**COMET BAY COLLEGE**

**Physics - Unit 1 – Task 5**

**Heating and Cooling Test**

**Name: SOLUTIONS Total Marks /60**

**Question 1:**

People in hot arid regions frequently store water in porous canvas bags through which some of the water can seep. What is the purpose of doing this and how is the purpose achieved?  **[3 marks]**

The purpose is to keep the water cool.

When the water seeps through onto the outside of the bag, the water starts to evaporate. (1 mark)

Evaporation is a phase change and needs energy (latent heat). (1 mark)

The energy to change phase is taken from the bag and hence the water in the bag so the water cools. (1 mark)

**Question 2:**

While Samantha was rugged up on a cold night, she noticed that her cat’s fur seemed very fluffy. Explain why the fluffy fur would help keep the cat warm. **[3 marks]**

The fluffy fur helps trap air between the cat’s body and the outside environment so it restricts the transfer of heat by convection. (1 mark)

Air is a poor conductor so it restricts the transfer of heat by conduction from the cat’s body to the cooler outside. (1 mark)

As a result the cat stays warmer. (1 mark)

**Question 3:**

What is the specific heat of an alloy if it requires 3.20 × 104 J of energy to heat 1.20 kg of the alloy from 15.0 0C to 92.5 0C? **[2 marks]**

Q = mcΔT

3.20 × 104 = 1.20 × c × (92.5 – 15) (1 mark)

3.20 × 104 = 93 × c

c = 344 J kg-1 K-1  (1 mark)

**Question 4:**

A student using a Bunsen burner, a thermometer, a clock and a substance in a beaker, does an experiment to obtain the following graph.

1. What state or states is/are present between

liquid

liquid and gas

1. B and C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**
2. C and D? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**
3. Explain on a molecular level why the temperature doesn’t change between C and D although heat is still being added to the substance. **[3 marks]**

Between C and D the substance is changing phase. (1 mark)

In phase change bonds are being broken and particles moving further apart. This involves an increase in potential energy and not kinetic energy. (1 mark)

Temperature is the measure of the average kinetic energy so if the kinetic energy is not increasing, the temperature remains the same. (1 mark)

1. Explain why section AB is shorter than section CD. **[2 marks]**

In AB the substance is changing from a solid to a liquid. While bonds are being broken, the particles are not moving much further apart. (1 mark)

In CD, the substance is changing from a liquid to a gas. After the bonds have been broken, extra energy is needed to move the particles much further apart in the gas and therefore much more energy is needed for particles to gain the extra potential energy to move further apart and the section is longer. (1 mark)

**Question 5:**

A laboratory technician was trying to find the latent heat of fusion of an alloy she had created. She found that she needed to add 6.84 × 105 J of energy to 1.95 kg of the alloy to fully melt it without changing the temperature. Find the latent heat of fusion of the alloy. **[2 marks]**

Q = mL

6.84 x 105 = 1.95 × L (1 mark)

L = 3.51 ×105 J kg-1  (1 mark)

**Question 6:**

On a cold morning, the metal handlebars on a bike feel colder than the rubber grips.

1. This is mainly because: (Choose the correct statement(s))
   * 1. Rubber is a better absorber of radiation than the metal.
     2. The metal is colder than the rubber.
     3. The rubber has a higher specific heat capacity than the metal.
     4. Metal is a better radiator of heat than rubber.
     5. Metal is a better conductor of heat than rubber.

E

Answer: \_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**

1. Explain your reasoning using your understanding of the process. **[2 marks]**

Metal and Rubber both have the atoms in the lattice structure passing energy from one atom to the next (1 mark)

However, metal has the free electrons that allow energy to travel at a greater pace throughout the metal, hence the conduction is not restricted by the energy transfer through the lattice matrix. (1 mark)

**Question 7:**

A large 3.50 × 103 W kettle uses 1.946 × 106  J to completely boil away the contents of a kettle. Calculate the time (in minutes) that it would take for this to occur. **[3 marks]**

P = 3500 W

P = = t = = (1 mark)

= 556 s

= (1 mark)

t = 9.27 minutes (1 mark)

**Question 8:**

A kettle is brought to the boil from 25.0oC and left boiling for 3.50 minutes. Half of the 1.250 litres of water boils away in that time leaving 0.625 litres boiling. How much energy has been converted?

QTotal = Qheating + QVaporisation Q = mwatercΔT + m Lv

mwater = 1.25 kg Q = 1.25 × 4180 × 75 + 0.625 × 2.25 × 106 (2 marks)

mg = 0.625 kg Q = 3.92 × 105 + 1.41 × 106

Lv = 2.25 × 106 Jkg-1 Q = 1.80 × 106 J (1 mark)

**[3 marks]**

**Question 9:**

How much steam at 1070C must be added to 50.0 g of ice at -4.000C in an insulated aluminium calorimeter of mass 47.0 g so that the ice just melts. Specific heat of Al = 900 J kg-1 K-1 **[5 marks]**

Heat lost = heat gained (1 mark)

Cool steam + condense steam + cool water from steam = heat ice + melt ice + heat Al calorimeter

mcΔTsteam + mLv + mcΔTwater = mcΔTice + mL + mcΔTaluminium

(m × 2000 × (107 – 100)) + (m × 2.26 × 106) + (m × 4180 × (100 – 0))

= (0.05 × 2100 × (0 – (-4))) + (0.05 × 3.34 × 105) + (0.047 × 900 × (0 – (-4)))

(1 mark) (1 mark)

