# Physics PAG 5: Energy

### Combined Science PAG P5: Energy

# Suggested Activity 1: Determining the specific heat capacity of a metal

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 9](#_Student_Activity). This Practical activity supports OCR GCSE Physics.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

|  |
| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity learners will be determining the specific heat capacity of a block of metal.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Physics**](http://www.ocr.org.uk/Images/323482-gcse-physics-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

**1a***[1]***:** Use of appropriate apparatus to make and record a range of measurements accurately, including: **iii**[*iii*]) mass; **iv** [*iv*]) time; **vi** [*v*]) temperature

**5** *[17]*) Safe use of appropriate apparatus in a range of contexts to measure: i) energy changes/transfers; ii) associated values such as work done

### Aims

To use appropriate apparatus to take measurements to determine energy transferred

To use appropriate apparatus to determine temperature rise

To calculate specific heat capacity using the measurements taken

### Intended class time

50-60 minutes

### Links to Specifications:

### Gateway Science (Suite A) including Working Scientifically (WS)

P1.2c describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

P1.2d define the term specific heat capacity and distinguish between it and the term specific latent heat

P1.2e apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved

P3.2l explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time

P3.2m apply the equations relating potential difference, current, [quantity of charge], resistance, power, energy, and time and solve problems for circuits which include resistors in series, using the concept of equivalent resistance

WS1.2e evaluate methods and suggest possible improvements and further investigations

WS1.3a presenting observations and other data using appropriate methodsWS1.3f presenting reasoned explanations

WS1.3h identifying potential sources of random and systematic error

WS1.4a use scientific vocabulary, terminology and definitions

WS1.4b recognise the importance of scientific quantities and understand how they are determined

WS1.4c use SI units and IUPAC chemical nomenclature unless inappropriate

WS1.4e interconvert units

WS1.4f use an appropriate number of significant figures in calculations

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

### Twenty First Century Science (Suite B) including Ideas about Science (IaS)

P3.4.1 describe the energy transfers that take place when a system is changed by work done when a current flows through a component

P3.4.2 explain, with reference to examples, how the power transfer in any circuit device is related to the energy transferred from the power supply to the device and its surroundings over a given time:

**power (W) = energy (J) ÷ time (s)**

P3.4.3 recall and use the relationship between the potential difference across the component and the total charge to calculate the energy transferred in an electric circuit when a current flows through a component:

**energy transferred (work done) (J) = charge (C) x potential difference (V)**

P3.4.3 recall and apply the relationships between power transferred in any circuit device, the potential difference across it, the current through it, and its resistance:

**power (W) = potential difference (V) x current (A)**

**power (W) = (current (A))2 x resistance (Ω)**

P6.1.3 describe the energy transfers involved when a system is changed by heating (in terms of temperature change and specific heat capacity)

P6.1.4 define the term specific heat capacity and distinguish between it and the term specific latent heat

P6.1.5 a) select and apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature:

**change in internal energy (J) = mass (kg) x specific heat capacity (J / kg / °C) x change in temperature (°C)**

P6.1.5 b) explain how to safely use apparatus to determine the specific heat capacity of materials

P6.1.8 make calculations of the energy transfers associated with changes in a system when the temperature changes, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes (M1a, M1c, M2a, M3b, M3c, M3d)

IaS1.3 Recognise the importance of scientific quantities and understand how they are determined

IaS1.4 Identify factors that need to be controlled, and the ways in which they could be controlled

IaS1.8 Use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms

IaS2.1 Present observations and other data using appropriate formats

IaS2.2 When processing data use SI units where appropriate (e.g. kg, g, mg, km, m, mm, kJ, J)

IaS2.5 When processing data interconvert units

IaS2.6 When processing data use an appropriate number of significant figures

IaS2.10 Evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations

### Mathematical Skills covered

M1a Recognise and use expressions in decimal form

M3b Change the subject of an equation

M3c Substitute numerical values into algebraic equations using appropriate units for physical quantities

M3d Solve simple algebraic equations

### Health and Safety

The heater and metal block will get hot, learners should be warned not to touch hot objects and a heatproof mat should be used to protect working surfaces.

