Thermodynamics Final Exam – Correction Key

Department: Physical Measurements – 1st Year MUP

Part One: Multiple Choice Answers10 marks

1. C – A process at constant temperature

2. C – No heat is exchanged

3. B – J

4. C – Isobaric

5. B – Entropy

6. C – Internal energy remains constant

7. B – Temperature of reservoirs

8. B – Conservation of energy

9. A – Work

10. A – Isobaric

11. C – Heat engine

12. A – 0.4

13. B – Zero

14. A – It transfers heat and performs work during the thermodynamic cycle

15. A – Because some heat must be rejected to a cold reservoir

16. A – U = 3/2 nRT

17. B – J/K

18. B – Isochoric

19. B – Cold to hot

20. B – It absorbs heat and does work

Part Two: Applications – Corrections

Application 01 – Radiator Analysis2.5 marks

1. Temperature of the radiator:

Using the Stefan-Boltzmann law $P = \sigma A T^4$, where the surface area $A = \pi \times d \times L$, we get:

$T = [P / (\sigma A)]^{(1/4)} \approx 788.2\ K$

2. Wavelength of maximum luminance (Wien's Law):

$\lambda\_max = b / T \approx 3.68\ \mu m$

3. Temperature for a wavelength $\lambda\_max = 1.8\ \mu m$:

$T = b / \lambda \approx 1610\ K$

4. Power emitted at this new temperature:

$P = \sigma A T^4 \approx 38.3\ kW$

Application 02 – Carnot Refrigeration Cycle5 marks

1. Theoretical work during one cycle (Carnot):

$W = Q_2 \times (T_1 - T_2) / T_2$

2. Freezing 0.5 L of water at 0 °C:

Given: $\rho = 1000\ kg/m^3$, $V = 0.5 \times 10^{-3}\ m^3$, $L = 334{,}000\ J/kg$

$Q = \rho \times V \times L = 167000\ J$

Theoretical work $W = 16507\ J$

Actual work W' (with 80% efficiency) = 20634 J

3. Coefficient of Performance (COP):

COP (ideal) = 10.12

COP (real, assuming 80% of ideal) = 8.09

Application 03 – Isothermal Compression of Nitrogen2.5 marks

Given: Reversible isothermal compression of nitrogen gas.

Initial pressure P_0, final pressure $P\_B = 10 \times P_0$.

Temperature T = 273.15 K, number of moles n = 1 mol.

1. Work done by the gas:

$W = -nRT \ln(P_B / P_0)$

$W = -1 \times 8.314 \times 273.15 \times \ln(10) \approx -5229$ J

2. Heat received by the gas:

Since the process is isothermal, internal energy remains constant.

$Q = -W \approx 5229$ J