Physics
Christ Church Grammar School

Science Department
Year 11 2020

ATAR PHYSICS
UNIT 1 THERMAL PHYSICS VALIDATION TEST 2020

SOLUTIONS

Time allowed for this paper
Working time for paper: **30 minutes.**

Instructions to candidates:

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to the correct level of precision as dictated by the measurements given.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

ADDITIONAL FORMULAE AND DATA

- Triple Point of water = 0.01°C = 273.16 K
- $\frac{T_\theta}{100} = \frac{X_\theta - X_0}{X_{100} - X_0} = \frac{L_\theta - L_0}{L_{100} - L_0} = \frac{R_\theta - R_0}{R_{100} - R_0}$
- K = C + 273.15
- $Power = \frac{Energy}{time}$

Mark:	/ 31
=	%

Question 1 **(3 marks)**

The words 'heat' and 'temperature' are often confused. In the space below, distinguish clearly between these two quantities using physics concepts covered in the course. In your answer, include the concept of internal energy.

Description	Marks
Heat is the transfer of energy from regions of high temperature to regions of low temperature.	1
Temperature is a measure of the mean translational velocities of all particles in a substance.	1
When heat is provided to a substance, it's internal energy increases OR Internal energy is the sum of all kinetic and potential energies of all particles in a substance.	1
Total	3

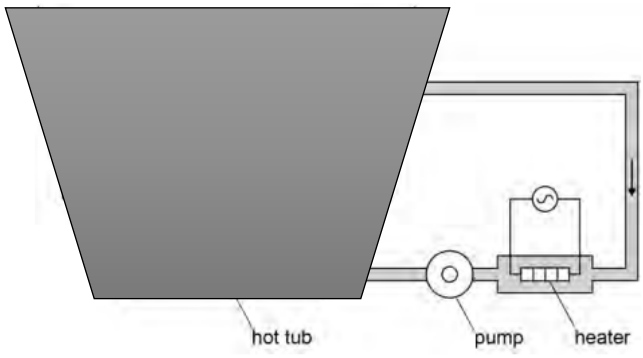
Question 2 **(3 marks)**

The water placed in a freezer is reduced from 298.0 K to -12.0 °C. Calculate the change in temperature in degrees Celsius.

Description	Marks
T_i = 298.0 – 273.15 = 24.9 °C (1.d.p)	1
$\Delta T = T_f - T_i$ = -12.0 – 24.9	1
= -36.9 °C (1.d.p)	1
Total	3

Question 3 **(6 marks)**

The diagram below shows how the temperature of the water is maintained in a hot tub.



The hot tub system shown above has a volume of 1.50 m^3 and is filled with water at a temperature of 28.0 °C. The heater transfers thermal energy to the water at a rate of 2.70 kW while a pump circulates the water. Assume that no heat is transferred to the surroundings and 1.00 m^3 of water has a mass of 1000 kg.

(a) Calculate the energy required in increase the water to 35.0 °C

(3 marks)

Description	Marks
$Q = mc\Delta T$	1
$= 1500(4180)(35.0 - 28.0)$	1
$= 4.4 \times 10^7$ J (2.s.f) (allow 3 sig fig = 4.49)	1
Total	3

(b) Calculate the time in minutes that the heater would take to heat the water to 35.0 °C

(3 marks)

Description	Marks
$Power = \frac{Energy}{time}$, $time = \frac{energy}{power}$	1
$= \frac{4.39 \times 10^7}{2.70 \times 10^3} = 16300$ s	1
= 270 minutes (allow 3 sig fig = 272 minutes)	1
Total	3

