Thermal Physics Revision

Q1.(a) Define the specific latent heat of vaporisation of water.

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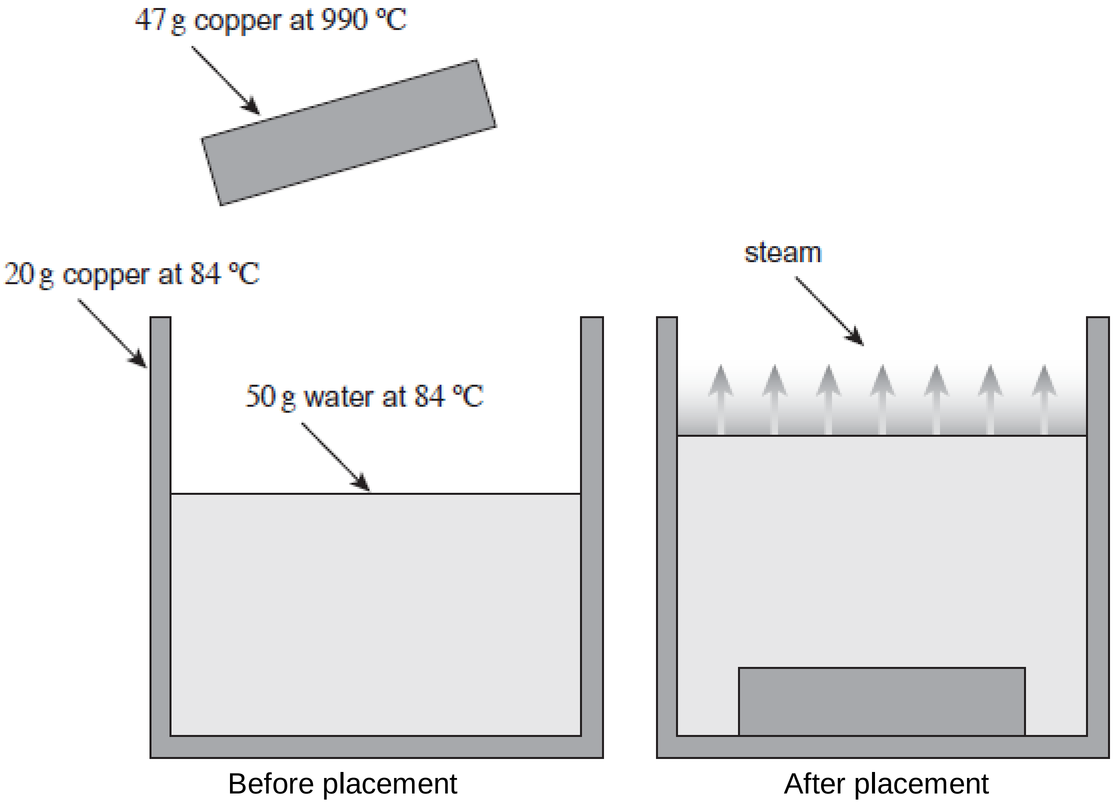
(2)

(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 copper = 390 J

specific heat capacity of water = 4200 J kgsup class="xsmall">–1 Ksup class="xsmall">–1

specific latent heat of vaporisation of water = 2.3×10^6 J kgsup class="xsmall">–1



(i) 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)

(ii) 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)

(iii) Calculate the maximum mass of steam that may be produced.

mass .... kg

(1)
(Total 7 marks)

Q2. The following data refer to a dishwasher.

power of heating element	2.5 kW
time to heat water	360 s
mass of water used	3.0 kg
initial temperature of water	20°C
final temperature of water	60°C

(a) Taking the specific heat capacity of water to be 4200 J kg^{-1} K^{-1}, calculate

(i) the energy provided by the heating element,

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(ii) the energy required to heat the water.

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(4)

(b) Give **two** reasons why your answers in part (a) differ from each other.

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(2)
(Total 6 marks)

Q3.(a) Outline what is meant by an *ideal gas*.

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(2)

(b) An ideal gas at a temperature of 22 °C is trapped in a metal cylinder of volume 0.20 m^3 at a pressure of 1.6×10^6 Pa.

(i) Calculate the number of moles of gas contained in the cylinder.

number of moles .... mol

(2)

(ii) The gas has a molar mass of 4.3×10^{-2} kg mol^{-1}.

