physics G4.5

GCSE A Level

C C C C C C

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

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 $^\circ\mathrm{C}$

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 $0.0\,^\circ\mathrm{C}$?

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Sea Level Rise

A Level

C C C

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:

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

Part B Melting ice on land

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

Estimate the rate of melting of land-based ice (in $\mathrm{kg\,year^{-1}}$) 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 $T_{\text{ice}} = -20\,^{\circ}\mathrm{C}$.

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

Created for Isaac Physics by the Royal Meteorological Society.

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