SPH3U7: Thermal Physics Worksheet Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 1.A quantity of water at temperature *θ* is placed in a pan and heated at a constant rate until some of the water has turned into steam. The boiling point of the water is 100°C.

(a) (i) Using the axes below, draw a sketch-graph to show the variation with time *t* of the temperature *θ* of the water. *(****Note****: this is a sketch-graph; you do not need to add any values to the axes.)*

(1)



(ii) Describe in terms of energy changes, the molecular behaviour of water and steam during the heating process.

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(5)

 Thermal energy is supplied to the water in the pan for 10 minutes at a constant rate of 400 W. The thermal capacity of the pan is negligible.

(b) (i) Deduce that the total energy supplied in 10 minutes is 2.4 × 105 J.

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(1)

(ii) Using the data below, estimate the mass of water turned into steam as a result of this heating process.

initial mass of water = 0.30 kg

initial temperature of the water *θ* = 20°C

specific heat capacity of water = 4.2 × 103 J kg–1 K–1

specific latent heat of vaporization of water = 2.3 × 106 Jkg–1

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(3)

(iii) Suggest **one** reason why this mass is an estimate.

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(1)

(Total 11 marks)

**2.** This question is about thermal physics.

(a) Explain why, when a liquid evaporates, the liquid cools unless thermal energy is supplied to it.

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(3)

(b) State **two** factors that cause an increase in the rate of evaporation of a liquid.

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2. .................................................................................................................................

(2)

(c) Some data for ice and for water are given below.

 Specific heat capacity of ice = 2.1 × 103 J kg–1 K–1
Specific heat capacity of water = 4.2 × 103 J kg–1 K–1
Specific latent heat of fusion of ice = 3.3 × 105 J kg–1

 A mass of 350 g of water at a temperature of 25°C is placed in a refrigerator that extracts thermal energy from the water at a rate of 86 W.

 Calculate the time taken for the water to become ice at –5.0°C.

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(4)

(Total 9 marks)

**3.** This question is about an experiment to measure the temperature of a flame.

(a) Define *heat (thermal) capacity*.

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(1)

 A piece of metal is held in the flame of a Bunsen burner for several minutes. The metal is then quickly transferred to a known mass of water contained in a calorimeter.



 The water into which the metal has been placed is stirred until it reaches a steady temperature.

(b) Explain why

(i) the metal is transferred as quickly as possible from the flame to the water;

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(1)

(ii) the water is stirred.

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(1)

 The following data are available:

heat capacity of metal = 82.7 J K–1

heat capacity of the water in the calorimeter = 5.46 × 102 J K–1

heat capacity of the calorimeter = 54.6 J K–1

initial temperature of the water = 288 K

final temperature of the water = 353 K

(c) Assuming negligible energy losses in the processes involved, use the data to calculate the temperature *T* of the Bunsen flame.

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(4)

(Total 7 marks)

**4.** This question is about the change of phase (state) of ice.

 A quantity of crushed ice is removed from a freezer and placed in a calorimeter. Thermal energy is supplied to the ice at a constant rate. To ensure that all the ice is at the same temperature, it is continually stirred. The temperature of the contents of the calorimeter is recorded every 15 seconds.

 The graph below shows the variation with time *t* of the temperature *θ* of the contents of the calorimeter. *(Uncertainties in the measured quantities are not shown.)*



(a) On the graph above, mark with an X, the data point on the graph at which all the ice has just melted.

(1)

(b) Explain, with reference to the energy of the molecules, the constant temperature region of the graph.

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(3)

 The mass of the ice is 0.25 kg and the specific heat capacity of water is 4200 J kg–1 K–1.

(c) Use these data and data from the graph to

(i) deduce that energy is supplied to the ice at the rate of about 530 W.

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(3)

(ii) determine the specific heat capacity of ice.

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(3)

(iii) determine the specific latent heat of fusion of ice.

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(2)

(Total 12 marks)

Answers:

**1.** (a) (i)

general shape (but constant ** range must be clear); 1

(ii) **  100°C:
the KE of the molecules is increasing;

 100°C:
when the water starts to change phase, there is no further increase in KE;
the energy goes into increasing the PE of the molecules;
so increasing their separation;
until they are far enough apart to become gas / their molecular bonds are
broken / until they are effectively an infinite distance apart / *OWTTE*; 5

(b) (i) total energy supplied = 400 × 600 = 2.4 ×105 J; 1

(ii) energy required to raise temperature of water = 0.30 × 80 × 4.2 × 103
 = 1.0 × 105 J;
energy available to convert water to steam = (2.4 – 1.0) × 105 = 1.4 × 105 J;
mass of water converted to steam =   60 g; 3

(iii) energy is lost to the surroundings *(must* *specify* *where* *the* *energy* *is* *lost)* /
water might bubble out of pan whilst boiling / anything sensible; 1 max

[11]

2**.** (a) more energetic molecules leave surface;
mean kinetic energy of molecules in liquid decreases;
and mean kinetic energy depends on temperature; 3

Award **[2]** if mean not mentioned.

(b) *eg* larger surface area;
increased draught;
higher temperature;
lower vapour pressure; 2 max

Award **[1]** if candidate merely identifies two factors.

(c) energy to be extracted = 0.35 × 4200 × 25;
 +0.35 × 330 000;
 +0.35 × 2100 × 5;
 = 156 000 J
time =  = 1800 s; 4

Allow ecf if one term incorrect or missing.

[9]

**3.** (a) the amount of energy / heat required to raise the temperature of a
substance / object through 1K / °C; 1

(b) (i) to ensure that the temperature of the metal does not change during
the transfer / negligible thermal energy / heat is lost during
the transfer; 1

Do not accept metal and water at same temperature.

(ii) to ensure that all parts of the water reach the same temperature; 1

(c) energy lost by metal = 82.7 × (*T* – 353) J;
energy gained by water = 5.46 × 102 × 65 J;
energy gained by calorimeter = 54.6 × 65 J;
equate energy lost to energy gained to get *T* = 825 K; 4

Award **[2 max]** if any energy term is missed.

[7]

**4.** (a) (165, 0); 1

(b) *Look for these points:*
to change phase, the separation of the molecules must increase;

Some recognition that the ice is changing phase is needed.

 so all the energy input goes to increasing the PE of the molecules;

Accept something like “breaking the molecular bonds”.

 KE of the molecules remains constant, hence temperature remains constant; 3

If KE mentioned but not temperature then assume they know that temperature is a measure of KE.

(c) (i) time for water to go from 0 to 15°C = 30 s;
energy required = *ms*** = 0.25 × 15 × 4 200 = 15 750 J;
power =  = 525 W  530 W; 3

(ii) ice takes 15 s to go from – 15°C to 0;
energy supplied = 15 × 530 J;
sp ht =  = 2100 J kg–1 K–1; 3

(iii) time to melt ice = 150 s;
*L* =  = 320 kJ kg–1; 2

[12]