Electric circuits should be checked to ensure that they are connected correctly.

### Method

Learners will construct a circuit to power the electric heater with meters to determine the energy transferred to the metal block over a fixed period of time.

In its most simple form this will be using the voltmeter and ammeter to determine power using P=IV, then converting this into energy by multiplying by time (in seconds).

The learners can then use the idea of ratio to determine energy per kilogram per degree centigrade.

Should the centre have joule meters then these can be used to provide the measurement for the amount of energy.

Should the centre have data logging equipment this can be used to record voltage and current to determine power and temperature as the block increases in temperature.

### Extension

In carrying out the activity learners can be challenged to identify factors contributing to inaccuracy or uncertainty.

The key aspect will be transfer of energy from the block to the surroundings. Providing insulation materials allows a comparative set of data to be obtained which should give a more accurate result.

### Notes

Learners should be encouraged to give a step by step explanation as to how their data was translated into a value for specific heat capacity in the appropriate S.I. units.

Teachers should trial this activity to be able to modify the learner sheet in the light of the equipment (e.g. metal used, voltage supply, etc) and lesson time available at the centre.

These should cover the appropriate voltage setting for the heater supply and a definition of either the time for which the block should be heated or the temperature rise that learners should work to.

Aspects of the activity which introduce uncertainty or cause inaccuracy are:

* Thermal capacity of the beaker
* Thermal capacity of the heater
* Conduction from the base to the surface
* Transfer from the sides of the beaker to the surroundings
* Convection and evaporation from the surface

### Technician Notes

### For this practical the teacher will require:

* Metal blocks (with provision to accommodate electric heater and thermometer)
* Low voltage electric heaters
* Low voltage power supplies
* Voltmeters
* Ammeters
* Stopclocks
* Thermometers
* Connecting leads
* Heatproof mats
* Insulating materials (for extension)

### Alternative equipment

* Joulemeters (in place of voltmeters and ammeters)
* Data loggers with voltage, current and temperature sensors (in place of voltmeter, ammeter, stopclock and thermometer)

### Answers for quiz questions

**1 [4 marks]**

Any two reasons and any two improvements from

Reasons

Heat escapes to the surroundings ✓

Part of the immersion heater is outside the block ✓

Poor thermal conduct between the immersion heater and block ✓

It takes time for the thermometer to reach its maximum temperature (once the heater is turned off) ✓

Improvements

Lag/insulate the metal block ✓

Make sure all the heater is in the block ✓

Use petroleum jelly to transfer heat between the immersion heater and the block ✓

Wait until the max temperature is reached ✓

**2a [1 mark]**

Lead ✓

**2b [4 marks]**

change in internal energy (J) = mass (kg) x specific heat capacity (J / kg°C) x change in temperature (°C) ✓

Temperature change = 40°C - 23°C = 17°C ✓

Energy = 10(kg) x 385(J/kg°C) x 17(°C) ✓

= 65460 J ✓

**2c [4 marks]**

converts 7000 g to 7 kg ✓

change in temperature = energy ÷ (mass x shc)✓

Change in temperature = 58548 ÷ (7 x 4182) ✓

= 2 °C ✓

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling of activities

v1.2 February 2017 Correction to Combined Science labelling

v1.3 June 2021 Updated to meet accessibility standards



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# Physics PAG 5: Energy

### Combined Science PAG P5: Energy

# Suggested Activity 1: Determining the specific heat capacity of a metal

# Learner Activity

### Introduction

In this activity you will be determining the specific heat capacity of a block of metal.

### Aims

To use appropriate apparatus to take measurements to determine energy transferred

To use appropriate apparatus to determine temperature rise

To calculate specific heat capacity using the measurements taken

### Intended class time

50-60 minutes

### Equipment (per group)

* Metal block (with provision to accommodate electric heater and thermometer)
* Low voltage electric heater
* Low voltage power supply
* Voltmeter
* Ammeter
* Stopclock
* Thermometer
* Connecting leads
* Heatproof mat
* Insulating materials (for extension)

### Alternative equipment

***CENTRE SHOULD AMEND WORKSHEET BASED ON EQUIPMENT PROVIDED***

* Joulemeter ( in place of voltmeter and ammeter)
* Data logger with voltage, current and temperature sensors (in place of voltmeter, ammeter, stopclock and thermometer)

