MEGA LECTURE

AQA, Edexcel, OCR

A Level

A Level Physics

Thermal Physics (Answers)

Name:

MME

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Total Marks: /30

1. Total for Question 1: 6

(a) Define thermal equilibrium. [2]

Solution: No net energy transfer between two bodies.
Same temperature.

(b) Why would a standard liquid-in-glass thermometer inserted into a mug of tea give an inaccurate insight into the initial temperature of the tea, even when thermal equilibrium has been reached? Is the reading randomly inaccurate, or is it systematically an over- or under-estimate? [2]

Solution: To reach thermal equilibrium there must be transfer of heat from the tea to the thermometer. This causes a change in the tea's temperature; the reading is systematically an underestimate.

(c) What transfer of heat, if any, happens when an 85°C metal rod is inserted into a 363 K vat of water? [2]

Solution: Thermal energy flows from the water (cooling down) to the metal (heating up).

2. The nature of solids, liquids and gases, and how they change with temperature, is best described by the kinetic theory, which states that all substances are a collection of atoms and molecules, each with a particular kinetic energy.

Total for Question 2: 12

(a) Compare and contrast the spacing, ordering and motion of atoms in solids and liquids. [2]

Solution: Solids: regular 3d lattice held by electrostatic forces; vibrations owing to kinetic energy.
Liquids: particles are free to move around but there are still forces of attraction; more kinetic energy.

(b) Explain, in the context of the kinetic model, why solid-liquid-gas transitions might occur. [3]

Solution: Vibrations in solids become evermore vigorous with heating. Eventually, atoms may be liberated from the lattice and are free to move around (it has melted, forming a liquid). If the liquid is heated, a particle may gain enough energy to overcome the electrostatic attraction and break free.

(c) Outline a simple experiment that could be performed to demonstrate the key principles of the kinetic model - that matter is made up of atoms and molecules and that they have kinetic energy. [2]

Solution: Under a microscope, illuminate a box of air containing smoke particles. The smoke particles are visible and will seem to change direction randomly as a result of elastic collisions with the air molecules.

(d) Define the internal energy of a substance. [1]

Solution: The sum of the randomly distributed kinetic and potential energies of the atoms or molecules within the substance.

(e) Why is the electrostatic energy of a liquid or solid conventionally assigned a negative value? [1]

Solution: It indicates that energy must be supplied to the substance to break the atomic bonds.

(f) State two ways in which a substance's internal energy can be increased. [2]

Solution: 1/ increase the temperature
2/ change its phase

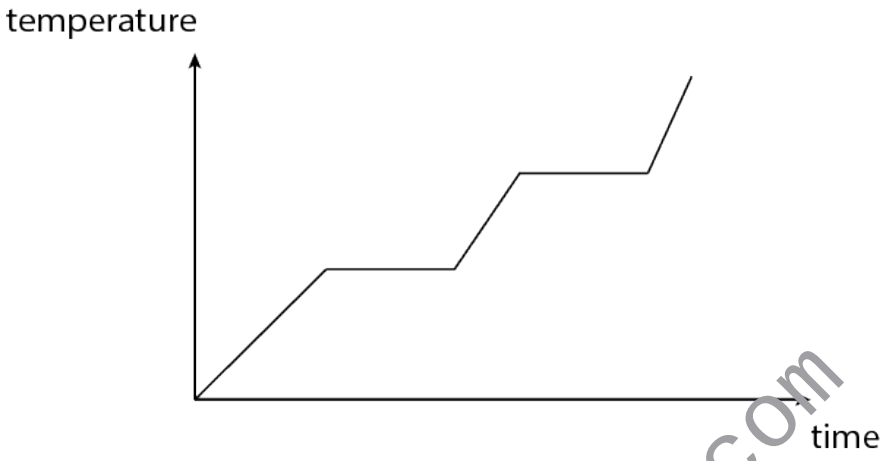
(g) Which of the following is correct? [1]

i. At absolute zero the internal energy of a substance is zero.
ii. At absolute zero the internal energy of a substance is negative.
iii. At absolute zero the internal energy of a substance is positive.

Solution: 3

3. The graph below shows the variation in temperature with time as a solid is heated using a hair dryer. The power of the hair dryer remains constant.

Total for Question 3: 12



(a) Label the graph to show the following: the phase of the substance and its melting and boiling points. [2]

Solution: Sloped sections should be labelled, from left to right: solid, liquid and gas
Horizontal slopes are transitions i.e. melting and boiling points.

(b) Why are the transitions not instantaneous? [2]

Solution: Latent heat. Energy is required to change the phase of the substance as well as to raise its temperature. The sloping legs represent changes only in T; the flat legs are when the same amount of power is being put into the system but it is going towards change the phase.
$L = \frac{E}{m}$

(c) The freezing point of peanut oil varies, but is approximately 3°C. Its specific heat capacities above and below freezing are 2.40 and 2.65 $kJkg^{-1}K^{-1}$, respectively, and its latent heat of fusion is $60kJkg^{-1}$. How long would it take for the 1000 W hairdryer to change 1 kg of the oil from a solid at 233 K to a liquid at 40°C? [4]

Solution: 261 s

(d) Outline two methods that could be used to determine the specific heat capacity of a substance. [4]

Solution: For all methods, heat the sample and a thermometer in an insulated environment (so as to minimise energy losses from the heater to the environment).
1/ power from heater is $P = IV$ and the energy required to change the temperature by θ is $mc\Delta\theta \rightarrow c = \frac{IVt}{m\Delta\theta}$
2/ more accurate would be to plot a graph of T vs t: $E = mc\Delta\theta$ can be rewritten as $\frac{E}{\Delta t} = P = mc\frac{\Delta\theta}{\Delta t}$. On a graph of T against t, therefore, $c = \frac{P}{m \times gradient}$.
3/ Known masses of 2 substances at different T are mixed together. Their equilibrium T allows one of their heat capacities to be calculated if the other is known. Based on $m_1c_1\Delta\theta_1 = m_2c_2\Delta\theta_2$