Essential Pre-Uni Physics G3.1

GCSE P P P 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.

Complete the values in the table below.

Energy / J	**Material**	**Mass / kg**	**Initial Temperature / $^\circ\mathrm{C}$**	**Final Temperature / $^\circ\mathrm{C}$**
(a)	Aluminium	0.290	15	82
45200	Paraffin	2.30	3.0	**(b)**
81000	Water	1.50	11	**(c)**

Part A Aluminium

a) What is the energy required?

Part B Paraffin

b) What is the final temperature in $^\circ\mathrm{C}$?

Part C Water

c) What is the final temperature in $^{\circ}\mathrm{C}$?

Essential Pre-Uni Physics G3.3

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 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

Home Gameboard Physics Thermal Heat Capacity Essential Pre-Uni Physics G3.4

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

Physics. You work it out.

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

Physics. You work it out.

Home Gameboard Physics Thermal Heat Capacity Essential Pre-Uni Physics G3.8

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 C C C A Level P P P

- 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

Physics. You work it out.

Home Gameboard Physics Thermal Heat Capacity Essential Pre-Uni Physics G4.2

Essential Pre-Uni Physics G4.2

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 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

- 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

Physics. You work it out.

Home Gameboard Physics Thermal Heat Capacity Sea Level Rise

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 $0.01\,{}^{\circ}\mathrm{C\,year^{-1}}$. 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.

Gameboard:

STEM SMART Physics 27 - Heat and mixtures

Melting a Snowman

GCSE A Level

Two red LEDs are the eyes of an evil snowman, with a circuit inside its head. This question will allow you to work out how long it takes for the snowman to melt.

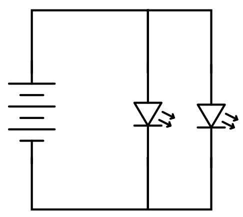

Figure 1: The circuit diagram for the snowman's eyes.

Part A Total power

The voltage across the battery is $6.0\ \mathrm{V}$ and the current drawn from the cell is $0.23\ \mathrm{A}$.

What is the total power produced by both LEDs?

Part B Mass of ice

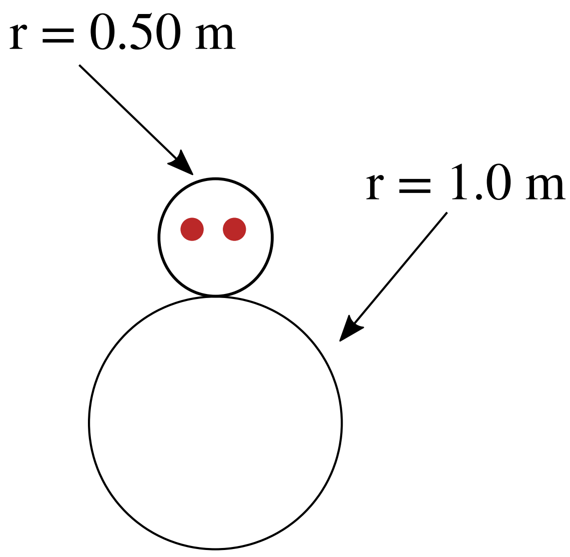

Figure 2: The snowman. The head and body are spherical with radii of $0.50\,\mathrm{m}$ and $1.0\,\mathrm{m}$ respectively.

The ice has a density of $930\,\mathrm{kg\,m^{-3}}$.

Work out the mass of ice in the snowman.

Part C Time taken to melt

The specific latent heat of fusion of ice is $335\,\mathrm{J\,g^{-1}}$. Assume that the snowman is at $0.0\,{}^{\circ}\mathrm{C}$ and the LEDs are $30\,\%$ efficient at converting electrical energy to light energy, with the remainder being converted to heat energy.

Calculate the time that it takes for all the ice in the snowman to melt due to the LEDs. Assume that the light emitted by the LEDs is not absorbed by the ice, and that all of the heat produced by the LEDs goes to melting the ice. Give your answer in years.

Created for isaacphysics.org by Vandan Parmar, Maria-Andreea Filip and Richard Simon