A Level Physics Knowledge Organiser

Thermal physics **14**

1. Lesson 1 Temperature

Thermal equilibrium	A state in which there is no net flow of thermal energy between the objects involved, that is, objects in thermal equilibrium must be at the same temperature.
Triple point	For a given substance, one specific temperature and pressure at which all three phases of that substance can exist in thermodynamic equilibrium.
Temperature	Temperature is related to the average kinetic energy of atoms and molecules in a system. Temperature is a measure of the hotness of an object on a chosen scale. The hotter an object is, the higher its temperature. Temperature is the quantity measured by a thermometer. SI unit of temperature is kelvin (K).
0^{th} law of thermodynamics	If two objects are each in thermal equilibrium with a third, then all three are in thermal equilibrium with each other. This means all three objects are at the same temperature.
Celsius scale	A temperature scale with 100 degrees between the freezing point and the boiling point of pure water (at atmospheric pressure 1.01×10^3 Pa), 0°C and 100°C.
Anders Celsius	(1701-1744), Swedish astronomer who invented the Celsius temperature scale (often called the centigrade scale).
Absolute scale of temperature	A scale for measuring temperature based on absolute zero and triple point of pure water, with gradations equal in size to those of the Celsius scale; unit kelvin (K)
Absolute zero	The lowest possible temperature, the temperature at which substances have minimum internal energy.
Kelvin (K)	The SI base unit of the absolute (thermodynamic) scale of temperature.
Lord Kelvin	(1824-1907), in full William Thomson, Baron Kelvin of Largs. Scottish engineer, mathematician, and physicist.
Kelvin to Celsius conversion	t (°C) = T (K) - 273
Celsius to Kelvin conversion	T (K) = t (°C) + 273

2. Lesson 2 Solids, liquids and gases

Kinetic model	A model that describes all substances as made of atoms, ions, or molecules, arranged differently depending on the phase of the substance.
Solids	The atoms or molecules are **regularly arranged** and **packed closely together**, with strong electrostatic forces of attraction between them holding them in fixed positions, but they can **vibrate** and so have kinetic energy.
Liquids	The atoms or molecules are still very **close together**, but they have more kinetic energy than the solids, and, unlike in solids, they can change position and **flow past each other**.
Gases	The atoms or molecules have more kinetic energy again than those in liquids, and they are **much further apart**. They are **free to move** past each other and there are negligible electrostatic forces between them, unless they collide with each other or the container walls. They **move randomly** with different speeds in different directions.
Plasma	An electrically conducting medium in which there are roughly equal numbers of positively and negatively charged particles, produced when the atoms in a gas become ionized. It is sometimes referred to as the fourth state of matter, distinct from the solid, liquid, and gaseous states.
Brownian motion	Describes the random movement of microscopic particles suspended in a liquid or gas.
Density	The mass per unit volume of a substance.
Albert Einstein	(1879-1955), was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics.
Robert Brown	(1773-1858), Scottish botanist and paleo botanist who made important contributions to botany largely through his pioneering use of the microscope.
Brownian motion - Einstein	1905 – Fully explained in terms of collisions between the pollen grains and millions of tiny water molecules. He explained that these collisions were elastic and resulted in a transfer of momentum from the water molecules to the pollen grains, causing the grains to move in haphazard ways. This provided the **first significant proof of the kinetic model** – the idea that matter is made up of atoms and molecules and they have kinetic energy.
Ice less dense than water	Water freezes into a regular crystalline pattern held together by strong electrostatic forces between the molecules. In this structure the molecules are held slightly further apart than in their random arrangement in liquid water, so ice is slightly less dense.

3. Lesson 3 Internal energy

Internal energy	The sum of the randomly distributed kinetic and potential energies of atoms or molecules within the substance.
Increasing the internal energy of a body	- increase the temperature of the substance - change the phase of the substance from solid to liquid, or from liquid to gas
Electrostatic potential energies of atoms or molecules of a substance	
Gas	The electrostatic potential energy is zero because there are negligible electrical forces between atoms or molecules.

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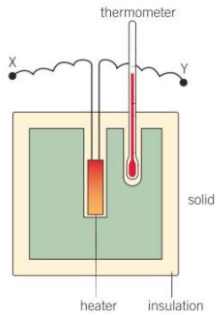
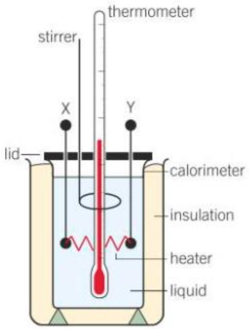
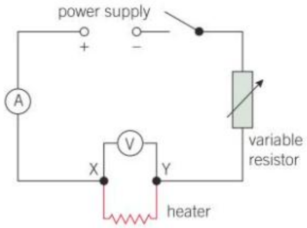
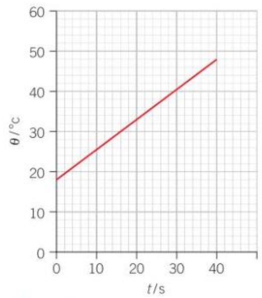
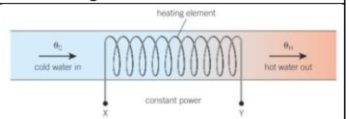
Liquid	The electrostatic forces between atoms or molecules give the electrostatic potential energy a negative value. The negative simply means that energy must be supplied to break the atomic or molecular bonds.
Solid	The electrostatic forces between atoms or molecules are very large, so the electrostatic potential energy has a large negative value.

