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| 17: Thermal Physics 1Specific Heat Capacity and Latent Heat  |
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| Paper 2 |  |
| 17: Thermal Physics 1Specific Heat Capacity and Latent Heat | 1. Internal energy is the sum of the randomly distributed kinetic energies and potential energies of the particles in a body.
2. The internal energy of a system is increased when energy is transferred to it by heating or when work is done on it (and vice versa), eg a qualitative treatment of the first law of thermodynamics.
3. Appreciation that during a change of state the potential energies of the particle ensemble are changing but not the kinetic energies. Calculations involving transfer of energy.
4. For a change of temperature: $Q=mc∆θ $where *c* is specific heat capacity.
5. Calculations including continuous flow.
6. For a change of state $Q=ml$ where *l* is the specific latent heat.
7. Brownian motion as evidence for existence of atoms.

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| 18: Thermal Physics 2Gas Laws and the MKTM |
| 19: Gravitational FieldsField Strength and Potential |
| 20: Electric FieldsFields Strength and Potential |
| 21: Fields ComparisonsOrbits and Comparisons |
| 22: CapacitorsEnergy Stored and Exponential Decay |
| 23: Magnetic Fields 1Magnetic Forces and Flux |
| 24: Magnetic Fields 2Induction and Transformers |
| 25: Radioactivity 1Nuclear Radius and Types of Radiation |
| 26: Radioactivity 2Modes and Rate of Decay |
| 27: Nuclear Physics Binding Energy, Fission and Fusion |
| Paper 3 |
| 28: Electron DiscoverySpecific Charge and Millikan |
| 29: Wave-Particle DualityWaves, Quantum and Microscopes |
| 30: Special RelativityMichelson-Morley & Relativistic Speed |

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| **Monday: Heat, Temperature and Internal Energy Notes**SolidsStructure ....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Movement ....…………….…………….……………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Bonding .....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..LiquidsStructure ....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Movement ....…………….…………….……………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Bonding .....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..GasesStructure ....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Movement ....…………….…………….……………………………..……………………….………………..………………………………….……….……………………………….………………………………………..Bonding .....…………….…………….………………………………..……………………….………………..………………………………….……….……………………………….………………………………………..**Brownian Motion**Describe the set up …...…………………………….…………….………………….…………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..Describe what was seen …...…………………………….…………….………………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..Explain why this happened …...…………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..Explain why this is important ....…………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..**Temperature**Temperature is the hotness of a body expressed on a numerical scale.If is a measure of the ………………………………………………………... of the particles/molecules that make up the body. A higher temperaturemeans …………………………………………………………………………. Complete this graph showing the Maxwell-Boltzmnn distribution for an object at higher temperature and one at lower temperature.**Heat**Heat is the flow of energy, it always flows from …………...………………………………………………..…………………………………….………………………………………………………………….…………….……………………………………………………….………………..**Thermal Equilibrium** (The Zeroth Law of Thermodynamics)………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..**Internal Energy** (The First Law of Thermodynamics)The internal energy of an object is the sum total of the ………………………………….. and ……………...………..………….. energies of all the individual molecules that the object is made from.The value of the internal energy can be changed based on two other quantities:$$∆U=∆Q+∆W$$Symbol $∆U$ Quantity ………………………………………………………………………………………………………………………………Symbol $∆Q$ Quantity ………………………………………………………………………………………………………………………………Symbol $∆W$ Quantity ………………………………………………………………………………………………………………………………How is work done on an object?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..**Heating**Sketch the graph of how temperature changes with time as a substance (like ice) is heated.