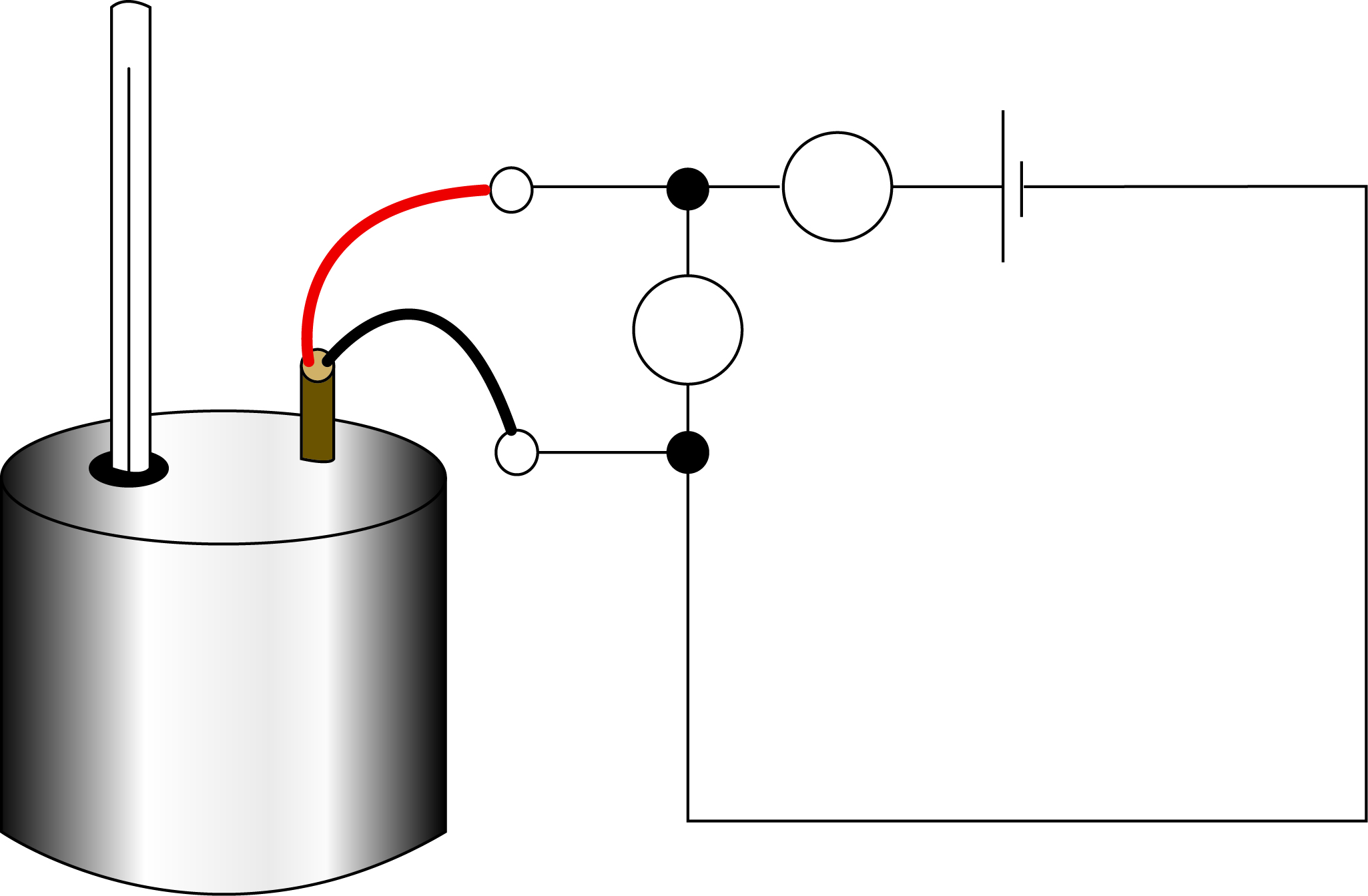
### Health and Safety

The heater and metal block will get hot, do not to touch hot objects and use a heatproof mat to protect working surfaces.