(m × 2000 × 7) + (m × 2.26 × 106) + (m × 4180 × 100)

= (0.05 × 2100 × 4) + (0.05 × 3.34 × 105) + (0.047 × 900 × 4)

14000m + 2260000m + 418000m = 420 + 16700 + 169.2

2692000m = 17289.2 (1 mark)

m = 6.42 × 10-3 kg (1 mark)

m = 0.00642 kg

= 6.42 g

(1 mark)

**Question 10:**

An ice-block tray holding 0.250 kg of water at 18.00C is placed in the freezing compartment of a refrigerator. If it takes 1.50 hours to form ice-blocks (at 0.000C), at what rate (in Js-1) was the refrigerator extracting heat from the water? **[4 marks]**

Q = cool water + freeze water

= (0.25 × 4180 × 18) + (0.25 × 3.34 × 105) (1 mark)

= 18810 + 83500

Q = 102310 J (1 mark)

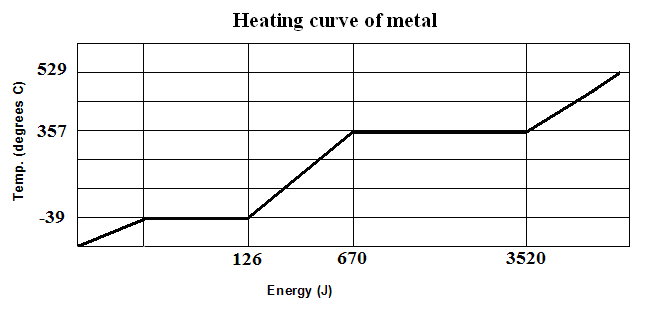
Rate = = (1 mark)

= 18.95 Js-1 (1 mark)

Rate = 19.0 Js-1

**Question 11:**

The graph below represents the heating curve for an unknown metal. Energy is added to 10.0 g of the solid metal initially at a temperature of –390C, until the metal evaporates (***graph not to scale***).



357 0C

1. What is the boiling point of the metal? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**
2. What is the latent heat of vaporisation of the metal? **[3 marks]**

Latent heat; Q = mL

3520 – 670 = 0.01 × L (1 mark)

2850 = 0.01 × L

L = (1 mark)

L = 285000

Latent heat of vaporisation = 2.85 × 105 J kg-1 (1 mark)

**Question 12:**

MetALwerx wants to decrease energy usage during its smelting of low grade bauxite to extract aluminium. They usually achieve this by raising the temperature of the bauxite ore to 2600o C at standard atmospheric pressure. This turns the aluminium to a gaseous state, allowing it to be separated from the hydroxide molecules. Using mathematical expressions, find the temperature required to achieve gaseous state if the pressure was decreased to two thirds standard atmospheric pressure. Since the pressure decrease is so small there is no volume change. **[3 marks]**

P1V1 = P2V2

T1 T2

2/3 × P1 = P2 (1 mark)

T1 = 2600 + 273 = 2873 K

V1 = V2 = V

P1 × V = 2/3 × P1 × V

2873 T (1 mark)

T = 2/3 × P × V× 2873

P × V

T = 1642o C (1915 K) (1 mark)

**Question 13:**

A 0.680 kg solid sample of an unknown substance is heated slowly while inside an insulated container. The graph below illustrates the heating curve of this substance.



**E**

**D**

**C**

1. State the temperature at which

84 oC (1 mark)

22 oC (21 – 23) (1 mark)

(i) the substance boils. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**

(ii) the substance melts. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **[1 mark]**

1. Explain on a molecular level why the temperature doesn’t change between A and B although heat is still being added to the substance. **[3 marks]**

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In phase change bonds are being broken and particles moving further apart. This involves an increase in potential energy and not kinetic energy. (1 mark)

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**Question 14:**

During a Physics experiment, Andrew heated equal masses of water and paraffin oil

(c = 2130 J kg-1 K-1) which were contained in separate but identical containers. Both were heated over the same Bunsen burner for a period of 4 minutes. Predict the outcome of Andrews experiment and explain why. **[4 marks]**

Parafin oil would have the highest change in temperature. (1 mark)

Q = mcΔT. With Q and m constant, (1 mark)

as c decreases then ΔT increases, or c determines ΔT (1 mark)

cw > cp, hence ΔTw < ΔTp (1 mark)

**Question 15:**

Steam produces much worse burns than does boiling water. Compare the amount of energy the body, at a temperature of 37°C, receives from the cooling of 0.10 g of water from 100°C, with that received from the cooling of 0.10 g of steam originally at 100°C. **[3 marks]**

Energy absorbed from boiling water:  
QW = mcΔT = 0.1 × 10−3 × 4180 × 63 = 26.334 J (1 mark)

Energy absorbed by steam:  
QS =mLv + mcΔT = 0.1 × 10−3 × 22.6 × 105 + 0.1 × 10−3 × 4180 x 63 ≈ 252.334 J (1 mark)

Therefore, steam provides 252.334 J − 26.334 J = 226 J more energy (or 9.5 times more). (1 mark)

**Question 16:**

A 350.0 g sample of a test liquid absorbed 15 kJ of energy as it rose in temperature by 20oC.

1. What is the heat capacity of the sample? **[2 marks]**

Heat capacity of a sample = = (1 mark) Asking for sample of 350g

= 750 J K-1 (1 mark) not for type of material.

1. What is the specific heat of the liquid? **[2 marks]**

Q = mcΔT hence c = = (1 mark)

= 2142.86 J kg-1 K-1 (1 mark)