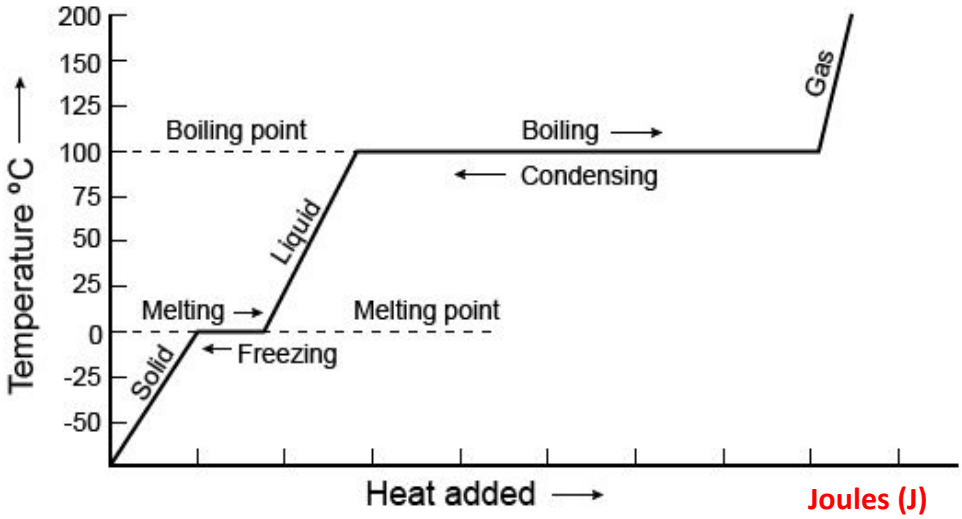
Question 4 **(3 marks)**

Provide the definition for the Triple Point of water and explain its significance in the Celsius scale.

Description	Marks
Triple point is a particular pressure and temperature at which water can exist in all 3 states of matter.	1
This is a physical constant which will never change.	1
So is a fixed point on the Celsius scale so thermometers can accurately be calibrated.	1
Total	3

Question 5 **(4 marks)**

Consider the heating curve for a mass of water showing the temperature change as heat is supplied to it at a constant rate.



(a) Correctly label the x-axis (1 mark)

(b) Describe how the gradient of each phase (solid, liquid, gas) can be used to compare the specific heat capacity of each phase. (3 marks)

Description	Marks
Gradient is proportional to °C J^{-1}	1
Given a constant mass, c = J° C^{-1} The inverse of c = °C J^{-1} hence the gradient is the inverse of the SHC.	1
The steeper the gradient, the lower the S.H.C.	1
OR Total	3
A steeper gradient means the temperature rises more for a given amount of energy	1
Since $c \propto \frac{1}{\Delta T}$	1
A higher ΔT would yield a lower S.H.C	1

Question 5 **(7 marks)**

An ice cube at 0.00 °C is placed into an insulated container with 151 g of water at 45.0 °C. In one minute, the ice cube had melted. The final mass of water in the glass was 175 g and the final temperature of the water was 28.0 °C.

(a) Using the data provided, calculate the latent heat of fusion of water.

(5 marks)

Description	Marks
$Q_g + Q_L = 0$ $mLf + mc\Delta T + mc\Delta T = 0$	1
$m_{ice} = 0.175 - 0.151$ $= 0.024g$	1
$0.024Lf + 0.024(4180)(28.0 - 0) + 0.151(4180)(28.0 - 45.0) = 0$ $0.024\ Lf + 2809 - 10{,}730 = 0$ $Lf = 7921 / 0.024$	2
$= 3.3 \times 10^5$ J kg^{-1} (2 sig fig) Don't deduct marks for 3 sig fig = 3.30×10^5	1
Total	5
Common errors: $C_{(metled\ ice)} = 2100$, $Lf = 5.11 \times 10^5$ max 4 marks	

(b) Calculate the percentage error compared with the accepted value.

(2 marks)

Description	Marks
$\text{Error} = \frac{\text{measured} - \text{accepted}}{\text{Accepted}} \times 100$ $= \frac{3.3 - 3.34}{3.35} \times 100$	1
$= -1.2\ \%$	1
Total	2

Question 6 **(6 marks)**

155 g of hot copper is immersed in an insulated 0.255 kg volume of water initially at 20.0 °C. The final temperature of the mixture is measured to be 24.4 °C. (c_{Cu} = 390.0 $Jkg^{-1}K^{-1}$)

(a) Calculate the initial temperature of the copper required to produce the final temperature.

(4 marks)

Description	Marks
$Q_g + Q_L = 0$ $mc\Delta T + mc\Delta T = 0$	1
$0.255(4180)(20.0-24.4) + 0.155(390)(24.4 - T_i) = 0$	1
$4690 + 60.45(24.4 - T_i) = 0$ $4690 + 1474 - 60.45T_i = 0$ $6164 = 60.45T_i$	1
102 °C	1
Total	4

(b) State two assumptions made in the above calculation.

(2 marks)

Description	Marks
No energy lost to environment	1
Sealed system	1
Pure samples	1
Accurate measurements	1
No phase changes / vapor produced	1
Total	2

END OF TEST