Electric circuits should be checked by the teacher before turning on to ensure that they are connected correctly.

### Method

1. Connect the circuit as shown in the diagram below and ask your teacher to check it. Make sure that the metal block and heater are placed on the heatproof mat.



Thermometer

Heater

Metal block

A

V

1. Record the mass of the metal block.
2. Record the temperature of the metal block before turning on the power supply.
3. Turn on the power supply with the voltage set at the value instructed by your teacher.
4. Leave the block to heat for 20 minutes or other time given by your teacher. Check that the voltage remains constant during this time.
5. Record the current at the start of the heating
6. Calculate the power of the heater from the voltage and current.
7. Calculate the energy transferred from the power and time.
8. Record the temperature at the end of the heating time.
9. Calculate the energy transferred for each degree centigrade
10. Calculate the energy which would be required to raise the temperature of 1kg of the metal by one degree centigrade.

### Results

| **Measurement** | **Value** | **Unit** |
| --- | --- | --- |
| Mass of block *(m)* |  |  |
| Initial temperature of block *(T1)* |  |  |
| Final temperature of block *(T2)* |  |  |
| Voltage *(V)* |  |  |
| Current *(I)* |  |  |
| Time taken *(t)* |  |  |

### Evaluation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **1.** | Work out the power of the heater | | |  |
|  |  | ***P = I x V*** | |  |
|  |  |  | |  |
|  |  | Power = | W |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **2.** | Work out the energy transferred by the heater | | |  |
|  |  | ***E = P x t*** | |  |
|  |  |  | |  |
|  |  | Energy = | J |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **3.** | Record the temperature at the end of the heating time and use this to work out temperature change. | | |  |
|  |  | ***T = T2 – T1*** | |  |
|  |  |  | |  |
|  |  | Temperature change = | oC |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **4.** | Work out the energy transferred for each degree centigrade that the temperature increased. | | |  |
|  |  | ***Eo = Eh ÷ T*** | |  |
|  |  |  | |  |
|  |  | Energy transferred for  each degree centigrade = | J |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **5.** | Work out the energy which would be required to raise the temperature of 1kg of the metal by one degree centigrade. | | |  |
|  |  | Mass of block = | kg |  |

|  |  |  |
| --- | --- | --- |
|  | To increase the temperature of 1 kg will require **more / less** energy than for my block.  Should I **multiply / divide** my answer in 4) by the mass of the block in kg to get the value for 1kg? (try it out) |  |
|  |  |  |

