Physics ATAR - Year 11

Thermal Physics Validation Test 2019

Name:	Mark: / 41 = %

Time Allowed: 50 Minutes

Notes to Students:

1. You must include **all** working to be awarded full marks for a question.
2. Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
3. **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

Question 1 **(2 marks)**

Explain in terms of physical concepts, the temperature of "Absolute Zero"

- A theoretical lowest possible temperature
- At which there is:
  - no movement/velocity of particles.
  - Zero kinetic (or internal) energy of particles in a substance
  - No pressure of an ideal gas exerted on its container. (allow any three)

Question 2 **(3 marks)**

The air in the classroom is reduced from 25.0 °C to 288.0 K. Calculate the change in temperature in Kelvin.

$T_i = 25.0 + 273.15$

$= 298.2$ K 1

$\Delta T = T_f - T_i$ ½

$= 288.0 – 298.2$ ½

$= -10.2$ K (1.d.p) 1

Question 3 **(3 marks)**

The capillary length of an uncalibrated glass thermometer when placed in ice water is measured to 2.5 cm and 16.3 cm in boiling water. Calculate the length of the capillary would be when placed in air of 25.0 °C.

$$\frac{T_?}{100} = \frac{L_\theta - L_0}{L_{100} - L_0}$$ ½

$$0.25 = \frac{L - 2.5}{16.3 - 2.5}$$

$(0.25)(16.3-2.5) = L – 2.5$

$L = 3.5 + 2.5$ 1.5

$L = 6.0$ cm (2.s.f) 1

Question 4 **(3 marks)**

Calculate the amount of energy the needs to be removed from 1.55 kg of water to freeze it.

$Q = mL_f$ 1

$= 1.55 \times 3.34 \times 10^5$ 1

$= 5.18 \times 10^5$ J (3.s.f) 1

Question 5 **(4 marks)**

Substance A (with specific heat capacity c_A) and substance B (with specific heat capacity c_B) are both initially at 20.0 °C. Both have the same mass and are provided the same amount of heat. If substance A records a final temperature of 22.4 °C and substance B records a final temperature of 32.1 °C. Express the specific heat capacity of substance B in terms of c_A.

$Q = mc\Delta T$ ½

$m_A c_A \Delta T_A = m_B c_B \Delta T_B$ ½

$c_A \Delta T_A = c_B \Delta T_B$ 1

$c_A (22.4-20) = c_B(32.1-20)$ 1

$$c_B = \frac{2.4}{12.1} . c_A$$

$= 0.20.c_A$ (2.s.f.) 1

Question 6 **(6 marks)**

(a) State the definition of temperature

(1 mark)

- Temperature is defined as the mean translational velocity of particles in a substance.

OR

- A Quantitative measure of the hotness or coldness of a substance with respect to a standard.

(b) State the definition of internal energy.

(1 mark)

- Internal energy is defined as the sum of all Ek and EP of particles in a substance

Consider a 0.1 kg sample of ice at 0 °C and a 0.1 kg sample of water at 0 °C.

(c) Choose which volume of water has more internal energy (Circle your chosen answer)

(1 mark)

(i) The ice

(ii) The water

(iii) They both have the same amount of internal energy

(d) Explain your answer to (c).

(3 marks)

- Since the water and ice are at the same temperature, the EK is the same.
- However, the liquid water, due to its state, each particle has more EP.
- Since Internal energy is defined as the sum of all Ek and EP of particles in a substance, the water has more internal energy.

Question 7 **(7 marks)**

A sample of water is measured to be 0.524 kg with a tolerance of $\pm$0.500 %. Its initial temperature is recorded at 14.5 °C and is then heated to 28.0 °C. The temperature is measured with an alcohol in glass thermometer with 1°C divisions.