4. Lesson 4 Specific heat capacity

Specific heat capacity	The energy required per unit mass to change the temperature by 1 K (or 1°C); unit $Jkg^{-1}K^{-1}$. $$c = \frac{E}{m\ \Delta\theta}$$ c – specific heat capacity ($Jkg^{-1}K^{-1}$) E – energy (J) m – mass of the substance (kg) Δθ – change in temperature (K)
Energy	$$E = m\ c\ \Delta\theta$$
Determining specific heat capacity of a solid	 It is important to minimise the energy transferred from the substance to the surroundings by carefully insulating the substance

Determining specific heat capacity of a liquid	 The liquid must be carefully stirred to ensure it has uniform temperature throughout.
Electrical circuit for the heater	
Energy equation	$$E = I\ V\ t$$ I – current (A) V – potential difference (V) t – time (s)
Specific heat capacity	$$c = \frac{I\ V\ t}{m\ \Delta\theta}$$

Temperature – time graph	 Plotting a graph allows for a more accurate determination of the specific heat capacity. Gradient Δθ/Δt P = m c Δθ/Δt P – power (W) $$c = \frac{P}{m\ x\ gradient}$$
Method of mixtures	Known masses of two substances at different temperatures are mixed together.
Constant – volume flow heating	 Is a technique used to heat a fluid passing over a heated filament. It is used to heat water in some showers and dishwashers and to transfer energy away from heat sources like car engines or nuclear reactors.

5. Lesson 5 Title Specific latent heat

Specific latent heat	The energy required to change the phase per unit mass while at constant temperature – symbol L. $$L = \frac{E}{m}$$ L- specific latent heat (Jkg^{-1}) E – energy supplied (j) m – mass of the substance (kg)
Specific latent heat of fusion	The energy required to change unit mass of a substance from solid to liquid while at constant temperature – symbol L_f. $$E = m\ L_f$$
Specific latent heat of vaporisation	The energy required to change unit mass of a substance from liquid to gas while at constant temperature – symbol L_v. $$E = m\ L_v$$
Melting	The energy transferred to the substance increases the internal energy of the substance without increasing its temperature.

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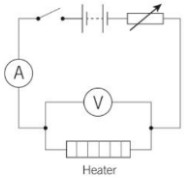
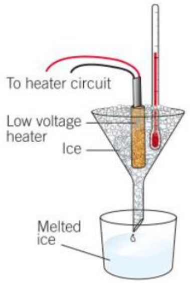
<table>
<tr><td>Determining specific latent heat of fusion</td><td>


- heating circuit

To measure:

- temperature of the ice at its melting point
- potential difference across the heater
- current in the heater
- time during which the heater is switched on
- mass of the substance (ice)



</td></tr>
<tr><td>Energy transferred equation</td><td>

$E = I\,V\,t$

E – energy (J)
V – potential difference (V)
I – current (A)
t – time (S)</td></tr>
<tr><td>Specific latent heat of fusion equation</td><td>

$L_f = I\,V\,t/m$

m – mass of the substance that changes phase from solid to liquid</td></tr>
<tr><td>Difference between L_f and L_v</td><td>L_v is greater than L_f for most substances.</td></tr>
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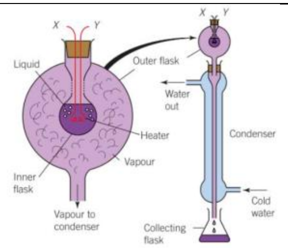
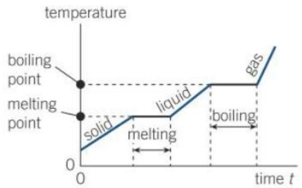
<table>
<tr><td>Determining specific latent heat of vaporisation</td><td>


An electrical heater can be used with a condenser to collect and then measure the mass of liquid that changes phase.</td></tr>
<tr><td>Specific latent heat of vaporisation</td><td>

$L_v = I\,V\,t/m$

m – mass of the substance that changes phase from liquid to gas</td></tr>
<tr><td>Combining specific latent heat and specific heat capacity</td><td>


The energy transferred to the substance in each section can be calculated using either the specific heat capacity or specific latent heat equation.
1. heating the solid to its melting point, $E = m\,c_{solid}\,\Delta\theta$
2. melting the solid at constant temperature, $E = m\,L_f$
3. heating the liquid to its boiling point, $E = m\,c_{liquid}\,\Delta\theta$
4. boiling the liquid at constant temperature, $E = m\,L_v$

The total energy can be determined by adding up the energy transferred in each section.</td></tr>
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