ESO 201A/202

Quiz 2A | 20 Marks | 40 min | 30 Oct 2014

Name **Roll No.** **Section**

Among the multiple choices given with each question, **only one** is the correct answer. Please tick (✓) the **correct/closest to the correct answer** and **RETURN** the question paper. A separate sheet will be provided for rough work. There will be **no** negative marking. Each question carries **one mark.**

Q.1. A heat pump is absorbing heat from the cold outdoors at 5°C and supplying heat to a house at 25°C at a rate of 18,000 kJ/h. If the power consumed by the heat pump is 1.9 kW, the coefficient of performance of the heat pump is

(a) 1.3 (b)2.6✓ (c) 3.0 (d) 3.8 (e) 13.9

Q.2. A heat engine receives heat from a source at 1000°C and rejects the waste heat to a sink at 50°C. If heat is supplied to this engine at a rate of 100 kJ/s, the maximum power this heat engine can produce is

(a) 25.4 kW (b) 55.4 kW (c) 74.6 kW✓ (d) 95.0 kW (e) 100 kW

Q.3. An air-conditioning system operating on the reversed Carnot cycle is required to remove heat from the house at a rate of 32 kJ/s to maintain its temperature constant at 20°C. If the temperature of the outdoors is 35°C, the power required to operate this air-conditioning system is

(a) 0.58 kW (b) 3.20 kW (c) 1.56 kW (d) 2.26 kW (e) 1.64 kW ✓

Q.4. A refrigerator is removing heat from a cold medium at 3°C at a rate of 7200 kJ/h and rejecting the waste heat to a medium at 30°C. If the coefficient of performance of the refrigerator is 2, the power consumed by the refrigerator is

(a) 0.1 kW (b) 0.5 kW (c) 1.0 kW✓ (d) 2.0 kW (e) 5.0 kW

Q.5. Two Carnot heat engines are operating in series such that the heat sink of the first engine serves as the heat source of the second one. If the source temperature of the first engine is 1300 K and the sink temperature of the second engine is 300 K and the thermal efficiencies of both engines are the same, the temperature of the intermediate reservoir is

(a) 625 K✓ (b) 800 K (c) 860 K (d) 453 K (e) 758 K

Q.6. A window air conditioner that consumes 1 kW of electricity when running and has a coefficient of performance of 3 is placed in the middle of a room, and is plugged in. The rate of cooling or heating this air conditioner will provide to the air in the room when running is

(a) 3 kJ/s, cooling (b) 1 kJ/s, cooling (c) 0.33 kJ/s, heating
(d) 1 kJ/s, heating✓ (e) 3 kJ/s, heating

Q.7. Steam is condensed at a constant temperature of 30°C as it flows through the condenser of a power plant by rejecting heat at a rate of 55 MW. The rate of entropy change of steam as it flows through the condenser is

(a) -1.83 MW/K (b) -0 .18 MW/K✓ (c) 0 MW/K (d) 0.56 MW/K
(e) 1.22 MW/K

Q.8. An apple with an average mass of 0.12 kg and aver age specific heat of 3.65 kJ/kg °C is cooled from 25°C to 5°C. The entropy change of the apple is

(a) -0.705 kJ/K (b) -0.254 kJ/K (c) -0.0304 kJ/K✓ (d) 0 kJ/K
(e) 0.348 kJ/K

Q.9. Helium gas ($k = 1.667$) is compressed from 1 atm and 25°C to a pressure of 10 atm adiabatically. The lowest temperature of helium after compression is

(a) 25 °C (b) 63 °C (c) 250°C (d) 384°C (e) 476°C✓

Q.10. Argon gas ($k = 1.667$) expands in an adiabatic turbine from 3 MPa and 750°C to 0.2 MPa at a rate of 5 kg/s. The maximum power output of the turbine is

(a) 1.06 MW (b) 1.29 MW (c) 1.43 MW (d) 1.76 MW✓
(e) 2.08 MW

Q.11. A unit mass of a substance undergoes an irreversible process from state 1 to state 2 while gaining heat from the surroundings at temperature T in the amount of q. If the entropy of the substance is s_1 at state 1, and s_2 at state 2, the entropy change of the substance $\triangle s$ during this process is