(a) Calculate the amount of energy that was added to heat the water to its final temperature. (3 marks)

(c_w = 4180 $Jkg^{-1}K^{-1}$)

$Q = m_W c_W \Delta T_W$

$= (0.524)(4180)(28.0-14.5)$

$= 2.96 \times 10^4$ J

(b) Calculate the absolute uncertainty of the heat supplied to the water. (4 marks)

% m = 0.500%

% $\Delta T = \frac{0.5+0.5}{13.5} \times 100$ 1
$= 7.41\%$

(-1 mark if abs abs unc for ΔT stated as 0.5)

Total % uncertainty = 7.41 + 0.500 1
= 7.91%

(f.t. marks = 3.70+0.500% = 4.20%)

Abs uncertainty = $2.96 \times 10^4 \times \frac{7.91}{100}$ 1
$= 0.234 \times 10^4$

(f.t marks = 0.12×10^4 J)

Q = $(2.96 \pm 0.23) \times 10^4$ J

= 29,600 $\pm$ 2,300

= $2.96 \times 10^4 \pm 0.23 \times 10^4$ J 1

= 29.6 $\pm$ 2.3 kJ

(error must be provided to same d.p as answer)

Question 8 **(8 marks)**

A 0.150 kg mass of copper is immersed in an insulated 0.125 kg volume of water initially at 18.00 °C. The final temperature of the mixture is measured to be 24.40 °C.
(c_{Cu} = 390.0 $Jkg^{-1}K^{-1}$)
(c_w = 4180 $Jkg^{-1}K^{-1}$)

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

$Q_g + Q_L = 0$ ½ $Q = mc\Delta T$ ½

$m_W c_W \Delta T_W + m_C c_C \Delta T_C = 0$

$(0.125)(4180)(24.40-18.00) + (0.150)(390)(24.40-T_i) = 0$ 2

$3340 + 1430 - 58.5T_i = 0$

$T_i = 81.5$ °C (3.s.f) 1

(allow 81.6 °C if intermediate calculations are kept at 3344 and1427.4, not penalising SIS here)

(b) State one assumption made in the above calculation.
(1 mark)

- No energy lost to environment
- Sealed system
- Pure samples
- Accurate measurements
- No phase changes / vapor produced

(c) In reality, state and explain whether the required initial temperature of copper would be greater, less, or no difference to raise the temperature of the mixture to 24.4 °C.
(3 marks)

- Initial temperature would be higher
- Energy would be gained by the surrounding environment (conduction convection etc)
- This additional energy would need to be supplied by the copper, hence a higher temperature.

Question 10 **(5 marks)**

0.055 kg of ice at -5.00 °C is placed into an aluminium calorimeter of mass 0.400 kg containing 0.340 kg of water, both initially at 30.0 °C. Calculate the resulting temperature of the mixture.

(c_{Al} = 890 Jkg^{-1}K^{-1})
(c_w = 4180 Jkg^{-1}K^{-1})
(c_{ice} = 2100 Jkg^{-1}K^{-1})

$Q_g + Q_L = 0$ ½ $Q = mc\Delta T$ ½

$m_ic_i\Delta T_i + m_iL_f + m_wc_w\Delta T_w + m_Ac_A\Delta T_A + m_wc_w\Delta T_w = 0$ 1

$0.055(2100)(0--5) + 0.055(3.34\times10^5) + 0.055(4180)(Tf - 0) + 0.4(890)(Tf-30) + 0.340(4180)(Tf-30) = 0$

2

577 + 18400 + 230 Tf + 356Tf-10700 + 1420Tf - 42600 = 0
(Allow 577.5 + 18370 + 229.9 Tf + 356Tf-10680 + 1421Tf - 42636 = 0)
(Intermediate rounding is not being assessed in this question)

2010 Tf – 34300 = 0
(2007 Tf – 34368.5 = 0)

Tf = 17.1 C (3.s.f) 1

Common errors

If c_i = 4180 then Tf = 16.8 °C

If Lf omitted then Tf = 26.3 °C

If Q_{AL} omitted then Tf = 27.3°C

If Qw omitted then Tf = -14.1°C

If Tf(ice) left as Tf = 16.2 °C
(Tf(ice) = 0°C)

END OF TEST