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|  | Stage | Tick the energies that change in each stage. |
| Internal Energy | Kinetic Energy | Potential Energy |
| S |  |  |  |
| S → L |  |  |  |
| L |  |  |  |
| L → G |  |  |  |
| G |  |  |  |

**Cooling**Sketch the graph of how temperature changes with time as a substance (like steam) is cooled.

|  |  |  |
| --- | --- | --- |
|  | Stage | Tick the energies that change in each stage. |
| Internal Energy | Kinetic Energy | Potential Energy |
| G |  |  |  |
| G → L |  |  |  |
| L |  |  |  |
| L → S |  |  |  |
| S |  |  |  |

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**Tuesday: Specifics Exam Questions 1**

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| **Q1.**       Molten lead at its melting temperature of 327°C is poured into an iron mould where it solidifies. The temperature of the iron mould rises from 27°C to 84°C, at which the mould is in thermal equilibrium with the now solid lead.mass of lead = 1.20 kg mass of iron mould = 3.00 kgspecific latent heat of fusion of lead = 2.5 × 104 J kg–1 specific heat capacity of iron = 440 J kg–1 K–1**Q1(a)**     Calculate the heat energy absorbed by the iron mould.    answer = ..................................... J **(2)****Q1(b)**      Calculate the heat energy given out by the lead while it is changing state.   answer = ...................................... J **(1)****Q1(c)**      Calculate the specific heat capacity of lead.    answer = ...................................... J kg–1 K–1 **(3)****Q1(d)**      State **one** reason why the answer to part (c) is only an approximation......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(1)** **(Total 7 marks)****Q2(a)**   Define the specific latent heat of vaporisation of water......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(2)****Q2(b)**   An insulated copper can of mass 20 g contains 50 g of water both at a temperature of 84 °C. A block of copper of mass 47 g at a temperature of 990 °C is lowered into the water as shown in the figure below. As a result, the temperature of the can and its contents reaches 100 °C and some of the water turns to steam.    specific heat capacity of water = 4200 J kg−1 K−1 specific heat capacity of copper = 390 J kg−1 K−1    specific latent heat of vaporisation of water = 2.3 × 106 J kg−1            Before placement                                        After placement**Q2(bi)**   Calculate how much thermal energy is transferred from the copper block as it cools to 100 °C.Give your answer to an appropriate number of significant figures.   thermal energy transferred ........................................... J **(2)****Q2(bii)**   Calculate how much of this thermal energy is available to make steam.Assume no heat is lost to the surroundings.   available thermal energy ........................................... J **(2)****Q2(biii)**   Calculate the maximum mass of steam that may be produced.   mass ......................................... kg **(1)****(Total 7 marks)** |

**Wednesday: Specific Heat Capacity Extended Writing**

You are provided with a small bottle of cooking oil and standard laboratory equipment (although a joule meter is unavailable). Describe how you could obtain an accurate and reliable measurement of the specific heat capacity of the oil. Your description should include:

* Details of the experimental set up including a labelled diagram
* Details of measurements you would take and how you would use your measurements to find the specific heat capacity
* Possible sources of uncertainty in your measurements and how these could be reduced.

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**Wednesday: Specifics Definitions**

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| Required  | Specific latent heat of fusion is the energy ….. to change 1kg of a solid to a liquid with no change of temperature. |
| Heat | The flow of energy from high temperature to lower temperature. |
| Kinetic | The type of energy associated with the movement of the particles in a material. |
| J kg-1  | The units of specific latent heat. |
| Thermal Equilibrium | When heat doesn’t flow between two objects they are said to be in .. |
| Potential | The type of energy associated with the bonds between the particles of a material/ |
| Brownian | This motion, named after the person observing it, describes the motion of smoke particles under a microscope. |
| Released | Specific latent heat of fusion is the energy ….. in changing 1kg of a liquid to a liquid with no change of temperature. |
| Higher | If given the same amount of energy the lower the specific heat capacity the ….. the temperature increase. |
| Kinetic | This type of energy increases when the temperature of an object increases. |
| Specific Heat Capacity | The energy required to raise the temperature of 1 kg of a substance by 1 degree Celsius. |
| Mean | Increasing the temperature of a solid will increase the …… kinetic energy of the particles. |
| Internal | The energy due to the bonding and the movement of the molecules. |
| Required | Specific latent heat of vaporisation is the energy ….. to change 1kg of a liquid to a gas with no change of temperature. |
| Specific Latent Heat | The energy required to change the state of 1 kg of a substance with no change of temperature. |
| Lower | If given the same amount of energy the higher the specific heat capacity the ….. the temperature increase. |
| Potential | This type of energy changes when an object changes state. |
| Liquid | A virtually incompressible state of matter where the particles can slide past each other. |
| Specific Heat Capacity | The energy released when the temperature of 1 kg of a substance falls by 1 kelvin. |
| Gas | A state of matter with virtually no potential energy. |
| Temperature | A measure of the kinetic energy of the particles in a material. |
| Released | Specific latent heat of vaporisation is the energy ….. in changing 1kg of a liquid to a gas with no change of temperature. |
| J kg-1 K-1 | The units of specific heat capacity. |
| Solid | A state of matter with the lowest kinetic energy of the particles. |

