HOLY CROSS COLLEGE
Life to the Full

Western Australian Certificate of Education
ATAR course examination, 2020

Question/Answer Booklet

11 PHYSICS

Test 3 - Heating and Cooling

Name SOLUTIONS

Student Number: In figures

In words

Mark: $\frac{}{35}$

Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: fifty minutes

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate

Standard items: pens, (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers					
Section Two: Problem-solving	7	7	50	35	100
Section Three: Comprehension					
				Total	100

Instructions to candidates

1. The rules for the conduct of examinations at Holy Cross College are detailed in the College Examination Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

6. Answers to questions involving calculations should be ***evaluated and given in decimal form***. It is suggested that you quote all answers to ***three significant figures***, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are ***clearly and legibly set out***.

7. Questions containing the instruction "estimate" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

8. Note that when an answer is a vector quantity, it must be given with magnitude and direction.

9. In all calculations, units must be consistent throughout your working.

DATA

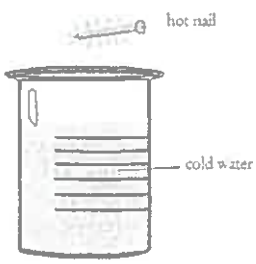
Use the data sheet plus the following table.

Table of Specific Heats ($Jkg^{-1}K^{-1}$)	
water	4.18×10^3
pewter	1.43×10^2
steam	2.00×10^3
glass	8.40×10^2
ice	2.10×10^3
aluminium	8.80×10^2
ethylene glycol	2.40×10^3
air	1.00×10^3
copper	3.90×10^2
stainless steel	4.45×10^2
lead	1.30×10^2
human body (average)	3.50×10^3

1. Explain the difference between the terms ***heat*** and ***temperature***. (2 marks)

HEAT: the amount of energy transferred from one object to another. (1)

TEMPERATURE: a measure of the average E_K of the particles in a substance (1)



2. A nail was heated in a blue Bunsen burner flame for one minute and is about to be dropped into a beaker holding 0.60 L of water at room temperature.

   (a) Which of the two (nail or water) would be expected to initially have:

   (i) the highest internal energy? water (1)

   (ii) the highest average kinetic energy? nail (1) (2 marks)

(b) The nail is dropped into the water and allowed to cool. What happens to the average kinetic energy of the atoms in the:

(i) nail? decreases (1)

(ii) water? increases (1) (2 marks)

3. (a) What is 143 K in °C? $-130\,^\circ C$ (1) (1 mark)

(b) Comment on the statement:

"At 40 °C, tomorrow is going to be twice as hot as the 20 °C today."

Is this true? Give an explanation for your answer. (3 marks)

- No (1)
- Absolute temperature scale is used. (1)
- $20\,^\circ C = 293\ K$ $\therefore$ Twice the temperature $= 586\ K = 313\,^\circ C$ (1)

4. Calculate the specific heat of a metal sample if 5.25×10^7 J of heat is required to raise the temperature of 245 kg of it from 25 °C to 455 °C. (3 marks)

$$Q = m_m c_m \Delta T$$

$$\Rightarrow c_m = \frac{Q}{m_m \Delta T} \quad (1)$$

$$= \frac{5.25 \times 10^7}{(245)(455-25)} \quad (1)$$

$$= \underline{498\ J\,kg^{-1}\,K^{-1}} \quad (1)$$

5. (a) How much heat energy is required to convert 47.6 g of ice at - 8.0 °C to water at 79.0 °C? (4 marks)

$\boxed{\text{ice}}$

$-8^\circ C \rightarrow 0^\circ C \rightarrow \text{melts} \rightarrow 79^\circ C$