Calculate the density of the gas in the cylinder.

State an appropriate unit for your answer.

density .... unit ....

(3)

(iii) The cylinder is taken to high altitude where the temperature is −50 °C and the pressure is 3.6×10^{4} Pa. A valve on the cylinder is opened to allow gas to escape.

Calculate the mass of gas remaining in the cylinder when it reaches equilibrium with its surroundings.

Give your answer to an appropriate number of significant figures.

mass .... kg

(3)
(Total 10 marks)

Q4. (a) (i) Write down the equation of state for *n* moles of an ideal gas.

....

(ii) The molecular kinetic theory leads to the derivation of the equation

$pV = \frac{1}{3} Nm\overline{c^2}$,

where the symbols have their usual meaning.

State **three** assumptions that are made in this derivation.

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(4)

(b) Calculate the average kinetic energy of a gas molecule of an ideal gas at a temperature
of 20 °C.

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(3)

(c) Two different gases at the same temperature have molecules with different mean square speeds.
Explain why this is possible.

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(2)
(Total 9 marks)

Q5. (a) (i) One of the assumptions of the kinetic theory of gases is that molecules make *elastic collisions.* State what is meant by an elastic collision.

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(ii) State **two** more assumptions that are made in the kinetic theory of gases.

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(3)

(b) One mole of hydrogen at a temperature of 420 K is mixed with one mole of oxygen at 320 K. After a short period of time the mixture is in *thermal equilibrium*.

(i) Explain what happens as the two gases approach and then reach thermal equilibrium.

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(ii) Calculate the average kinetic energy of the hydrogen molecules before they are mixed with the oxygen molecules.

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(4)
(Total 7 marks)

Q6. In an experiment to measure the temperature of the flame of a Bunsen burner, a lump of copper of mass 0.12 kg is heated in the flame for several minutes. The copper is then transferred quickly to a beaker, of negligible heat capacity, containing 0.45 kg of water, and the temperature rise of the water measured.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific heat capacity of copper = 390 J kg^{-1} K^{-1}

(a) If the temperature of the water rises from 15 °C to 35 °C, calculate the thermal energy gained by the water.

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(2)

(b) (i) State the thermal energy lost by the copper, assuming no heat is lost during its transfer.

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(ii) Calculate the fall in temperature of the copper.

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(iii) Hence calculate the temperature reached by the copper while in the flame.

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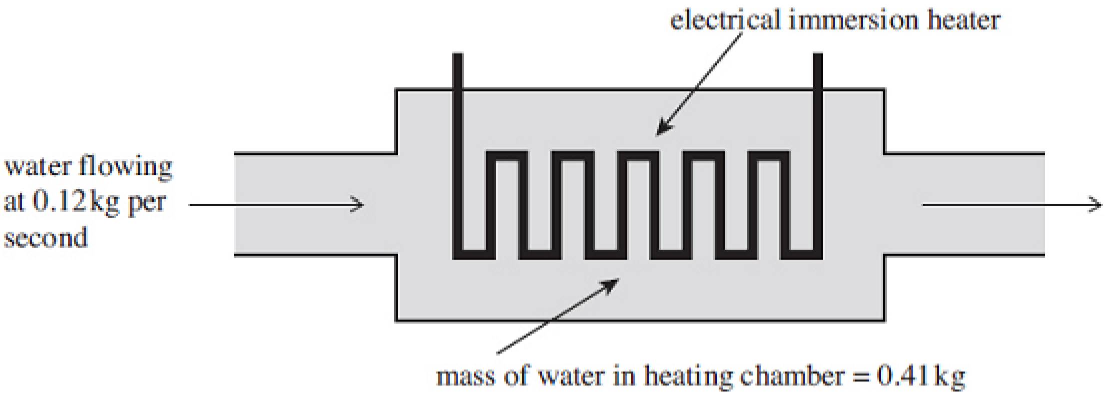
(4)
(Total 6 marks)

Q7. 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.



(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)

(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)

Q8. (a) Calculate the energy released when 1.5 kg of water at 18 °C cools to 0 °C and then freezes to form ice, also at 0 °C.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of fusion of ice = 3.4×10^5 J kg^{-1}

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(4)

(b) Explain why it is more effective to cool cans of drinks by placing them in a bucket full of melting ice rather than in a bucket of water at an initial temperature of 0 °C.

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(2)
(Total 6 marks)