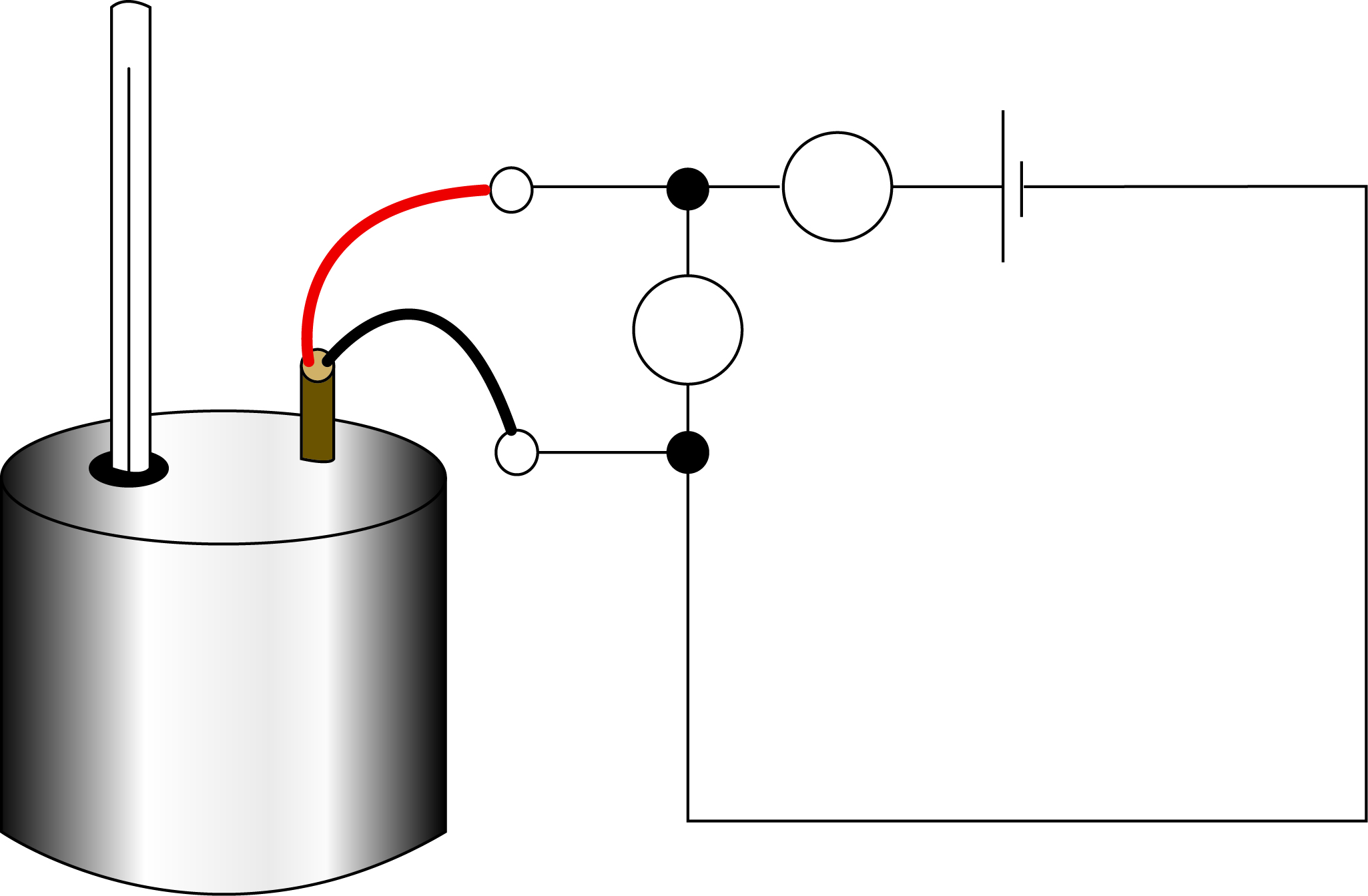
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | The specific heat capacity is the amount of energy required to raise the temperature of 1 kg of a material by one degree centigrade. | | |  |
|  |  | Specific heat capacity = | J/kg/ oC |  |

### Extension

|  |  |
| --- | --- |
| Think through the process of carrying out this activity and list things about this activity which would cause your result to be inaccurate.  For each of these, write down what you could do to make your result more accurate.  If there is time and there is material available for you to carry out any of these improvements and repeat the activity. |  |
|  |  |

### Quiz - test your knowledge and understanding

1. A student completes an experiment to find the specific heat capacity of a metal.



Thermometer

Heater

Metal block

A

V

|  |  |
| --- | --- |
| The value obtained from the experiment is much higher than expected.  Give two reasons how this could have occurred and write down two improvements to the experimental procedure. **[4 marks]** |  |
|  |  |

**2.** Use the table below to answer the following questions

|  |  |
| --- | --- |
| **Substance** | **Specific heat capacity (J/kg°C)** |
| Copper | 385 |
| Aluminium | 897 |
| Lead | 129 |
| Water | 4182 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **(a)** | Which substance requires the least amount of energy to raise its temperature? **[1 mark]** | | |  |
|  |  | | |  |
|  |  |  |  |  |
| **(b)** | A 10 kg block of copper is at 23°C. Work out the energy required to raise its temperature to 40°C. **[4 marks]** | | |  |
|  |  | | |  |
|  |  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **(c)** | What is the rise in temperature of 7000 g of water if it is given 58548 J of heat energy? **[4 marks]** | | |  |
|  |  | | |  |
|  |  |  |  |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

| **Physics** | | | |  | ***Combined Science*** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1a-iii | 1a-iv | 1a-vi | 5-i |  | *1-iii* | *1-iv* | *1-v* | *17-i* |
| 5-ii |  |  |  |  | *17-ii* |  |  |  |