(a) $\triangle s < s_2 - s_1$ (b) $\triangle s > s_2 - s_1$ (c) $\triangle s = s_2 - s_1$ ✓
(d) $\triangle s = s_2 - s_1 + q/T$ (e) $\triangle s > s_2 - s_1 + q/T$

Q.12. A unit mass of an ideal gas at temperature T undergoes a reversible isothermal process from pressure P_1 to pressure P_2 while losing heat to the surroundings at temperature T in the amount of q. If the gas constant of the gas is R, the entropy change of the gas $\triangle s$ during this process is

(a) $\triangle s = R\ ln(P_2/P_1)$ (b) $\triangle s = R\ ln(P_2/P_1) - q/T$
(c) $\triangle s = R\ ln(P_1/P_2)$✓ (d) $\triangle s = R\ ln(P_1/P_2) - q/T$ (e) $\triangle s = 0$

Q.13. Air is compressed from room conditions to a specified pressure in a reversible manner by two compressors: one isothermal and the other adiabatic. If the entropy change of air is $\triangle s_{isot}$ during the reversible isothermal compression, and $\triangle s_{adia}$ during the reversible adiabatic compression, the correct statement regarding entropy change of air per unit mass is

(a) $\triangle s_{isot} = \triangle s_{adia} = 0$ (b) $\triangle s_{isot} = \triangle s_{adia} > 0$ (c) $\triangle s_{adia} > 0$
(d) $\triangle s_{isot} < 0$ ✓ (e) $\triangle s_{isot} = 0$

Q.14. Heat is lost through a plane wall steadily at a rate of 600 W. If the inner and outer surface temperatures of the wall are 20°C and 5°C, respectively, the rate of entropy generation within the wall is

(a) 0.11 W/K✓ (b) 4.21 W/K (c) 2.10 W/K (d) 42.1 W/K
(e) 90.0 W/K

Q.15. Heat is lost through a plane wall steadily at a rate of 600 W. If the inner and outer surface temperatures of the wall are 20°C and 5°C, respectively, and the environment temperature is 0°C, the rate of exergy destruction within the wall is

(a) 30 W✓ (b) 17,500 W (c) 765 W (d) 32,800 W (e) 0 W

Q.16. Liquid water ($c = 4.18$ kJ/kgK) enters an adiabatic piping system at 15°C at a rate of 3 kg/s. It is observed that the water temperature rises by 0.3°C in the pipe due to friction. If the environment temperature is also 15°C, the rate of exergy destruction in the pipe is

(a) 3.8 kW✓ (b) 24 kW (c) 72 kW (d) 98 kW (e) 124 kW

Q.17. A heat engine receives heat from a source at 1500 K at a rate of 600 kJ/s and rejects the waste heat to a sink at 300 K. If the power output of the engine is 400 kW, the second-law efficiency of this heat engine is

(a) 42% (b) 53% (c) 83%✓ (d) 67% (e) 80%

Q.18. A house is maintained at 21°C in winter by electric resistance heaters. If the outdoor temperature is 9°C, the second-law efficiency of the resistance heaters is

(a) 0% (b) 4.1%✓ (c) 5.7% (d) 25% (e) 100%

Q.19. A 12-kg solid whose specific heat is 2.8 kJ/kg°C is at a uniform temperature of -10°C. For an environment temperature of 20°C, the *exergy* content of this solid is

(a) Less than zero (b) 0 kJ (c) 4.6 kJ (d) 55.4 kJ✓ (e) 1008 kJ

Q.20. Keeping the limitations imposed by the second law of thermodynamics in mind, choose the **wrong** statement below:

(a) A heat engine cannot have a thermal efficiency of 100%.

(b) For all reversible processes, the second-law efficiency is 100%.

(c) The second-law efficiency of a heat engine cannot be greater than its thermal efficiency.✓

(d) The second-law efficiency of a process is 100% if no entropy is generated during that process.

(e) The coefficient of performance of a refrigerator can be greater than 1 .