Physics ATAR - Year 11

Thermal Physics Validation Test 2018

Name: SOLUTIONS	Mark: / 47 = %

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
- $\frac{T_\theta}{100} = \frac{X_\theta - X_0}{X_{100} - X_0} = \frac{R_\theta - R_0}{R_{100} - R_0}$
- K = C + 273.15

Question 1 **(2 marks)**

The Celsius scale was originally calibrated as a centigrade scale with 0 °C for the freezing point of water and 100 °C for the boiling point of water at 1 atm pressure as the fixed points. These were later deemed unreliable and changed to two other fixed points. State these fixed points and explain why they are considered more reliable.

- Triple point of water and absolute zero
- They are physical constant which cannot change
  Or
- m.p and b.p can vary depending on pressure, humidity, impurities etc

Question 2 **(3 marks)**

A pan of water is heated from 25.0 °C to 355 K. Calculate the change in temperature in the Kelvin scale.

Ti = 25 + 273

= 298 K (1)

$\Delta T = T_f - T_i$ (½)

= 355 - 398 (½)

= 57 K (0.d.p) (1)

Question 3 **(3 marks)**

The electrical resistance an uncalibrated thermostat thermometer is 0.250 Ω in ice water and 3.56 Ω in boiling water. When placed in a liquid with an unknown temperature the resistance is recorded as 3.99 Ω. Calculate the value of the unknown temperature.

$$T_? = \frac{R_\theta - R_0}{R_{100} - R_0} \times 100$$ (1)

$$= \frac{3.90 - 0.250}{3.56 - 0.250} \times 100$$ (1)

= 110 = 1.10 x10^2 °C (3.s.f) (1)

Question 4 **(3 marks)**

Calculate the amount of energy the needs to be removed from a 1.55 kg piece of metal to reduce the temperature from 120.0 °C to 20.5 °C. (c_{metal} = 655 $Jkg^{-1}K^{-1}$).

$Q = mc\Delta T$ (1)

$= 1.55\,(655)(20.5 - 120)$ (1)

$= -101017 = 1.01 \times 10^5$ J (1)

-1 mark if students writes -99.5
All working out must be shown

Question 5 **(4 marks)**

Metal A has a specific heat capacity of 2.00x. Metal B has a specific heat of 4.50x. Equal masses of each metal are provided with equal amounts of heat and Metal A records a ΔT of 5.55 K. Calculate, through an adequate mathematical relationship, the ΔT of Metal B.

$Q = mc\Delta T$ (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)

$2.00x(5.55) = 4.50x(\Delta T_B)$ (1)

$\Delta T_B = \frac{2.00x(5.55)}{4.50x} = 2.47$ K (1)

Question 6 **(8 marks)**

A large bucket of water at 30.0 °C sits next to a small cup of water at 30.0 °C.

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

(1 mark)

(i) The bucket

(ii) The cup

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

(b) Explain your answer to (a).

(3 marks)

- Internal energy is defined as the sum of all Ek and EP of particles in a substance
- Since the bucket and cup are at the same temperature, the EK is the same but the bucket has many more particles.
- Hence a greater internal energy

(c) Choose which has the fastest moving molecules (Circle your chosen answer)

(1 mark)

(i) The bucket

(ii) The cup

(iii) They both have the same mean speed of particles

(d) Explain your answer to (c).

(3 marks)

- Temperature is defined as the mean translational velocity of particles in a substance.
- Since both objects are at the same temperature,
- the particles in each container are moving with the same mean speed.

Question 7 **(4 marks)**

Calculate the total energy required to vaporise 5.00 x10^2 grams of water initially at 25.0 °C.

$Q = mc\Delta T + mL_f$ (1)

$= \frac{5.00\times10^5}{1000}(4180)(100-25) + (\frac{5.00\times10^5}{1000} \times 22.6 \times 10^5)$ (1)

$= 1.57 \times 10^5 + 1.13 \times 10^6$ (1)

$= 1.29 \times 10^6$ J (1)

-1 mark if students writes 75 °C or 0.5 kg
All working out must be shown

Question 8 **(7 marks)**

A 1.50×10^3 W copper kettle of mass 0.350 kg contains 1.80 kg of water at 25.0 °C.
(c_{Cu} = 390 $Jkg^{-1}K^{-1}$)
(c_W = 4180 $Jkg^{-1}K^{-1}$)

(a) Calculate the amount of energy required to bring the water (and the copper) to its boiling point.

(3 marks)

$Q = m_C c_C \Delta T_C + m_W c_W \Delta T_W$ (1)

$= 0.35(390)(100-25) + (1.80(4180)(100-25)$ (1)

$= 5.75 \times 10^5$ J (1)

(b) Calculate the time, in minutes, required to bring the water to boil

(4 marks)

$P = E / t$

$t = E / P$ (1)

$= 5.75 \times 10^5 / 1.50 \times 10^3$ (1)

$= 383$ s (1) $\div 60$ 6.38 minutes (1)

Question 9 **(8 marks)**

A mass of aluminium at 90.0 °C 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_{Al} = 900.0 $Jkg^{-1}K^{-1}$)
(c_W = 4180 $Jkg^{-1}K^{-1}$)

(a) Calculate the mass of aluminium required to produce the final temperature.

(4 marks)

$Q_g + Q_L = 0$ ½ $Q = mc\Delta T$ ½

$m_W c_W \Delta T_W + m_A c_A \Delta T_A = 0$

$(0.255)(4180)(24.4-20.0) + m_A(900)(24.4-90.0) = 0$ 2

$46899.6 - 59040 m_A = 0$

m = 0.0794 kg 1

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

(1 mark)

- No heat loss to surroundings/vessel or air

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

(3 marks)

- Greater
- As energy is lost to surroundings, more energy must be provided to the water
- As more energy is required, the mass of aluminium must be greater.

Question 10 **(5 marks)**

1.40 kg of water is placed in a calorimeter of mass 1.00 kg and specific heat capacity of 655 $Jkg^{-1}K^{-1}$. Both are cooled to 4.00°C. 0.250 kg of copper at 90.0°C is then placed into the calorimeter. Calculate the resulting temperature of the mixture. (c_{Cu} = 390 $Jkg^{-1}K^{-1}$)

½

$Q_g + Q_L = 0$ $Q = mc\Delta T$ (½)

$m_w c_w \Delta T_w + m_c c_c \Delta T_c + m_w c_w \Delta T_w = 0$

$(1.4)(4180)(Tf - 4) + 1(655)(Tf-4) + 0.25(390)(Tf - 90) = 0$ (3)

$5852Tf - 23408 + 655Tf - 2620 + 97.5Tf - 8775 = 0$

$6604.5\ Tf = 34803$

$Tf = 5.27\ °C$ (1)

END OF TEST