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| --- | --- | --- | --- |
| Brownian | Gas | Heat | Higher |
| Internal | J kg-1  | J kg-1 K-1 | Kinetic |
| Kinetic | Liquid | Lower | Mean |
| Potential | Potential | Released | Released |
| Required | Required  | Solid | Specific Heat Capacity |
| Specific Heat Capacity | Specific Latent Heat | Temperature | Thermal Equilibrium |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **Thursday: The Specifics Notes**The energy required to change **temperature** is given by the equation:$$Q=mc∆θ$$Symbol $Q$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $m$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $c$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $∆θ$ Quantity …………………………………………………………………………………………… Units ………………………The **specific heat capacity** is:1 The energy required ……………..………………………………………………………………….…………..………………………………..2 The energy released ……………..………………………………………………………………….…………..………………………………..Complete this table by calculating the missing values.

|  |  |  |  |
| --- | --- | --- | --- |
| *Q* | *m* | *c* | *∆θ* |
|  | 4.9 | 4200 | 10.2 |
| 7200 |  | 900 | 53.2 |
| 1600 | 0.3 |  | 35 |
| 450 000 | 5.8 | 130 |  |

Assumption: ……………………………………………………………………………...……………………………….…………..………………The energy required to change **state** is given by the equation:$$Q=ml$$Symbol $Q$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $m$ Quantity …………………………………………………………………………………………… Units ………………………Symbol $l$ Quantity …………………………………………………………………………………………… Units ………………………The specific latent heat of **fusion** is:1 The energy released when 1 kg of ……..…………………………………………………………………….………………………………….2 The energy required when 1 kg of ………………………………………………………………….…………..……………………………….. without ………………..…………………………………….……………………….………………………………..The specific latent heat of **vaporisation** is:1 The energy released when 1 kg of ……..…………………………………………………………………….………………………………….2 The energy required when 1 kg of ………………………………………………………………….…………..……………………………….. without …..………………………………………………….……………………….………………………………..Complete these tables by calculating the missing values.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Q* | *m* | *l* |  | *Q* | *m* | *l* |
|  | 0.82 | 3.3 × 105 |  |  | 0.018 | 2.3 × 106 |
| 195 800 |  | 1100 |  | 115 000 |  | 22.6 × 103 |
| 634 000 | 2.3 |  |  | 756 | 0.03 |  |

Why is the specific latent heat of vaporisation a much bigger value than the specific latent heat of fusion for the same material?………………………………………………………………….…………….……………………………………………………….………………..………………………………………………………………….…………….……………………………………………………….………………..……………………………………………………………………….……….……………………………….………………………………………..Label on these diagrams where $Q=ml$ is used and where $Q=mc∆θ$ is used.