$\Delta T \quad L_f \quad \Delta T$

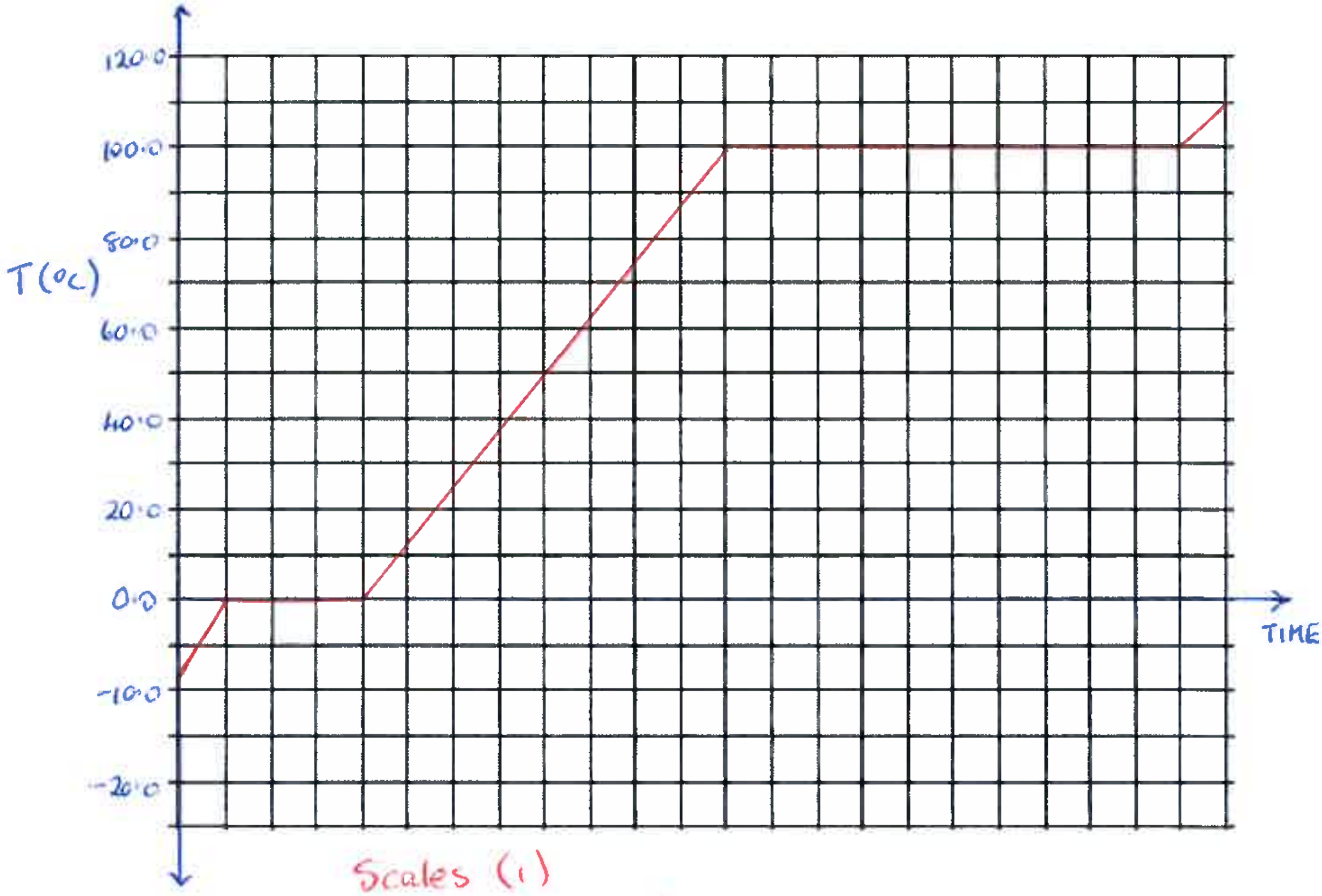
$$Q_{needed} = m_i c_i \Delta T + m_i L_f + m_i c_w \Delta T \quad (2)$$

$$= (0.0476)(2.10\times10^3)(0-(-8.0)) + (0.0476)(3.34\times10^5)$$

$$+ (0.0476)(4.18\times10^3)(79.0-0.0) \quad (1)$$

$$= \underline{3.24\times10^4 \text{ J}} \quad (1)$$

(b) Draw a heating curve (temperature versus time) for the ice changing from - 8.0 °C to steam at 110 °C, indicating clearly where the phase changes occur. (3 marks)