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**Example Problems**A regular iron can of mass 25 g contains 50 g of water both at temperature 81 °C. A block of copper of mass 57 g at a temperature of 990 °C is lowered into the water. As a result, the temperature of the can and its contents reaches 100 °C and some water turns to steam. Specific heat capacity of iron = 440 J kg–1 °C –1 Specific heat capacity of water = 4200 J kg–1 °C –1 Specific heat capacity of copper = 390 J kg–1 °C –1 Specific latent heat of vaporisation of water = 2.3 × 106 J kg−1Calculate the mass of steam that may be produced.

|  |  |  |
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|  | Calculate the energy lost by the cooling copper block (1) | Calculate the energy gained by the iron can (2) |
| Calculate the energy gained by the water (3)  | Calculate the energy left to change state and then the mass (4) |

Molten lead at its melting temperature of 327°C is poured into an iron mould where it solidifies. The temperature of the iron mould rises from 25°C to 82°C, at which the mould is in thermal equilibrium with the now solid lead.Mass of lead = 1.30 kg Specific latent heat of fusion of lead = 2.5 × 104 J kg–1Mass of iron mould = 3.30 kg Specific heat capacity of iron = 440 J kg–1 °C–1Calculate the specific heat capacity of lead.

|  |  |  |
| --- | --- | --- |
| Calculate the heat energy gained by the iron mould. | Calculate the heat energy given out by the lead as it changed state. | Calculate the energy that the lead gave out at it cooled and then shc. |

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**Friday: Specific Exam Questions 2**

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| **Q11(a)**   Lead has a specific heat capacity of 130 J kg−1 K−1. Explain what is meant by this statement......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(1)****Q11(b)**   Lead of mass 0.75 kg is heated from 21 °C to its melting point and continues to be heated until it has all melted.Calculate how much energy is supplied to the lead.Give your answer to an appropriate number of significant figures.melting point of lead = 327.5 °C specific latent heat of fusion of lead = 23 000 J kg−1        energy supplied ................................................... J **(3)****(Total 4 marks)****Q7.**   A cola drink of mass 0.200 kg at a temperature of 3.0 °C is poured into a glass beaker. The beaker has a mass of 0.250 kg and is initially at a temperature of 30.0 °C.specific heat capacity of glass = 840 J kg−1 K−1 specific heat capacity of cola = 4190 J kg−1 K−1**Q7(i)**    Show that the final temperature, *T*f, of the cola drink is about 8 °C when it reaches thermal equilibrium with the beaker. Assume no heat is gained from or lost to the surroundings.     **(2)****Q7(ii)**    The cola drink and beaker are cooled from *T*f to a temperature of 3.0 °C by adding ice at a temperature of 0 °C.Calculate the mass of ice added.Assume no heat is gained from or lost to the surroundings.specific heat capacity of water = 4190 J kg−1 K−1 specific latent heat of fusion of ice = 3.34 × 105 J kg−1     mass .......................................... kg **(3)****(Total 5 marks)****Q3.**      An electrical heater is placed in an insulated container holding 100 g of ice at a temperature of –14 °C. The heater supplies energy at a rate of 98 joules per second.**Q3(a)**     After an interval of 30 s, all the ice has reached a temperature of 0 °C. Calculate the specific heat capacity of ice.    answer = ............................J kg–1 K–1 **(2)****Q3(b)**     Show that the final temperature of the water formed when the heater is left on for a further 500 s is about 40 °C.specific heat capacity of water = 4200 J kg–1 K–1 specific latent heat of fusion of water = 3.3 × 105 J kg–1**(3)****Q3(c)**     The whole procedure is repeated in an uninsulated container in a room at a temperature of 25 °C. State and explain whether the final temperature of the water formed would be higher or lower than that calculated in part (b)......................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................................... **(2)** **(Total 7 marks)****Q5.**      An electrical immersion heater supplies 8.5 kJ of energy every second. Water flows through the heater at a rate of 0.12 kg s–1 as shown in the figure below.**Q5(a)**     Assuming all the energy is transferred to the water, calculate the rise in temperature of the water as it flows through the heater. specific heat capacity of water = 4200 J kg–1 K–1                                                        answer = ....................................... K **(2)****Q50(b)**      The water suddenly stops flowing at the instant when its average temperature is 26 °C.The mass of water trapped in the heater is 0.41 kg.Calculate the time taken for the water to reach 100 °C if the immersion heater continues supplying energy at the same rate.                                                        answer = ....................................... s **(2)****(Total 4 marks)** |

**Saturday: Scalars, Vectors and Moments Checklist**

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