Scales (1)

Correct MP/BP (1)

Correct plateau lengths (1)

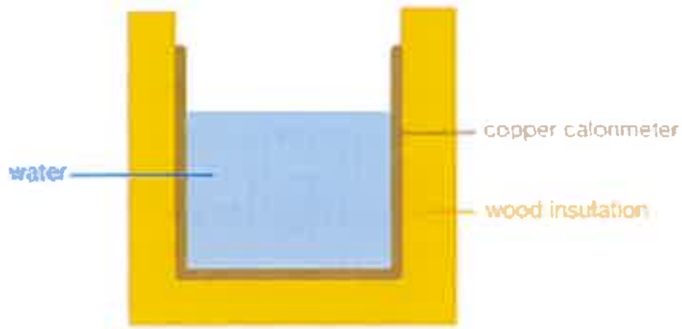
(c) Why is there a plateau in the heating curve for water turning into steam? Using the Kinetic Theory, explain what is occurring at the molecular level. (3 marks)

- No temperature change occurs. (1)
- E_p of the particles is increasing. (1)
- Particles move further apart until they move independently. (1)

6. A 145 g copper calorimeter inside wood insulation contains 86.3 g of water at 73.0 °C. What mass of ice at - 5.0 °C is required to lower the temperature to 21.0 °C? (Assume no heat is lost to the surroundings.) (4 marks)

$\boxed{\text{ice}}$ $-5°C \rightarrow 0°C \rightarrow$ melts $\rightarrow 21°C$

ΔT L_f ΔT



$\Delta T = 73°C \rightarrow 21°C$

$$Q_{lost} = Q_{gained}$$

$$\Rightarrow m_w c_w \Delta T + m_{Cu} c_{Cu} \Delta T = m_i c_i \Delta T + m_i L_f + m_i c_w \Delta T \quad (2)$$

$$\Rightarrow (0.0863)(4.18\times10^3)(73.0-21.0) + (0.145)(3.90\times10^2)(73.0-21.0) =$$

$$m_i(2.10\times10^3)(0-(-5.0)) + m_i(3.34\times10^5) + m_i(4.18\times10^3)(21.0-0.0) \quad (1)$$

$$\Rightarrow 2.170\times10^4 = m_i(4.323\times10^5)$$

$$\Rightarrow \underline{m_i = 5.02\times10^{-2}\ \text{kg}} \quad (1)$$

7. A microwave rated at 1.10 kW is used to heat a 215 g porcelain cup holding 275 mL of water from 18.0 °C to 90.0 °C. Given $c_{porcelain}$ = 1085 $Jkg^{-1}K^{-1}$ and the microwave is 68.0% efficient, calculate:

(a) how long it takes to heat the water. (5 marks)

$$Q_{needed} = m_w c_w \Delta T + m_p c_p \Delta T \quad (1)$$

$$= (0.275)(4.18\times10^3)(90.0-18.0) + (0.215)(1085)(90.0-18.0)$$

$$= 9.956\times10^4 \text{ J} \quad (1)$$

$$0.680\,P = \frac{Q_{needed}}{t} \quad (1)$$

$$\Rightarrow t = \frac{9.956\times10^4}{(0.680)(1.10\times10^3)} \quad (1)$$

$$= \underline{133\text{ s}} \quad (1)$$

(b) the cost of heating the water, given 1.00 unit of electrical energy costs 28.8 cents. (3 marks)

$$\text{cost} = P(\text{kW}) \times t(\text{h}) \times r \quad (1)$$

$$= (1.10)\left(\frac{133}{3.60\times10^3}\right)(28.8) \quad (1)$$

$$= \underline{1.17\text{ cents}} \quad (1)$$